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Canadian Demand for Meats

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ABSTRACT

The demand for meat in Canada is examined in a manner similar to that employed in previous work. The current effort differs from previous studies in two important ways. First, beef demand is disaggregated into ground beef and table-cut beef. This is an attempt to allow a more detailed understanding of beef demand and beef products' relation to other meats. Second, Canadian livestock production costs and trade are incorporated in the calculation of demand estimates. This is motivated by previous findings of significant shifts in Canadian consumers' meat preferences sometime in the 1970s. Shocks to the supply side during the decade of the 1970s may have caused findings of shifts in demand. If this is so, then incorporating supply factors when calculating demand estimates should cause structural change to disappear.

Results show that, as they typically estimated, ground and table-cut beef are very different products in consumption. Ground beef is more expenditure elastic and less own-price elastic than table-cut beef. Both products compete about equally with pork, but ground beef is more substitutable for chicken. Demands also appear to have undergone a significant shift in 1978. However, incorporating the supply side and trade in estimation of Canadian meat demands produces significantly better estimates and causes the apparent differences between ground and table-cut beef and all structural shifts to disappear.

The implications for producers and processors of red meats are that it is in improved production and marketing efficiencies that the chicken producers and processors are winning the battle for market share of the Canadian consumers' declining food budget.

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INTRODUCTION

Agricultural economists have spent great efforts, attempting to understand the demand for meats. This is motivated by the relatively large portion of consumers' budget which is allocated to meats. Over the last three decades, Canadian consumers have spent approximately 30% of their annual food budget on beef, pork, and chicken. Thus, an adequate understanding of the demands for these commodities is important to consumers, producers, processors, retailers, policy makers, and researchers, alike. The question is: Do we have an "adequate" understanding of the demand for meats? The answer depends upon the purpose for which that knowledge is to be used.

One usage of such knowledge is to improve the producers' and processors' understanding of consumers' desires, to help each gain in their competitive struggle for market share. Until the mid 70s, the proportion of meat expenditures spent on beef was about 0.50, by the last half of the 80s, it had fallen to 0.45. Likewise, expenditures on pork have dropped from 0.40 of meat expenditures in the first half of the 60s to under 0.35 in the last half of the 80s. Chicken was the beneficiary of these declines. Its share moved from 0.10 in the 60s to 0.20 by the later half of the 80s.

The context of these developments is one of a declining portion of consumers' budgets being spent on food (from about 18% of total expenditures in the early 60s to 11% in the late 80s) and a 2 - 3% real growth rate in consumer expenditures. Thus, chicken producers and processors appear to be winning the battle for market share amongst the meats. Meats as a group are holding their own against other foods, and foods as a group are declining.

One of the more frequently advanced arguments to explain the shift in consumption from red meats to chicken is that consumers' preferences for meats have shifted. The argument is that, because of health concerns and/or an increased demand for convenience, consumers have been substituting amongst the meats, with chicken winning market share from beef and pork.

Recent findings (Chen and Veeman, 1991; Reynolds and Goddard, 1991) have reconfirmed earlier studies (Young, 1987; Atkins, Kerr, and McGivern, 1989) that there has been a shift in the demand for meats in Canada. Using a dynamic Almost Ideal Demand System (AIDS) model Chen and Veeman found there had been a shift in meat preferences in the third quarter of 1976, when the per capita consumption of beef peaked. Reynolds and Goddard examined Canadian preference shifts, employing the same methodology used by Moschini and Meilke (1989) to examine US meat demands for structural change. They found that Canadian demands had undergone a gradual shift starting in the 1st quarter of 1975 and finally subsiding in the 1st quarter of 1984. The study by Chen and Veeman was more careful in the specification of the dynamics of Canadian meat demand, but allowed only an abrupt shift in preferences. The study of Reynolds and Goddard used a more flexible model of the shift in consumer preferences, capable of discerning from the data whether the shift had been sudden or gradual. The common finding of both efforts is a reaffirmation of previous efforts that have found a shift in preferences starting sometime during the 1970s.

These studies suffer from two potential deficiencies. First, they examined aggregate meat products, such as "beef." Earlier work by Wohlgenant (1986), Eales and Unnevehr (1988), and Brester and Wohlgenant (1991), suggest that the own-price and expenditure elasticities of disaggregated beef products in the US are very different. Second, recent evidence (Wahl and Hayes, 1990; Eales and Unnevehr , 1993) suggests that prices and quantities of meats are simultaneously determined. This implies that what is interpreted as shifting consumer preferences for meats may actually be caused by supply shocks. That is, the high feed and energy costs of the mid 70s resulted in a liquidation of the breeding stocks and this causes demand estimates, which do not account for the supply side, to appear to have undergone a shift. In the case of Canadian meats, the cost of livestock production in both Canada and the US may have an effect on demand estimates, since the US - Canadian border is relatively open to trade in beef and pork. Finally, Chalfant and Alston (1988) showed using revealed preference techniques, that there exists a utility function which would rationalize Canadian meat consumption data, implying the demands shifts found in parametric demand studies are suspect.

The objective of this paper is to examine the impacts of disaggregation of beef into table cuts and ground beef on demand estimates and to incorporate determinants of North American livestock production costs in the calculations of those demand estimates. Toward this goal, the next section reviews the state of knowledge of the determinants of meat demand in both Canada and the US. The third section presents a methodology with which to disaggregate Canadian beef consumption. This is followed by a description of the rest of the data and the demand model estimated. The fifth section gives results. The final section summarizes and draws some conclusions.

RESULTS OF PREVIOUSLY ESTIMATED MEAT DEMANDS

In attempting to establish the status of our knowledge of the determinants of demands for meats in North America, it is natural to look to results reported in the literature. In Appendix A, an annotated bibliography gives brief descriptions of thirty-nine meat demand studies which have appeared over the last two decades. Information in this bibliography is organized as follows. For each study a reference is given. Next, the data frequency, period, and country are noted. This is followed by the functional form used to represent consumers' demands, the commodities which were studied, and the estimation technique(s). Then, if elasticities were reported, own-price and income elasticities are given. If more than one estimate of a relevant elasticity was reported, then ranges are given in parentheses. Findings of each study are listed and notes of interesting or peculiar aspects made.

What stands out is the myriad of different data sets, functional forms, estimation techniques which have been employed in analyzing meat demand. Some studies used quarterly data. Some used annual data. Some estimated systems of demand equations, while others looked at a single demand. Some estimate demands which are "quantity-dependent," meaning that it is being assumed that it is price that determines the quantity demanded. Others specify "price-dependent" or inverse demands, assuming that it is the quantities which are fixed and so prices must adjust. Still others allow for both price and quantity to be determined by the equilibrium between supply and demand.

What is also clear is that results vary widely. Probably the most important results of meat demand studies are the reported elasticities. Two elasticities are of primary concern. Own-price elasticities measure the percentage decrease in quantity demanded for a 1%

increase in that meat's own price and income elasticities which show how much meat demand increases in percentage terms for a 1% growth in consumers' income. Reported own-price and income elasticity estimates vary by as much as ten-fold in size and change signs. Some studies find significant shifts in consumer preferences for meats, while others find none. It is to the differences in data and approaches that the variance in results is often attributed. So, we turn next to an analysis of the findings as to own-price and income elasticities for meats. Note, a third type of elasticity, cross-price elasticities, will not be discussed. This is because the variability of reported cross-price elasticities is so great as to be daunting.

Beef Demand - Results from Time-Series Studies

Of the studies employing time-series data listed in the annotated bibliography, twenty-eight present results on the demand for beef. Twenty-six of these studies give one or more estimates of the own-price elasticity (or flexibility) for beef in some form. Twenty-five report estimates of beef's income elasticity. The averages of these are summarized in table 1.

Table 1. Beef Elasticities: Summary Statistics for North American Studies

Elasticity	Mean	Std. Dev.	Minimum	Maximum
Own-Price	-0.653	0.260	-1.120	-0.106
Income	0.671	0.408	-0.357	1.575

This shows that, on average, beef has been found to be own-price and income inelastic. The standard deviations, minimums, and maximums suggest there has been some variability in the findings of these studies and that estimates of own-price elasticities are less variable than those of income elasticities. As indicated earlier, this is not surprising. Twenty-one of the studies concern US demand, eleven focus on Canadian demand, one estimates demand in the UK, one estimates demand in Japan, and two look at Australian demands. Twenty use annual data, twelve use quarterly observations, and one employs monthly data. Since the studies have been done over the last two decades, some data sets start as early as 1947, others as late as 1969. One data set ends in 1970, while another ends in 1990. Four studies incorporated what was happening on the supply side of the market in calculating their demand estimates, most did not. Seven different functional forms were employed. Finally, twenty of the studies found no shifts in consumers' preferences for meats. Fourteen did find a significant demand shift. We will return to an analysis of the impact of these differences across studies, but first a brief look at pork and chicken demands.

Pork Demand - Results from Time-Series Studies

Twenty-two studies published between 1973 and 1992 include estimates of own-price and income elasticities for pork. The averages of these are reported in table 2.

Table 2. Pork Elasticities: Summary Statistics for North American Studies

Elasticity	Mean	Std. Dev.	Minimum	Maximum
Own-Price	-0.797	0.194	-1.250	-0.392
Income	0.456	0.379	-0.070	1.281

As was the case with beef, pork has been most often found to be inelastic with respect to own-price and income. The income elasticities vary more than do the own-price elasticities. Of the three meats, pork appears to be the most responsive to changes in its own price, on average, and the least responsive to changes in income.

Chicken Demand - Results from Time-Series Studies

Twenty-seven studies published between 1973 and 1992 include demand for chicken or poultry. Twenty-four give estimates of own-price and income elasticities. The averages of these are given in table 3.

Table 3. Chicken Elasticities: Summary Statistics for North American Studies

Elasticity	Mean	Std. Dev.	Minimum	Maximum
Own-Price	-0.496	0.280	-0.950	-0.087
Income	0.554	0.429	-0.090	1.841

Chicken has the lowest average own-price elasticity. Its income elasticity is also more variable.

Differences in Reported Own-Price Elasticities

An obvious question when one is confronted by the myriad of results listed in Appendix A is: What is the source of the differences in the elasticity estimates for meat demands? Typically, the reason given is that different studies have used different data, functional relationships, and estimation techniques to develop their estimates of consumers' meat demands. One way of controlling for the changing factors employed across studies is to estimate what will be called a "descriptive" regression. Since many of these studies have used data which was similar or at least overlapped, it is hard to imagine that the individual estimates of elasticities are independent, so the statistical properties of the descriptive regression coefficients are suspect. The descriptive regression does give us a relatively simple method for summarizing the impacts of various factors that vary across studies on the magnitudes of the elasticities estimated.

From each study of either Canadian or US demand, in which an estimate of beef's own-price elasticity is given, we specify a series of dummy variables as follows:

QUARTER	one if quarterly data was used; 0 otherwise
MONTH	one if monthly data was used; 0 otherwise
US	one if US data was used; 0 otherwise
S1	one if the first observation was prior to 1960; 0 otherwise
E1	one if last observation was prior to 1980; 0 otherwise
E2	one if the last observation was after 1985; 0 otherwise
SUPPLY	one if model estimation incorporated upward sloping supply; 0 otherwise
ADHOC	one if the functional form employed was not theoretically plausible; 0 otherwise
SC	one if study found structural change was important in demand; 0 otherwise
CONSTANT	average elasticity for studies employing annual Canadian data, which began after 1959, ended prior to 1986, did not incorporate supply, used theoretically consistent demand model, and found no structural change.

