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AN ANALYSIS OF MARKET DEMAND FOR MEATS IN CANADA

BY

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THE UNDERSIGNED CERTIFY THAT THEY HAVE READ, AND RECOMMEND TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH FOR ACCEPTANCE, A THESIS ENTITLED AN ANALYSIS OF MARKET DEMAND FOR MEATS IN CANADA SUBMITTED BY PETER YANPING CHEN IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN AGRICULTURAL ECONOMICS.

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ABSTRACT

In this study, demand for meat in Canada was analyzed using several versions of single-equation and demand system models. The issue of structural shift in demand for meat was examined by testing for parametric constancy using a number of different tests. Specifically, demand elasticity estimates and testing for structural change were based on the single-equation models after two major specification issues were examined. Dynamic and static versions of demand systems in almost ideal functional form and translog functional form were also estimated to obtain demand elasticity estimates and evidences of structural shift. The results from these different demand models were compared to evaluate the sensitivity of estimates and structural change tests to model specification choices. The hypothesis of no structural change in demand for meat in Canada is rejected in every case. Overall, the results were not very sensitive to model specification choices. It is concluded that Canadian meat consumption patterns over time can be explained by a combination of changes in prices, consumer expenditures and tastes. Consumption expenditures have shift from beef to chicken but remained stable for pork; about six percent decline in expenditure shares on beef and about thirty percent increase in expenditure shares on chicken seem to have been due to this structural shift at constant prices and consumer expenditures.

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I. Introduction

A. Background

In Canada, as in some other nations, meat consumption patterns have changed over the past twenty years. At the retail level, beef consumption increased from 24.0 kg per capita in 1960 to a peak level of 39.1 kg in 1976, and then fell continuously to 27.8 kg in 1987. Per capita pork consumption has shown much year-to-year variation, with a general trend of slight increase over the period from 1960 to 1987. On a wholesale carcass basis, per capita poultry meat consumption has shown an upward trend, rising from 12.6 kg in 1960 to 20.3 kg in 1976, and 27.6 kg in 1987.

The decline in beef consumption and the changes in the meat consumption mix since 1976 have led to considerable interest in measuring both magnitudes and stability of demand parameters for various meats. A major issue is whether or not there has been structural change in the demand for meat (due, perhaps, to consumers' perceptions of health and diet, or perhaps, to demographic change in composition of population), or whether changes in relative prices and income explain the changes in meat consumption patterns. There is an ongoing debate in Canada, as in the United States and Australia, concerning this issue of a possible structural change in demand for meat. It is also possible that changes in the demographic structure of the Canadian population may have influenced meat consumption trends. Quantitative measures of the influence of these various factors in the observed changed pattern are of great interest to livestock suppliers and meat processors, as well as to government policy makers. For example, empirical estimates of demand for meat are essential in providing forecasts and analyzing the effects of changes in consumer expenditure and prices of meat. The analysis of structural change in demand for meat is of importance in designing appropriate marketing strategy for this sector. If a structural change stemming from perceptions of healthy diets has adversely affected red meat consumption, promotional activities to modify consumers' perceptions may be warranted. If declining consumption levels for red meats primarily result from changes in relative prices and incomes of consumers, an appropriate strategy for red meat producers would involve emphasizing the search for cost-reducing production technologies. These results are also useful in evaluating meat market institution efficiency. However, in estimation and testing the stability of demand parameters, it is important that demand models be properly specified; mis-specification can lead to biased parameter estimates and to incorrect conclusions of structural change.

B. The Purpose of Study

The general objective of this study is to contribute to the empirical knowledge of elasticities of demand for meats in Canada and the inquiry about structural change in consumer preferences or tastes for meat consumption over the last two decades.

The specific objectives of this study are:

1. (a) To assess some specification issues and thus the accuracy of elasticity estimates based on single-equation demand models; (b) to estimate the almost ideal demand system and the Translog demand system and compare their performance.

2. To empirically evaluate the properties of consumer demand theory with

dynamic and static versions of the specific demand systems.

3. To provide parameter estimates of demand for meats by analyzing budget share behavior, using annual and quarterly Canadian data.

4. To test whether or not there was a structural change in the demand for meats during mid- to late 1970s.

C. The Organization of the Study

This thesis study contains the following chapters[1]. A review of the theoretical basis of consumer demand is given in Chapter 1. In Chapter 2, some specification issues relating to single-equation demand models are examined. Test results and demand elasticities are computed based on annual data. Results of estimating two alternative demand systems for the retail demand for meats with a test of structural change are given in Chapter 3 and 4. Chapter 5 provides a general discussion and conclusions, based on the previous chapters, relating to demand elasticity estimation and the issue of structural shift in demand for meat in Canada.

1 This thesis is prepared according to a paper format, which provides the student with the opportunity to present individual studies in a paper format within the thesis.

D. The Theoretical Framework of Consumer Behavior and Demand

In most applications of demand analysis to policy questions, it is necessary to know specific economic parameters that describe consumers' behavior. For example, what are the price and income elasticities of demand for beef, pork, and poultry meats? What is the degree of substitution between beef and pork in consumption? Are some types of meat inferior or normal goods? The answers to these questions can be very useful for policy-making purposes and are necessary to provide projections and outlook information to guide industry members. To find the precise answers one needs both appropriate economic theory and econometric techniques to analyze the data describing consumers' behavior.

The Demand Theory

Demand theory is concerned with how a consumer allocates his budget among commodities such that the maximum level of satisfaction is attained. The neoclassical theory postulates that a utility function can be used to describe and measure the level of satisfaction that a consumer attains from consuming a particular bundle of commodities. For the existence of such a utility function, a set of axioms of consumer choice is assumed.[2] Following Johnson, *et al.*, (1984), the utility function is denoted as:

$$U = f(q)$$

2 These axioms are reflexivity, completeness, transitivity, continuity and nonsatiation, which are discussed in Deaton and Muellbauer (1980, pp.25-29).

where $q = (q_i), i = 1, \ldots, n$, is an n-element vector whose elements represent quantities of the commodities consumed per unit of time.

An individual consumer's preference relationship may be described by a form of utility function, which is assumed to be:

1. Monotonically increasing; the utility level can be higher even if the consumer is restricted to only small changes in the consumption bundle.

2. Strictly quasi-concave; this is the generalization of the assumption of the diminishing marginal rates of substitution.

3. Twice differentiable; this is for ease of derivation of analytical results.

The basic hypothesis is that a rational consumer will always chooses a most preferred bundle from the feasible consumption set. The set of feasible alternatives is the set that the consumer can afford. Let $p' = (p_i)$ be the n-element column vector of prices, and E be the consumer's income; the budget constraint can be expressed by $p'q = E$.

The consumer will maximize utility subject to his/her budget constraint. The problem of preference maximization can be written as:

maximize $U(q)$

subject to $p'q = E$

This constrained optimization problem can be solved by the Lagrangian method. Following this procedure, the Lagrangian function is formed:

$$L(q,\lambda) = U(q) - \lambda(p'q - E),$$

where λ is the Lagrangian multiplier which is interpreted at the point of optimization as the marginal utility of income. Differentiating the Lagrangian function with respect to each choice variable, q_i and λ, yields the first order conditions:

$$U_{qi} - \lambda p_i = 0$$

$$p'q - E = 0$$

The second order conditions for a utility maximum are assured by the assumption that the utility function U is strictly concave. Solving from the above first-order-condition equations, a unique set of equations, $q_1, \ldots, q_n$ and λ can be obtained in terms of prices and income. The resulting expressions are

$$q_i = q_i(p_1, \ldots p_n, E)$$

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

The demand equations, q_i's, are important in both theory and practice because they describe how the consumer simultaneously chooses the quantity of each commodity subject to his/her budget constraint. Along with the demand functions, a number of testable propositions have been derived and developed from the constrained utility maximization framework.

Properties of Demand Functions

Demand functions derived from the theory of consumer demand satisfy several important conditions. For example, the linear budget constraint has the following implications: substituting a demand function $q_i = q_i(p, E)$ into the linear constraint, $\Sigma p_i q_i = E$, yields $\Sigma p_i q_i(p, E) = E$. This is known as the adding-up condition which imposes restrictions on the functional form $q_i(p, E)$. The adding-up condition states that as a result of any change in prices and income, the consumer will adjust the consumption of q in such a way that his/her budget constraint is still satisfied.

The second implication of the linear budget constraint is that demand functions are homogeneous of degree zero in prices and income. In $\Sigma p_i q_i(p, E) = E$, the demand function $q_i(p, E)$ is *invariant* when prices are raised, along with expenditure, by the same multiplier. The condition of homogeneity states that if all prices and income simultaneously increase by the same proportion, the consumer will not change his/her consumption bundle q_i. For example, this condition implies the sum of price elasticities and income elasticities should equal zero for double-log demand functions.

In addition to the above two restrictions from the linear budget constraint, the properties of symmetry and negativity are the other analytical results from the constrained preference maximization. The symmetry of cross-price derivatives, by Young's theorem, can be expressed mathematically as:

$$\frac{dh_i(u, p)}{dp_j} = \frac{dh_j(u, p)}{dp_i}$$

where h_i and h_j are the Hicksian demands.

The property of negative semi-definiteness of the matrix of compensated price derivatives implies that when the consumer's income is compensated such that his/her level of utility is held constant, he/shewill purchase less of a good if the price of that good increases. This is viewed as the "law of demand".[3] The above theoretical properties will be imposed, tested, or checked in the empirical demand systems modelled in Chapters 3 and 4.

Duality in Consumption and Demand Analysis

With the development and adoption of duality concepts in economics, there now are several alternative ways of representing consumer preferences. There are, for example, direct utility functions, indirect utility functions, and cost or expenditure functions, although the existence of these functions requires some regularity conditions to hold. Varian (1984, p. 162) provides a precise definition of utility and cost and a proof of equivalence between utility maximization and cost minimization. By using duality relationships, theoretically consistent demand systems can be obtained by relatively simple differentiation. For instance, some properties of the underlying consumer preferences as well as the resulting demand systems can be derived more easily by using an indirect utility or cost function with duality methods rather than by employing the traditional direct utility maximization techniques. This will be further discussed in Chapters 3 and 4, in which demand systems analysis approaches are applied.

Weak Separability and Multistage Budgeting

3 For more detailed discussion of these properties, see Deaton and Muellbauer (1980), Phlips (1983), Johnson, *et al.* (1984).

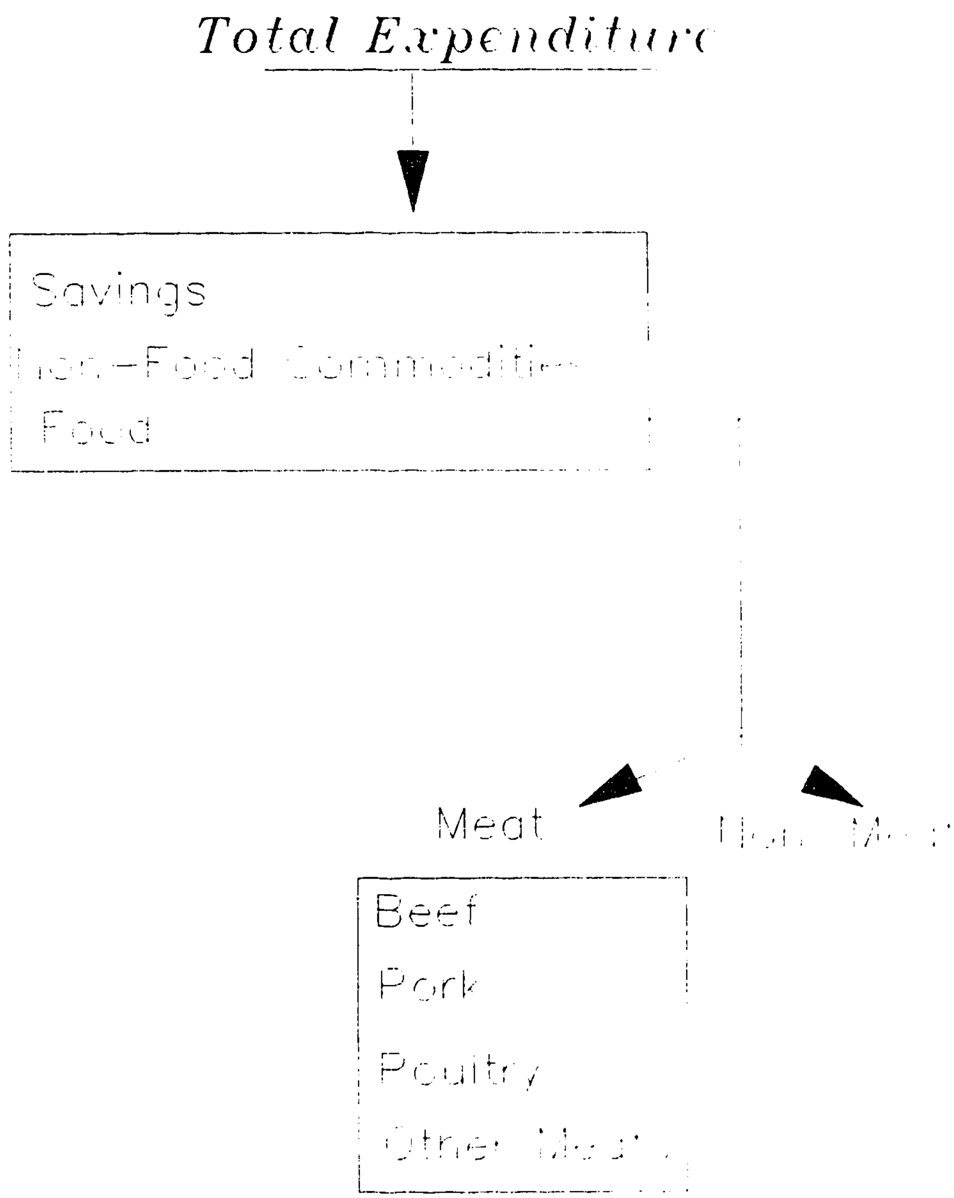
In standard consumer demand theory as outlined above, it is hypothesized that a consumer considers the prices of all goods in deciding the desired quantity of any particular good. All goods compete for the consumer's budget. In many cases, the analyst wants to focus the inquiry on the groups of consumption of most immediate interest rather than on the entire consumption decision.

In order to derive useful results, the analyst needs to partition commodities into groups such that preferences concerning goods in any one group are independent of quantities in other groups. This requires the assumption that the consumer's utility function consists of separable sub-utility functions for each different group. The utility function $U(q)$ is defined as weakly separable with respect to a partition of s groups of sub-utility functions $\{n_1, \ldots n_i, \ldots n_s\}$ if

$$\frac{d(U_i/U_j)}{dq_k} = 0, \frac{d(q_i/q_j)}{dp_k} = 0$$

where all i and j is an element of n_i, and k is not an element of n_i (Johnson, *et al.* 1984). If this separability of preferences holds, the consumer's level of satisfaction from consuming each of the subgroups of goods depends only on the goods in that subgroup. Here the analyst hopes that such groupings are correct, i.e. they reflect the actual decision process of the consumer. As Deaton and Muellbauer (1980, p.122) have pointed out that there is no reason why each subutility function could not have one or more deeper subgroupings within it. The following notion of a "utility tree" illustrates the concept of separable preferences. Note that the following figure is only one of many possible utility trees.

FIGURE 1: A POSSIBLE UTILITY TREE



This diagram reflects another useful concept, that of branch or multistage budgeting. In branch budgeting, one can think of the consumption decision as taking place in three or more stages: first the consumer allocates his/her budget or total expenditure to broad groups such as food and non-food commodities; then the consumer allocates group expenditure to meat and non-meat foods; finally the consumer considers how much of a particular meat, say pork, to consume given the prices of various meats and total expenditure on meat. Such a multistage budgeting process is very useful in applied demand analyses. The necessary and sufficient condition for the second or higher stage of multistage budgeting is the assumption of weak separability.[4] An important result from weak separability and multistage budgeting is as follows: if any subgroup of commodities appears in a separable sub-utility function, then quantities purchased in that group (e.g. meats) can be written as a function of group expenditure (e.g. expenditure on meat) and the prices of goods in that group (Deaton and Muellbauer, 1980). For example, consider a demand function $q_i = q_i(p_r, E_r)$, where good i is an element of goods in group r. The demand equation for good i is derived from the maximization of utility subject to expenditure on group r. Thus, if interested in demand for meats and if weak separability applies, the analyst does not need information on total expenditure on all goods and prices of non-food items. However, the usefulness of weak separability is at the price of imposing severe restrictions on the degree of substitutability between goods in different groups[5]. Furthermore, the hypothesized grouping of consumption goods involves prior judgement and is subject to empirical testing.

4 For a discussion see Deaton and Muellbauer (1980, p.124).

5 For some empirical restrictions implied by weak separability see for example Alston and Chalfant (1987) and Eales and Unnevehr (1987).

Market Demand and Aggregation Problems

The data usually available for demand estimation are the aggregate quantities sold to all consumers and the market prices. One is generally interested in analyzing these data series. The demand theory as outlined above describes individual consumer behavior. In estimating market demand functions, it is assumed that all consumers have the same preferences, with a fixed distribution of incomes (Chipman 1974).[6] This is a very restrictive assumption that guarantees the result of aggregate utility maximization. However, a reasonable way of viewing the assumption of identical utility functions is that if preferences can be regarded as distributed around some average or representative utility function, aggregate demand behavior can be represented by market demand curves plus a random component (Varian, 1984).[7] In other words, for large groups of consumers the differences in behavior tend to average out, and the aggregate consumers act as if they were a representative individual consumer. Another argument for aggregation is based on the notion that if all consumers have the same marginal propensity to consume a good, then the aggregate of consumers will behave as though it were an average individual consumer.[8] Despite such efforts made in the economic literature, the aggregation process remains as a problem in empirical demand studies.

E. Empirical Studies of Demand for Meat and Structural Change

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6 Also see Green (1976, p.139) for a discussion on the problems of stating what the aggregation conditions are.

7 See Samuelson (1956) on aggregation with the utility distribution held constant.

8 For a technical discussion on aggregation, some recent results, and bibliographic notes, see Deaton and Muellbauer (1980, pp.148-165).

Literature on the demand for meat and related structural change analysis has contained a variety of estimates and conclusions, with many contradictions due largely to differences in model specifications.[9] A typical empirical study of the demand for meat would involve estimation of only one specific functional form. Often the specification of the demand for meat is diagnostically tested for structural stability after estimating the parameters of the model. The empirical evidence of model instability is interpreted as a structural change in demand.

As Alston and Chalfant (1990) have pointed out that it is rare for such studies to examine whether an alternative demand system would have resulted in different conclusions as to structural change. To avoid the problem that conclusions derived from these studies are functional specific, they argued for the use of nonparametric methods to test the preference stability. For the purposes of estimation for demand elasticities, however, it is necessary to specify an explicit functional form for meat demand.

It is not known that any previous Canadian meat demand studies has systematically analyzed the sensitivity or fragility of inference of structural change tests to specification choices. To analyze the fragility of inference in econometric studies of Canadian meat demand, we estimate meat demand functions using both single equation and demand system models. In addition, we also use both annual and quarterly data. The resulting estimates and conclusions of structural change tests are compared and analyzed to evaluate the sensitivity of these results to specification choices.

9 Specific empirical studies on meat demand are reviewed in following individual chapters.

F. References

Alston, J. and J. Chalfant (1987). "Weak Separability and a Test for the Specification of Income in Demand for Meat in Australia." *Australian Journal Agricultural Economics* 31-(1):1-15.

Alston, J. and J. Chalfant (1990). "Can We Take the Con Out of the Meat Demand Studies" Paper Presented in the Annual Meeting of Western Agricultural Economists Association, Vencouver, B.C.

Al-Zand, O. and G. Lavoie (1987). "Consumer Demand For Meat in Canada." *Food Market Commentary.* Ottawa: Agriculture Canada.

Barten, A. (1969). "Maximum Likelihood Estimation of a Complete System of Demand Equations." *European Economic Review* 1:7-73.

Braschler, B. (1983). "The Changing Demand Structural for Pork and Beef in 1970's: Implications for the 1980's", *Southern Journal Agricultural Economics* 9:271-82.

Chalfant, J. And J. Alston (1988). "Accounting for Changes in Tastes", *Journal of Political Economy* 96(2):391-410.

Chavas, J. P. (1983). "Structural Change and Demand for Meat", *American Journal Agricultural Economics* 65:148-53.

Chipman, J. S. (1974), "Homothetic Preferences and Aggregation", *Journal of Economic Theory* 8:26-38.

Christensen, R. *et al.* (1975). "Transcendental Logarithmic Utility Functions", *American Economic Review*. 65:367-83.

Curtin, L. *et al.* (1987). "Demand for Foods in Canada." Working Paper 13/87, Agriculture Canada.

Dahlgran, R. (1987). "Complete Flexible Systems and the Stationarity of U.S. Meat Demand", *Western Journal of Agricultural Economics* 12:152-63.

Deaton, A. and J. Muellbauer (1980). *Economics and Consumer Behavior* (Cambridge: Cambridge University Press).

Eales, J. and L. Unnevehr (1987). "Demand for Beef and Chicken Products: Separability and Structural Change." AAEA Annual Meeting, Working Paper No. 358 University of Illinois.

Fisher, B. (1979). "The Demand for Meat--An example of an incomplete Commodity Demand System", *Australian Journal of Agricultural Economics* 23(3):220-30.

Green, H. A. (1976). Consumer Theory (New York: MacMillan).

Haidacher, R. C. (1983). "Structural Change in the Demand for Meat", *Southern Journal of Agricultural Economics* 9:31-38.

Hassan, Z. and S. Johnson (1976). "Consumer Demand for Major Foods in Canada", Economics Branch Publication No.76/2,Agriculture Canada.

________, (1979). "The Demand for Meat in Canada: An Application of the Transformation of Variables", *Canadian Journal Agricultural Economics* 27(3):1-12.

________, (1983). "Quarterly Demand for Meat in Canada with Alternative Seasonality Hypothesis", *Canadian Journal Agricultural Economics* 31(1):77-94.

Kennedy, P. (1985). *A Guide to Econometrics* (Cambridge: MIT Press).

Martin, W. and D. Porter, (1985). " Testing for Changes in the Structure of the Demand for Meat in Australia" *Australian Journal Agricultural Economics* 29(1):16-31.

Moschini, G. and K. Meilke (1984). "Parameter Stability and the U.S. Demand for Beef", *Western Journal of Agricultural Economics* 9:271-82.

Murray, J. (1985). "Retail Demand for Meat in Australia: A Utility Approach", *The*

Economic Record 9:45-56.

Muellbauer, J. (1976). "Community Preferences and the Representative Consumer", *Econometrica* 44:979-99.

Nyankori, J. C. and G. H. Miller (1982). "Some Evidence and Implications of Structural Change in Retail Demand for Meats", *Southern Journal Agricultural Economics* 14:65-70.

Phlips, L. (1983). *Applied Consumption Analysis* (Oxford: North-Holland).

Samuelson, P. (1956). "Social Indifference Curves", *Quarterly Journal of Economics* 70:1-22.

Ryan, David. (1987). The Lecture Notes of Applied Econometrics. Edmonton: Department of Economics, The University of Alberta. Unpublished.

Tryfos, P. and N. Tryphonopoulos, (1973). "Consumer Demand for Meat in Canada", *American Journal of Agricultural Economics* 55(1):84-91.

Varian, H. (1984) *Microeconomic Analysis* (New York: North Holland).

Young, L. (1987). "Canadian Meat Demand", Working Paper 10/87Ottawa: Agriculture Canada, Policy Branch.

II. Model Specification and Elasticities of Market Demand for Meat

Introduction

In this chapter two features of the specification of single-equation models of the demand for meat are explored using Canadian data, specifically the use of meat expenditures versus disposable income in the demand equation and the use of quantity versus price as the dependent variable in the demand models. The appropriateness of the expenditure or income variable is examined using non-nested J tests, and the appr ›riateness of quantity or price as the dependent variable is explored by testing for exogeneity. The prediction performance of the alternative models of demand for meat are also assessed. Estimates of price, income and expenditure elasticities of demand for meat are computed and compared with those from some previous studies. The stability of demand for meat is tested.

Observed changes in meat consumption patterns in Canada since the mid-1970s have led to interest in the size and stability of demand parameters for different types of meat. The issues of whether there have been structural changes in demand for red meats due, for example, to consumers' perceptions of healthy diets, or whether changes in prices and incomes largely explain observed changes in meat consumption patterns, are of importance to producers' choice of marketing strategies and to policy makers. The focus of this chapter is that in estimating and testing the stability of demand parameters it is important that demand models be properly specified; misspecification can lead to biased parameter estimates and to invalid conclusions of structural change.

The following three specific questions are explored: (1) are prices predetermined in quantity-dependent models of demand for meats? (2) what is the appropriate income variable to include in such models of demand for meats? and (3) has there been a structural change in demand for meat in Canada, as judged by testing whether demand elasticities have changed, based on model specifications from 1 and 2?

Overview of Previous Studies of Canadian Demand for Meat

A number of studies have estimated parameters of Canadian consumer demand for meat. Tryfos and Tryphonopoulos (1973) estimated demand equations for beef, veal, mutton and lamb, pork and chicken over the years from 1954 to 1970. Hassan and Katz (1975) estimated Canadian domestic consumption of beef, pork, lamb, veal, chicken and turkey from 1954 to 1972 using Zellner's seemingly unrelated regression and full information maximum likelihood estimators. Hassan and Johnson (1976) estimated demand elasticities for all foods, including individual meats. Hassan and Johnson (1979, 1983) also estimated demand functions for beef, pork, veal, chicken and turkey using non-linear single equation models with quarterly data. Curtin et al. (1987) estimated the demand for food, including various meats, from 1973 to 1985.

Using single equation models and quarterly data, Young (1987) investigated the issue of structural change in Canadian meat demand and found no evidence of a structural shift in demand for beef. Kerr et al. (1989) examined the same issue but found evidence of structural change in demand for beef. The empirical results assessing whether there have been structural changes in U.S. and Australian meat demand are also mixed. A number of studies have concluded that there is evidence of structural change in beef demand during the 1970s (Nyankori and Miller 1982; Chavas 1983; Braschler 1983), while others have found no such evidence (Moschini and Meilke 1984; Martin and Porter 1985). As Dahlgran (1987) has pointed out, the contradictory results and conclusions from such studies seem, in large measure, to be due to differences in model specification, data, and definitions of structural change.

The Specification of the Income Variable in Single-Equation Demand Models

In principle, Marshallian demand functions specify quantity demanded as a function of a vector of relative prices and some measure of consumer income or expenditure, that is, $q_i = q_i(P_1, \ldots P_n, E)$. The theory of individual consumer's behavior suggests that: (a) all prices of consumption goods and services as well as consumer's income enter the demand functions; and (b) the individual consumer faces predetermined or exogenous prices. However, in specifying models of empirical demand, for example, for meat, the estimated equations commonly include only the prices of the product and its close substitutes. These models incorporate the notion of weak separability and multi-stage budgeting to exclude all non-meat prices from their models. As Alston and Chalfant (1987) have pointed out, the separability assumption, in turn, suggests that expenditures on meat, rather than the commonly used levels of per capita disposable income, is the appropriate explanatory variable. The issue of whether or not it is appropriate to assume separability is an empirical question.

Two alternative single-equation models of meat demand are used in this study for estimation and hypothesis testing. These are the double-logarithmic demand function specification and the single-equation version of the almost ideal demand specification of Deaton and Muellbauer (1980). The first formulation, although widely used due to its good data fitting features, has the disadvantage of lacking consistency with standard utility maximization theory, a feature that does not apply to the second functional form used in this study. Models 1a and 1b are the double-logarithmic model versions; they differ mainly in their inclusion of expenditure or income as explanatory variables. They are:

(1a) $ln q_i = \alpha_i + \sum_j \gamma_{ij} ln P_j + e_i ln E + u_i$, and

(1b) $ln q_i = \alpha_i + \sum_j \gamma_{ij} ln\left(\frac{P_j}{CPI}\right) + e_i ln\left(\frac{Y}{CPI}\right) + u_i$

where:

q_i = kilograms per capita of meat i (i.e. beef, pork, poultry meat, fish);

p_j = price of meat j (in \$/kg);[1]

E = per capita expenditure for meat$\left(E = \sum_i p_i q_i\right)$; and

---

1 The meat price data series are derived from the consumer price indexes series for specific meats (1981=100) by multiplying these by the city average retail prices of specific meats in 1981. The price of beef is a weighted average of prices for loin and round steak, roast, hamburger listed in Statistics Canada (Cat. # 62-010). The weights are the expenditure weights listed in Statistics Canada (Cat. #62-553). The same method is applied to derive the price of pork, which is a weighted average of prices of center cuts, roast, and boneless pork.

y = per capita disposable income. The consumption data for pork and beef are revised unpublished retail-weight per capita consumption data from Agriculture Canada. The other data are from Agriculture Canada (1988).

The single equation versions of Deaton and Muellbauer's model are also tested with alternative expenditure and income variables. These are:

(2a) $s_i = \alpha + \sum_j \gamma_{ij} \ln\left(\frac{P_j}{CPI}\right) + e_i ln\left(\frac{E}{P*}\right) + u_i$, and

(2b) $s_i = \alpha_i + \sum_j \gamma_{ij} ln\left(\frac{P_i}{CPI}\right) + e_i ln\left(\frac{Y}{CPI}\right) + u_i$

where:

s_i = the share of meat i (beef, pork, poultry, fish) in total meat expenditure;

CPI = the consumer price index for all items; and

$P* = \sum_i s_i \ln P_i$ (Stone's geometric index). The other variables are as previously defined.

In choosing among the alternative demand models, non-nested hypothesis tests of Davidson and MacKinnon (1981) are used to assess the appropriateness of the income or expenditure measures as alternative explanators of meat consumption patterns. The hypotheses are:

H_0: Expenditure on meat explains the demand for meat;

H_1: Disposable income explains the demand for meat.

The non-nested tests for Models a and b are based on a compound regression model formed as:

(3) $\ln q_i = (1-\alpha)Model\,1a + \alpha(Model\,1b) + u$

Following the Davidson and McKinnon procedure, Model b is replaced by its forecast values to perform J tests. The test of the null hypothesis H_0, is equivalent to the test that $\alpha = 0$ in Equation 3. The hypothesis H_0 is rejected if the t-statistic for α exceeds its critical value. The test procedure is also reversed, i.e. Model b is tested against a. The results of these tests are reported in Table 1. The computer program SHAZAM (White, 1978) was used.

The results in Table 1 support the use of expenditure on meat, rather than per capita disposable income, as the income variable in all but one instance. The exception applies in the case of the almost ideal specification of the demand for pork. In this equation both the income variables considered here are rejected, suggesting that some other measure may be a more appropriate income measure in this instance. This requires further examination.

The results also provide some support for the hypothesis that weak separability of the meat group consumption from other consumption groups applies. Based on the results of these non-nested specification tests, endogeneity tests and stability tests are applied to Models 1a and 2a.

4 Exogeneity Tests of Functions Estimating Market Demand for Meat

The other major issue of specification addressed in this chapter is the question of whether or not prices are predetermined in market demand functions. As Thurman (1987) has pointed out, the proper specification of quantity or price as the appropriate

Table 1

Results of Non-Nested J Tests of Income Variables and Expenditures

t-statistics of $\alpha = 0$

Model Type:		H_0: Expenditure on Meat is Appropriate Explanatory Variable	H_1: Per Capita Disposable Income is Appropriate Explanatory Variable
$\ln q_i$	Beef	1.034	15.089*
	Pork	-1.443	5.096*
	Poultry	-1.074	3.367*
S_i	Beef	-0.719	13.655*
	Pork	7.478*	4.841*
	Poultry	1.389	4.290*

1 Autocorrelation is corrected using the Beach-MacKinnon ML procedure prior to application of the J test.

* Denotes α is statistically significant different from zero at the 5 percent level; significant t-statistics indicate the rejection of the hypothesis. The critical value of t* is 2.080.

dependent variable in market demand estimation has received little attention. Yet, if price is endogenous in the quantity-dependent market demand equations, the resulting estimates will be biased and inconsistent due to the presence of simultaneous equation bias. Consequently, tests of structural change based on such a model may not be valid. To assess whether price, quantity, or both are endogenous for aggregate market demand for meat in Canada, the Wu-Hausman test procedure is applied.

The basic concept of the Wu-Hausman test is that if a single equation quantity-dependent demand model is well specified (i.e. if price is predetermined) the estimated slope coefficient of the price from an OLS estimator should not differ significantly from the corresponding estimates from an instrumental variable estimator of a simultaneous equation model of supply and demand. Such estimates of slope coefficients of the price are expected to be quite different from one another if the single equation demand model omits the significant effects of supply equation.

Specifically, the Wu-Hausman test statistic is:

(4) $WH = (\beta_{iv} - \beta_0)'[V(\beta_{iv} - \beta_0)]^{-1}(\beta_{iv} - \beta_0) \sim \chi^2(q),$

where:

β_{iv} = the estimate from the instrumental variable technique;

β_0 = the estimate from the OLS technique;

q = the number of variables for which exogeneity is questioned; and

V = the variance of the variables.

For poultry meat, prices of chicken have, at least for recent years, been somewhat indirectly affected by Canadian poultry marketing boards; prices are based on a cost of production formula. It can be expected that poultry meat prices are predetermined and that the quantities demanded are endogenous, suggesting that a quantity-dependent model of the demand for chicken is reasonable. Since the Canadian red meat market is relatively small compared to the much larger U.S. market and since prices of beef and pork are believed to be determined by market forces in the total North American market, it may be reasonable to assume that retail prices are predetermined and that quantities in the Canadian market are endogenous.

Nevertheless, it is possible that for some meats, quantities supplied to the Canadian market may have an effect on market prices in Canada. Thus, whether prices, or quantities, may be treated as predetermined or exogenous, or whether these are interdependent in the Canadian market for meat is a question subject to empirical investigation.

To examine the exogeneity of the price and quantity variables in demand models, both quantity- and price-dependent demand equations must be tested. In this section, the commonly used double-logarithmic functional form is applied to test alternative versions of this model.

The quantity-dependent version of demand is:

$$(5)\quad lnQ_i = a_i + \sum_j b_{ij} lnP_j + e_i lnE + u$$

A price-dependent version of demand is:

$$(6)\quad lnP_i = b_i + \sum_j C_{ij} lnP_j + g_i lnQ_i + f_i lnE + u$$

where:

Q_i = kilograms per capita of meat i (specifically, beef, pork, poultry, and fish);

P_i = price of meat i; and

E = per capita expenditure on the four meat types. Data are as for Models 1 and 2.

The supply equation is taken as a function of output and input prices, based on the concept of profit maximization:

$$(7)\quad lnQ_i = h_i + k_i lnP_i + \sum_j m_{ij} lnZ_i + u$$

where:

$Z_i = (P_{if}, P_{il})$

and:

P_{if} = one-period lagged price index of feed; and

P_{il} = price index of hired farm labor.[2]

The null hypotheses to be tested are the predeterminedness of P_t in equation (5) and the predeterminedness of Q_i in equation (6). The instrumental variable estimator used in the tests is two-stage least squares (2SLS).

The initial estimation of demand equations (5) and (6) show the problem of autocorrelation in the error terms.[3] The WH test statistic is not valid in the presence of autocorrelated error terms. Among the several possibilities that may cause autocorrelated disturbances are factors such as consumption habits, missing relevant variables, or structural shifts. The possibility of structural shifts was examined because of the suspicion of possible structural change in the demand for red meats. To investigate this, demand equations (5) and (6) were respecified. Based on the observed change in consumption patterns in mid-1970s, a dummy variable ($d_t = 0$ for the period of 1960-1975, and $d_i = 1$ for 1976-1987) was added to equations (5) and (6). The variable d_i was allowed to interact with P_t and E in equation (5) and to interact with Q_t and E in equation (6), as well as with the intercept terms. The respecified models were estimated

2 Data on P_{if} and P_{il} for Canada are from Statistics Canada, *Farm Input Price Index*, Cat. 62-004.

3 Specifically, autocorrelation patterns of an AR (1) process with estimated coefficients of one-period error term ranging from .60 to .80 in both OLS and 2SLS residuals was found.

using OLS and 2SLS. The results indicated that the problem of autocorrelation in the error terms had disappeared. Based on the estimates of these models, Wu-Hausman statistics were calculated. These are reported in Table 2.

Table 2

Exogeneity Test Results of Each Quantity- Price-dependent Demand for Meat Equations

		Chi-square Statistics (W-H value)	
Dependent Variable:	Meat Type (i)	H_0: Price of Meat (i) is Predetermined (1960-75)	H_0: Price of Meat (i) is Predetermined (1976-87)
$\ln q_i$	Beef	2.389	1.322
	Pork	0.276	0.167
	Poultry	0.039	1.736

		Chi-square Statistics (W-H value)	
Dependent Variable:	Meat Type (i)	H_0: Quantity of Meat (i) is Predetermined (1960-75)	H_0: Quantity of Meat (i) is Predetermined (1976-87)
$\ln P_i$	Beef	1.667	2.378
	Pork	0.249	0.146
	Poultry	0.127	1.912

Note: The critical value of Chi-square at the 5 percent level of significance is 3.841 with one restriction. The null hypothesis is rejected when the W-H test statistic exceeds its critical value.