The rationale for these categorizations of meat demand studies is that differences in data and in the functional forms employed from one study to the next may well have caused the variations in reported results across studies. Results of the descriptive regression for the own-price elasticities of beef, pork, and chicken are reported in table 4.

Table 4. Own-Price Elasticity - Descriptive Regression[1]

	BEEF		PORK		CHICKEN	
	COEF	STD ERR	COEF	STD ERR	COEF	STD ERR
QUARTER	-0.182	0.106	-0.012	0.170	0.050	0.218
MONTH	-0.220	0.206	-0.153	0.279	0.221	0.305
US	-0.097	0.091	-0.073	0.113	0.168	0.150
S1	-0.404	0.118	-0.098	0.183	-0.074	0.211
E1	0.033	0.109	-0.384	0.189	-0.192	0.236
E2	-0.318	0.146	-0.109	0.172	0.277	0.229
SUPPLY[2]			-0.215	0.184	-0.177	0.227
ADHOC	0.132	0.127	0.138	0.163	0.357	0.269
SC	-0.058	0.082	-0.106	0.136	-0.006	0.161
CONSTANT	-0.308	0.159	-0.573	0.188	-0.747	0.233
	$R^2 = 0.545$	N = 31	$R^2 = 0.517$	N = 27	$R^2 = 0.285$	N = 29

1. Variables are defined in the text.
2. SUPPLY was not included in the beef regression as only one study estimated demand for beef incorporating supply.

The coefficients of these descriptive regressions, given in the columns labelled COEF, may be interpreted as follows. The value taken by the CONSTANT is an estimate of the average elasticity for studies employing annual Canadian data, which began after 1959, ended prior to 1986, did not incorporate supply, used a theoretically consistent demand model, and found no structural change. Each of the other coefficients are the adjustments to this base estimate when the condition represented by the associated variable is true. For example, if the data employed quarterly, rather than annual data, then the estimate of own-price elasticity for beef changes from -0.308 to -0.490 (the sum of -0.308 and -0.182). The columns labelled STD ERR give the standard error of the descriptive regression coefficients. In general, the larger the ratio of the coefficient to its standard error, the more important that particular characteristic was in determining the size of the elasticity found in the studies. Again, caution must be exercised in a strict statistical interpretation of these results.

In the base case, demands for beef, pork, and chicken are all inelastic, beef being the least elastic of the three. More frequently-observed data results in more elastic demand for the red meats and less elastic demand for chicken. US demands for red meats are more elastic than Canadian demands. US chicken demand is less elastic. An early start for the data produced more elastic meat demands, though the effect is more dramatic for the red meats. Data sets which ended later had large impacts on all three demands, but differed in direction between red meats and chicken. The red meats' own-price elasticity was larger in absolute value, while chicken's was smaller. An early end to the data set had little effect on beef, but produced more elastic pork and chicken demands. Taken together, these results suggest that the data employed has had an important effect on estimates of own-price elasticities for meats.

The last three variables represent differences in estimation methods across studies. Note that the variable, SUPPLY, was excluded in the analysis of beef's own-price and income elasticities, since only one study estimated elasticities for beef incorporating supply. The other three studies which included supply either did not estimate demand for beef or disaggregated beef into components. For pork and chicken demands, accounting for supply produces more elastic demands. ADHOC indicates the study did not employ functional forms which were consistent with theory. This led to less elastic meat demands. Finally, if consumer preferences for meats were found to have shifted, SC, the affect on each of the meats was negligible.

As indicated above, the ratio of an individual coefficient to its standard error gives a rough idea of the importance of the effect in determining the magnitude of the elasticity. A rule of thumb used in statistical analysis is that an individual effect is important if the ratio exceeds two (in absolute value). Most of the isolated effects would not be classified as important by this criteria. The R^2 given at the bottom of the table is a measure of how well the right-hand-side variables as a group did in "explaining" the variations in own-price elasticities. Chicken results suggest about three tenths of the variation in estimates of own-price elasticity is due to the factors included in these descriptive regressions. Thus, seven tenths of the variation remained unexplained. For beef and pork, over half the variability in own-price elasticities is due to included factors. In each case N is the number of reported elasticities, used to estimate the descriptive regressions.

Differences in Reported Income Elasticities

Next, the ability of these determinants to explain estimated income elasticities is examined. Results of descriptive regressions are given in table 5.

The base estimates of income elasticities are all inelastic. Pork is inferior and chicken is the most elastic of the three. Again, use of quarterly or monthly observations results in more elastic demand for beef. Pork is more elastic with quarterly data and less with monthly. Chicken is less elastic with quarterly data and more elastic with monthly. US demands for beef and chicken were less income elastic, while US pork demand was more elastic. The most dramatic effects were for red meat demands estimated using data which ended after 1985. They became considerably more elastic. Chicken demand, estimated with data which ended early, was also considerably more income elastic.

Considering supply in estimation made both pork and chicken more elastic. Using ad hoc demand specifications made beef and pork more elastic, and chicken less elastic. Allowing for changes in consumers' preferences for meats made all three more elastic.

The variation explained in these descriptive regressions was higher in each case than for the own-price elasticities. The pork regression explained over three quarters of the variation in estimates of pork's income elasticity. For beef the proportion was over 50%. For chicken almost three quarters of the variation remained unexplained.

Overall, the most important determinants of the magnitudes of elasticities seems to be the data period and frequency. However, the results are not consistent across the meats. Estimation methods' impact was more consistent, but the effects were smaller. Including supply made demands more own-price and income elastic. Employing ad hoc demand

Table 5. Income Elasticity - Descriptive Regression[1]

	BEEF		PORK		CHICKEN	
	COEF	STD ERR	COEF	STD ERR	COEF	STD ERR
QUARTER	0.061	0.162	0.090	0.180	-0.124	0.337
MONTH	0.264	0.316	-0.202	0.276	0.404	0.472
US	-0.127	0.140	0.188	0.114	-0.371	0.232
S1	0.269	0.181	-0.054	0.180	0.013	0.326
E1	-0.181	0.167	0.253	0.212	0.575	0.366
E2	0.872	0.224	0.762	0.171	-0.397	0.354
SUPPLY[2]			0.229	0.203	0.466	0.351
ADHOC	0.258	0.195	0.211	0.162	-0.804	0.415
SC	0.021	0.126	0.243	0.162	0.147	0.249
CONSTANT	0.266	0.244	-0.224	0.191	0.971	0.360
	$R^2 = 0.567$	N = 31	$R^2 = 0.767$	N = 27	$R^2 = 0.276$	N = 29

1. Variables are defined in the text.
2. SUPPLY was not included in the beef regression as only one study estimated demand for beef incorporating supply.

structures resulted in less elastic demands. Incorporating some sort of shift in demand produced more elastic results.

Thus, as to the sensitivity of meat demands to changes in own-price or income, we can say that they are inelastic. While, in general, reported income elasticities are more variable than own-price elasticities, they appear to be more "explainable" by the different approaches and data employed in the study of meat demand. Data differences seemed to be the most important determinant of differences, but the effects were not consistent across commodities. Differences in approaches were less important, but were more consistent across commodities.

Results of Previously Estimated Meat Demands - Summary

This section examined the findings of many studies of meat demand in North America, paying particular attention to the similarities and differences in reported own-price and income elasticities (remember, these elasticities measure the percentage change in meat demand for a 1% increase in own-price or income). The emphasis on own-price and income elasticities is justified because these two determinants of meat demand are the most important. The simple averages of all elasticities were less than one in absolute values, suggesting that meats are own-price and income inelastic. These are summarized in table 6.

Table 6. Average Reported Elasticities

Meat	Own-Price	Income
Beef	-0.653	0.671
Pork	-0.797	0.456
Chicken	-0.496	0.554

Meat demands are not very sensitive to changes in their own prices or incomes. However, these averages mask variability in findings between studies. To determine the importance of differences in approaches between studies, we had to control for all the important differences in approaches taken in estimating meat demands. This was done using regression. Regressions show that the most important factors were different time periods covered by the data and data frequency employed in the analysis. Less important, but more consistent across meats, were the effects of the different approaches used in estimating meat demands.

We will return to these results later for comparison, so as to be able to put findings of the present study in context. First, however, we turn to a re-examination of Canadian meat demand. In the next section we present a method for decomposing aggregate consumption of beef into hamburger and table-cut beef.

DISAGGREGATION OF BEEF CONSUMPTION

People do not consume "beef" or "chicken" or "pork." People consume ground beef, sirloin steak, chicken breasts, ham, bacon, etc. The difficulty faced by researchers is that time-series data on meat consumption is generated by calculating how many cattle, chickens, and hogs "disappeared" in a particular time period and then converting these disappearance numbers into "apparent" per capita beef, chicken, and pork consumption.

One objective of this research is to try and further refine our understanding of Canadian meat consumption by disaggregating beef into what will be called ground beef and table-cut beef. The advantage of such an approach is that it will allow the development of a more detailed picture of the structure of consumer preferences. Is chicken substituting for ground beef or table-cut beef in consumer diets? Is ground beef less own-price and expenditure elastic than table-cut beef? Do the commonly found changes in preferences amongst consumers affect both beef demands equally?

One would, of course, like to disaggregate all the meats into their constituent components. Unfortunately, such is not possible using the time-series data currently gathered in Canada. This has caused researchers to examine other data sources, such as the family expenditure survey data and scanner data from retail outlets. The difficulty with survey data is that there is reason to suspect the variability of prices implied in such data. This makes estimation of demands problematic. The scanner data is difficult to obtain and then seldom includes information on consumer characteristics, especially income.

The method utilized to disaggregate beef consumption is similar to that which has been employed in analyzing US beef product consumption. It requires information on the makeup of animal slaughter in terms of steers, heifers, cows, and bulls and assumptions about how much of each type of carcass ends up as ground beef. Wohlgenant was one of the first to utilize this sort of approach in meat demand analysis. He found the major interaction between beef and poultry occurred between ground beef (nonfed beef) and poultry and attributed this to the rise in importance of chicken in fast-food outlets. Eales and Unnevehr (1988) used the fed-nonfed disaggregation for beef along with chicken disaggregated into whole-bird chicken and parts/processed chicken. They looked at how to group these products to best reflect consumer decisions and found that the data supported grouping fed beef (table-cut beef) with parts/processed chicken and nonfed beef (ground beef) with whole-bird chicken rather than by animal origin. They also found initial growth and then decline in fed beef consumption and continuous growth in parts/processed chicken demand. In neither ground beef nor whole-bird chicken was growth or the mid-70s shift significant. Brester and Wohlgenant developed a more sophisticated methodology for disaggregating beef and found that it was a significantly better representation of demand for beef products.