The tests of exogeneity indicate that none of the null hypotheses that the price of meat i are predetermined in the quantity-dependent model of demand for meat i are rejected for the periods from 1960 to 1975 and from 1976 to 1987. These results support the assumption that consumers face exogenous prices. This, in turn, suggests that quantity can be legitimately specified as the dependent variable in models of the demand for meat. In the case of the models in which price is specified as the dependent variable, the empirical results suggest that quantity variables are exogenous, suggesting that price-dependent demand models can also be justified. The results indicate that the simultaneous supply-demand model specification does not yield significantly different demand parameters from the single equation models.

5. Elasticity Estimates and Discussion

The empirical findings from estimation of Models 1a, 1b, and 2a are reported in Tables 3 to 5. The econometric program SHAZAM (White) was used. All the own-price and expenditure elasticities of demand for beef, pork, and chicken in Model 1a have the expected signs, are plausible in magnitude, and are significant at the 5 percent level. All the own-price elasticities of demand from Model 1b have expected signs and are statistically significant at the 5 percent level. This is not the case for the estimates of income elasticity of demand from this model; only for beef is the coefficient both significant and with the expected positive sign. The results suggest that the quantity of beef demanded in Canada will increase by 4.2 percent if per capita disposable income increases by 10 percent whereas Canadian demand for beef will increase by 9.5 percent if per capita expenditure on meat increases by 10 percent. Overall, the estimated expenditure elasticities are considerably higher than are the income elasticities of demand for meats. Note that the conditional expenditure elasticities from Model 1a will y be equivalent to the unconditional income elasticities from Model 1b if the income elasticity for the entire meat group is unitary or close to this.[4] From the expenditure elasticity and income elasticity of beef demand, the derived income elasticity for the entire meat group is 0.44, which is consistent with the expectation of income inelasticity for necessities. The estimated own-price elasticity of demand for beef is -0.39 (Model 1b) when disposable income is included and -0.76 when expenditure on meat is included. Similarly, the own-price elasticity estimate is -0.57 when disposable income is included but -0.72 when expenditure on met is uesd. Therefore, own-price elasticity estimates tend to be higher in Model 1a in which expenditure, rather than income, is included as the explanatory variable.

The estimates reported in Table 3 were obtained after correcting autocorrelation. An alternative and preferable way of correcting the problem of autocorrelation is to correct the cause of this problem. The results reported in Table 4 show that in this instance, the problem of autocorrelation can be avoided by breaking the data set into two sub-sample periods. On examining the results in Table 4, it is seen that all own-price and expenditure elasticities have the expected signs and are statistically significant at the 5 percent level. For beef, the estimated coefficients on the dummy variables for price, expenditure, and the intercept are all significantly different from zero, indicating shifts in the price and expenditure coefficients over time.

4 See Theil, Chung, and Seale (1989, pp. 133-37) for the derivation of the exact relation between the expenditure elasticity and income elasticity.

Table 3
Elasticity Estimates from the Double Logarithmic Models[a, b, c]

	Dependent Variables: logarithms of quantity of meat(i)					
Explanatory	q_{beef}		q_{pork}		$q_{chicken}$	
Variables:	Model 1b	Model 1a	Model 1b	Model 1a	Model 1b	Model 1a
P_b	-0.39 (5.510)[a]	-0.76 (6.387)	0.32 (3.975)	-0.01 (0.136)	0.16 (1.581)	-0.11 (0.950)
P_p	0.07 (1.038)	-0.12 (1.303)	-0.47 (6.144)	-0.74 (9.162)	0.10 (1.174)	-0.01 (0.065)
P_c	0.02 (0.474)	-0.06 (0.487)	-0.123 (0.903)	-0.08 (0.881)	-0.57 (3.429)	-0.72 (6.247)
P_f	-0.14 (0.928)	-0.07 (0.571)	0.20 (1.071)	-0.13 (1.143)	0.35 (1.621)	0.13 (1.054)
Y	0.49 (3.189)		-0.004 (0.028)		0.35 (0.679)	
E		0.95 (3.652)		0.89 (4.287)		0.84 (3.464)
Constant	1.36 (1.956)	-0.64 (0.557)	3.44 (4.632)	-0.44 (0.478)	1.56 (1.753)	1.18 (1.113)
R^2-adjusted	0.93	0.92	0.89	0.93	0.96	0.97
D.W.	1.827	1.709	1.776	1.556	1.637	2.049

[a] t-statistics are in parentheses. The critical t-statistic at the 5% level of significance is 2.080.

[b] The subscripts b, p, c, and f refer to beef, pork, chicken, and fish, respectively.

[c] Corrected for autocorrelation.

Table 4
Own-Price and Expenditure Elasticity Estimates of Demand for Meat Based on Model 1a with Time Dummy Variables[a,b]

Explanatory Variables:	Dependent Variables: logarithms of quantity of meat(i) Beef (1960-75)	Beef[c] (1976-87)	Pork (1960-87)	Chicken (1960-87)
$\ln P_b$	-1.09 (-4.260)	-0.53	0.17 (0.998)	-0.30 (-2.099)
$d_1 \ln P_t$	0.56 (2.068)		0.38 (1.593)	0.11 (0.323)
$\ln P_p$	-0.13 (-1.267)	-0.13	-0.89 (-5.988)	0.05 (0.400)
$\ln P_c$	-0.19 (-2.140)	-0.19	-0.01 (-0.109)	-0.85 (-7.448)
$\ln P_f$	-0.04 (-0.297)	-0.04	-0.05 (-0.323)	0.02 (0.083)
$\ln E$	1.40 (5.678)	0.57	0.69 (2.563)	1.13 (3.910)
$d_2 \ln E$	-0.83 (-3.440)		-0.26 (-1.199)	0.13 (0.427)
d_0	4.88 (4.704)		0.59 (0.600)	-1.58 (-1.261)
Constant	-2.64 (-2.734)	2.24	0.55 (0.493)	2.22 (-1.816)
R^2-adjusted	0.96		0.91	0.97
D.W.	2.195		1.403	1.452
F-statistics[d]	22.216		2.075	5.321

[a] t-statistics are in parentheses.

[b] The subscripts b, p, c, and f represent beef, pork, chicken, and fish, respectively.

[c] These are derived by adding the coefficients of $\ln P_b$ and $d_1 \ln P_b$ and of $\ln E$ and $d_2 \ln E$ respectively; dummy variables for cross-price effects were tested, found to be not significant, and deleted.

[d] The null hypothesis is all $d_i = 0$. The critical F value is 2.75 at the 5% level.

Table 5

Single Equation Estimates of Demand for Meat Based on Model 2a[a,b]

Explanatory Variables:	Coefficient Estimates[a,b] Beef	Pork	Chicken
$\ln P_b$	0.26 (3.941)	0.07 (0.499)	-0.02 (0.021)
$\ln P_p$	0.12 (1.347)	0.03 (0.144)	0.16 (1.160)
$\ln P_c$	-0.13 (-1.317)	0.76 (3.820)	0.48 (3.111)
$\ln P_f$	-0.28 (-2.415)	-1.44 (-6.020)	-0.86 (-4.620)
$\ln(E/P^*)$	-0.38 (-13.831)	-0.18 (-3.141)	-0.20 (-4.419)
Constant	5.175 (15.404)	2.659 (3.811)	2.957 (5.462)
R^2-adjusted	0.99	0.98	0.98
D.W.	1.225	1.406	1.391
$\hat{\rho}$	0.356[c]	0.270	0.254

[a] t-statistics are in parentheses.

[b] The subscripts b, p, c, and f represent beef, pork, chicken, and fish, respectively.

[c] As the Durbin-Watson value falls in the inconclusive range, an asymptotic test for detecting autocorrelation is used. The critical ρ value is $\frac{2}{\sqrt{T}} = 0.388$. Thus the hypothesis of non-autocorrelation cannot be rejected.

The estimates for beef suggest that price elasticity fell from -1.09 over the period of 1960-75 to -0.53 over 1976-87, and expenditure elasticity fell from 1.40 to 0.57 between these two time periods. Over time, Canadian consumption of beef has become less responsive to price and income changes. This is less obvious for pork and chicken. For both these meats, the estimated coefficients on the dummy variables are not significantly different from zero, although the F-statistic testing all $d_i = 0$ is significant at the 1% level for chicken. The feature that some cross-price elasticities are negative implies that different types of meat are complementary goods; for all but one pair these implausible estimates are statistically insignificant.

The expenditure share model yields coefficients of expenditure variables that are statistically significant at the 1 percent level and have negative signs (Table 5). In elasticity terms, the results suggest a 10 percent increase in real expenditure on meats will cause a reduction of 3.8 percent in the expenditure share of beef and a 1.8 percent and 2 percent reduction in the expenditure shares of pork and chicken, respectively, holding all else constant. This indicates that a lower proportion of income is spent on beef, pork, and chicken as real income increases, and that beef, pork and chicken are necessities for Canadian consumers. The estimated expenditure coefficients conform with prior expectations.

The price and expenditure elasticities were calculated based on the parameter estimates of Model 2a, which is known as the linear approximation to almost ideal demand system (LA/AIDS).The price elasticity formulas for LA/AIDS are derived in Appendix 1. The computed elasticities are reported in Table 7, in which comparisons were made.

6 Prediction Performance of the Demand Models

In view of the usefulness of demand elasticities in economic analysis, it is necessary to choose among alternative models for best predictive performance. This is measured here for the demand models by the final prediction errors (FPE) criterion. Prediction errors for each model and each meat type are computed based on Akaike's (1969) FPE formula (Judge *et al* 1985, p. 242). These are reported in Table 6. For each meat type, Model 1a (which includes expenditure on meat) produces smaller prediction errors than does Model 1b (which includes disposable income). For beef and chicken, Model 2a with the expenditure variable produces smaller prediction errors than does Model 2b with the disposable income variable. On the basis of the FPE criterion, the results clearly favour the use of Model 1a over Model 1b, and the use of Model 2a over Model 2b for forecasts. Based on these results, the use of expenditure on meat, rather than disposable income, is recommended in demand analysis.

7 Comparison With Other Empirical Results of Elasticities

Table 5 summarizes own-price and income elasticities obtained from selected previous Canadian studies of demand for meats. The results are compared with those from this study.[5] In the case of demand for beef, Model 1b (including per capita disposable income) yields slightly lower own-price elasticity estimates than those found in previous studies.

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5 For a comparison of demand elasticities from studies prior to 1975, see Hassan and Katz (1975).

Table 6

Final Prediction Errors for Model 1 and Model 2 Series

	Final Prediction Error (FPE)[a]			
Meat Type	Model 1a	Model 1b	Model 2a	Model 2b
Beef	.00098	.00110	.58E-7	.56E-6
Pork	.00056	.00108	.25E-5	.12E-5
Chicken	.00089	.00126	.78E-7	.11E-6

[a] Prediction errors can not be compared between Model 1 and Model 2 series since the dependent variables are different.

The income elasticity estimate falls within the range of others' estimates. Model 1a (which includes per capita expenditures on meat) provides consistently higher own-price elasticity estimates and slightly higher income/expenditure elasticity estimates than those found in earlier studies.

The own-price elasticity estimates for pork from this study generally fell within the range of estimates of the other studies reported in Table 7. Again, Model 1a yields consistently higher expenditure elasticities than the income elasticities of other studies. The own-price and income or expenditure elasticities for chicken from this study are similar to those found by Tryfos and Tryphonopoulus (1973) and Hassan and Johnson (1976).

8 Conclusions

Prior to estimation of the single equation demand models, two specification tests were conducted. The results of the non-nested hypotheses tests support the use of expenditure on meat, rather than per capita disposable income as the income variable in the regression models. In applying the Wu-Hausman specification tests, the exogeneity of meat prices in quantity-dependent demand functions was not rejected, although one remains uncertain about the endogeneity of meat quantity in the market from the results.

Different specifications of models of Canadian demand for meats used in previous studies have given somewhat different price and income elasticity estimates although most estimates fall within a fairly narrow range. Our results indicate that the own-price elasticity estimates based on models which include expenditure rather than income as an explanatory variable, are consistently higher than those including disposable income. An interesting question arising from these findings is which own-price elasticity estimate to use for forecasting and policy purpose? This study recommends the use of price elasticity estimates from the model in which the expenditure is used as the income variable based on the following reasons. The use of expenditure, rather than income, as an explanatory variable is supported by the test of predictive performance reported in Table 6; it is also supported by non-nested tests for model selection reported in Table 1. Finally, Model 1a indicates structural change in Canadian demand for beef and chicken, but not for pork, in the mid-1970s.

Table 7

Own-price and Income Elasticities of Canadian Demand for Meats Reported in Selected Studies

Source	Time Period	Estimation Method	Functional Form[a]	Elasticities Own-price	Elasticities Income/ Expenditure
Beef Demand:					
(1) Tryfos and Tryphonopoulus (1973)	Annual 1954-70	SURE	Linear	-0.52	0.84
(2) Hassan and Johnson (1976)	Annual 1957-72	FIML	DL	-0.48	0.40
(3) Young (1987)	Quarterly 1967(2)-83(4)	ML	DL	-0.43	0.91
(4) This study	Annual 1960-87	ML	DL	-0.40	0.42[b]
		ML	DL	-0.76	0.95[c]
		OLS	DL	-0.53	0.57[d]
		SURE	LA/AIDS	-0.64	0.55
Pork Demand:					
(1) Tryfos and Tryphonopoulus (1973)	Annual 1954-70	SURE	Linear	-1.05	-0.004
(2) Hassan and Johnson (1976)	Annual 1957-72	FIML	DL	-0.95	0.26
(3) Young (1987)	Quarterly 1967(2)-83(4)	ML	DL	-0.67	0.37
(4) This study	Annual 1960-87	ML	DL	-0.49	-0.004[b]
		ML	DL	-0.74	0.89[c]
		OLS	DL	-0.89	0.69[d]
		SURE	LA/AIDS	-0.91	0.47
Chicken Demand:					
(1) Tryfos and Tryphonopoulus (1973)	Annual 1954-70	SURE	Linear	-0.87	1.13
(2) Hassan and Johnson (1976)	Annual 1957-72	FIML	DL	-0.56	0.73
(3) Young (1987)	Quarterly 1967(2)-83(4)	ML	DL	-0.28	0.28
(4) This study	Annual 1960-87	ML	DL	-0.72	0.11[b]
		ML	DL	-0.72	0.84[c]
		OLS	DL	-0.85	1.13[d]
		SURE	LA/AIDS	-0.99	1.07

[a] DL denotes double logarithmic form. [b] Income elasticity (Model 1b). [c] Expenditure elasticity (Model 1a). [d] Expenditure elasticity (Model 1a with time dummy variables).

9 References

Agriculture Canada. (1988). *Handbook of Food Expenditures, Prices, and Consumption.* Ottawa: Agricutural Canada.

Alston, J. and J. Chalfant (1987). "Weak Separability and a Test for the Specification of Income in Demand for Meat in Australia." *Australian Journal of Agricultural Economics.* 31(1): 1-15.

Braschler, B. (1983). "The Changing Demand Structure for Pork and Beef in the 1970's: Implications for the 1980's." *Southern Journal of Agricultural Economics.* 9: 271-82.

Chalfant, J. and J. Alston (1988). "Accounting for Changes in Tastes." *Journal of Political Economy.* 96(2): 391-410.

Chavas, J.P. (1983). "Structural Change and Demand for Meat." *American Journal of Agricultural Economics.* 65: 148-53.

Curtin, L. *et al.* (1987). "Demand for Foods in Canada." Working Paper 13/87, Agriculture Canada.

Dahlgran, R. (1987). "Complete Flexible Systems and the Stationarity of U.S. Meat Demand." *Western Journal of Agricultural Economics.* 12: 152-63.

Davidson, R. and J. MacKinnon. (1981). "Several Tests for Model Specification in the Presence of Alternative Hypotheses." *Econometrica.* 49: 781-94.

Deaton, A. and J. Muellbauer. (1980). "An Almost Ideal Demand System." *American Economic Review.* 70: 312-27.

Hassan, Z. and L. Katz. (1975). "The Demand for Meat in Canada." *Canadian Journal of Agricultural Economics.* 23(1): 53-63.

Hassan, Z. and S. Johnson. (1976). "Consumer Demand for Major Foods in Canada." Economics Branch Publication No. 76/2, Agriculture Canada.

Hassan, Z. and S. Johnson. (1979). "The Demand for Meat in Canada: An Application of the Transformation of Variables." *Canadian Journal of Agricultural Economics.* 27(3): 1-12.

Hassan, Z. and S. Johnson. (1983). "Quarterly Demand for Meat in Canada with Alternative Seasonality Hypotheses." *Canadian Journal of Agricultural Economics.* 31(1): 77-94.

Judge, G. G., W.E.Griffiths, R. Carter Hill, H. Lutkepohl and Tsoung-Chao Lee. (1985). *The Theory and Pratice of Econometrics. 2ed ed.* (New York:John Wiley and Sons).

Kerr, W. *et al.* (1989). "An Alternative Hypothesis for Structural Change in Canadian Demand for Meat." Discussion Paper Series No. 89-114, University of Calgary.

Martin, W. and D. Porter. (1985). "Testing for Changes in the Structure of the Demand for Meat in Australia." *Australian Journal of Agricultural Economics.* 29(1): 16-31.

Moschini, G. and K. Meilke. (1984). "Parameter Stability and the U.S. Demand for Beef." *Western Journal of Agricultural Economics.* 9: 271-82.

Nyankori, J.C. and G.H. Miller. (1982). "Some Evidence and Implications of Structural Change in Retail Demand for Meats." *Southern Journal of Agricultural Economics.* 14: 65-70.

Stone, J.R.N. (1953). *The Measurement of Consumers' Expenditure and Behaviour in the United Kingdom, 1920-38.* Cambridge: Cambridge University Press.

Thurman, W. (1987). "The Poultry Market: Demand Stability and Industry Structure." *American Journal of Agricultural Economics.* 69(1): 30-37.

Tryfos, P. and N. Tryphonopoulos. (1973). "Consumer Demand for Meat in Canada." *American Journal of Agricultural Economics.* 55(1): 84-91.

White, K. (1978). "A General Computer Program for Econometric Methods - SHAZAM." *Econometrica* 46 (1): 239-40.

Young, L. (1987). "Canadian Meat Demand." Working Paper 10/87. Ottawa: Agriculture Canada, Policy Branch.

III. Consumption Expenditure Allocation Over Meat Groups: An AIDS Analysis with Habit Formation and Structural Change

Introduction

In this chapter, meat consumption patterns in Canada are analyzed using a dynamic version of the almost ideal demand system (AIDS). Structural change in the demand for four meats is examined by testing for nonconstancy of the parameters of the nonlinear system. It is concluded that Canadian meat consumption patterns can be explained by a combination of habit persistence as well as changes in prices, consumer expenditures and tastes. Incorporating the dynamic element of a habit effect in the AIDS model improves the consistency between demand theory and the observed data. The hypothesis of structural change in demand for meat in Canada during the late 1970s cannot be rejected. The detected structural shift is related to the intercept terms of the expenditure share equations, suggesting changes in taste in the demand for different meats. Consumption expenditures have shifted from beef to chicken but remained stable for pork.

Since the introduction of the almost ideal demand system (AIDS) by Deaton and Muellbauer (1980), many applications of this model have been made to analyze consumer demand for food groups. These have included studies by Blanciforti and Green (1983), Eales and Unnevehr (1988), Fulponi (1989), Moschini and Meilke (1989), and Chalfant et al (1989). Except for Blanciforti and Green (1983), these studies have applied the linear approximation of AIDS using Stone's geometric price index (known as LA/AIDS) to obtain price and income elasticity estimates. This is not the case for this study on Canadian demand for meat; the complete AIDS price index rather than its linear approximation is used.

Most applications of AIDS have also involved static demand systems, in which consumers are assumed to fully and instantaneously adjust their optimal purchase of commodities to current changes in prices and income. It is not uncommon, however, for conditions such as homogeneity and symmetry implied by consumer theory to be rejected empirically with static LA/AIDS models. One problem of the static AIDS model is that it ignores the features of persistence in habits and the possibility of dynamic behaviour in consumer demand. It has been suggested that inappropriate specification of the dynamics of behaviour may account for the rejection of theoretically based demand conditions (Deaton and Muellbauer, 1980 p.320; Anderson and Blundell, 1983). Attempts to incorporate dynamic elements have sometimes involved testing linear approximations of AIDS in first difference form. An example is given by Eales and Unnevehr (1988) who found that in this form neither homogeneity or symmetry were rejected, which was not the case for the static form of their model. In this paper the alternative dynamic form of AIDS that incorporates a habit effect in the consumer expenditure function is evaluated empirically to examine whether this specification yields empirical results that are consistent with the economic theory of consumer behaviour.

The estimates and associated tests are based on quarterly Canadian data for four meats (beef, pork, chicken, and turkey) from 1967 quarter I to 1987 quarter IV. The results indicate that the incorporation of habit formation gives an AIDS model that is superior to its static version. A related issue of demand studies is whether or not there has been structural change in the demand for meats in Canada. Health concerns, for instance, are thought by many to have shifted consumer preferences away from red meat. Previous studies by Young (1987) and Atkins et al (1989) tested for structural change in single equation models of the demand for meat. Such models are, strictly speaking, inconsistent with the theory of consumer behaviour. Using nonparametric tests, Alston and Chalfant (1990) found that Canada's time series of annual meat consumption data from 1960 to 1987 could have been generated by a stable system of well-behaved demand equations. Nonetheless, they found the frequency with which the nonparametric tests correctly rejected the hypothesis of stable preferences was low, which reduced their confidence in concluding that structural change had not occurred.

In this paper, we use parametric tests to examine the issue of demand stability. The issue of structural change in demand for meat groups is explored, based on the preferred model, to determine whether consumers' preferences and consumption habits for meats have changed over the past twenty years. Application of a recently proposed test procedure for detecting structural change in non-linear simultaneous equation systems indicates that the hypothesis of structural change cannot be rejected.

1 Model Specification

The almost ideal demand system of Deaton and Muellbauer is derived, by use of duality concepts, from the flexible consumer expenditure function known as the price-independent generalized logarithmic (PIGLOG) form. The expenditure function is defined as the minimum expenditure necessary to attain a given level of consumer utility at given current prices. The assumption of price exogeneity and weak separability of preferences which implies budgeting in stages is invoked. In the framework of multi-stage budgeting, it is assumed that consumers first allocate their expenditures to broad aggregate commodity groups. Subsequently, consumers' decisions are based on group expenditures and commodity prices within each group. Detailed derivation of the AIDS model is given in Deaton and Muellbauer (1980).

The resulting demand functions in expenditure share form are:

$$S_i = \alpha_i + \sum_j \gamma_{ij} \ln P_j + \beta_i (\ln E - \ln P) \qquad i = 1 \ldots n \qquad (1)$$

Where P is a price index defined by:

$$\ln P = \alpha_0 + \sum_k \alpha_k \ln p_k + \frac{1}{2} \sum_j \sum_k \gamma_{kj} \ln p_k \ln p_j$$

Subscripts $(i, j) = 1, \ldots, n$ refer to the four meat groups. Variable S_i is the expenditure share of the i th meat type; the p_j are prices; E is the total expenditure on all commodities in the system; and α_i, γ_{ij}, and β_i are the demand parameters to be estimated.

Parameter α_i can be interpreted as the basic budget share of meat type i (ignoring changes in relative prices and real expenditure); γ_{ij} measures the change in the i th budget share following a unit change in price p_j with real expenditure held constant; β_i measures the effect on the i th budget share of a change in real expenditure. To be consistent with the fundamental postulates of demand theory, the following conditions must hold in terms of parameter restrictions:

$\Sigma\alpha_i = 1,\ \sum_i \gamma_{ij} = 0, \Sigma\beta_i = 0,$ specifying the adding-up condition; (2a)

$\sum_j \gamma_{ij} = 0,$ the property of homogeneity of degree zero of prices and income; and (2b)

$\gamma_{ij} = \gamma_{ji},$ the Slutsky symmetry condition. (2c)

The standard AIDS specification of (1) is non-linear in parameters.

The AIDS model is derived from a framework of consumer cost minimization. From Equation (1) it is seen that the budget share of good i is a function of prices and total expenditure:

$$S_i = s_i(P, E) \quad (3)$$

To incorporate consumption habit variables into the AIDS model, the "dynamic translating" procedure proposed by Pollack (1970) and Pollack and Wales (1981) was adopted. Following this procedure, the original demand system is replaced by a new system which contains translating parameters, and it is assumed that only these parameters(α_i) depend on the habit persistence variables. The process can be applied to classes of demand system models such as the linear expenditure or translogarthmic systems. Applying this procedure to the AIDS model involves replacing Equation (3) by the modified system:

$$S_i = \alpha_i + S_i(P, E - \Sigma p_i \alpha_i) \qquad (4)$$

and specifying the linear dynamic translating parameter as : $\alpha_i = \alpha_i^* + d_i q_{it-1}$.

where d_i is the coefficient that measures the impact of previous consumption on the current expenditure share of meat type i. Then, the habit persistence version of the AIDS model becomes:

$$S_i = \alpha_i^* + d_i q_{it-1} + \sum_j \gamma_{ij} + \beta_i (lnE - lnP) \qquad i, j = 1, \ldots n \qquad (5)$$

where $\ln P = \alpha_0 + \sum_j (\alpha_i^* + d_i q_{it-1}) \ln P_j + \frac{1}{2} \sum_i \sum_j \gamma_{ij} lnP_i lnP_j$

If the original demand equations associated with a utility function of $u(q_i)$ satisfy the first-order conditions of cost minimization, then such conditions are also satisfied for the modified system associated with the utility function of $u(q_i - \alpha_i)$. Given that the original AIDS equation was generated by the consumer's cost minimization problem of:

$$c(u(q), p) = \min_q \{p.q : u(q) = u_0\},$$

the modified AIDS equation, in principle, can be generated by solving the following problem:

$$c(u(q^*), p) = \min_{q^*} \{pq^* : u(q^*) = u_0\},$$

where $q^* = q - \alpha$;

According to the duality principle, the consumer chooses $(q - \alpha)$, given the prices P and budget $(E - \sum p_i \alpha_i)$, in the corresponding utility maximization framework. The question of whether duality between the two optimization problems prevails is dependent on non-violation of regularity conditions. Typical regularity conditions of the cost function being positively monotonic and concave can be checked empirically.

An alternative derivation of the habit persistence version of the AIDS model is to follow a procedure indicated by Blanciforti, Green and King (1986). The dynamic feature in the adjustment of demand is incorporated by specifying an ad hoc dynamic cost function through the introduction of one-period lagged consumption levels, q_{it-1}, to the PIGLOG consumer expenditure function:[1]

$$\ln C(p,u,q_{it-1}) = \alpha_0 + \sum_i (\alpha_i^* + d_i q_{it-1}) \ln p_i + \frac{1}{2} \sum_i \sum_j \gamma_{ij} \ln p_i \ln p_j + U\beta_0 \prod p_k^{\beta_k} \qquad (6)$$

By Shephard's lemma:

$$\frac{\partial \ln C}{\partial \ln P_i} = S_i = \alpha_i^* + d_i q_{it-1} + \sum_{ij} \gamma_{ij} \ln p_j + \beta_i u \beta_0 \prod p_k^{\beta_k} \qquad i = 1 \ldots n \qquad (7)$$

Substituting $\ln C = \ln E$, for $u(P, E)$, Blanciforti *et al* apply the procedure of Deaton and Muellbauer (1980) to incorporate the habit persistence variable, yielding:

$$S_i = \alpha_i^* + d_i q_{it-1} + \sum_j \gamma_{ij} \ln p_j + \beta_i (\ln E - \ln P) \qquad i = 1 \ldots n \qquad (8)$$

where

$$\ln P = \alpha_0 + \sum_i (\alpha_i^* + d_i q_{it-1}) \ln p_i + \frac{1}{2} \sum_i \sum_j \gamma_{ij} \ln p_i \ln p_j \qquad (9)$$

Equation 9 is identical to equation (5) which is derived from the dynamic translating procedure.

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1 Note that the well-defined consumer cost function is c(p,u). The inclusion of the previous consumption level, q_{it-1}, in the cost function makes this non-standard but dynamic.

The adding-up condition in the modified system changes to:

$$\sum \alpha_i = 1 \,,\ \sum_i \gamma_{ij} = \sum \beta_i = \sum d_i = 0 \tag{10}$$

As is the case with the original AIDS model, the adding-up restrictions only hold locally. The restriction $\sum d_i = 0$ requires that at least one of the d_i is negative. While a positive sign indicates habit persistence, a negative sign implies inventory depletion effects. The conditions of homogeneity and symmetry, expressed in terms of the parameter restrictions, remain as $\sum_j \gamma_{ij} = 0$ and $\gamma_{ij} = \gamma_{ji}$, respectively. The habit persistence extension adds n parameters to the static AIDS model.

2 The Data and Estimation Procedures

Quarterly time series data available from Agriculture Canada for the period of 1967(I)-1987(IV), with 84 observations on each meat group, were used to estimate the models and for hypothesis testing. The data are quarterly per capita disappearance (in lbs) and retail prices of beef, pork, chicken, and turkey (in $/lb).[2] For beef and pork, the revised retail weight per capita consumption series was used.

To estimate the static AIDS system of equation 1 and the dynamic system of equation 5 with data on Canadian meat groups, an error term must be added to each equation in both systems. Since the sum of expenditure shares equals the exact linear

2 Retail prices of these meats were derived from the consumer price index series for meats (1981 = 100) and from the base-year (1981) prices of meats which are available from Statistics Canada (Cat. # 62-010). The retail prices are averages weighted by the different components of each meat type. Expenditures and expenditure shares for each meat were calculated from the price and quantity series as $E = \sum p_i q_i$ and $S_i = \frac{p_i q_i}{E}$ respectively.

combinition of the regressors, the variance-covariance matrix for the complete n-good system is singular and the standard procedure of arbitrarily deleting one of the equations, rendering the remaining $(n-1)$ by $(n-1)$ variance-covariance matrix nonsingular, is applied (Barten, 1969). The estimates are invariant as to which equation is deleted since the maximum likelihood estimator is used. In this study, the expenditure share equation for turkey consumption is deleted to enable estimation. The nonlinear maximum likelihood procedure of SHAZAM (White et al 1989) was used for estimation.

Both static and dynamic AIDS model systems were estimated. Subsequently, restricted versions of both systems, with the parameter restrictions implied by consumer theory, were also estimated. The resulting log likelihood function values are tested to assess whether the exclusion of the habit formation variable may account for the instances of rejection of the theoretical restrictions of homogeneity and symmetry. As the theory of consumer behaviour proposes that the homogeneity and Slutsky symmetry conditions hold for utility-maximizing consumers, non-rejection of these conditions is used as one criterion of model selection.

Since the classical test of structural change in linear regression models is not applicable to nonlinear systems of equations, the procedure proposed by Andrew and Fair (1988), involving a likelihood-ratio equivalent test of structural stability is applied.[3] In testing for structural change in a non-linear simultaneous equation model situation, the parameter vector Q is of the form $Q=(Q_1, Q_2)$, where the likelihood function for $t_1=-T_1,\ldots-1$ depends only on Q_1 and the likelihood function for $t_2=1,\ldots,T_2$ depends on Q_2. The asymptotically equivalent likelihood ratio-like test statistic is:

3 This is a variant of the LR-equivalent test developed by Gallant and Holly (1980) and reported in Judge et al (1985, p. 217).

$$\lambda_{LR} = (T_1 + T_2)(ln(S_u) - ln(S_r)) \sim \chi^2_k,$$

where:

$T_1 + T_2 = T$ is $\{t = -T_1, \ldots, -1, 1, \ldots, T_2\}$. S_r is the value of the constrained minimum of $S(Q)$, the residual sum of squares; and $S(Q_u)$ is the value of the unconstrained $S(Q)$, which equals the sum of the residual sum of squares, $S(Q_1)$ and $S(Q_2)$ for periods t_1 and t_2, respectively. Thus, in calculating the above test statistics to test the null hypothesis of structural stability given by $Q_1 = Q_2$, it is necessary to compute the restricted estimate of $Q(Q_1 = Q_2)$ using the whole data set. Then the unrestricted estimates of Q_1 and Q_2 are computed using data for the sub-sample periods t_1 and t_2 respectively. The number of restrictions, k, is the total number of parameters in Q that are restricted to be the same for the two sub-sample periods. The application of this test includes the case where the structural change is only partial, i.e. it can test only a subset of the coefficients in the model.

3 Empirical Results and Discussion

To choose a suitable maintained framework within which the issue of structural change may be examined, the performance of the static and dynamic AIDS specifications is compared. Likelihood ratio test statistics, $LR = -2(L_r - L_u)$, where L_r is the maximum value of the log likelihood function with restrictions imposed and L_u is the unrestricted value are presented in Table 1.

The test results indicate that the restrictions of homogeneity and symmetry are rejected for the static AIDS system. However, this is not the case for the dynamic AIDS

Table 1

R...ults of Likelihood Ratio Tests for Homogeneity and Symmetry

Model	Unrestricted Log Likelihood Value (L_u)	Homogeneity and Symmetry Restricted Log Likelihood Value (L_r)	LR Test Statistic Value $-2(L_r - L_u)$	Number of Restrictions	Critical Value at 5%
Static AIDS	792.946	774.555	36.782	10	18.307
Dynamic AIDS	795.787	787.234	17.106	10	18.307

system. Incorporation of habit formation into the AIDS model appears to improve the consistency between theory and the data that are analyzed in this study.[4] Monotonicity of the cost function was examined by computing the predicted values of the budget shares. For all observations, the predicted budget shares of each meat type are all between 0 and 1, which implies that monotonicity holds. Negativity was checked from

4 The results in Table 1 also enable more direct testing of the hypothesis of habit persistence by applying likelihood ratio tests to compare the AIDS model version in which $d_1 = d_2 = d_3 = 0$ with the dynamic AIDS model. For the models in which homogeneity and symmetry are restricted, the computed likelihood ratio value is 25.358, which exceeds the critical value of $\chi^2(.05, 3) = 7.81$. The static model is thus rejected in favour of the dynamic AIDS version at the 5% level of significance. However, for the models in which homogeneity and symmetry are not restricted, preference for the dynamic version is based on a low level of confidence (85%), as the computed likelihood ratio value is 5.682.

compulations of the eigenvalues of the Slutsky matrix at each sample point using the actual values of budget shares. For all observations these were negative, implying a concave cost function.

Estimates of the structural parameters for both the static and dynamic AIDS versions are reported in Table 2. Fifteen of the 19 coefficients are significantly different from zero for the dynamic AIDS model while 8 of 12 coefficients are significant for the static model. Minimum budget shares, α_i, are between zero and one for each meat type in the dynamic model version but the minimum budget share for chicken with the static AIDS model is negative. The significant coefficients on the habit persistence variables suggest that this feature, as well as price and expenditure effects, has some influence on consumers' budget share allocations for beef, pork, and chicken.

Table 2
Maximum Likelihood Estimates of the Structural Parameters of AIDS for Beef, Pork, and Chicken[a,b]

	Static AIDS		Dynamic AIDS	
Parameters[c]	Estimates	Standard Errors	Estimates	Standard Errors
α_1	.8148*	(.0388)	.7169*	(.0454)
d_1			.0023*	(.0008)
γ_{11}	.0639*	(.0146)	[illegible]3*	(.0154)
γ_{12}	-.0531*	(.0139)	-.0631*	(.0139)
γ_{13}	-.0089	(.0059)	-.0304*	(.0061)
β_1	-.0389*	(.0051)	-.0346*	(.0059)
α_2	.2887*	(.0342)	.2678*	(.0358)
d_2			.0043*	(.0014)
γ_{22}	.0234	(.0165)	.0675*	(.0217)
γ_{23}	-.0092	.0086)	.0455*	(.0108)
β_2	.0102*	(.0044)	.0016	(.0045)
α_3	-.1302*	(.0130)	.0033	(.0244)
d_3			.0167*	(.0033)
γ_{33}	.0044	(.0119)	.0456*	(.0108)
β_3	.0289*	(.0017)	.0032	(.0049)
α_4	.0301	(.0530)	.0001	(.0456)
d_4			-.0430*	(.0171)
γ_{14}	-.0021	(.02100)	.0037	(.0216)
β_4	-.0002	(.0069)	.0163*	(.0090)
Log likelihood value		774.5546		787.3235

a The parametric restrictions of homogeneity and symmetry were imposed.
b * denotes significance at the 1% level is denoted by *.
c The subscripts of the parameters represent the meat type, i.e. 1 = beef, 2 = pork, 3 = chicken.

Marshallian demand elasticities are calculated using the structural parameter estimates. Rearranging budget shares $(p_i q_i)/E = S_i$ as $q_i = (E/p_i)S_i$, and applying the definition of Marshallian elasticities gives the total expenditure elasticity for the AIDS system of equation 5 as:

$$\epsilon_i = 1 + \frac{\beta_i}{S_i}$$

Price elasticities are:

$$\epsilon_{ij} = \frac{1}{S_i}\left[\gamma_{ij} - \beta_i\left(\alpha_j + d_j q_{it-1} + \sum_k \gamma_{jk} \ln p_k\right)\right] - \delta_{ij}$$

where

$\delta_{ij} = 1$ for $i = j$ and $\delta_{ij} = 0$ for $i \neq j$.