A difficulty with disaggregation of Canadian beef consumption is that while data on the distribution of numbers of animals slaughtered by type has been kept since the early 60s, averaged dressed weights for each type has only been kept since mid 1975. Prior to that only the average dressed weight for all slaughtered animals is available. Hence, the following procedure was adopted. The available data was used to estimate models of the following form:

(1) $ADW_{it} = \beta_{0i} + \beta_{1i}\,ADW_t + \beta_{2i}\,NST_t + \beta_{3i}\,NHE_t + \beta_{4i}\,NCOW_t + \beta_{5i}\,TIME + \varepsilon_{it}$

where: ADW_{it} is the average dressed weight for animal type i (steers, heifer, cows, and bulls) in year t, ADW_t is the average dressed weight for all cattle in year t, NST_t is the number of steers slaughtered in year t, NHE_t is the number of heifers slaughtered in year t, $NCOW_t$ is the number of cows slaughtered in year t, TIME is a time trend, and ε_{it} is an error term. The rationale behind this formulation is: if it is adequate to explain the variation in ADW by animal type, then it can be used to forecast (actually in this case "backcast") the dressed weights by animal type. ADW_t is included, since it is the only dressed weight measure available over the entire sample period. The numbers of animals slaughtered by type is included, since one would expect the ADW_t figure to be higher if there were a larger number of steers slaughtered and lower if the numbers of cows and heifers were high. Finally, time is included to capture the trends in slaughter weight for each animal type. Results of these estimations are given in table 7. All models were estimated by OLS and fit well, although many of the coefficients are not significant.

Results of these equations are of little direct interest. Their value is in their use to "backcast" average dressed weights by type which are then combined with slaughter numbers to allocate total slaughter amongst the types by weight. Assuming that a fixed portion of each type of carcass becomes ground beef, total beef disappearance is allocated to ground and table-cut beef. Finally, the proportion of ground and table cut disappearance is applied to per capita consumption to derive retail beef product per capita consumption. This is similar to the methodology recommended by Brester and Wohlgenant. It is an adaptation of that used by the Western Livestock Marketing Information Project to allocate US per capita consumption to ground and table-cut beef. The procedure for Canadian consumption is somewhat simplified, since due to climatic differences the fed-nonfed distinction in

TABLE 7. Backcasting Equations for Average Dressed Weights by Type[1]

	Total	Numbers Slaughtered					
	ADW	Steers	Heifers	Cows	Time	CONST	R^2 / DW
Steers	1.154	-222.4	-105.7	42.2	-1.604	3269.7	.992
	(0.165)	(668.2)	(681.5)	(631.0)	(1.090)	(2385.0)	2.130
Heifers	1.118	831.5	858.6	961.4	1.792	-4538.3	.998
	(0.125)	(507.7)	(517.8)	(479.5)	(0.828)	(1812.1)	1.908
Cows	0.982	-1092.4	-940.6	-1077.6	-0.152	1289.8	.986
	(0.216)	(876.1)	(893.4)	(826.3)	(1.429)	(3126.7)	2.224
Bulls	3.100	4423.3	4123.0	5302.6	10.741	15779.0	.937
	(0.986)	(3997.3)	(4076.6)	(3774.7)	(6.519)	(14267.0)	2.614

1. Figures in parentheses are standard errors.

production is not significant in Canada. The procedure is as follows:

1. Use the estimates in table 7 to estimate the average dressed weights of steers, heifers, cows, and bulls, annually from 1961 through 1975.
2. Combine those estimates of dressed weights with the published dressed weights for 1976 through 1990 and with the numbers slaughtered in each category from 1961 through 1990 to calculate the total dressed weight produced from each animal type.
3. Assume that 25% of heifer and steer carcasses, 90% of cow carcasses, and 100% of bull carcasses become ground beef.
4. Adjust for imports and exports, assuming that 30% of imports are from the US and 80% of exports go to the US, both of which are assumed to be high quality, that is imports would produce 25% ground beef. The residual imports from the rest of the world are assumed to be 100% ground, while exports to the rest of the world are also high quality, producing 25% ground beef.
5. Combining all ground production from these sources and dividing by total production gives the proportion of ground beef production. This proportion is then applied to the per capita retail consumption of beef to produce a per capita consumption of ground beef. Table-cut beef is the difference between total and ground beef consumption.
6. Ground beef price is obtained by converting the consumer price index (CPI) for ground beef to a price using the prices published in the *Handbook of Food Expenditures, Prices, and Consumption.* Similarly, a price for all beef is created from the CPI for beef and the prices in the *Handbook.* Finally, a price for table-cut beef is calculated such that the expenditures on ground beef and table-cut beef are equal to

the total expenditure on all beef in each year.

The results of these calculations are given in table 8. The proportions of total beef that end up as ground beef range from a low of .393 in 1979 to a high of .472 in 1962. The average over all 30 years is .424. As a check on the validity of this procedure for disaggregation of Canadian beef consumption, the same methodology was applied to US beef consumption for the period 1961 through 1990. That is, even though average dressed weights were available by class over this entire period, only those from 1976 through 1990 were used to estimate the same models estimated for Canada. The resulting models were used to calculate estimates of US average dressed weights by animal type for 1961 through 1975. Ground beef proportions were then estimated from both the estimated and the actual average dressed weight data. The root mean square percentage error between the estimated and actual proportion of US ground beef consumption was 1.5%. This shows that the "backcasting" of average dressed weights does not adversely affect estimates of the proportion of beef that is ground.[1]

Table 8. Disaggregated Canadian Beef Prices and Consumption 1961-1990[1]

	Prices			Consumption		
Year	Ground Beef	Table-cut Beef	All Beef	Ground Beef	Table-cut Beef	All Beef
1961.	.91	2.19	1.61	11.02	13.30	24.32
1962.	.98	2.46	1.76	11.57	12.94	24.51
1963.	.98	2.30	1.71	11.43	14.19	25.62
1964.	.95	2.19	1.65	11.88	15.49	27.37
1965.	.97	2.37	1.72	13.32	15.49	28.81
1966.	1.10	2.55	1.90	13.10	15.86	28.96
1967.	1.16	2.63	1.99	12.38	16.29	28.67
1968.	1.16	2.69	2.03	12.71	16.64	29.35
1969.	1.26	2.87	2.19	12.44	17.09	29.53
1970.	1.32	2.92	2.26	11.98	17.12	29.10
1971.	1.35	2.59	2.07	12.79	17.73	30.52
1972.	1.55	2.76	2.26	13.41	19.10	32.51
1973.	1.98	3.27	2.74	13.20	18.76	31.96
1974.	2.05	3.69	3.02	13.56	19.63	33.19
1975.	1.51	3.86	2.86	15.65	21.23	36.88
1976.	1.49	3.53	2.68	16.33	22.70	39.03
1977.	1.58	3.73	2.85	15.23	21.90	37.13
1978.	2.52	5.30	4.16	14.19	20.56	34.75
1979.	3.77	6.57	5.47	11.60	17.93	29.53
1980.	3.85	7.32	5.94	11.66	17.59	29.25
1981.	3.88	7.55	6.10	11.91	18.14	30.05
1982.	3.60	7.78	6.05	12.30	17.55	29.85
1983.	3.58	7.87	6.10	12.23	17.50	29.73
1984.	3.43	8.83	6.50	12.21	16.20	28.41
1985.	3.37	9.22	6.67	12.59	16.23	28.82
1986.	3.30	9.39	6.81	12.20	16.60	28.80
1987.	3.59	10.25	7.43	11.82	16.08	27.90
1988.	3.60	10.37	7.55	11.66	16.34	28.00
1989.	3.65	10.78	7.71	11.81	15.59	27.40
1990.	3.90	10.98	8.01	11.09	15.31	26.40

1. Prices are given in dollars per kilogram. Quantities are in kilograms per year.

DATA

The resulting disaggregated data on beef consumption is then combined with prices and quantities of pork, chicken, non-meat foods, and all other goods to estimate demand models for Canadian meats. The CPIs and quantities of pork and chicken are taken from the 1992 edition of the *Handbook of Food Expenditures, Prices, and Consumption* (HFEPC). CPIs for food and non-food, total personal expenditures on goods and services, food expenditures, and population are taken from Cansim. As indicated above, CPIs for meats are converted to prices using 1986 city-average retail prices for various cuts (HFEPC, 1990; table 44) and combining them using the weights used in calculating the overall CPI (HFEPC, 1990; table 45).

The inclusion of the categories, non-meat foods and all other goods, is due to an objection raised by LaFrance. He showed that excluding these categories, i.e. estimating a conditional demand model for meats with meat expenditures as an explanatory variable, produces estimates that are biased and inconsistent, since meat expenditures are endogenous to such a conditional demand system. Including non-meat foods and all other goods requires the use of total per capita expenditure as a right-hand-side variable, which it is reasonable to take as predetermined. This avoids a potential source of inconsistency in estimation.

A second data requirement is a set of variables which characterize livestock production costs and US-Canadian trade. The set employed was the following: price indexes for fuel and electricity, wages of farm and meat-packing labour, barley and corn price (both on a calendar year basis), interest rate, average dressed weight of slaughter cattle, fat removed per 100 pounds of pork carcass, and US-Canadian exchange rate. These variables do not constitute an exhaustive list in the sense that, if one were interested in building livestock supply models, these variables would be inadequate. However, the interest here is in characterizing the cost of production and marketing of livestock well enough to produce consistent estimates of the demands for meats. The variables listed should capture the essence of livestock production and processing costs, as well as the technological innovation which has increased livestock production efficiency over the last three decades.

A final data need is suggested by previous researchers' assumption that meat prices in Canada are determined by US meat and/or livestock prices (Tryfos and Tryphonopoulos; Hassan and Katz). Trade in chicken has been restricted since the implementation of the chicken marketing boards in the mid 70s. However, even in chicken, net imports were 47.71 kilotonnes in 1990 versus a production of 572.87 kilotonnes. Beef and pork are more clearly subject to the influence of foreign markets. The net imports of beef constituted about 12% of Canadian production in 1990, while net exports of pork were 10% of Canadian production. Since a majority of this trade was with the US, this implies that it will be important to incorporate variables which characterize the US market for meats in the list of instruments. Therefore, US beef, pork, and chicken prices are included.

MODELLING DEMAND

The data will be used to estimate a model similar to that of Moschini and Meilke and of Reynolds and Goddard. It is called a gradual-switching AIDS model by Reynolds and Goddard. The form of the demands is:

(2)
$$\Delta w_{it} = \alpha_i + \theta_i tn_t + \sum_j (\gamma_{ij} \Delta \ln p_{jt} + \mu_{ij} tn_t \Delta \ln p_{jt}) + \beta_i \Delta \ln (X_t / P_t) + \mu_i tn_t \Delta \ln (X_t / P_t)$$

where:

Δ is the first difference operator, i.e. $\Delta x_t = x_t - x_{t-1}$
w_{it} is the budget share of the ith commodity in period t.
$\ln p_{jt}$ is the natural logarithm of the price of jth good.
$\ln (X_t / P_t)$ is the log of the ratio of total expenditure on all goods in the demand system to Stone's price index ($\ln P_t = \Sigma_j w_{jt} \ln p_{jt}$).
tn_t is a generalization of a dummy variable, which can change quickly from one regime to the next or may make the transition slowly. It is defined as follows:

$tn_t = 0$	for $t = 1,...,t_1$
$tn_t = (t - t_1) / (t_2 - t_1)$	for $t = t_1 + 1,...,t_2 - 1$
$tn_t = 1$	for $t = t_2 ,...,T$

where
t_1 is the end of the first regime.
t_2 is the beginning of the second regime.

The advantage of this definition of the transition function is that it allows a gradual or abrupt shift from one regime to the next. If demand shifts are the result of changes in consumer tastes and preferences then a pattern more in keeping with the typical reasons given for such changes is one which occurs gradually. That is, as information on the ties between cholesterol and heart disease disseminates through the population of meat consumers or the opportunity cost of meal-preparation time rises as the number of households headed by two wage earners, single parents, and women increase in the population, demands move slowly from the old regime to the new.

The difficulty with such a transition function is that one must specify t_1 and t_2. The technique employed by Moschini and Meilke and by Reynolds and Goddard was to examine the likelihood values, as t_1 and t_2 were varied over their data and pick the values for t_1 and t_2 which maximized the likelihood function. This technique will be employed here, as well.

There are several differences between the gradual switching AIDS model specified here and those of Moschini and Meilke and of Reynolds and Goddard. First, a constant is included in the equation, even though differencing the AIDS model, as in equation 2, would cause the constant to fall out. This follows Deaton and Meullbauer who also include a constant when estimating their differenced AIDS model. Second, the model above, will be applied to annual data, rather than the quarterly data employed by Moschini and Meilke and by Reynolds and Goddard. This is because the data necessary to disaggregate beef was only available on an annual basis. Third, the model includes ground and table-cut beef, pork, chicken, non-meat foods, and all other goods, while the previous studies looked at beef, pork, chicken, and fish (Moschini and Meilke) or at beef, pork, and chicken (Reynolds and Goddard). Fourth, the transition function tn_t is applied after the differencing and so is not differenced itself. Finally, the model will be estimated twice, once without accounting for the supply side and meat/livestock trade and then again, taking account of the supply/trade instruments. The first estimation is by Seemingly Unrelated Regressions (SUR) with homogeneity and symmetry imposed. This is similar to what was done by Moschini and Meilke and by Reynolds and Goddard. The second estimation will be by Three Stage Least Squares (3SLS) using the set of instruments which characterizes the cost of livestock production and US meat markets, again, with homogeneity and symmetry imposed.

RESULTS

The first step is to identify the beginning and ending points of the transition function, i.e. t_1 and t_2. As indicated above, this is done by varying t_1 and t_2 over all possible combinations and picking the values which maximize the likelihood function.[2] These values turned out to be 1978 and 1979, respectively. Thus, even though the transition was allowed to be gradual, the data prefers a rapid transition in the late 70s. This is similar to Moschini and Meilke's findings for the US, where the transition took place between the last quarter of 1975 and the third quarter of 1976. It differs from the findings of Reynolds and Goddard for Canada. They found that the change in demand began in the first quarter of 1975 and subsided in the first quarter of 1984.

Once the transition points have been identified, the next step is to estimate the gradual switching AIDS model conditional of the identified regimes and then test for the significance of the shift in consumer preferences. The results of these tests are given in the top half of table 9.[3] They show that all parameters change with the exception of those associated with expenditure. Thus, in taking the typical approach, a significant shift was identified starting in 1978 and ending in 1979.

Next, the gradual switching AIDS model is re-estimated with 3SLS using the supply/trade instruments. The tests for a shift in structure are recalculated with these estimates and results are given in the bottom half of table 9. After accounting for supply/trade, none of the parametric shifts are now significant.

Two questions arise in examining these results. First, is the difference between the two sets of estimates statistically significant? That is, does the data really show evidence that

Table 9. Tests for Structural Change

Without Supply/Trade Instruments

No Structural Change	Wald Statistic	Degrees of Freedom	.05 CutOff
All Parameters	54.20	25	37.66
Price Parameters	32.56	15	25.00
Expenditure Parameters	3.69	5	11.07
Intercepts	18.46	5	11.07

With Supply/Trade Instruments

No Structural Change	Wald Statistic	Degrees of Freedom	.05 CutOff
All Parameters	27.61	25	37.66
Price Parameters	19.97	15	25.00
Expenditure Parameters	2.44	5	11.07
Intercepts	6.55	5	11.07

the consideration of the supply side is important? Second, if it is significant, does it make a "real" difference?

To answer the first of these questions, the two sets of estimates are used to calculate a Wu-Hausman test. This test compares the estimates which are best if accounting for supply/trade is not important in calculating demand estimates (SUR in this case) to those which are consistent whether the meat prices are predetermined or not (3SLS). The intuition of the test is that the two sets of estimates should be similar if supply and trade are unimportant when calculating demand. The results of the test are distributed chi-square with 40 degrees of freedom (five equations each of which contains four meat prices and four interactions between the transition and the meat prices). The 0.05 cutoff of this distribution is 55.76. The calculated value of the Wu-Hausman statistic is 714.97, suggesting there is a significant difference between the two sets of coefficients. This implies that the typically applied SUR estimator of meat demand models produces estimates which are suspect due to the probable endogeneity of meat prices.[4]

The second question is more fundamental. Since there is a statistically significant difference in the coefficients, is this difference enough to affect the decisions made by producers or processors of livestock products? To address this question, it is most natural to examine the elasticity estimates. The SUR estimates are given in table 10 and the 3SLS estimates table 11. For the SUR estimates, there are two relevant sets of elasticities, those before and after the structural change.[5] The 3SLS estimates showed no significant shifts, so the 3SLS estimates were recalculated without the transition or interactions, and elasticities are calculated over the entire sample period.

Table 10. Elasticities Based on SUR Estimates[1]

Without Supply/Trade Instruments - Before the Structural Change

	Ground Beef	Table-cut Beef	Pork	Chicken	Non-Meat Food	Other	Income
Ground	-0.325	-0.133	0.142	0.310	-0.566	-0.091	0.663
Table-cut	-0.046	-0.353	0.079	-0.006	0.000	-0.396	0.723
Pork	0.048	0.079	-0.689	0.140	-0.481	0.281	0.621
Chicken	0.337	-0.042	0.440	-1.297	0.771	-2.157	1.948
Non-Meat	-0.037	-0.004	-0.095	0.049	-0.324	-0.514	0.925
Other	-0.003	-0.015	-0.001	-0.010	-0.076	-0.915	1.021

Without Supply/Trade Instruments - After the Structural Change

	Ground Beef	Table-cut Beef	Pork	Chicken	Non-Meat Food	Other	Income
Ground	-0.336	0.121	0.004	0.216	-1.059	0.410	0.644
Table-cut	0.034	-0.812	0.101	-0.018	0.057	-0.510	1.148
Pork	0.003	0.123	-0.634	0.150	-0.268	0.294	0.333
Chicken	0.138	-0.034	0.286	-0.704	0.888	-1.390	0.816
Non-Meat	-0.054	0.020	-0.044	0.074	-0.328	-0.116	0.448
Other	0.000	-0.007	-0.005	-0.012	-0.063	-0.976	1.064

1. Elasticities are calculated using elasticity formulae in endnote 5. The "before change" elasticities are calculated using the sample mean shares from 1961 through 1978. The "after change" elasticities are calculated using the sample mean shares from 1979 through 1990. No standard errors are calculated, since the elasticities are based on the inconsistent SUR estimates.

Table 11. Elasticities Based on 3SLS Estimates[1]

With Supply/Trade Instruments - No Structural Change

	Ground Beef	Table-cut Beef	Pork	Chicken	Non-Meat Food	Other	Income
Ground	-.281*	-.106	.218*	.225*	-.531*	-.412	.882*
	(.076)	(.134)	(.076)	(.094)	(.278)	(.408)	(.357)
Table-cut	-.035	-.411*	.140*	.019	-.164	-.450	.896*
	(.045)	(.113)	(.055)	(.065)	(.208)	(.306)	(.289)
Pork	.075*	.150*	-.633*	.111*	-.481*	.320	.440
	(.026)	(.055)	(.064)	(.044)	(.153)	(.293)	(.295)
Chicken	.206*	.051	.295*	-.803*	.727	-1.378*	.899
	(.088)	(.182)	(.123)	(.254)	(.464)	(.552)	(.461)
Non-Meat	-.029	-.023	-.086*	.049	-.138	-.332*	.545*
	(.016)	(.037)	(.027)	(.033)	(.128)	(.167)	(.138)
Other	-.003	-.013	-.006	-.012	-.089	-.941	1.063

1. The elasticities are based on the consistent estimates of the AIDS model and use mean shares over the entire sample. Standard errors are calculated assuming the mean shares are fixed.

* Indicates the elasticity is significant at the five percent level.

We can get some sense of how the estimated elasticities in the previous tables fit in with findings from previous research by using the regression results in tables 4 and 5 to account for the impacts of data and methodology employed in the current study. The own-price and income elasticities in table 10 correspond to demands estimated using annual data which started after 1960, ended after 1985, which found structural change, and did not account for supply. Using the results from table 4 and 5, we find that on average previous studies done with similar data and approaches have found:

	Beef	Pork	Chicken
own-price	-0.684	-0.788	-0.476
income	1.159	0.781	0.721

Thus, the red meat results in table 10 are less elastic with respect to own-price and income than have been found previously. Chicken is more elastic with respect to own-price and income.

Corresponding to table 11, previous studies using annual data starting after 1960, ending after 1985, which did not find demand shifts, and did account for supply, have found on average (from table 4 and 5):

	Beef	Pork	Chicken
own-price	-0.626	-0.897	-0.647
income	1.138	0.767	1.040

In this case all three meats are less elastic in table 11 than have been found by previous researchers (on average), except chicken which is more elastic with respect to own-price. The size of elasticities in both tables 10 and 11 differ from previous studies, but they are qualitatively similar.

Next, turn to a comparison of implications of the differences between tables 10 and 11. To do this examine the SUR elasticities (table 10) ignoring the statistical problems. That is, examine the elasticities in table 10 as if we had proceeded in the typical manner, ignoring supply/trade. Before and after the structural change, ground beef remains unaffected in terms of own-price and expenditure elasticities. Table-cut beef becomes both more own-price and income elastic. While chicken becomes less own-price and expenditure elastic. The substitutability between ground beef and chicken lessens. Pork's own-price elasticity is unaffected, but it becomes less expenditure elastic. These results might suggest to producers and processors that it is the increased demand for convenience that is driving consumers away from table-cut beef and to chicken products, since the more convenient-to-prepare product, ground beef, is little affected by the shift, while table-cut beef demand changes dramatically.[6] The shift in chicken demand is in part due to the change in the makeup of "chicken." While figures for Canada are not available, the makeup of US chicken consumption has gone from 74% of purchases being whole-bird chicken in the mid-1960s, to over 85% being parts and processed chicken by the late 1980s. Assuming similar trends are operating in Canada, the competition between ground beef and chicken, especially in fast-food consumption, can be seen as a lessening of their substitutability for one another. Again, these findings are in keeping with what previous studies have found.

However, the statistical analysis showed that the results in table 10 are contaminated by not incorporating supply. Thus, the observations in the last paragraph are artifacts of the estimation technique employed in the calculation of the SUR estimates. When the supply and trade are taken into account, none of these shifts are significant (bottom half of table 9). This implies that what many have identified as shifts in consumer preferences for meats is in reality contamination of demand estimates which fail to account for livestock supply and the relative openness of the Canadian markets. Note also, in table 11 the significant substitution relationship between chicken and ground beef, while that between chicken and table-cut beef is comparatively weak and insignificant. A possible explanation of this finding, which is similar to that found for the US by Wohlgenant, is that the major competition between beef and chicken is being driven by increased development of the fast-food market. Finally, ground and table-cut beef appear to have become very different products after the "change in structure," when examined using the SUR estimates, showing differing sensitivity to their own-prices and expenditures, as well as differing substitutability for chicken and for pork. Again, the story is very different when the 3SLS estimates are used. While the own-price, cross-price, and expenditure elasticities all differ, all have the same sign and none of the differences is significant.