The calculated demand elasticities are reported in Table 3. Own-price elasticity estimates are -0.77, -0.82, -0.95, and -0.09 for beef, pork, chicken, and turkey, respectively. The estimates for chicken and beef are slightly higher but generally comparable to those reported in other studies (for example, in Hassan and Johnson (1976) and Young (1987)).

Table 3

Uncompensated Price and Expenditure Elasticities[a]

	Price Elasticity				Expenditure Elasticity
	Beef	Pork	Chicken	Turkey	
Beef	-.77 (.202)	.12 (.067)	.21 (.083)	.07 (.104)	.93 (.148)
Pork	.19 (.088)	-.82 (.098)	-.08 (.073)	.02 (.025)	1.01 (.337)
Chicken	.02 (.017)	.08 (.112)	-.95 (.129)	.14 (.089)	1.04 (.196)
Turkey	-.22 (.711)	.16 (.698)	-.16 (.059)	-.09 (.024)	.99 (.210)

[a] Elasticity estimates are calculated at the sample means. Standard errors are in parentheses.

4 Testing for Structural Change

To investigate the issue of parameter constancy, Equation 5, which incorporates habit formation, was taken as the maintained framework and estimated for two subsample periods. For this purpose the time series data set was partitioned at 1976

(II), when beef consumption peaked.[5] Table 4 reports the results of applying the Andrews-Fair likelihood-ratio equivalent test of the hypothesis of structural stability to the nonlinear parametric system of model 5.

Table 4

Results of Likelihood Ratio Tests for Structural Change

Hypotheses	# of Restrictions	LR-like Test Statistic	Critical Value ($\chi^2_{.05}$)
No structural change in:			
(1) All parameters	15	49.980	24.996
(2) Price parameters	6	7.970	12.592
(3) Expenditure parameters	3	7.332	7.815
(4) Intercepts	3	16.012	7.815

Notes: The LR-like test statistics are obtained by including intercept dummy variables and slope dummy variables for the cases (2), (3), and (4).

The hypothesis of no structural change in the complete set of parameters is rejected. The results suggest that there is a difference in some or all the structural parameters of the model before and after the mid-1970s. The assumptions of common slopes and common intercepts of the model were tested separately. From Table 4, it

5 Per capita levels of beef consumption increased to a peak in 1976, fell continuously to 1980, and have remained relatively stable since then. A standard criticism of this type of parameter stability test relates to specification of the breakpoint. In the context of the linear version of AIDS, CUSUM tests and sequential Chow tests were applied to the data set using OLS. The LA/AIDS shows no sign of instablity up to 1975(I) and after 1979(I). This accords with the observation of the pattern of changes in the consumption data. Due to computational complexity, this approach was not pursued for the dynamic non-linear estimator.

is seen that the hypothesis of common intercepts for the share equations is rejected, while the hypothesis of no shift in price and expenditure coefficients cannot be rejected. In the beef expenditure share equation the estimated intercept is 0.540 and the coefficient of the intercept dummy variable is -0.033 and significant, which implies that the average drop of 6 percent in the expenditure share on beef between the two periods can be accounted for by structural change with prices and expenditure held constant. The estimated intercept of 0.09 and the coefficient of the intercept dummy variable of 0.03 in the chicken expenditure share equation reflects the increase of about 30% in expenditure on this meat. For pork, the coefficient of the intercept dummy variable was 0.001 and non-significant.[6] Evidently the estimated intercept terms of the AIDS expenditure share equations from the preferred model exhibited a shift during the mid-1970s.

It is of interest to compare the above estimates of changes in expenditure shares on meats, holding prices and total expenditrue on meat constant, with those that have actually occurred since the mid-1970s. In Table 5, the means of the expenditure shares for beef, pork and chicken before and after the apparent structural break are given. We used t- and F-statistics to test the hypothesis that the mean value of meat expenditure shares is the same for the periods before and after the structural break. This hypothesis is rejected in the case of beef and chicken, but not in the case of pork. The differences between the mean expenditure shares before and after the structural break periods were then calculated. The results indicate a significant and positive effect of structural

6 Note that t test statistics for the coefficients of the intercept dummy variables are -3.287, 4.596, and 0.242 from the beef, chicken, and pork equations, respectively.

change on chicken consumption, a negative effect on beef, and neutral effects on pork consumption. The results are consistent with those based on the likelihood ratio-like tests and estimation with intercept dummy variables.

Table 5

Effects of Structural Change on Expenditure Shares for Meats[a,b]

Meat Type	Expenditure Shares 1967 (I)-1976 (II)	1976 (III)-1987 (IV)	Absolute Change	Percentage Change from Period 1	F-ratio[c]
Beef	0.523	0.499	-0.024* (-4.150)	-4.6%	2.96
Pork	0.374	0.377	0.003 (0.652)	+0.8%	1.18
Chicken	0.075	0.098	0.023* (9.531)	+30.7%	1.62
Turkey	0.027	0.026	-0.001 (2.493)	-3.7%	1.50

[a] t-statistics in brackets

[b] * denotes significance at the 5% level. The critical value is 1.96 at the 5% level of significance.

[c] The critical value of the F-statistic is 1.40 at the 5% level.

5 Conclusions

In this study, we evaluate empirically a dynamic AIDS model of the Canadian demand for major meat groups and compare this to a static AIDS model. The properties of homogeneity and symmetry implied by consumer theory are rejected for the static model. The dynamic model incorporates a habit persistence effect; this model does not reject these properties. The results support the inclusion of a consumption habit effect in analysing demand for meats using quarterly data.

Empirical estimates from the AIDS model incorporating habit persistence indicate that the demand for chicken is more expenditure elastic than for beef and pork. The hypothesis of no structural change in Canadian demand for meats was rejected by likelihood ratio-like tests which indicate that expenditure shares on beef and chicken since mid-1970 are different than in the preceding period. This finding is supported by the measurement of the effects of structural change on meat expenditure shares. Consumption expenditure shares have trended away from beef and toward chicken. It is found that the basic expenditure share spent on beef has dropped by about 6 percent for the post-1976 period while the basic expenditure share for chicken increased by 30 percent in the same time period. Based on this, we conclude that while changes in relative prices and total expenditure explain much of the variation in meat consumption, a portion of the observed changes in meat consumption patterns over the last twenty years is consistent with a structural change in consumer preferences. It may be that these changes are associated with increasing health concerns regarding diets; other possible causes of the structural shift include the changing nature of poultry products and the growth of fast food outlets (See Eales and Unnevehr, 1988). The finding of a structural shift in Canadian meat consumption during the mid-1970s suggests the use by researchers of post-1976 data or the use of dummy variables that allow regression intercepts to change in models for policy analysis and forecasting.

6 References

Alston, M.J. and J.A. Chalfant. 1990. Can We Take the Con out of the Meat Demand Studies? Invited Paper Presented at the Western Agricultural Economists Meeting, Vancouver, Canada.

Andrews, D.W. and R.C. Fair. 1988. Inference in Nonlinear Econometric Models with Structural Change. *The Review of Economic Studies* 55:615-640.

Anderson, G. and R. Blundell. 1983. Testing Restrictions in a Flexible Dynamic Demand System: An Application to Consumers' Expenditure in Canada. *The Review of Economic Studies* 50:397-410.

Barten, A.P. 1969. Maximum Likelihood Estimation of a Complete System of Demand Equations. *European Economic Review* 1:7-73.

Blanciforti, L. and R. Green. 1983. The Almost Ideal Demand System Incorporating Habits: An Analysis of Expenditure on Food and Aggregate Commodity Groups. *Review of Economics and Statistics* 65:511-515.

Blanciforti, L., R. Green and G. King. 1986. U.S. Consumer Behavior Over the Postwar Period: An Almost Ideal Demand Analysis. Giannini Foundation Monograph No. 40.

Chalfant, James A. 1987. A Globally Flexible Almost Ideal Demand System. *Journal of Business and Economic Statistics* 5:233-242.

Chalfant, J., R. Gray and K. White. 1989. Evaluating Prior Beliefs in a Demand System: The Case of Meats Demand in Canada. Working Paper 483. Berkeley: University of California, Department of Agricultural Economics and Natural Resources.

Deaton, A. and J. Muellbauer. 1980. An Almost Ideal Demand System. *American Economic Review* 70:312-326.

Eales, J.S. and L.J. Unnevehr. 1988. Demand for Beef and Chicken: Separability and Structural Change. *American Journal of Agricultural Economics* 70:521-532.

Fulponi, L. 1989. The Almost Ideal Demand System: An Application to Food and Meat Groups for France. *Journal of Agricultural Economics* 82-92.

Gallant, A.R. and A. Holly. 1980. "Statistical Inference in an Implicit, Nonlinear, Simultaneous Equation Model in the Context of Maximum Likelihood Estimation." *Econometrica* 48: 697-720.

Hassan, Z. and S. Johnson. 1976. Consumer Demand for Major Foods in Canada. Economics Branch Publication 76/2. Ottawa: Agriculture Canada.

Johnson, S., Z. Hassan and R. Green. 1984. *Demand System Estimation: Methods and Applications*. Ames: The Iowa State University Press.

Judge, G.G. *et al*, 1985. *The Theory and Practice of Econometrics*. 2nd ed. New York: John Wiley and Sons.

Menser, M.E. 1976. Elasticities of Demand for Food: An Analysis Using Non-additive Utility Functions Allowing for Habit Formation. *Southern Economic Journal* 43:879-891.

Moschini, G. and K.D. Meilke. 1989. Modeling the Pattern of Structural Change in U.S. Meat Demand. *American Journal of Agricultural Economics* 71:253-261.

Pollak, R.A. 1970. Habit Formation and Dynamic Demand Functions. *Journal of Political Economy* 78:745-763.

Pollak, R.A. and T. Wales. 1981. Demographic Variables in Demand Analysis. *Econometrica* 49:1533-1551.

White, K.J., S.A. Haun, N.G. Horsman and S.D. Wong. 1988. *SHAZAM Econometric Computer Program*. New York: McGraw Hill.

Young, L. 1987. Canadian Meat Demand. Working Paper 10/87. Ottawa: Agricultural Canada, Policy Branch.

IV. Meat Expenditure Share Behavior in Canada: A Dynamic Translog Demand System Analysis

1 Introduction

A review of previous empirical studies on the demand for meat and the related issue of structural change reveals different results and contradictory conclusions on the existence of structural change. Such econometric results are generally sensitive to differences in functional form. For example, estimation and tests based on the AIDS model in the previous chapter provided some evidence that there is a structural shift in demand for meat in Canada. This may or may not be the case for some other demand system. One way to analyze the sensitivity of demand elasticity estimates and structural change tests to specification choices is by making comparisons of empirical results from different demand systems.

The purpose of this chapter is to evaluate an alternative demand system to analyze the sensitivity of results to different functional forms by using the same data set employed in the previous chapter. In particular, the role of meat prices, consumer expenditures, and consumers' habit formation in explaining the changes in meat consumption patterns in Canada is assessed by estimating the translogarithmic model with a habit effect incorporated. Further, this chapter provides evidence of the existence and effects of structural change in the demand for meat in Canada by applying a different testing procedure applied by Anderson and Blundell (1984).

2 The Translogarithmic Demand System and Extension

As one of the most commonly applied demand systems, the Transcendental Logarithmic (Translogarithmic) system of Christensen, Jorgensen and Lau (1975) is derived from consumer utility maximization framework. Their indirect utility function is specified as the following utility approximation function which is quadratic in the logarithmic of the ratios of prices (P_i) to the value of total expenditure (E):

$$\ln V = \alpha_0 + \sum_i \alpha_i \ln\left(\frac{P_i}{E}\right) + \frac{1}{2}\sum_i \sum_j \beta_{ij} \ln\left(\frac{P_i}{E}\right) \ln\left(\frac{P_j}{E}\right) \qquad (1)$$

Denote $P_i{}^* = \left(\frac{P_i}{E}\right)$ and assume symmetry in the utility function, i.e. $\beta_{ij} = \beta_{ji}$. Apply the logarithmic form of Roy's identify of:

$$\frac{P_i q_i}{E} = \frac{\partial \ln V / \partial \ln P_i}{\partial \ln V / \partial \ln E} \qquad (2)$$

The demand system in expenditure shares, $s_i = \frac{P_i q_i}{E}$ can be obtained as:

$$S_i = \frac{\alpha_i + \sum_j \beta_{ij} \ln P_j{}^*}{\sum_j \alpha_j + \sum_i \sum_j \beta_{ij} \ln P_j{}^*}, \qquad i = 1, 2, 3, 4 \qquad (3)$$

where α_i and β_{ij} are parameters. The budget share equations corresponding to the indirect Translogarithmic utility function are used to characterize consumer utility maximization behavior. The application of the model to meat demand further assumes three-stage budgeting so that consumers maximize a utility function that is weakly separable in meat consumption (Deaton and Muellbauer, 1980). With the assumption of meat separability, expenditures on the individual meat within the meat group are determined by maximizing the utility function for the group subject to the total expenditure for the meat group.

The indirect utility function (1) has been extended to allow habit formation by Manser (1976). She specifies parameter α_i, which depends linearly on one-period previous consumption(q_{it-1}):

$$\alpha_i = \alpha_i^* + d_i q_{it-1} \tag{4}$$

By introducing this dynamic specification of habit formation into the indirect utility function and using Roy's identity, the resulting demand equation is:

$$S_i = \frac{\alpha_i^* + d_i q_{it-1} + \sum_j \beta_{ij} \ln P_j^*}{\sum_j \alpha_j^* + \sum_j d_j q_{jt-1} + \sum_i \sum_j \beta_{ij} \ln P_j^*} \tag{5}$$

The static demand system, Model (3), is nested within Model (5), which incorporates the habit effect as the dynamic element. The more general Model (5) reduces to Model (3) if:

$$d_i = 0, \quad for \quad i = 1,2,3,4 \tag{6}$$

In both Models (3) and (5), the adding-up condition is automatically satisfied because $\sum P_i q_i = E$. The budget share equations are homogeneous of degree zero in prices and expenditure. As $\sum s_i = 1$, only $n - 1$ of the share equations are independent.

Thus, one equation must be deleted in estimation and the coefficient estimates will be invariant as to which equation is deleted. To estimate the share equations, an error term must be appended to each equation and the normalization $\Sigma\alpha_i^* = -1$ is commonly adopted.

From the equation (5), the following expenditure and price elasticity formulae can be derived. For the price elasticity derivation being manageable the assumption that q_{it-1} and p_t are independent is invoked. The expenditure elasticity of demand is derived as:

$$e_i = 1 + \frac{-\sum_j \beta_{ij}/s_i + \sum_i \sum_j \beta_{ij}}{-1 + \sum_i \sum_j \beta_{ij} \ln P_j^*} \qquad (7)$$

The own price elasticity formula is:

$$e_{ii} = -1 + \frac{\beta_{ii}/s_i - \sum_j \beta_{ij}}{-1 + \sum_i \sum_j \beta_{ij} \ln P_j^*} \qquad (8)$$

and the cross price elasticity formula is:

$$e_{ij} = \frac{\beta_{ij}/s_i - \sum_i \beta_{ij}}{-1 + \sum_i \sum_j \beta_{ij} \ln P_j^*} \qquad (9)$$

It can be seen that the demand elasticities are independent of α_i.

3 Data and Estimation of the Models

Quarterly time series data available from Agriculture Canada for the period of 1967(I) to 1987(IV), with 84 observations on each variable, are used for model estimation and hypothesis testing. The consumption and price set are the quarterly per capita disappearance and retail prices of beef, pork, chicken, and turkey. The retail prices of these meats were converted from CPI (1981 = 100) series. The base-year (1981) prices of meats are available from Statistics Canada (Cat. #62-010). The retail prices are the weighted avarages by the weights of the different components in each meat type. For beef and pork, quantities are retail weight per capita consumption.

Like most other demand systems, the Translogarithmic demand system requires the assumption of price exogeneity and weak separability of preferences. If the assumption of weak separability is correct, the commodities can be divided into groups or subgroups such that preference within a group is independent of other groups. In this study, if meat consumption is properly treated as a group, the consumer chooses the quantities of individual meat types so as to maximize the utility from meat consumption independent of consumption of other goods outside the meat group.

The static and dynamic version of the Translogarithmic demand system model in (3) and (5) were estimated using the non-linear maximum likelihood procedure available in White's (1988) computer program SHAZAM. After deleting the equation for turkey, the model has three equations, i.e. the expenditure share equations of beef ($i = 1$), pork($i = 2$), and chicken($i = 3$). As the prices are normalized in the indirect utility function, the homogeneity condition is automatically imposed. To be consistent with underlying consumer theory, the demand models are also expected to satisfy the symmetry condition. The cross-equation parametric restriction of symmetry is tested for both models (3) and (5) to compare the performance of the two specifications. Both models are tested using likelihood ratio (LR) tests. The results of the LR tests are compared to see whether the exclusion of the habit effect in the Translogarithmic system accounts for the rejection of the Slutsky symmetry condition. For ease of estimation of the indirect Translogarithmic parameters, the normalized price indexes, P_i / E, were scaled to equal 1.00 for 1976(II). The parameter estimates in Table 2 are not invariant to such a rescaling. Christensen and Manser (1977) show, however, that the implied price and expenditure elasticities and test results are invariant to such multiplicative rescaling of data.

4 Empirical Results and Discussion

Prior to the discussion of the structural parameter estimates of demand, test results for the choice of model specification are reported. Table 1 reports the results of likelihood ratio tests for model selection.

Table 1
Results of LR Tests for Symmetry

Model	Symmetry Imposed Log Likelihood (L_r)	Unrestricted Log Likelihood (L_u)	LR Test Statistic $2(L_u - L_r)$	Number of Restrictions	Critical Value at 5% (1%)
Static Translog (3)	801.209	813.148	23.878	6	12.592 (16.812)
Dynamic Translog (5)	858.418	861.750	6.664	6	12.592 (16.812)

The results of LR tests reported in Table 1 indicate that the theoretical restriction of symmetry is rejected in the static Translogarithmic demand system at the one percent level of significance. This restriction is not rejected in the dynamic Translogarithmic demand at the one percent level of significance, nor it is rejected at the five percent level. These results give some support to the habit formation specification in terms of the theoretical consistency of the model. Furthermore, the habit effect specification is supported by the LR test for the restriction of all $\alpha_i = 0$ in model (5). The computed LR test statistic is 97.204, which exceeds the critical value of chi-square of 15.086 at the 1% level of significance. Thus, the hypothesis of no habit effects in Canadian meat demand is rejected.