CONCLUSIONS

Prior to presenting new results on Canadian demand for meats, the status of our knowledge on meat demand in North America was reviewed and analyzed. It was found that studies found all meats to be inelastic with respect of own-price and income on average. It was also found that results varied from one study to another. This variation was explained by the differing data periods and frequencies and to a lesser degree the differences in methodology across studies. Results of statistical analysis found shifts in consumers' preferences in about half the studies, while the other half found none.

Shifts in Canadian meat demand was then examined in a gradual switching AIDS model similar to earlier work by Moschini and Meilke and by Reynolds and Goddard. The work differs from these two previous studies by including disaggregated beef products, ground and table-cut beef, and non-meat food and non-food goods. It differs, as well, by estimating demands for meats in two ways. First, by SUR as was done in these earlier studies and, second, by 3SLS where instruments include variables which characterize the costs of livestock production and conditions in US meat markets.

Disaggregation of beef into ground and table-cut beef had been shown in previous work to be important, because it allows the examination of the competition between chicken and the two beef products. The two different estimation techniques produced drastically different pictures of the importance of this disaggregation. The SUR estimates showed that breaking up beef was important, primarily because chicken interacted differently with the two beef products. The 3SLS estimates showed that the disaggregation was not important. Since the 3SLS estimates are preferred in this case (on statistical grounds), one basic conclusion of the study suggests that the importance of disaggregation found in past studies may have been spurious and caused by improperly assuming that prices and income are exogenous to meat demands.

Comparison of the two sets of estimates was done in two ways. A Wu-Hausman test shows that the models differ significantly, suggesting that the typical SUR estimates should be viewed with caution. Also, tests for structural change were done on both models. In the SUR framework, significant structural change was found, as in Moschini and Meilke and in Reynolds and Goddard. However, when the livestock supply and trade are taken into account, no significant structural shift is detected.

The debate over whether consumer preferences for meat have shifted continues. It has even spilled over into more popularly oriented venues, e.g. the exchange between Purcell, Dahlgran, and Lambert in *Choices*. Results from this study suggest previous findings of changes in consumer preferences in Canadian meat demands may be artifacts of estimation techniques which ignore the supply side and openness of the markets. If consumer preferences have not shifted, then there is little sense in attempting to woo back disaffected consumers through persuasive advertising. They have been lured away by more attractive prices for goods which embody more appealing characteristics.

ENDNOTES

1. This procedure underestimates US ground beef proportion, since it makes no allowance for nonfed steers and heifers, which are significant for US production. It does show that "backcasting" of average dressed weights for steers, heifers, cows, and bulls does well in determining the overall portion of beef which is ground.

2. The search was carried out using iterative SUR. All calculations are done with the SHAZAM program (White, 1978).

3. Coefficient estimates are not easily interpreted. Therefore, they and the diagnostics for the SUR estimates of the gradual switching AIDS model (as well as the 3SLS estimates of the model) are given in Appendix B.

4. Due to the interconnectedness of the US and Canadian meat markets, some possibility exists that US meat prices may cause problems when employed as instruments. To address this, the Wu-Hausman test was recalculated leaving the US meat prices off of the list of instruments. The calculated value was 79.60. Thus, Canadian livestock production costs were enough, by themselves, to identify the dangers of treating meat prices as predetermined when estimating meat demands.

5. Elasticities are calculated as follows:

$$\varepsilon_{ij} = \frac{\gamma_{ij} + \mu_{ij} - (\beta_i + \mu_i)\, w^k_j}{w^k_i} - \delta_{ij}$$

where ε_{ij} is the price elasticity of demand of the ith good with respect to the jth price, γ_{ij} and γ_i are either the SUR of 3SLS estimates, μ_{ij} and μ_i are the estimates of the change in the price and expenditure coefficients for the SUR model or 0 for the 3SLS model, δ_{ij} which is one if $i = j$ and zero otherwise, and w^k_j is the average share (before or after the structural change for the SUR model and over the entire sample for the 3SLS model). The expenditure elasticities are:

$$\varepsilon_i = \frac{\beta_i + \mu_i}{w^k_i} + 1$$

where ε_i is the expenditure elasticity, and others are as previously defined.

6. This insight seems further enhanced by the results in table B1. The transition variable is significant and negative for table-cut beef and significant and positive for chicken.

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Thurman, W. 1986. Endogeneity Testing in a Supply and Demand Framework." *Review of Economics and Statistics.* 68: 638-646.

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

Tryfos, P. and N. Tryphonopoulos. 1973. Consumer Demand for Meat in Canada. *American Journal of Agricultural Economics* 55: 647-52.

Wahl, T.I. and D.J. Hayes. 1990. Demand System Estimation with Upward-Sloping Supply. *Canadian Journal of Agricultural Economics* 38: 107-22.

White, K.J. 1978. A General Computer Program for Econometric Methods- SHAZAM. *Econometrica* 47: 239-40.

Wolhgenant, M. and W. Hahn. 1982. Dynamic Adjustments in Monthly Consumer Demand for Meats. *American Journal of Agricultural Economics*. 64: 553-57.

Wohlgenant, M.K. 1983. Discussion: Assessing Structural Change in the Demand for Food Commodities. *Southern Journal of Agricultural Economics.* 15: 39-41

Wohlgenant, M. 1984. Conceptual and Functional Form Issues in Estimating Demand Elasticities for Food. American Journal of Agricultural Economics. 66: 211-215.

Wohlgenant, M. 1985. Estimating Cross Elasticities of Demand for Beef. *Western Journal of Agricultural Economics*. 10: 322-329.

Wohlgenant, M. 1986. Effects of the Changing Composition of Beef Consumption on the Elasticities for Beef and Poultry. presented and the S-165 Symposium. *The Demand for Meat: What Do We Know and What Does it Mean?* Charleston, S.C. 20 pp.

Wu, D. 1973. Alternative Tests of Independence Between Stochastic Regressors and Disturbances. *Econometrica* 41: 733-50.

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

APPENDIX A

This annotated bibliography gives brief descriptions of thirty-nine meat demand studies which have appeared over the last two decades. Information in this bibliography is organized as follows. For each study a reference is given. Next, the data frequency, period, and country are noted. This is followed by the functional form used to represent consumers' demands, the commodities which were studied, and the estimation technique(s). Then, if elasticities were reported, own-price and income elasticities are given. If more than one estimate of a relevant elasticity was reported, then ranges are given in parentheses. Findings of each study are listed and notes of interesting or peculiar aspects made.

Tryfos, P. and N. Tryphonopoulos. 1973. Consumer Demand for Meat in Canada. *American Journal of Agricultural Economics* 55: 647-52.

data:	Annual; 1954 - 1970. Canada.			
functional form:	Linear. Beef, pork, and chicken, lamb, and veal			
method of estimation:	SUR			
elasticities	beef	pork	chicken	other
own-price	-.521	-1.049	-.087	-1.801
expenditure	.835	-.004	1.129	-2.909
findings:	Lots of negative cross-p elasticities, which was resolved by restricting the corresponding coefficients to be 0. w/i sample forecasting examined.			
structural change:	no			
notes:	First to use SUR. Cdn Ps predetermined by US livestock Ps. Include imported lamb in mutton & lamb D and Q of turkey in chk D. !No autocorrelation! No D restr or testing. Did not appear to notice SUR = OLS when RHS vars same. Deflated to real using CPI.			

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

data:	Annual; 1957 - 1972. Canada.			
functional form:	Log-log. Q dependent. Beef, pork, chicken, lamb, veal, & turkey			
method of estimation:	FIML probably Iterative SUR.			
elasticities	beef	pork	chicken	other
own-price	-.767	-.955	-.564	-1.866
expenditure	.553	.257	.730	.393
findings:	Include trend in beef. Negative autocorrelation for pork, positive for veal & turkey. Also est SUR, but prefer FIML due to smaller std errors.			
structural change:	no			
notes:	Again, Cdn Ps predetermined by US livestock Ps. No unrestr est. Forecast 1973 consumption. No D restr or testing. Use nominal values.			

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

data:	Quarterly; 1965Q1 - 1976Q4. Canada.			
functional form:	Box-Cox; diff transformations on dependent and independent vars. Beef, pork, chicken, turkey, and veal.			
method of estimation:	Conditional MLE with quarterly dummies. Box-Cox params in (-1, 1). Single equation.			
elasticities	beef	pork	chicken	other
Box-Cox params	(1.0, 0.4)	(0.2, -0.4)	(0.0, 0.4)	(1.0, -1.0)
own-price	-0.453	-0.836	-0.732	-0.405
expenditure	0.355	0.437	0.622	0.089
findings:	Seems to show that most functional forms produce reasonable estimates of own-p and income elasticities.			
structural change:	no			
notes:	Beef - negative autocorrelation; rest positive autocorrelation (pork & veal significant). No D restr or testing.			

Hassan, Z.A. and S.R. Johnson. 1979. Structural Stability and Recursive Residuals: Quarterly Demand for Meat. *Agricultural Economics Research* 31: 20-29.

data:	Quarterly; 1965Q1 - 1976Q4. Canada.
functional form:	Linear. Beef, pork, chicken, turkey, and veal
method of estimation:	OLS (fixed effects) then apply forward and backward CUMSUM & CUMSUMSQ
findings:	Structural change in beef D in 1969Q4. Don't seem to think it very important in conclusions. In fact, they state in conclusions that evidence suggests structural stability!
structural change:	yes
notes:	Same model as last paper. Seasonality by OLS with fixed effects, estimates differ somewhat.

Pope, R., R. Green, and J. Eales. 1980. Testing for Homogeneity and Habit Formation in a Flexible Demand Specification of U.S. Meat Consumption. *American Journal Of Agricultural Economics*. 62: 778-784.

data:	Annual; 1950-1975. US.			
functional form:	Box-Cox. Beef, pork, poultry, and fish.			
method of estimation:	Conditional MLE, single equation; static, partial adjustment, trend, state adjustment; local vs global homogeneity.			
elasticities	beef	pork	chicken	other
own-price	-.679	-.814	-.609	-.457
expenditure	.607	.383	.572	.810
findings:	Global homogeneity rejected in all cases; local rejected only in beef for state adjust.			
structural change:	no			
notes:	No attempt at measuring structural change. Homogeneity either imposed or tested. No symmetry, but dynamics important. Usually, could not test for autocorrelation, i.e. couldn't calculate Durbin's h.			

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

data:	Quarterly; 1965Q1 - 1979Q3. US.			
functional form:	Linear. Beef, pork, chicken, and turkey.			
method of estimation:	OLS; linear splines; CUMSUMSQ to identify knots.			
elasticities	beef	pork	chicken	other
own-price	-.106	-.392	-.704	n/a
expenditure	.216	.597	.726	1.220
findings:	Structural changes in all meats identified, those in beef and chicken significant. Elasticities are, as near as I can tell, those calculated over entire sample. Change in beef 1971Q4. Change in chicken 1973Q4. Discussion of why limited to general terms in introduction.			
structural change:	yes			
notes:	D-W statistics range from a low of 5.4 to high of 7.2! Claim to have 79 qtrs in table 3 supported by graphs 1-4. Of course, 79 qtrs means that if their data started in 1965Q1 it would end in 1984Q3, about 2 years after their paper was published.			

Wolhgenant, M. and W. Hahn. 1982. Dynamic Adjustments in Monthly Consumer Demand for Meats. *American Journal of Agricultural Economics.* 64: 553-57.

data:	Monthly; 1965M1 - 1976M6. US.		
functional form:	Linear. Beef, pork, and chicken		
method of estimation:	State adjustment or flow adjustment. 2nd order autocorrelation. NLLS. Single equation		
SR elasticities	beef	pork	chicken
own-price	-.49	-1.25	-.14
expenditure	.51	.27	.49
LR elasticities	beef	pork	chicken
own-price	-.43	-.84	-.30
expenditure	.45	.18	1.06
findings:	No structural change included.		
structural change:	no		
notes:	Both beef and pork show inventory effect rather than habits. Both have large depreciation of stocks. Chicken unstable, therefore re-estimated as essentially a partial adjustment (still poorly behaved).		

Braschler, C. 1983. The Changing Demand Structure for Pork and Beef in the 1970s: Implications for the 1980s. *Southern Journal of Agricultural Economics.* 15: 105-10.

data:	Annual; 1950 - 1982. US.	
functional form:	Linear. P dependent. Beef and pork	
method of estimation:	OLS. Single equation.	
flexibilities before	beef	pork
own-price	-1.34	-1.44
expenditure	1.40	.89
flexibilities after	beef	pork
own-price	-.99	-1.50
expenditure	.92	2.08
findings:	Significant change in pork in 1969. Significant change in beef in 1970. Errors in forecasting from outlook experience increased during 1970s. Regimes shifted from price and quantity stability to instability, due to exogenous shocks: oil embargo, energy shortages, wage & price controls, inflation.	
structural change:	yes	
notes:	Income flexibilities? (see Dahlgran below) W/i sample forecasts compared, I think for period 2. Structural change model much better in forecasting price.	

Chavas, J. P. 1983. Structural Change in the Demand for Meat. *American Journal of Agricultural Economics.* 65: 148-153.

data:	Annual; 1950-1970 & 1971-1979. US.		
functional form:	Linear in $\Delta X/X_{-1}$. Beef, pork, and poultry.		
method of estimation:	1950-1970: SUR w homog & symmetry imposed. 1971-1979 Kalman filter.		
ranges of elasticities	beef	pork	chicken
own-price	(-.889,-.593)	(-.732,-.707)	(-.696,-.478)
expenditure	(.183,.696)	(.429,.477)	(.001,.185)
findings:	Structural change in 1974 in beef and poultry. Elasticities change from observation to observation. Ranges are for the 1975-1979 period.		
structural change:	yes		
notes:	Beef less elastic, pork no change, poultry more income elastic. Imposed homog & symmetry on estimates.		

Hassan, Z.A. and S.R. Johnson 1983. Quarterly Demands for Meat in Canada with Alternative Seasonality Hypotheses. *Canadian Journal of Agricultural Economics* 31: 77-94.

data:	Quarterly; 1965Q1 - 1976Q4. Canada.
functional form:	Linear. Q dependent. Beef, pork, chicken, turkey, and veal
method of estimation:	OLS (no seas, fixed effects) GLS (random effects, fixed and random effects, error components, SUR)
elasticities	None
findings:	Looked at within and out of sample forecasts. Within - OLS fixed effects. Out - differed for pork, chicken, turkey, and veal.
structural change:	no
notes:	Ways to measure seasonality in meat D. Conclude - turkey fixed effects; evidence not very strong. Autocorrelation - all pos except beef; significant in pork and veal! No trend in beef this time. No D restr or testing.

Haidacher, R.C. 1983. Assessing Structural Change in the Demand for Food Commodities. *Southern Journal of Agricultural Economics.* 15: 31-37.

findings: Discussion of the intractability of directly determining structural change in parametric analysis of demand, essentially because of the unspecified nature of the alternative hypotheses. Proposes an indirect approach - comparing actual and predicted (from estimated and tested demand model) and using the computed error to bound potential structural change. If your model explains all the variation in consumption without structural change, then any changes in structure not very significant.

structural change: no

notes: Indirect approach does not seem to me to address the intractability of the problem.

Wohlgenant, M.K. 1983. Discussion: Assessing Structural Change in the Demand for Food Commodities. *Southern Journal of Agricultural Economics.* 15: 39-41

findings: Suggests Haidacher does not go far enough. Refers to articles which attempt to identify the source of mis-specification of demand. Points out that structural change hypothesis is a dead end for economists. If it truly is a change then it is the province of psychologists, anthropologists, phrenologists (?!), sociologists.

structural change: no

notes: Some good points, but seems to ignore another group which is interested in whether consumers' tastes have shifted: producers.

Moschini, G. and K. D. Meilke. 1984. The U.S. Demand for Beef -- Has There Been a Structural Change? *Western Journal of Agricultural Economics.* 9: 271-82.

data: Quarterly; 1966Q1 - 1981Q4. US.

functional form: Box-Cox. Q dependent. Single equation beef demand. 5 models(income, food exp, both deflated, food/non-food.

method of estimation: Conditional MLE. CUMSUMSQ. Chow and Farley-Hinich

elasticities	beef	pork	CPI/CPIOF	PCDY/PCEXF
beef	(-.39, -.57)	(0.09, 0.18)	(-.10, 0.12)	(0.19, 0.52)
food/non-food			0.40	0.38

findings: No simple functional forms acceptable. Autocorrelation important. Evidence of structural change (early rather than late) is weak. Food equation is interesting!?

structural change: no

notes: If there was a change in structure it came before 1973... Chavas found structural change because of constant elasticity functional form! Homogeneity imposed by deflating in models C & D.

Capps, O., J. Tedford, and J. Havlicek. 1985. Household Demand for Convenience and Nonconvenience Foods. *American Journal of Agricultural Economics*. 67: 862-869.

data: NFCS 1977-78; 13136 households. US.
functional form: LA/AIDS. Q dependent. Non-convenience, basic convenience, complex convenience, manufacturing convenience.
method of estimation: Iterative SUR with demographics. IVs for employment of household manager and expenditure.

elasticities	non conven	basic conven	complex conven	manuf conven
own-price	-.220	-.497	-.456	-.849
expenditure	1.053	0.862	0.960	1.031

findings: Demographics important: region, employment, education, sex, age, urban, suburban, race, HH size.
notes: Anticipated LaFrance, i.e. instrumented food expenditures.

Wohlgenant, M. 1985. Estimating Cross Elasticities of Demand for Beef. *Western Journal of Agricultural Economics*. 10: 322-329.

data: Annual; 1947 - 1983. US.
functional form: Fourier flexible. Single equation. beef q vs beef, pork, poultry, fish ps & income.
method of estimation: OLS. Compared to quadratic model with & w/o structural change. Non-nested J-test. Homogeneity imposed by deflating.

elasticities	beef	pork	chicken	income
Fourier	(-.97, -.27)	(0.16, 0.16)	(-.03, 0.61)	(0.68, 0.68)
Quad w Str Chg	(-1.12, -.45)	(0.15, 0.15)	(0.02, 0.44)	(0.72, 0.72)

findings: Structural change significant in quadratic model, but not in Fourier model. Fourier model rejects quad w str chg but not vice versa.
structural change: no
notes: Again, Chavas found str chg because of constant elasticity functional form! Some strange fish results...he advocates system approach to remedy.

Dahlgran, R. 1986. The Changing Structure of U.S. Meat Demand: Implications for Meat Price Forecasting. *Proceedings of the NCR-134 Conference on Applied Commodity Price Analysis, Forecasting, and Market Risk Management*. St. Louis, Missouri. pp 274-286.

data: Annual; 1959 - 1984. US.
functional form: Inverse Rotterdam. P dependent. Beef, pork, chicken, and other.
method of estimation: NL Iterative SUR with logit generalization of dummy vars.

elasticities	beef	pork	chicken	other
own-price	(-.823, -.724)	(-.923, -.758)	(-.486, -.903)	(-1.037, -1.008)
expenditure	(-.357, 0.978)	(0.024, 0.139)	(0.123, 1.297)	(0.998, 1.017)

findings: Significant structural change. Either gradual beginning in 1954 and dying out in the mid 1960s or an abrupt shift in 1973.
structural change: yes
notes: If E is matrix of p elasticities, 1 & e are vectors of 1s and y elasticities, Dahlgran shows: $E\,1 = -e \rightarrow -E^{-1} e = 1$. This means essentially that inverse demands must be formulated in terms of normalized ps, or as Smallwood et al. say require income flexibilities to be one. He leaves out Anderson's scale effect and makes no mention of homogeneity. Does impose symmetry, I think.

Smallwood, D.M., R.C. Haidacher, and J.R. Blaylock. 1986. A Review of the Research Literature on Meat Demand. in *The Economics of Meat Demand*, R.C.Buse, Ed. pp. 93-124.

findings: A fairly comprehensive survey of US meat demand studies. Includes a summary of elasticities (flexibilities) from 17 studies and structural change findings from 11 studies.

Thurman, W. 1986. Endogeneity Testing in a Supply and Demand Framework." *Review of Economics and Statistics*. 68: 638-646.

data: Annual; 1955-1981. US.
functional form: Log-log. Q & P dependent. Poultry demand.
method of estimation: OLS & 2SLS with structural change in 1973.

poultry	own-price	beef	pork	income
elasticity	-.65	0.23	0.36 (-.06)	0.54
flexibility	-1.56	0.35	0.55 (-.11)	0.85!

findings: If S is relatively flat then power of Q dependent test is low. Likely to find P dependent rejects but Q dependent does not even though simultaneous. If S is almost vertical things reverse.
structural change: yes
notes: Tests just poultry variables and then all meat variables, but keeps the same set of instruments.

Unnevehr, L. J. 1986. Income Distribution and Structural Change in U.S. Meat Demand. *Selected Paper presented at the AAEA Meetings* 21 pp.

data: NFCS 1977-78 and income distribution 6 groups 1970 - 1985. US.
functional form: Leser's semi-log budget share Engel curves then simulate changes in income distribution's impact on beef consumption.
method of estimation: Tobit. Single equation for each income group.

elasticities	< 7.5	7.5-15	15-25	25-35	35-50	> 50
expenditure	0.341	-.092	-.071	0.131	0.642	0.138

findings: The income distribution in the US has become more skewed, with more people in the lowest and highest income brackets. The fact that income elasticities tend to decrease with increases in income, means that the aggregate response to income will decrease.
notes: Doesn't include any relative price effects.