Table 2

Non-linear ML Estimates of the Parameters of Translogarithmic Demand System, 1967 (I)-1984 (IV), for Beef, Pork, Chicken, and Turkey[a,b]

	Static Translogarithmic		Dynamic Translogarithmic	
Parameters[c]	Estimates	Standard Erro.	Estimates	Standard Errors
α_1	-.5535*	(.0062)	.0122	(.120)
α_2	-.3597*	(.0054)	-.4897*	(.1037)
α_3	-.0599*	(.0032)	.0457	(.0508)
α_4	-.0269*	(.0088)	-.5682*	(.0117)
d_1	0		.0019*	(.0007)
d_2	0		-.0012	(.0008)
d_3	0		.0019*	(.0008)
d_4	0		.0073*	(.0025)
β_{11}	.3428*	(.0170)	.1068*	(.0433)
β_{12}	.1313*	(.0142)	-.0212	(.0595)
β_{13}	.0076	(.0064)	.0105	(.0156)
β_{14}	.0093	(.0111)	-.0759	(.0618)
β_{22}	.1572*	(.0193)	.1964*	(.0818)
β_{23}	.0076	(.0060)	-.0216	(.0289)
β_{24}	.0152	(.0118)	.1847*	(.1032)
β_{33}	.0240*	(.0078)	.0506*	(.0134)
β_{34}	.0099	(.0062)	-.0468	(.0318)
β_{44}	-.0109	(.1318)	.2633*	(.1459)

[a] The parametric restrictions of symmetry were imposed.

[b] * denotes significance at 5% level.

[c] The subscripts of parameters represent the meat type, i.e. 1 = beef, 2 = pork, 3 = chicken, and 4 = turkey.

The estimates of the structural parameters of the two Translogarithmic models versions are reported in Table 2. The results indicate that 8 out of 14 parameters are significantly different from zero at the 95% level of confidence for the static Translog model and that 10 out of 18 parameters are significant for the dynamic Translog model. The asymptotic t-statistic values of the habit effect coefficients are 2.623, -1.489, 2.436, 2.848 for beef, pork, chicken and turkey, respectively. The positive sign is as expected for the habit persistence effect. The results indicate that habit persistence of beef, chicken and turkey has some influence on consumers' budget share allocations of these meats. The negative sign on the coefficient of the one-period lagged pork consumption variable is the one exception and is statistically insignificant. Overall, the results suggest that habit effects should be considered in analyzing Canadian meat consumption.

The calculated demand elasticities based on the estimated parameters from the model are reported in Table 3. The own-price elasticity estimates are -0.63, -0.91, -0.98, -0.06 for beef, pork, chicken, and turkey demand, respectively. None of these meat types are found to be price elastic, but the demand for turkey is least price elastic and the elasticity of demand for chicken is almost unitary.

Table 3
Elasticity Matrix for Four-Meat Translogarithmic Demand System

	Price Elasticity				Expenditur Elasticity
	Beef	Pork	Chicken	Turkey	
Beef	-0.63	-0.10	-0.12	0.25	0.78
	(.138)	(.089)	(.148)	(.221)	(.267)
Pork	-0.04	-0.91	0.34	-0.03	0.76
	(.078)	(.259)	(.211)	(.089)	(.175)
Chicken	0.08	0.07	-0.78	0.15	1.14
	(.106)	(.134)	(.147)	(.189)	(.266)
Turkey	0.11	0.07	0.05	-0.06	1.37
	(.086)	(.127)	(.022)	(.036)	(.410)

Note: The elasticities were calculated at the sample mean. Numbers in parentheses are the standard errors.

5 Testing the Hypotheses of Structural Change

In this section the issue of structural change in Canadian meat consumption is examined. The classical tests for structural change for linear regression models do not apply to systems of equation that are nonlinear in parameters. Anderson and Mizon (1983) have, however, constructed a test statistic to test for structural change in the nonlinear simultaneous equations model. Their test statistic is based on the value of the log likelihood function, L_1, calculated over a restricted period of sample of T_1. The statistic has the following form:

$$2\left[\frac{T}{T_1}L_1+\frac{T}{2}ln\left(\frac{T}{T_1}\right)-L\right]\sim\chi^2_{n(T-T_1)}$$

where T is the number of observations for the complete sample; L is the value of log likelihood function evaluated over the complete sample; and n is the number of equations in the system. The statistic is distributed as a χ^2 statistic with $n(T-T_1)$ degrees of freedom.

This test was applied to the dynamic Translogarithmic system of Model (5) to test the stability of the model structure. The sample T_1, is restricted by removing the last 42 observations and the value of log likelihood function is evaluated over T_1 period. The choice of these subperiods is based on the observation that per capita expenditure share of beef reached [illegible] in 1976 (II) and fell thereafter. In an attempt to test the stability of exper[illegible]re behavior within before and after 1976(II) subperiods, the same test was also applied within each of the subperiods. In so doing, the two subsamples were futher split at mid-sample points, and Anderson and Mizon's test statistics for structural change were calculated and reported in Table 4. The null hypothesis of structural stability is rejected for consumer demand for meats for the period from 1967 to 1987 but not within either of the two subperiods.[1]

1 Altering the sample split points at the time period from 1975(I) to 1979(I) to test the appropriateness of partitioning the sample around 1976(II) did not alter the conslusion of this test.

Table 4
Results of Anderson-Mizon Test Statistic for Structural Change

Hypothesis	Anderson-Mizon Test Statistic	Degrees of Freedom	$\chi^2_{0.05}$
No structural change during:			
Period: 1967 (I) - 1987 (IV)	175.93	126	155.46
Period: 1967 (I) - 1976 (II)	4.359	36	49.765
Period: 1976 (III) - 1987 (IV)	34.560	36	49.765

In spite of the apparent structural break in the later 1970s, the dynamic Translogarithmic demand system model of (5) can still be viable if the model is estimated on the two separate subsamples indicated in Table 4. An alternative way to account for the detected structural break is to include certain time dummy variables that allow the parameters to change in the econometric models. To gain further insight into the nature of this structural change, the hypotheses of common intercepts and common slope coefficients were tested separately. Intercept dummy variables and slope dummy variables were introduced to the model and likelihood ratio tests were employed. The results of these tests are reported in Table 5. The results indicate that the intercepts of the expenditure share equations and the coefficients of habit formation have been subject to structural change. The hypothesis of constant parameters of the normalized prices, however, cannot be rejected at the 5% level of significance. These results suggest that prices and expenditures have tended to have stable effects on consumers' budget share behavior. The estimated differential intercept coefficients for the 1976 (III) - 1987 (IV) period are -0.014, 0.010, and 0.05 for the beef, pork, and chicken demand equations, respectively. The estimated coefficient of the intercept differential of beef equation, -0.014, indicates that the basic budget share for beef during 1976 (III) to 1987 (IV) is 0.014 lower than in the period of 1967 (I) to 1976 (II) given that the basic budget share was 0.47 for the earlier period. It is apparent that there has been a relatively large increase in chicken expenditures and a moderate increase in pork expenditure shares for the post-1976 (II) period. Based on this evidence, it appears that consumers' preferences have shifted away from beef to chicken.

Table 5
Results of Likelihood Ratio Test for Structural Change

Hypothesis			
No structural change in:	LR Test Statistic	Number of Restrictions	Critical Value ($\chi^2_{.05}$)
(1) Intercept terms	9.043	3	7.815
(2) Intercepts and habit effect coefficients	16.720	6	12.592
(3) Normalized price parameters (P_i/E)	6.664	10	18.307

6 Summary and Conclusion

In empirical demand analyses it is useful and desirable to choose a suitable maintained framework within which restrictions from consumer theory and issue of structural stability may be examined. In this paper, a Translogarithmic model of demand for meats incorporating a habit persistence effect is empirically evaluated and compared to a static version to assess the impact of habit formation in explaining Canadian consumption of four major types of meat. The demand for beef, chicken, and turkey meat appears to be significantly affected by habit persistence as well as the economic variables of price and expenditure. Price elasticity is highest for chicken (-0.98) and lowest for turkey (-0.06). The estimate for beef is -0.63 and for pork, -0.91. Expenditure elasticities exceed one for turkey, beef and chicken and are less than one for pork. With the dynamic element of habit formation, the model does not reject the cross-equation restrictions of consumer demand theory at the 1% level of significance. Based on these results, the dynamic Translogarithmic model with habit formation is chosen as the preferred specification for elasticity estimates and structural stability tests.

Tests for structural change in demand for meat with this model and data set indicate that there is a structural shift in the parameters of consumer preference during the later 1970s. No evidence of structural change was revealed when the samples from 1967 (I) to 1976 (II), and from 1976 (III) to 1987 (IV) were tested. An analysis of the effects of change on the meat consumption expenditure share equation was made. The validity of the assumption of common slope and common intercept was tested by introducing the appropriate time dummy variables to the original dynamic Translogarithmic demand model. It appears that structural change may have caused a decline in the basic expenditure share on beef as indicated by the decline of the intercept of the beef demand equation. The assumption of common slope coefficients on the normalized prices cannot be rejected. This indicates the effects of price and expenditure on meat demand have not changed significantly. The findings indicate that observed meat consumption patterns in Canada cannot be fully explained by changes in relative prices and consumer budgets. Although this study does not identify the cause of structural change in meat demand, the declining expenditure share on beef and the increase in chicken expenditure share tend to support that health perceptions or dietary concerns, in part, explain the change in meat demand (Moschini and Meilke, 1989). The finding of a structural break in Canadian meat consumption during the late 1970s also suggest including appropriate dummy variables that allow this shift in econometric models for meat demand analysis.[2]

2 For an evaluation and a comparison of results from this and the previous chapters, see next chapter.

7 References

Anderson, G. and R. Blundell. 1984. Consumer Non-durables in the U.K.: A Dynamic Demand System. *The Economic Journal* 94: 35-44.

Anderson, G.J. and G.E. Mizon. 1983. Parameter Constancy Tests: Old and New. Discussion Paper No. 8325, University of Southampton.

Atkins, F.J., W.A. Kerr and D.B. McGiven. 1989. A Note on Structural Change in Canadian Beef Demand. *Canadian Journal of Agricultural Economics* 37: 513-524.

Braschler, B. 1983. The Changing Demand Structure for Pork and Beef in the 1970s: Implication for the 1980s. *Southern Journal of Agricultural Economics* 9: 271-282.

Chalfant, J. and J. Alston. 1988. Accounting for Changes in Tastes. *Journal of Political Economy* 96(2): 291-410.

Chavas, J.P. 1983. Structural Change and Demand for Meat. *American Journal of Agricultural Economics* 65: 185-193.

Christensen, L.R., D.W. Jorgenson and L.J. Lau. 1975. Transcendental Logarithmic Utility Functions. *American Economic Review* 65(3): 367-383.

Christensen, L.R. and M. Menser. 1977. Estimating U.S. Consumer Preferences for Meat with a Flexible Utility Function. *Journal of Econometrics* 5: 37-53.

Dahlgran, R. 1987. Complete Flexible Systems and the Stationarity of U.S. Meat Demand. *Western Journal of Agricultural Economics* 12: 152-163.

Deaton, A. and J. Muellbauer. 1980. Economics and Consumer Behavior. Cambridge MA: Cambridge University Press.

Johnson, S.R., Z.A. Hassan and R. Green. 1984. Demand Systems Estimation: Methods and Applications. Ames: The Iowa State University Press.

Martin, W. and D. Porter. 1985. Testing for Changes in the Structural of the Demand for Meat in Australia. *Australian Journal of Agricultural Economics* 29(1): 16-31.

Menser, M. E. 1976. Elasticities of Demand for Food: An Analysis Using Non-additive Utility Functions Allowing for Habit Formation. *Southern Economic Journal* 43:879-891.

Moschini, G. and K.D. Meilke. 1984. Parameter Stability and the U.S. Demand for Beef. *Western Journal of Agricultural Economics* 9: 271-82.

Moschini, G. and K. Meilke. 1989. Modeling the Pattern of Structural Change in U.S. Meat Demand. *American Journal of Agricultural Economics* 71: 253-261.

Nyankori, J.C. and G.H. Miller. 1982. Some Evidence and Implication of Structural Change in Retail Demand for Meats. *Southern Journal of Agricultural Economics* 14: 65-70.

Young, L. 1987. Canadian Meat Demand. Working Paper 10/87. Ottawa: Agriculture Canada, Policy Branch.

White, K.K., S.A. Haun, H.G. Horsman and S.D. Wong. 1988. SHAZAM Econometric Computer Program. New York: McGraw Hill.

V. General Discussion and Conclusions

The purpose of this study is to contribute to the empirical knowledge of elasticity of demand for meats in Canada and the inquiry about structural change in consumer preferences or tastes in meat consumption over the last two decades. To this end, different demand systems as well as single-equation econometric methods were applied to analyze the demand for meat in Canada. Methodological issues such as appropriate model specification and test procedures were addressed prior to the estimation and hypothesis testing. The hypothesis testing for consumer behavior and structural change are performed based on the preferable maintained frameworks. In this concluding chapter, the major empirical findings of this study are summarized and the implications discussed. Finally, the directions for future research in the area of applied demand analysis are addressed.

A. Summary and Implications

In Chapter 2, the estimates of price, income and expenditure elasticities are computed, based on annual data series from 1960 to 1987. Single-equation demand models were used. Within the chapter, efforts were made to explore the issue of whether or not prices are exogenous in quantity-dependent models of demand for meats by applying Wu-Hausman specification tests. In checking the exogeneity of prices in the context market demand for meat, the supply-side factors are also analyzed within the conventional demand-supply market framework. One has to observe the supply-side data such as prices of inputs and analyze their potential effects on the market-supply quantity to be consumed or demanded. The market equilibrium is, as usual, assumed in the model. Although the empirical results of the exogeneity tests did not reject the exogeneity of meat prices in market demand functions, unfortunately the endogeneity of meat quantity is still unclear from the results. Re-specification of the model was attempted to provide more convincing conclusion, but these efforts were not successful.

In specifying and estimating the demand for meat, using single equation models, particularly for beef, the hypothesis of non-autocorrelation in the random error term was not rejected when the time dummy variables were introduced to account for structural shift in the regression model. Using sequential Chow tests which split the sample in two sub-samples at every possible point it was found that the hypothesis of structural change during the mid-1970s in demand for beef and chicken cannot be rejected. These results indicate a structural shift and give support to the modeling strategy of introducing dummy variables to allow parameters to vary in the regression models analyzing meat demand in Canada.

Another specification issue analyzed in Chapter 2 is the appropriate use of total income or expenditure on meat in modeling the demand for meat. When the model only includes meat prices and quantities, concepts of weak separability within demand theory suggest expenditure on meat, rather than the commonly used per capita disposable income, is the appropriate explanatory variable. The results of the non-nested hypothesis tests support this theoretical proposition with this set of meat demand data. Based on performance, as measured by prediction accuracy, the use of expenditure variables consistently yield smaller final prediction errors for each type of meat than does the use of income variables. Thus, it is concluded that the demand models using expenditure variables outperform those using income variables.

The demand analyses discussed in Chapter 2 were carried out by using the linear single-equation regression method. The principal advantage of the single-equation method was that it allows focus on such model specification problems as price exogeneity and the choice of income or expenditure variables. Use of demand systems methods to check such model specification problems would be more complex. The process of analysis involves many more unchecked maintained hypotheses; the confidence about the end result of the initial inquiry problem normally would be reduced. On the other hand, the major shortcoming of single-equation demand analysis is that the simple model does not allow examination of interdependencies between different types of meat. Thus the cross-equation properties implied by consumer demand theory cannot be examined appropriately. To investigate the parametric restrictions from consumer theory and consumer preference or tastes changes, two demand systems models that are consistent with utility maximization were empirically evaluated.

In Chapter 3, meat consumption patterns in Canada were analyzed, using a dynamic version of the Almost Ideal Demand System (AIDS). The estimates of price and expenditure elasticities as well as the statistics for hypothesis testing were computed using quarterly data series from the first quarter of 1967 to the fourth quarter of 1987. As mentioned earlier, it is important to choose a suitable maintained framework within which restrictions from the theory of consumer behavior and the issue of structural shift may be examined. Thus, efforts were made to evaluate a dynamic version of the AIDS model versus the original static AIDS to determine the role of habit formation in explaining meat consumption in Canada. The analyses of quarterly demand data on beef, pork, chicken, and turkey indicate that the effect of consumption habits on these types of meats cannot be rejected. Furthermore, the empirical evidence shows the AIDS model with habit formation did not reject the properties of homogeneity of symmetry implied by consumer theory; the static AIDS model, however, did reject these theoretical conditions. It appears that incorporating the dynamic element of a habit effect in the AIDS model reduced the inconsistency between the theory and the observed data.

Based on the above results, the dynamic AIDS with habit formation specification is chosen for demand elasticity estimates and for testing structural shifts. None of the meat types is found to be price elastic. The hypothesis of no structural change in Canadian demand for meats during the last two decades was rejected by likelihood ratio-equivalent tests. When the data on meat demand were partitioned into two sub-samples at the break point of 1976, it was found that expenditure shares on beef and chicken were significantly different before and after 1976. The effect of the structural shift was such that expenditure shares trended away from beef to chicken. This is consistent with the idea that increasing dietary health concerns from the mid-1970s had an important effect on the changes in meat consumption patterns.

The AIDS model and its habit formation extension evaluated in this study are based on minimization of consumption expenditure subject to a given utility level. Flexible functional forms were used to approximate the expenditure or cost functions. As a dual problem to expenditure or cost minimization, demand system equations can also be derived from the constrained utility maximization framework. The Translog demand system model is another example of flexible demand functions that assume consumer utility-maximizing behavior over the observed time period. In fact, there are strong similarities between the AIDS and Translog indirect utility functions.

In order to assess the relative explanatory and predictive power of the AIDS and Translog demand system, the Translog model was also estimated both with and without the habit formation extension (Chapter 4). The demand for beef, chicken and turkey meat was found to be significantly affected by habit persistence as well as by the traditional economic variables of prices and expenditure. The results of likelihood ratio tests show that the Translog model with habit formation is better in terms of consistency with implications of the theory of demand, namely the symmetry restriction, than the model without habit formation. The dynamic Translog model with habit formation is used to derive demand elasticity estimates and is tested for structural stability. While no individual meat was found to be price elastic, the demand for turkey was least price elastic.

To test for structural change, we used Anderson and Mizon's (1983) procedure, which is different from the testing procedure used for the AIDS model. The results of the Anderson-Mizon test indicate that there was a structural shift in the parameters of consumer preference during the late 1970s. An analysis of the effects of the structural shift on meat expenditure share equations reveals that the structural change reflected a decline in the basic budget on beef but a increase in the budget share of chicken. This finding of a detected structural shift was the basis of the suggestion that an intercept dummy variable be included as a viable regression model for Canadian meat demand analysis. The alternative modeling strategy is to use the data after 1976 and onward for forecasting purposes.