Wohlgenant, M. 1986. Effects of the Changing Composition of Beef Consumption on the Elasticities for Beef and Poultry. presented and the S-165 Symposium. *The Demand for Meat: What Do We Know and What Does it Mean?* Charleston, S.C. 20 pp.

data:	Annual; 1956 -1983. Disaggregated beef. US.				
functional form:	Rotterdam system. Fed & nonfed beef, pork, and poultry. Ps CPI-deflated. Estimated both Q & P dependent forms.				
method of estimation:	Nothing mentioned. Probably Iterative SUR.				
Q-dep elasticities	hamburger	other beef	pork	chicken	income
nonfed beef	-2.99	2.76	0.14	0.39	-.07
fed beef	0.85	-1.45	0.12	-.07	0.86
P-dep elasticities	hamburger	other beef	pork	chicken	income
nonfed beef	-3.46	2.79	-.13	0.30	0.47
fed beef	0.86	-1.95	0.07	0.08	0.78
findings:	Hamburger more substitutable for poultry than other beef. Due to growth in fast-food industry. If taste changes because of increased health concerns, would expect more uniform pattern in cross-p elasticity with poultry. Hamburger's doubled while other beef's unchanged.				
structural change:	no				
notes:	Concerned over Rotterdam model forcing the pattern found on elasticities, so estimated Fourier flexible form and found same pattern. No estimates of model parameters or diagnostics provided. No structural changes. Another factor: cattle cycle in liquidation phase -> more hamburger.				

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

data:	Annual; 1950 - 1985. US.		
functional form:	Partially inverted Rotterdam. P dependent for meats. Q dependent for other foods and all other goods. Beef, pork, chicken, other food, and all other goods.		
method of estimation:	Iterative SUR. Logit or exponential generalization of dummy. Search for NL parameters.		
elasticities ranges	beef	pork	chicken
own-price	(-1.041, -.659)	(-.914, -.584)	(-.863, -.602)
expenditure	(.438, .435)	(-.056, -.054)	(.262, .202)
flexibilities ranges	beef	pork	chicken
own-price	(-1.069, -1.725)	(-1.243, -1.960)	(-1.184, -1.720)
findings:	Changes in direct pork price parameter start 1955 & end 1960. Changes in interaction of beef and chicken start 1969 over by 1980. Concludes: shifts are " most likely the result of changing supply conditions interacting with stable meat demands." i.e. meat demands have stabilized again in the 1980s, but they are all less elastic.		
structural change:	no		
notes:	Estimated about 17,500 models! No mention of nonlinearity in this version.		

Bewley, R. and T. Young. 1987. Applying Theil's Multinomial Extension of the Linear Logit Model to Meat Expenditure Data. *American Journal of Agricultural Economics*. 69: 151-157.

data:	Quarterly; 1969 -1983. UK.			
functional form:	Multinomial logit model for share equations. Linearized. Beef, lamb, chicken, pork, and other food.			
method of estimation:	Seasonal differencing. Corrected for AR(1)			
elasticities	beef	pork	chicken	other
own-price	-1.778	-1.421	-.513	-1.527
expenditure	1.730	1.138	1.003	1.305
findings:	Tested for homogeneity and symmetry neither rejected. No mention of structural change.			
structural change:	no			
notes:	Use logit model to guarantee adding up and no negative shares.			

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

data:	Annual; 1955-1981. US.			
functional form:	Log-log. Q & P dependent. Poultry demand.			
method of estimation:	OLS & 2SLS with structural change in 1973.			
	own-price	beef	pork	income
elasticity	-.65	0.23	0.36 (-.06)	0.54
flexibility	-1.56	0.35	0.55 (-.11)	0.85!

findings: Same application as REStat (1986). More emphasis on results. Found significant shift in poultry demand in 1973 and a change in the cross-p elasticity with pork (changed to value in parentheses).

structural change: yes

notes: Considers whether input prices might be endogenous (no) and whether results indicate poultry production is perfectly competitive-constant returns to scale industry!

Young, L.J. 1987. Canadian Meat Demand. Working Paper 10/87. Agriculture Canada. 63 pp.

data:	Quarterly; 1967Q2 - 1984Q4. Canada.			
functional form:	4 (log-log, linear, linear-log, Box-Cox) Beef, pork, chicken, and turkey(!). Includes CPI for non-food & income is disposable income.			
method of estimation:	Corrected for AR(1) except Box-Cox. No D restr imposed.			
elasticities - Box-Cox	beef	pork	chicken	other
own-price	-.48	-.66	-.47	0.06
expenditure	0.88	0.39	0.26	0.04
findings:	CUMSUMSQ to determine structural change. Found none in beef, but significant breaks in pork (74Q1), chicken (78Q2), and turkey (78Q1). Elasticities are for Box-Cox. Changes in structure due to demographics, health concerns.			
structural change:	yes			
notes:	I can't believe that he could include turkey in a quarterly model.			
demand influences:				
demographic factors:	Declining population growth rate due to decreased immigration and fertility. Median age of population increasing and will be more rapid. Effect lower total food consumption. Female participation in the labour force up male rate down. Effect - higher per capita incomes and less meal preparation time. Increasing number of childless couples and singles who tend to eat out more often. They also tend to have lower incomes.			
economic factors:	Increasing real incomes. From 1960 through 1984 food expend (at home) increased by 30%. However, expend on durables and on services increased by 100% and 170%, respectively. Real incomes increased by 110% over the period. Proportion spent on food at home dropped from .173 to .119. Food away from home exp increased more rapidly. Then looks at real meat prices. Starkest feature: all meats cheaper in real terms. Chicken only by 15% in Canada but by 40% in the US (due poultry supply control).			
health factors:	Canadians growing more health conscious, but most evidence is anecdotal and even that is conflicting.			

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

data:	Quarterly; 1967Q1 - 1984Q4. Australia. Annual; 1947-78 & 1947-1983. US.
functional form:	None. Beef, chicken, lamb, mutton, & pork. Australia. Beef and veal, fish, pork, & poultry. US.
method of estimation:	Non-parametric. Tested for SARP.
findings:	Some rejections in Australia due to mutton consumption. Small adjustments or deletion of mutton took care of it. None in the US.
structural change:	no
notes:	Findings indicate "stable preferences." Therefore, structural change findings in parametric demand systems must be a rejection of the functional form.

Dahlgran, R.A. 1988. Changing Meat Demand Structure in the United States: Evidence from a Price Flexibility Analysis. *North Central Journal of Agricultural Economics* 10: 165–76.

data:	Annual; 1950 - 1985. US.			
functional form:	Inverse Rotterdam system. Beef, pork, and chicken.			
method of estimation:	Iterative SUR. Uses multivariate CUMSUMSQ to identify potential structural change. Tested for structural change, homogeneity, and symmetry.			
flexibilities (1972)	beef	pork	chicken	
own-price	-1.264	-1.163	-2.134	
flexibilities (1985)	beef	pork	chicken	
own-price	-1.8991	-1.639	-2.347	
findings:	Significant structural change in 1973, both in terms of coefficients and covariance matrices. Neither homogeneity nor symmetry is rejected.			
structural change:	yes			
notes:	Estimates income coefficient, but provides no flexibility. Makes no mention of the *WJAE* paper. Says he can't put confidence bands on CUMSUMSQ, because would require normality, but then does likelihood ratio tests!			

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

data:	Annual; 1965 - 1985. US.			
functional form:	LA/AIDS. Beef, pork, chicken, non-meat food, and non-food. Nonfed beef, fed beef, whole-bird chicken, parts & processed chicken, pork, non-meat food, and non-food.			
method of estimation:	Iterative SUR. Test for weak separability of meats by animal type and quality.			
elasticities	beef	pork	chicken	other
own-price	-.570	-.762	-.276	-.642
expenditure	0.344	0.278	0.527	0.479
findings:	Found that meat products were not separable by animal origin, but were by high versus low quality. Significant structural change in 1974 in growth rate of beef, fed beef, and chicken, continuous growth in parts & processed chicken.			
structural change:	no			

Atkins, F.J., W.A. Kerr and D.B. McGivern. 1989. A Note on Structural Change in Canadian Beef Demand. Canadian Journal of Agricultural Economics 37: 513-24.

data:	Quarterly; 1968Q1-1986Q3. Canada.
functional form:	Log-log. Q dependent. Static. High-quality beef, pork, and chicken. Uses real per capita disposable income and ratio of per capita food expenditures to disposable income (S).
method of estimation:	OLS with quarterly dummies. Chow tests breaking data up into 1968Q1-1974Q4 & 1977Q1-1986Q3.
findings:	Structural break significant in beef demand. S is supposed to be a better representation of consumers' discretionary income.
structural change:	yes
notes:	They have a plot of per capita consumption showing pork exceeding beef by as much as 50% during all of the 1980s. The beef pattern does not look like anything I have seen. This is because they model "high-quality" beef taken from an Ag Canada working paper by Charlebois (1987). They state that Young found no structural change! They must have had a different paper than the one I read.

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

data:	Quarterly; 1967Q1-1987Q4. US.			
functional form:	1st differenced LA/AIDS with quarterly dummies. Beef, pork, chicken, and fish.			
method of estimation:	Iterative SUR. Structural changes allowed to be either abrupt or gradual starting and ending where ever the data dictates, i.e. the periods which minimizes the log likelihood.			
elasticities - before	beef	pork	chicken	other
own-price	-.983	-1.015	-.090	-.138
expenditure	1.220	1.041	0.238	0.432
elasticities - after	beef	pork	chicken	other
own-price	-1.050	-.839	-.104	-.196
expenditure	1.394	0.853	0.211	0.314
findings:	Significant changes in structure, starting in 1976Q4 and ending in 1977Q3. Affects the intercepts and quarterly dummies. Therefore the elasticities reported are not significantly different.			
structural change:	yes			
notes:	Other change paths were not significantly different than the one that minimized the log likelihood and covered a wide range, from very long covering most of the sample period to short in the early 1970s to short in the late 1980s.			

Choi, S. and K. Sosin. 1990. Testing for Structural Change: The Demand for Meat. *American Journal of Agricultural Economics.* 72: 228-236.

data:	Annual; 1953-1984. US.		
functional form:	Indirect translog with logistic dummies similar to Dahlgran (not referenced). Red meat, poultry, and other food.		
method of estimation:	MLE		
elasticities	red meat	poultry	other food
own-price	-.917	-.893	0.523
expenditure	2.090	1.841	0.536
findings:	Significant structural change in red meat demand entirely attributed to dissemination of information on the effects of fat and cholesterol consumption on health.		
structural change:	yes		
notes:	An odd paper.		

Green, R. and J.M. Alston. 1990. Elasticities in AIDS Models. *American Journal of Agricultural Economics.* 72: 442-5.

data:	To illustrate, use data from Blanciforti, Green, and King.			
functional form:	NL and LA/AIDS models. Meats, fruits & vegetables, cereals & bakery products, and miscellaneous food			
method of estimation:	Calculate AIDS elasticities using 5 different formulae			
elasticities	Meats	Fruit & Veg	Cereal & Bakery	Misc. Food
True	-.994	-.256	-.799	-.787
(i)	-.411	-.229	-.736	-.325
(ii)	-.664	-.200	-.888	-1.066
(iii)	-.988	-.255	-.811	-.764
(iv)	-.996	-.255	-.810	-.761
findings:	True nonlinear formula is not a good way to calculate AIDS elasticities if you have estimated the LA/AIDS. The last two formulae appear to behave well.			
notes:	It seems to me that the crux of the matter is what you consider to be the true model. If it is the nonlinear AIDS model, and LA/AIDS is only considered as an approximation, I do not see how using the true formula is incorrect. Adolph Buse from the U of A has a working paper which shows that they are wrong. The true formula is best.			