B. A Comparison of Results Between Two Demand Systems and Single-equation Models

The Translog Demand System and the Almost Ideal Demand System are two of the alternative demand systems. Given that the AIDS and Translog models have identical endogenous variables, namely the expenditure or budget shares, it is possible to compare the models in terms of their predictive performance and information criteria. Within this chapter, the following alternative model selection criteria are used, namely:

1) Akaike final prediction error (FPE):

$$(1)\ FPE = \frac{T+K}{T-K}\hat{\sigma}_k^2$$

and 2) the Akaike information criterion (AIC):[1]

$$AIC = \frac{2}{(nT)}(\ln L_0 - K)$$

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1 AIC in this form is cited in Hansen and Sienknecht (1989, p.46).

where $\ln L_0$ is the value of the log likelihood-function with k parameters and nT observations under. The computed results are reported in Table 1. The AIC criterion is similar to the adjusted R-square. The information provided by the maximum value of the log likelihood function is discounted by the additional parameters to account for the sample size in the regression model.

Table 1.
Model comparison by means of prediction error and information criteria

Model	k	AIC	Meat Type	FPE
			Beef	0.00051
AIDS:	15	6.130	Pork	0.00043
			Chicken	0.00004
			Beef	0.00047
Translog	18	6.435	Pork	0.00023
			chicken	0.00003

Note: the above results are computed based on the dynamic versions of the two demand systems.

Table 1 shows that the two demand systems do not differ very much according to the AIC information criterion. In terms of predictive accuracy, the prediction errors of both models are quite small, indicating both models fit the data well. Overall, the Translog system slightly outperforms the AIDS with this data set. It is useful to note that the sample size (84) in the regression model is large relative to the parameters (18) in the Translog demand system model and (15) in the AIDS model. It could be of interest to compare the two models when the sample size is considerably smaller, e.g. when using annual data.

Table 2 summarizes the price and income elasticity estimates derived from the two alternative demand systems. In the case of the demand for chicken, the expenditure and own-price elasticity estimates from the AIDS and the Translog models are almost identical. The own-price elasticity estimates derived from the two models for both beef and pork fall within a fairly narrow range. The two demand systems give slightly different expenditure elasticity estimates, although the magnitudes are not far apart.

Table 2.

Own price and expenditure elasticity estimates from the two dynamic demand system models.

Model Type	Meat Type	Own-price Elasticities	Expenditure Elasticities
	Beef	-0.77	0.93
AIDS:	Pork	-0.82	1.01
	Chicken	-0.95	1.04
	Turkey	-0.09	0.99
	Beef	-0.63	0.78
Translog:	Pork	-0.91	0.76
	Chicken	-0.78	1.14
	Turkey	-0.06	1.37

Based on these results, it appears that the two alternative flexible demand systems give similar results with respect to own-price elasticities, but there are some minor differences with respect to expenditure elasticities of demand for beef and pork. It should be noted that all elasticity estimates were calculated at the sample means.

It may be of interest to compare the demand elasticity estimates from the system models and those from the single equation models. Table 3 summarizes the demand elasticity estimates from the single equation models.

Table 3.

Own price and expenditure elasticity estimates of single equation model

Model	Meat Type	Own-price Elasticities	Expenditure Elasticities
Model 1a	Beef	-0.76	0.95
	Pork	-0.74	0.89
	Chicken	-0.72	0.84
Model 1a (with time dummies)	Beef	-0.53	0.57
	Pork	-0.89	0.69
	Chicken	-0.85	1.13

It can been seen that the expenditure elasticity estimates from the single equation model are slightly lower than those from the systems models for the beef and pork demand. This is also the case when comparing the own-price elasticity estimates for beef and chicken demand.

To compare the demand elasticity estimates from the system models and those from single equation models the following must be taken into account. First, quarterly data are used in estimating the systems models while annual data are used in estimating the single equation models. Second, the consumption of beef, pork, and chicken are grouped with turkey in the demand systems analyses whereas the consumption of beef, pork, and poultry meat are grouped with fish in the single equation demand analysis. Comparison of the results suggests that the quarterly demand for meat is more volatile with respect to changes in prices and expenditures as opposed to annual demand. The resulting demand elasticity estimates are generally comparable to those from other demand studies summarized in Young (1987).

Similar conclusions were evident from both models on the issue of structural change in demand for meats in Canada. Tests for structural change with both the AIDS and the Translog demand system indicated a structural shift in household preference parameters during the mid- to the late-1970s. Based on further analyses of the effects of the detected structural shift it was concluded that a shift in the intercept terms of the meat demand equations accounted for the shift in budget shares. We interpret the shift in the intercept terms of the demand systems as an indication of change in tastes or preferences. The test results from the system analyses also indicate the effects of price and expenditure on meat demand have not changed significantly over time. Moschini and Meilke (1989) arrived at a similar conclusion from analyzing U.S. meat demand data. The effects of the structural shift appear to have caused the shift in basic budget shares away from beef to chicken.

The analysis of structural change based on the AIDS models with habit formation indicates that a 6 percent decline in expenditure share on beef and a 33 percent increase in expenditure share on chicken seem to have been due to structural shift at constant prices and expenditures. In order to measure the relative importance of structural shift effect as opposed to price and income effect in determining the variation in per capita meat consumption, the breakdown of the coefficients of determination, i.e., the R-square statistics were used. Such procedures are only valid when the independent variables, including time dummy variables proxing structural change, are uncorrelated. In the case of structural change analysis, it is reasonable to expect this variable representing a structural break is uncorrelated to other independent variables such as prices and consumer expenditures. Thus, the use of R^2 statistic in this context is justified.[2]

As the measurement of R^2 is meaningful in the case of a linear relationship estimated by least squares, the breakdown of R^2 was applied to the LA/AIDSmodel. This model was first estimated without the time dummy variables to seperate the intercept terms and the resulting R^2 was 0.72. The R^2 was 0.92 when the model was estimated with the time dummy variables to seperate intercept terms. The conclusion derived from this is that about 25% of the change in the system demand for meat can be attributed to the structural shift in consumer preference (changes in eating habits). A further application of the above procedure to demand for individualmeats (Model 1a) indicates that an average of 20% of the changes in per capita chicken consumption and an average of 25% of changes in per capita beef consumption were due to the structural shift. The

2 Kennedy (1985, pp.60-61) notes that such tests must be interpreted with caution.

remaining proportion of variations in per capita meat demand were determined by changes in prices and consumer expenditures. The implication of this finding to beef producers is that the concerns of the beef consumers underlying this shift could be probed. If there is a misperception of health related to beef consumption, industry promotion efforts could be directed toward this.

C. Future Research on Applied Demand Analyses

Advances in applied demand analysis have narrowed the gap between the economic theory of consumer behavior and the application of econometrics to observed data in generating estimates of demand parameters. Among these developments, the Transcendental Logarithmic (Translog) Demand System of Christensen, Jorgensen, and Lau (1975), and the Almost Ideal Demand System (AIDS) of Deaton and Muellbauer (1980) are two of the most frequently cited demand systems. There are several similar properties that are common to both demand systems. For example, both models give a local approximation to any demand system; both have been extensively estimated and been used to test the homogeneity and symmetry restrictions of demand theory; both analyzing the behavior of budget shares and have the functional forms of polynomials in log prices. There are many criteria by which these demand systems may be compared. The basic criteria used in this study are the consistency with economic theory, goodness of fit, and forecast accuracy.

Another way to compare the model adequacy and relative explanatory power of the two models of demand system is to develop a more general model that has both models nested within it. Lewbel (1989) has constructed a joint system model nesting the AIDS and Translog demand system. In this paper, he adopted the utility functions U_1 and U_2 for the AIDS and the Translog, respectively. The "joint" system is developed from maximization of $U_3 = \lambda U_1 + (1 - \lambda) U_2$ for a constant λ between zero and one nests U_1 and U_2. Using Roy's identity method, the joint demand system in expenditure share forms was derived and estimated by Lewbel using U.S. aggregate consumption data. Comparing the AIDS and the Translog model, he found that both models are equal in terms of explanatory power, although his joint model is slightly superior statistically. It is concluded from Lewbel's (1989) study that "the controversy over the relative merits of AIDS and Translog systems appears to be unnecessary, since both yield very similar elasticity estimates". This supports the conclusion on the performance of the two dynamic demand systems derived from this study. Lewbel's joint demand system nesting AIDS and Translog models may serve as an alternative specification to either model when there is doubt over which of the demand systems to use. It may be of interest to see how dynamic elements can be introduced to Lewbel's model.

In general, the demand system models with dynamic elements outperform their static counterparts in terms of consistency with economic theory, goodness of fit, and model specification adequacy. In addition to the dynamic specification evaluated in this study, other dynamic specification such as the first-difference demand system model of Anderson and Blundell (1983, 1984), and the partial-adjustment type model of Ray (1984) are the other alternative functional forms.

The impacts of socio-demographic variables on meat consumption have been analyzed mainly from cross-sectional data (Ray 1980; Heien and Pompelli 1988). The empirical finding of Heien and Pompelli suggested that demographic effects, such as household size, region, and ethnic origin, played a significant role in explaining the demand for beef products. They found some other demographic variables, such as employment status, shopper, and occupation, were generally not significant. The incorporation of socio-demographic variables in time-series demand analysis is one of the major challenges for both theoretical and applied research.

The development of flexible functions of demand systems such as the Translog and AIDS models has made it possible to represent any arbitrary consumer demand function. The use of these demand systems sometimes may violate theoretical restrictions such as symmetry or homogeneity. In this study, it is demonstrated that introducing dynamic elements improves the accord between theory and observed data. Two recent papers by Chalfant and White (1988) and Chalfant, Gray, and White (1989) provide useful alternatives by which the consistency between the demand theory and data may be enhanced. Chalfant, Gray and White have argued that the violation of theoretical restrictions of homogeneity and symmetry by the estimated demand systems may be caused by failure of imposing substitution elasticities or curvature restrictions. The difficulty facing the demand analyst is that the restrictions on the sign of elasticity of substitution and negativity involve inequality restrictions. To determine whether an estimated demand system is consistent with prior beliefs from the theory of consumer behavior, they maintained it is important to be able to impose the inequality restrictions. These inequality restrictions can be handled by a Bayesian procedure. Using the linear approximate AIDS model with annual Canadian data on demand for beef, pork, chicken, and fish, Chalfant, Gray, and White found substantial support for the concavity of the consumer's expenditure function underlying the linear approximate almost ideal demand system. In the same paper, they concluded that the probability that the above four meats are all substitutes is very low. These findings lend support to the results that obtained here from Chapter 3 and 4, where the non-Bayesian or 'frequency' approach was used.

It can be seen that the Bayesian procedure proposed by Chalfant and White to impose inequality restrictions of demand theory may serve as an alternative way of evaluating competing functional forms for demand systems. So far, in discussing the ways to improve consistency between the theory and data, it is implicitly assumed that the theoretical model is "correct" and the parametric approaches are explored and applied. Varian (1983) and Chalfant and Alston (1988) have shown that non-parametric demand analysis approach may be used to explain commodity consumption patterns and to test the stability of consumer preferences. The advantage of non-parametric demand analysis is that it gives a test for stable preferences for a commodity group that does not require a particular functional form, such as AIDS or Translog. Underlying the methods of non-parametric demand analysis, is the theory of revealed preference, which argues that economists do not observe preferences, but they observe the consumption behavior based on the choices made by consumers. How can economists tell whether observed behavior is generated from the maximization of a preference or utility function? Non-parametric demand analysis method provides an important development to answer this question.

While the above discussion mentions a few areas in which additional research is needed, there is another major facet of consumer demand that we know very little about. As Myers (1986) has pointed out, economists have little empirical knowledge of the way supplier behavior interacts with consumer behavior.

D. References

Anderson, G. J. and G. E. Mizon. 1983. Parameter Constant Tests: old and new. Discussion Paper No.8325 University of Southamption.

Anderson, G. J. and R. Blundell 1983. Testing Restrictions in a Flexible Dynamic Demand System: An Application to Consumers' Expenditure in Canada. *Review of Economic Studies* 50:397-410.

Alston, J. And J. Chalfant (1987). "Weak Separability and a Test for the Specification of Income in Demand for Meat in Australia." *Australian Journal of Agricultural Economics* 31(1):1-15.

Braschler, B. (1983). "The Changing Demand Structural for Pork and Beef in 1970's: Implications for the 1980's", *Southern Journal Agricultural Economics.* 9:271-82.

Chaltant, J. (1987). A Global Flexible, Almost Ideal Demand System. *Journal of Business and Economic Statistics* 5(2):233-242.

Chalfant, J. R. Gray and K. White. (1989). Evaluating Prior Beliefs in A Demand System: The Case of Meats Demand in Canada. Working Paper No.483 Department of Agricultural and Resource Economics, University of California.

Chalfant, J. And J. Alston (1988). "Accounting for Changes in Tastes", *Journal of Political Economy* 96(2):391-410.

Chalfant, J. and K. White. (1988). Estimation of Demand System with Concavity and Monotonicity Constraints. University of British Columbia Discussion Paper.

Chavas, J. P. (1983). "Structural Change and Demand for Meat", *American Journal of Agricultural Economics.* 65:148-53.

Christensen, R., D. W. Jorgenson and L. J. Lau. (1975). "Transcendental Logarithmic Utility Functions", *American Economic Review* 65:367-83.

Curtin, L. *et al.* (1987). "Demand for Foods in Canada." Working Paper 13/87, Agriculture Canada.

Dahlgran, R. (1987). "Complete Flexible Systems and the Stationarity of U.S. Meat Demand", *Western Journal of Agricultural Economics* 12:152-63.

Deaton, A. And J. Muellbauer (1980). *Economics and Consumer Behavior* (Cambridge: Cambridge University Press).

Eales, J. And L. Unnevehr (1987). "Demand for Beef and Chicken Products: Separability and Structural Change." AAEA Annual Meeting, Working Paper No. 358 University of Illinois.

Fisher, B. (1979). "The Demand for Meat--An example of an incomplete Commodity Demand System", *Australian Journal of Agricultural Economics* 23(3):220-30.

Green, H. A. (1976). *Consumer Theory* (New York: MacMillan).

Haidacher, R. C. (1983). "Structural Change in the Demand for Meat", *Southern Journal Agricultural Economics* 12:31-38.

Hansen, G. and H. P. Sienknecht. (1989). A Comparison of Demand Systems- A case study for West-Germany. *Empirical Economics.* 14(1):43-61.

Hassan, Z. And S. Johnson (1976). "Consumer Demand for Major Foods in Canada", Economics Branch Publication No.76/2,Agriculture Canada.

________, (1979). "The Demand for Meat in Canada: An Application of the Transformation of Variables", *Canadian Journal Agricultural Economics* 27(3):1-12.

________, (1983). "Quarterly Demand for Meat in Canada with Alternative Seasonably Hypothesis", *Canadian Journal Agricultural Economics* 31(1):77-94.

Heien, Dale and Grey Pompolli. (1988). The Demand for Beef Products: Cross-section Estimation of Demographic and Economic Effects. *Western Journal of Agricultural*

Economics. 13(1):37-44.

Johnson, S.R., Z.A. Hassan, and R.D. Green (1984). *Demand Systems Estimation: Methods and Application.* (Ames: The Iowa State University Press).

Kennedy, P. (1985). *A Guide to Econometrics* (Cambridge: MIT Press).

Lewbel, A. (1989). Nesting the AIDS and Translog Demand System. *International Economic Review*. 30(2):349-356.

Martin, W. And D. Porter, (1985). " Testing for Changes in the Structure of the Demand for Meat in Australia" *Australian Journal of Agricultural Economics* 29(1):16-31.

Moschini, G. And K. Meilke (1984). "Parameter Stability and the U.S. Demand for Beef", *West Journal of Agricultural Economics* 9:271-82.

Moschini, G. and K. Meilke (1989). Modeling the Pattern of Structural Change in U.S. Meat Demand. *American Journal of Agricultural Economics* 71:253-261.

Murray, J. (1985). "Retail Demand for Meat in Australia: A Utility Approach", *The Economic Record* 11:45-56.

Myers, Lester H. (1986). "What Do We Know and What Does it Mean" in Buse, Rueben Ed. *Proceedings of the Conference on The Economics of Meat Demand.* (Madison: University of Wisconsin Press) 1988.

Nyankori, J. C. And G. H. Miller (1982). "Some Evidence and Implications of Structural Change in Retail Demand for Meats", *Southern Journal of Agricultural Economics* 14:65-70.

Phlips, L. (1983) Applied Consumption Analysis (Oxford: North-Holland).

Ray, R. (1980). Analysis of a Time Series of Household Expenditure for India. *Review of Economics and Statistics* 62: 595-602.

Ray, R. (1984). A Dynamic of Generalization of the Almost Ideal Demand System. *The*

Economic Letters 14:235-239.

Varian, Hal (1982) "Non-parametric Approach to Demand Analysis." *Econometrica* 50(2): 99-110.

_____, (1983) "Non-parametric Tests of Consumer Behavior." *Review of Economic Studies* 50(May): 579-97.

Young, L. (1987). "Canadian Meat Demand", Working Paper 10/87Ottawa: Agriculture Canada, Policy Branch.

Zellner, A. (1984) *Basic Issues in Econometrics.* (Chicago: The University of Chicago Press).

APPENDIX 1

ELASTICITY FORMULAS IN AIDS MODELS

The original static AIDS model is specified as

$$(1) S_i = \alpha_i + \sum_j \gamma_{ij} \ln P_j + \beta_i (\ln E - \ln P),$$

where $S_i = \frac{p_i q_i}{E}$, and $\ln P$ is the price index.

The uncompensated price elasticity (e_{ij}) and expenditure

elasticity (e_i) defined as

$$e_{ij} = \frac{d \ln q_i}{d \ln p_j} = \frac{d q_i}{d p_j} \frac{p_i}{q_j},$$

and $$e_i = \frac{d \ln q_i}{d \ln E}.$$

Form $S_i = \frac{p_i q_i}{E}$, it gives $\ln q_i = \ln E - \ln p_i + \ln S_i$.

The expenditure elasticity formula is:

$$\frac{d \ln q_i}{d \ln E} = 1 + \left(\frac{1}{S_i}\right) \frac{d S_i}{d \ln E} = 1 + \frac{\beta_i}{S_i}$$

The price elasticity formula, in general, can be expressed as:

$$e_{ij} = \frac{d \ln q_i}{d \ln p_j} = -\delta_{ij} + \left(\frac{1}{S_i}\right) \frac{\partial S_i}{\partial \ln p_j} = -\delta_{ij} + \frac{1}{S_i}\left(\gamma_{ij} - \beta_i \frac{\partial \ln P}{\partial \ln p_j}\right)$$

Thus, it depends on the partial deferentiation of the price index (ln P).

For the case of LA/AIDS:

as

$$\frac{\partial \ln P}{\partial \ln p_j} = \frac{\partial(\Sigma S_i \ln p_i)}{\partial \ln p_j} = S_j + \Sigma\left(\frac{\partial S_i}{\partial \ln p_j}\right)\ln p_i = S_j + \sum_i \gamma_{ij} \ln p_i$$

Therefore, the price elasticity for LA/AIDS is:

$$e_{ij} = -\delta_{ij} + \frac{1}{S_{ij}}\left\{\gamma_{ij} - \beta_i\left(S_j + \sum_i \gamma_{ij} \ln p_i\right)\right\}$$

where $\delta_{ij} = 1$, if i = j ;

$\delta_{ij} = 0.$, if i does not equal to j.

For the case of habit version of AIDS, where the price index ($\ln P$) is:

$$\ln P = \alpha_0 + \sum_j (\alpha_j + d_j q_{it-1}) \ln p_j + \frac{1}{2}\Sigma\Sigma\gamma_{ij} \ln p_i \ln p_j,$$

and $\dfrac{\partial \ln P}{\partial \ln p_j} = \alpha_i + d_i q_{it-1} + \sum_j \gamma_{ij} \ln p_j;$

therefore, the price elastcity formula for habit version of AIDS is:

$$e_{ij} = -\delta_{ij} + \frac{1}{S_i}\left\{\gamma_{ij} - \beta_i\left(\alpha_i + d_i q_{it-1} + \sum_j \gamma_{ij} \ln p_j\right)\right\}.$$

APPENDIX 2

PER CAPITA CONSUMPTION OF MEAT IN KILOGRAM

YEAR	BEEF	PORK	POULTRY	FISH
1960	24.06	20.66	13.00	5.13
1961	24.32	19.82	13.50	5.32
1962	24.51	19.72	13.70	5.35
1963	25.62	19.67	14.94	5.49
1964	27.37	20.14	15.90	5.80
1965	28.81	18.63	16.59	5.10
1966	28.96	18.30	17.84	4.99
1967	28.67	21.23	18.50	4.83
1968	29.35	20.81	18.04	4.82
1969	29.53	19.97	19.55	4.99
1970	29.10	22.61	20.48	4.92
1971	30.52	25.08	19.73	5.46
1972	32.51	24.20	20.16	5.88
1973	31.96	22.77	20.85	5.98
1974	33.19	23.72	20.30	6.14
1975	36.88	20.32	19.00	5.93
1976	39.03	20.77	20.28	6.79
1977	37.13	20.76	20.71	6.35
1978	34.75	21.58	21.35	6.73
1979	29.53	24.30	22.83	6.72
1980	29.25	26.31	22.71	6.77
1981	30.05	25.34	22.52	6.51
1982	29.85	23.60	22.62	5.98
1983	29.73	24.30	22.91	6.18
1984	28.41	23.51	23.70	6.29
1985	28.82	24.06	25.06	6.82
1986	28.84	23.43	26.21	7.41
1987	27.86	23.47	27.64	6.84

SOURCE: DATA ON PER CAPITA CONSUMPTION OF BEEF AND PORK WERE UNPUBLISHED RETAIL WEIGHTS FROM L. ROBINS, AGRICULTURE CANADA. THE METHODOLOGY FOR DERIVING A FACTOR THAT CONVERTS CARCASS WEIGHT TO RETAIL WEIGHT FOR THESE WAS PUBLISHED IN FOOD MARKET COMMENTARY, VOL.11-2, AGRICULTURE CANDADA (1989, PP.24-25). OTHER DATA WERE FROM AGRICULTURE CANADA (1988).

RETAIL PRICES OF MEAT ($/kg)

YEAR	BEEF	PORK	POULTRY	FISH
1960	1.421173	1.701356	1.125933	0.9111171
1961	1.415177	1.792230	1.012000	0.9490803
1962	1.553097	1.862909	1.035457	0.9761969
1963	1.505125	1.847763	1.062264	0.9978901
1964	1.457152	1.777084	1.012000	1.008737
1965	1.517118	1.973977	1.042159	1.057547
1966	1.667030	2.276889	1.125933	1.160590
1967	1.756978	2.049705	1.079019	1.182283
1968	1.786961	2.039608	1.109178	1.203976
1969	1.930877	2.387957	1.105827	1.290749
1970	1.990842	2.246598	1.072317	1.431755
1971	2.038814	1.938637	1.102476	1.491412
1972	2.230702	2.423296	1.263324	1.713768
1973	2.692434	3.185625	1.662092	2.109670
1974	2.968273	2.978635	1.886608	2.652002
1975	2.812364	3.816692	2.050807	2.711658
1976	2.632469	3.942905	2.114476	2.982824
1977	2.800371	3.715721	2.121178	3.291953
1978	4.095618	4.417467	2.436171	3.752935
1979	5.384868	4.503292	2.761217	4.170530
1980	5.846599	4.321545	2.885204	4.745401
1981	5.996512	5.048534	3.350992	5.423316
1982	5.960533	6.002707	3.498436	5.938531
1983	6.002509	5.886591	3.612369	6.236813
1984	6.398278	5.856299	3.840237	6.540519
1985	6.560184	6.007755	3.786621	6.817108
1986	6.704100	6.977074	4.088210	7.158777
1987	7.315745	7.598044	4.312727	7.961428

SOURCES: HANDBOOK OF FOOD EXPENDITURES, PRICE AND CONSUMPTION, AGRICULTURE CANADA (1988).
NOTE: THE RETAIL PRICES ARE DERIVED FROM CPI SERIES FOR SPECIFIC MEATS (1981=100) BY MULTIPLYING THESE BY THE CITY AVERAGE RETAIL PRICES OF SPECIFIC MEATS IN 1981. THE PRICE OF BEEF IS A WEIGHTED AVERAGE OF PRICES OF LOIN AND ROUND STEAK, ROAST, HAMBERGER LISTED IN STATISTICS CANADA (CAT. #62-010). THE WEIGHTS ARE THE EXPENDITURE WEIGHTS LISTED IN STATISTICS CANADA (CAT. #62-553). THE SAME METHOD IS APPLIED TO DERIVED THE PRICE OF PORK, WHICH IS A WEIGHTED AVERAE OF OF PRICES OF CENTER CUTS, ROAST, AND BONELESS PORK. FOR POULTRY MEAT AND FISH, THERE WAS ONLY ONE RETAIL PRICE FOR EACH IN 1981; THESE WERE APPLIED TO CPI, RESPECTIVELY, FOR CHICKEN AND FISH.

APPENDIX 3

QUARTERLY PER CAPITA CONSUMPTION OF MEAT (IN POUND)

TIME	BEEF	PORK	CHICKEN	TURKEY
1967.1	21.34050	12.55400	5.313968	1.438502
1967.2	21.91140	12.74600	5.970939	1.692692
1967.3	21.89430	12.89700	6.255332	1.979290
1967.4	21.24220	13.39000	5.201313	4.399720
1968.1	21.67750	13.26600	5.364012	1.159399
8.20	22.31670	12.72790	5.865779	1.718706
8.30	22.34090	12.08540	6.396206	1.745602
8.40	22.99280	12.48810	5.773847	4.528469
1969.1	22.18610	12.23620	6.007315	1.434754
9.20	21.49570	11.97470	6.845944	1.881626
9.30	22.66530	11.29770	6.915610	1.621263
9.40	24.91800	12.28040	6.774515	4.668020
1970.1	21.62880	12.42620	6.569928	1.340397
0.20	22.11880	12.32200	7.358293	1.559093
0.30	24.03010	13.20270	7.550535	2.020736
0.40	22.23030	14.16090	6.748722	4.354746
1971.1	21.43230	14.93270	6.889595	1.313942
1.20	22.69500	14.82860	6.842637	1.694896
1.30	23.75400	14.65610	7.172005	1.782199
1.40	22.18400	14.58480	6.855204	4.798973
1972.1	22.63500	14.13060	6.700000	1.487003
2.20	23.83200	13.71670	7.353664	1.464957
2.30	24.25600	13.15360	7.612043	1.920427
2.40	24.21200	13.48590	7.167375	4.663390
1973.1	23.14200	13.22540	7.215215	1.256842
3.20	22.96700	12.70380	7.627034	1.666016
3.30	23.38800	11.62690	7.386953	2.067033
3.40	24.81900	12.82320	7.298328	4.516784
1974.1	22.47700	13.88570	7.021210	1.175272
4.20	23.90500	13.71730	7.542818	1.851644
4.30	24.55800	13.22530	7.753358	2.035948
4.40	24.88800	13.39900	6.963890	4.830279
1975.1	25.42000	11.93220	6.511286	1.483255
5.20	25.74500	11.51790	7.326547	1.401905
5.30	27.10000	10.72550	7.446698	1.780435
5.40	26.68700	11.07680	6.821253	4.427057
1976.1	26.75400	11.24360	7.165611	1.207239
6.20	27.66400	11.56510	7.858958	1.497805
6.30	28.64000	11.66090	8.172232	1.856053
6.40	28.24100	14.08590	7.643128	4.244737
1977.1	26.74700	13.08610	7.692290	1.184972
77.2	27.53000	12.33170	8.267625	1.518749
7.30	27.88100	12.38230	8.390928	1.800938
7.40	25.92300	13.24210	7.765263	4.471370

1978.1	25.89500	13.11690	7.875934	1.353183
8.20	24.34200	12.78150	8.778056	1.519631
8.30	25.93500	13.22580	8.678849	2.144745
8.40	24.69400	13.71480	8.569501	4.052496
1979.1	21.85400	14.23970	9.015050	1.105386
9.20	22.28800	14.99720	9.345740	1.389118
9.30	22.49400	15.04930	9.703106	2.362229
9.40	21.32100	16.28410	8.839564	4.086226
1980.1	20.36800	16.76990	8.912977	1.446438
0.20	22.93000	16.98380	9.776299	1.485239
0.30	22.44400	15.45800	9.149531	1.951732
0.40	21.48100	16.24170	8.324570	4.411625
1981.1	21.86300	16.67250	8.810023	1.305785
1.20	23.00500	15.88400	9.414524	1.681448
1.30	22.89900	14.91780	9.241904	1.914916
1.40	22.36710	16.27310	8.220072	4.102320
1982.1	21.30500	15.85030	8.763726	1.418660
2.20	21.68300	14.57550	9.490583	1.451509
2.30	23.09300	13.19240	9.320387	2.027571
2.40	23.20200	15.56710	8.649528	3.729522
1983.1	21.15300	14.94040	9.121973	1.629640
3.20	22.76700	14.86690	9.716334	1.233033
3.30	22.91800	15.11990	9.239699	2.266990
3.40	21.77800	16.13210	8.509315	3.747600
1984.1	20.39800	15.34020	9.707736	1.221348
4.20	21.97400	14.61140	10.18702	1.578273
4.30	22.29500	14.20180	10.09619	2.064167
4.40	20.48400	15.24400	9.599269	3.817926
1985.1	20.46000	15.18210	10.42930	1.348554
5.20	22.16400	15.33050	10.97274	1.361341
5.30	23.44100	15.10410	10.90594	1.834161
5.40	20.26500	15.24370	10.17269	4.188740
1986.1	20.44400	15.20220	10.55915	1.546747
6.20	23.00000	14.62760	11.46348	1.398819
6.30	23.01700	13.79890	11.14954	2.117739
6.40	20.93500	15.40870	10.66762	4.188299
1987.1	20.97800	15.53940	11.24831	1.261648
7.2	21.02200	13.89750	11.96128	1.761034
7.3	21.91500	14.62430	12.33452	2.131848
1987.4	19.53800	15.01390	11.15704	4.321898

SOURCES: FARMBASE, AGRICULTURE CANADA. CANSIM (MATRICES 1175 AND 1178), STATISTICS CANADA.

QUARTERLY RETAIL PRICES OF MEAT ($/POUND)

YEAR	BEEF	PORK	CHICKEN	TURKEY
1967.1	0.7716123	0.9160000	0.4889323	0.2787197
7.2000	0.7620515	0.8969151	0.4752523	0.2735195
7.3000	0.8160218	0.9106551	0.4605600	0.2628600
7.4000	0.8357581	0.8854743	0.4793062	0.2659800
1968.1	0.8073858	0.8633300	0.4858923	0.2719626
8.2000	0.7811731	0.8480626	0.4767723	0.2750795
8.3000	0.8221907	0.9083651	0.4843723	0.2745600
8.4000	0.8292818	0.9595100	0.4858923	0.2794974
1969.1	0.8292818	0.9679051	0.4869062	0.3036774
9.2000	0.9017562	0.9648526	0.4848800	0.2857374
9.3000	0.9218026	1.025155	0.4934923	0.3044574
9.4000	0.8514878	1.045765	0.4747462	0.3099174
1970.1	0.8992891	1.058743	0.4848800	0.3065400
.20000	0.9224200	1.003783	0.4788000	0.2966574
.30000	0.9190254	0.9610351	0.4585323	0.2836626
.40000	0.8678323	0.8999700	0.4565062	0.2870400
1971.1	0.9003200	0.8389026	0.4590400	0.2860026
1.2000	0.9202658	0.8213451	0.4706923	0.2833974
1.3000	0.9429315	0.8396651	0.5152800	0.2826174
1.4000	0.9374915	0.8587500	0.5086923	0.2833974
1972.1	0.9946115	0.9259226	0.5314923	0.2948400
2.2000	0.9964258	0.9709600	0.5593600	0.3133026
2.3000	1.035412	1.058743	0.5694923	0.3190200
2.4000	1.015458	1.099963	0.5882400	0.3221400
1973.1	1.115200	1.179350	0.6237062	0.3455400
3.2000	1.174132	1.207593	0.7042616	0.3892200
3.3000	1.302880	1.368655	0.7904000	0.4368000
3.4000	1.293812	1.403005	0.8319462	0.4924374
1974.1	1.374506	1.342703	0.8030662	0.5056974
4.2000	1.317386	1.193090	0.8430923	0.4726800
4.3000	1.377226	1.302245	0.8390400	0.4570800
4.4000	1.318292	1.400715	0.8537323	0.4643574
1975.1	1.222186	1.436593	0.8354923	0.4485000
5.2000	1.183200	1.500713	0.8755200	0.4568226
5.3000	1.338240	1.854900	0.9611462	0.4984200
5.4000	1.363626	1.919783	1.014852	0.5577000
1976.1	1.247572	1.819023	0.9859723	0.5379426
6.2000	1.232160	1.744980	0.9231462	0.5579574
6.3000	1.156000	1.780855	0.9120000	0.5621148
6.4000	1.139680	1.643455	0.8669062	0.5556174
1977.1	1.146026	1.609205	0.8821062	0.5506800
77.200	1.175040	1.624373	0.9069232	0.5457426
7.3000	1.309226	1.796885	0.9429062	0.5592600
7.4000	1.455200	1.814443	0.9804000	0.5473026

1978.1	1.510506	1.874745	0.9717862	0.5699148
8.2000	1.838720	1.919783	1.054880	0.5821374
8.3000	2.042720	2.011383	1.128852	0.6156774
8.4000	2.036372	2.094585	1.154692	0.6803940
1979.1	2.298400	2.084663	1.197760	0.7443774
9.2000	2.495143	1.990773	1.223092	0.7636200
9.3000	2.444372	1.977033	1.168880	0.7722000
9.4000	2.532317	1.970925	1.158746	0.7059000
1980.1	2.648372	1.916730	1.195226	0.7308600
.20000	2.565858	1.820550	1.194720	0.6996600
.30000	2.632957	1.996880	1.287946	0.7225374
.40000	2.762622	2.228168	1.430318	0.7269600
1981.1	2.775298	2.244177	1.491625	0.7337226
1.2000	2.706397	2.222825	1.448052	0.7898826
1.3000	2.754462	2.381600	1.540778	0.7846800
1.4000	2.643840	2.379310	1.599542	0.8119800
1982.1	2.535943	2.368616	1.598538	0.8538426
2.2000	2.810658	2.594570	1.531142	0.8527974
2.3000	2.812480	2.862500	1.554960	0.8704800
2.4000	2.651997	2.836554	1.555462	0.8616426
1983.1	2.608477	2.811364	1.518478	0.8738574
3.2000	2.807938	2.651064	1.542800	0.8954400
3.3000	2.729982	2.646484	1.636690	0.8964774
3.4000	2.749022	2.586944	1.765738	0.8395374
1984.1	2.862338	2.602196	1.772822	0.8944026
4.2000	2.922178	2.638836	1.726218	0.9073974
4.3000	2.893182	2.841134	1.696320	0.9419826
4.4000	2.932160	2.818234	1.691258	0.9245574
1985.1	2.991102	2.840356	1.623360	1.014523
5.2000	3.027360	2.757160	1.634000	1.005677
5.3000	2.950302	2.841890	1.696320	1.041043
5.4000	2.935778	2.878530	1.651222	0.9841026
1986.1	3.001058	2.948764	1.669462	1.027783
6.2000	2.940320	2.954856	1.663898	1.043640
6.3000	3.014658	3.396826	1.877702	1.085503
6.4000	3.205058	3.557904	1.984102	1.052735
1987.1	3.220480	3.436511	1.928880	1.092523
1987.4	3.331102	3.414390	1.904058	1.078483
1987.3	3.351938	3.646436	1.907600	1.115135
1987.4	3.368258	3.494540	1.893418	1.031417

SOURCE: FARMBASE, AGRICULTURE CANADA AND STATISTICS CANADA (CAT. #62-010). NOTE THAT THE MEAT PRICE DATA ARE DERIVED FROM CPI SERIES FOR SPECIFIC MEATS (1981=100) BY MULTIPLYING THESE BY THE CITY AVERAGE RETAIL PRICES OF SPECIFIC MEATS IN 1981. FOR CHICKEN AND TURKEY, THERE WAS ONLY ONE RETAIL PRICE FOR EACH; THESE WERE APPLIED TO CPI, RESPECTIVELY, FOR CHICKEN AND TURKEY. THE PRICE OF BEEF IS A WEIGHTED AVERAGE OF PRICES OF STEAK, ROAST, HAMBURGER LISTED IN STATISTICS CANADA (CAT. #62-010). THE WEIGHTS OF THESE BEEF COMPONENTS ARE LISTED IN STATISTICS CANADA (CAT. #62-553). THE SAME METHOD IS APPLIED TO DERIVE THE PRICE OF PORK, WHICH IS A WEIGHTED AVERAGE OF PRICES OF CENTER CUTS, ROAST, AND BONELESS PORK.