Wahl, T.I. and D.J. Hayes. 1990. Demand System Estimation with Upward-Sloping Supply. *Canadian Journal of Agricultural Economics.* 38: 107-22.

data:	Annual; 1965-1986. Japan			
functional form:	LA/AIDS. Wagyu beef, import-quality beef, pork, chicken, and fish.			
method of estimation:	Iterative SUR and iterative 3SLS. Compare with Wu-Hausman test.			
elasticities	beef	pork	chicken	other
own-price	-2.45 (-1.03)	-.74	-.87	-1.02
expenditure	0.74 (1.16)	1.03	1.01	0.99
findings:	First to estimate and test a demand system considering potential endogeneity of prices. Elasticity estimates are from the 3SLS estimates which assume all prices are endogenous.			
structural change:	no			

Brester, G.W. and M.K. Wohlgenant. 1991. Estimating Interrelated Demands for Meats Using New Measures for Ground and Table Cut Beef. *American Journal of Agricultural Economics.* 73: 1182-94.*

data:	Annual; 1962-1989. US.		
functional form:	Rotterdam model. Use two different disaggregations of beef, fed & nonfed and ground & table cut, along with pork, poultry, and non-meats.		
method of estimation:	Iterative SUR (SYSNLIN in SAS). Symmetry and homogeneity imposed		
elasticities	beef	pork	chicken
own-price	-1.015 (-.811)	-.779	-.296
expenditure	-.197 (.805)	.343	.417
findings:	Compare the two systems using a non-nested P test. Find the ground/table-cut beef disaggregation is better. No structural change.		
structural change:	no		

Alston, J. and J. Chalfant. 1991. Can We Take the Con Out of Meat Demand Studies. *Western Journal of Agricultural Economics.* 16: 36-48.

data:	Annual; 1947-1983. US. 1960-1988. Canada.			
functional form:	Compare linear, log-log, LA/AIDS (static & 1st differenced), and Rotterdam (absolute and relative price versions). Also apply nonparametric tests to Canadian data. Beef, pork, poultry, and fish.			
method of estimation:	Iterative SUR for the last section.			
elasticities - Rotterdam	beef	pork	chicken	other
own-price	-.66	-.74	-.74	-.90
expenditure	0.82	0.85	0.44	2.09
findings:	1. Show that using incorrect functional form log-log (linear) has a high probability of finding structural change even when true model linear (log-log) is stable. Structural change is either maximum Chow test or autocorrelation. 2. Non-parametric tests of Canadian data show it can be rationalized, i.e. is stable. Power is found to be "disappointingly low." 3. Compared LA/AIDS to Rotterdam for Canada. Found significant trends for both, but then decided that those for the LA/AIDS were significant, while those for the Rotterdam model were not!			
structural change:	no			
notes:	By part 3 of their application it appears that poultry has become chicken. The Rotterdam model is the best since it does not show structural change.			

Chalfant, J.A., R.S. Gray, and K.J. White. 1991. Evaluating Prior Beliefs in a Demand System: The Case of Meats Demand in Canada. *American Journal of Agricultural Economics* 73: 476-490. *

data:	Annual; 1960-1988. Canada.			
functional form:	LA/AIDS! with trends apparently starting in 1975. Beef, pork, poultry, and fish.			
method of estimation:	NL iterative SUR. Use Geweke's Bayesian technique with "importance sampling" to estimate the probability of consistency with monotonicity, concavity, and substitutability.			
compensated elasticities	beef	pork	chicken	other
own-price	-.403	-.591	-.769	-.253
expenditure	1.575	0.537	0.832	0.745
findings:	Data is consistent with monotonicity and to a lesser extent with concavity. It is not consistent with "all meats are substitutes." Significant negative trends in beef and pork. Significant positive trends in poultry and fish.			
structural change:	no			
notes:	Certainly, one of the most sophisticated econometric analyses of meat demand in existence. Still confused between poultry and chicken.			

Chen, P.Y. and M.M. Veeman. 1991. An Almost Ideal Demand System Analysis for Meats with Habit Formation and Structural Change. *Canadian Journal of Agricultural Economics* 39: 223-235.

data:	Quarterly; 1967Q1-1987Q4. Canada.			
functional form:	Dynamic AIDS with structural change in 1976Q2 (?). Beef, pork, chicken, and turkey (!). Note, they do not include quarterly dummies			
method of estimation:	NL iterative SUR			
elasticities	beef	pork	chicken	other
own-price	-.77	-.82	-.95	-.09
expenditure	0.93	1.01	1.04	0.99
findings:	Significant structural change in 1976Q2 affecting the intercepts. Changes in structure possibly due to health, changes in nature of poultry product, and the growth in fast food outlets.			
structural change:	yes			
notes:	Say the change was in the quarter when beef consumption peaked, which would have been 1976Q3. Amazing that they could get anything with turkey in a quarterly model with no quarterly dummies.			

Green, R. and J.M. Alston. 1991. Elasticities in AIDS Models: A Clarification and Extension. *American Journal of Agricultural Economics.* 73: 874-5.

findings:	They originally had assumed that expenditure elasticities should be calculated in the same way as for the true nonlinear model. Now they have decided that since the expenditure elasticities depend on the shares, they must also be calculated taking this into consideration.
notes:	It still appears to me to boil down to what you feel the true model is.

Reynolds, A. and E. Goddard. 1991. Structural Change in Canadian Meat Demand. *Canadian Journal of Agricultural Economics* 39: 211-222.

data:	Quarterly; 1968Q1-1987Q4. Canada.		
functional form:	1st differenced LA/AIDS with quarterly dummies. Beef, pork, and chicken.		
method of estimation:	Iterative SUR with structural change allowed to be abrupt or gradual starting and ending where ever the data dictates, i.e. the periods which minimizes the log likelihood.		
elasticities - before	beef	pork	chicken
own-price	-1.048	-.809	-.114
expenditure	1.265	0.758	0.349
elasticities - after	beef	pork	chicken
own-price	-.736	-.676	-.334
expenditure	1.136	1.139	0.183
findings:	Significant structural change starting 1975Q1 and subsiding in 1984Q1. Affected price & expenditure effects and quarterly dummies, but not the intercepts. They found the elasticities to have changed significantly, as well. Probably due to health concerns.		
structural change:	yes		
notes:	Essentially same analysis as Moschini and Meilke, but applied to Canadian data.		

Eales, J.S. and L.J. Unnevehr. 1993. Simultaneity and Structural Change in US Meat Demand. *American Journal of Agricultural Economics*. 75: 259-268.

data:	Annual; 1962-1989. US.		
functional form:	LA/AIDS & LA/IAIDS. Beef, pork, chicken, other food, and non-food.		
method of estimation:	Iterative SUR and iterative 3SLS with homogeneity and symmetry.		
elasticities	beef	pork	chicken
own-price	-.850	-1.234	-.233
expenditure	0.791	1.281	0.693
flexibilities	beef	pork	chicken
own-price	-1.189	-.879	-2.257
scale	-1.284	-.912	-1.832
findings:	Found a significant structural change in 1975 when supply was ignored. When supply is considered all significant shifts disappear.		
structural change:	no		

APPENDIX B

Table B1. SUR Estimates of the Gradual Switching AIDS Model

	GBP	TCP	PKP	CKP	NMP	NFP	EXP	INT	R^2/DW
Ground Beef	.0045*	-.0009	-.0009	.0021*	-.0040*	-.0025	-.0023	.0000	.9080
	(.0004)	(.0007)	(.0005)	(.0006)	(.0014)	(.0014)	(.0035)	(.0001)	2.1434
	-.0016*	.0014	-.0009	-.0011	-.0007	.0029	.0007	-.0001	
	(.0008)	(.0014)	(.0011)	(.0009)	(.0030)	(.0033)	(.0048)	(.0002)	
Table-cut Beef	-.0009	.0125*	.0014	-.0001	-.0006	-.0123*	-.0054	.0000	.8799
	(.0007)	(.0016)	(.0010)	(.0010)	(.0027)	(.0029)	(.0070)	(.0003)	2.1464
	.0014	-.0098*	.0001	-.0001	.0015	.0068	.0076	-.0006*	
	(.0014)	(.0038)	(.0022)	(.0021)	(.0067)	(.0073)	(.0096)	(.0003)	
Pork	.0009	.0014	.0061*	.0028*	-.0104*	-.0007	-.0076	-.0002	.7177
	(.0005)	(.0010)	(.0015)	(.0008)	(.0027)	(.0033)	(.0100)	(.0004)	2.0308
	-.0009	.0001	-.0013	-.0008	.0061	-.0031	-.0013	.0000	
	(.0011)	(.0022)	(.0033)	(.0015)	(.0060)	(.0083)	(.0136)	(.0004)	
Chicken	.0020*	-.0001	.0028*	-.0017	.0052*	-.0081*	.0057	-.0003	.7261
	(.0006)	(.0010)	(.0008)	(.0014)	(.0023)	(.0021)	(.0046)	(.0002)	2.0213
	-.0011	-.0001	-.0008	.0038	-.0007	-.0024	-.0069	.0004*	
	(.0009)	(.0021)	(.0015)	(.0021)	(.0047)	(.0049)	(.0062)	(.0002)	
Non-Meat Food	-.0040*	-.0006	-.0104*	.0052*	.0720*	-.0622*	-.0081	-.0026*	.8118
	(.0014)	(.0027)	(.0027)	(.0023)	(.0097)	(.0103)	(.0206)	(.0008)	1.8252
	-.0007	.0016	.0061	.0007	-.0194	.0117	-.0384	.0021*	
	(.0030)	(.0067)	(.0060)	(.0047)	(.0222)	(.0253)	(.0283)	(.0009)	

Table gives SUR coefficients of Gradual Switching AIDS model. The first line for each commodity represents the effect before the "structural change." The second line for each commodity, gives the adjustment that must be made to these effects after the "structural change." A "*" indicates the coefficient exceeds it asymptotic standard error by a factor of two or more.

Table B2. 3SLS Estimates of the AIDS Model

	GBP	TCP	PKP	CKP	NMP	NFP	EXP	INT	R^2/DW
Ground Beef	.0040*	-.0006	.0012*	.0013*	-.0030	-.0028	-.0007	-.0001	.8813
	(.0004)	(.0008)	(.0004)	(.0006)	(.0016)	(.0016)	(.0021)	(.0001)	2.3086
Table-cut Beef	-.0006	.0099*	.0023*	.0003	-.0029	-.0091*	-.0017	-.0003	.7641
	(.0008)	(.0020)	(.0010)	(.0011)	(.0036)	(.0036)	(.0051)	(.0002)	2.0175
Pork	.0012*	.0023*	.0060*	.0018*	-.0089*	-.0024	-.0094	-.0001	.7398
	(.0004)	(.0010)	(.0011)	(.0008)	(.0026)	(.0030)	(.0052)	(.0002)	2.0726
Chicken	.0013*	.0003	.0018*	.0012	.0044	-.0089*	-.0006	.0000	.5944
	(.0006)	(.0011)	(.0008)	(.0016)	(.0029)	(.0025)	(.0029)	(.0001)	1.8573
Non-Meat Food	-.0030	-.0029	-.0089*	.0044	.0779*	-.0674*	-.0433*	-.0012*	.7098
	(.0016)	(.0036)	(.0026)	(.0029)	(.0126)	(.0126)	(.0137)	(.0005)	1.8047

Table gives 3SLS coefficients of the AIDS model. Since the "structural change" was found to be insignificant, the model was re-estimated without the "structural change" parameters. A "*" indicates the coefficient exceeds it asymptotic standard error by a factor of two or more.