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A Symmetric Approach to Canadian Meat Demand Estimation

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Variability in published meat demand elasticity estimates for Canada motivates examining the importance of dynamics and endogeneity of right-hand-side variables. Wickens and Breusch suggest a re-parameterization of dynamics which allows estimating the long-run parameters directly and maintains linearity. A symmetric approach, employing both ordinary and inverse demand systems, to endogeneity of right-hand-side variables is used. Endogeneity of both prices and quantities is examined. Results show both dynamics and endogeneity are important in quarterly Canadian meat demand.

Key words: demand, diagnostics, dynamics, elasticities, flexibilities, specification

Introduction

Canadian meat demand is important for a number of reasons. Canadian consumers spend approximately 30% of their food budgets on beef, pork, and chicken; so understanding meat demand is important for Canadian agricultural policy. In addition, livestock production is one of the most successful ways Canadian producers can add value to their grain production. Finally, what is meant by the retail demand for meats is more clear than, say, the retail demand for wheat. Thus, consumer demand for meats provides an important case study for demand analysts.

Past studies produced different estimates of Canadian meat demand own-price and expenditure elasticities. Six studies published in the 1990s included at least one set of estimated elasticities for beef, pork, and chicken or poultry. Results from the six studies published in the 1990s are summarized in table 1. If a study included more than one set of elasticity estimates, then those which appeared to be preferred were used. A table of results from studies done in the 1970s, 1980s, and 1990s is given in the appendix. Only those from the 1990s are summarized in table 1 to illustrate that variability of published results persists.

Of the studies, three used annual data; three used quarterly data. All six employ theoretically consistent demand systems. All assumed meats were separable, but some include other meats. Two explicitly incorporate dynamics. One study allows for supply control in the chicken market. The earliest data set started in 1960 and ended in 1988; the latest started in 1980 and ended in 1990.

The mean values of published results are plausible. However, the minimum and max-

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Table 1. Summary Statistics for Canadian Meat Demand Elasticity Estimates Published in the 1990s

Meat	Number of Studies	Mean	Standard Deviation	Minimum Absolute Value	Maximum Absolute Value	Max./ Min.
Own-price elasticity						
Beef	6	−0.76	0.23	0.40	1.08	2.7
Pork	6	−0.59	0.26	0.10	0.82	8.2
Chicken	6	−0.65	0.26	0.32	0.95	3.0
Expenditure analysis						
Beef	6	1.24	0.41	0.82	1.88	2.3
Pork	6	0.81	0.32	0.31	1.14	3.7
Chicken	6	0.57	0.36	0.18	1.04	5.7

Notes: All own-price elasticities are negative. Absolute values are taken of the maximum and the minimum so that their ratios (given in the last column) are comparable for both own-price and expenditure elasticities.

imum absolute values suggest fairly dramatic ranges into which the sensitivities of Canadian meat demands might fall. Clearly, use of minimums versus maximums would produce strikingly different results if used in a policy model, for example.

Two of the differences among these studies are examined further, below. One is explicit modeling of dynamics. Two studies explicitly incorporate demand dynamics and present long-run elasticities (Chen and Veeman; Goddard and Cozzarin). Eight of the twelve elasticities presented in these two studies are either the most or least elastic of the 1990s studies. This suggests that, if including demand dynamics is appropriate, it is likely to have an important impact on elasticities, as well.

The other difference in approaches, given further attention below, is that all but one of the studies assume Canadian meat prices to be predetermined. Canadian meat demand is a convenient choice when the possible endogeneity of meat prices and quantities is at issue, since it is a relatively small, open market with respect to beef and pork.[1] The Canadian chicken market became a federally supply-controlled industry by the end of 1979 administered by the Chicken Marketing Agency. Provincial boards predated the Chicken Marketing Agency (Veeman). Since 1979, imports are restricted by quota and domestic supply is regulated, as well. Quotas are set nationally and allocated to the provinces and then to producers. Moschini and Meilke show that both the Canadian wholesale chicken price and the implicit tariff of the import quota are quite variable. This caused Moschini and Vissa (1993) to model the Canadian meat markets with a mixed demand system, taking beef and pork prices as predetermined by U.S. livestock prices (flat supply curves) and chicken quantity as predetermined by the Canadian Chicken Marketing Agency (vertical supply curve). Their study produced the second highest (in absolute value) own-price elasticities for beef and chicken and expenditure elasticity for pork. Thus, accounting for potential endogeneity of prices/quantities also seems to affect demand elasticities. The sample employed here includes observations from before

[1] Researchers, typically, assume Canadian meat prices are predetermined by U.S. livestock prices either implicitly or explicitly (e.g., Tryfos and Tryphonopoulos; Hassan and Katz).

the national chicken supply control was instituted. Because of this a different approach is taken.

A distinction between this and previous work on Canadian meat demand is that a symmetrical approach to estimation is taken. That is, both ordinary (Marshallian) and inverse demand systems will be estimated. Several previous studies have employed a symmetrical approach in the same sense used here, for example, Thurman, Shonkwiler and Taylor, and Eales and Unnevehr (1993). In the next section, ordinary (AIDS) and inverse differential almost ideal demand system (IAIDS) models (Barten 1993; Barten and Bettendorf) are specified for Canadian meat demand. While this model is similar to the almost ideal demand system model (Deaton and Muellbauer) and its inverse (Eales and Unnevehr 1994; Moschini and Vissa 1992), it is derived as an approximation to the unknown demands rather than from the AIDS log-cost function or the IAIDS log-distance function. This choice is motivated by several considerations. The symmetrical approach implicitly assumes that the ordinary and inverse demand systems can model the same preferences. As pointed out by Moschini and Vissa (1993, pp. 3–4), such is not possible with many of the theoretically consistent demand systems used in current applications. Differential demand systems, such as the Rotterdam or AIDS, are attractive for such applications, since both ordinary and inverse demands are derived as differential approximations to unknown demands. Essentially, the problem is circumvented by admitting that the systems are approximations to which the theoretical restrictions will be applied. The advantages and disadvantages of the Rotterdam and AIDS models have been debated at length (Barten 1993; Alston and Chalfant 1993). However, the advantage of the differential AIDS model relevant to the current study is that the dependent variables of both the ordinary and the inverse systems are the same, which allows them to be tested against one another with a generalization of Davidson and MacKinnon's (DM) nonnested P-test.

Allowing for consumer habits, incomplete information and inventory adjustments have a long history in studies of consumer demand, for example, Anderson and Blundell (1982, 1983); Green, Hassan and Johnson; Pope, Green, and Eales; and Wohlgenant and Hahn. To examine demands for potential dynamics, the approach of Kesavan et al. is implemented. They follow Wickens and Breusch in separating the short-run dynamics from the long-run steady-state relationship. This allows demand restrictions to be imposed on long-run parameters, while not imposing them on short-run shocks. To examine the potential endogeneity, U.S. livestock prices and variables representing livestock production cost and the overall health of the Canadian economy are employed as instruments for current prices or quantities and real meat expenditures.

Demand Systems

The ordinary AIDS model was developed by Deaton and Muellbauer in which they show the first differenced form of their linearized model is similar to the Rotterdam. In contrast, the ordinary differential AIDS model was developed as a variant of the Rotterdam system (Barten 1993). It mirrors the Rotterdam model of Barten (1964) and Theil in that demand is approached directly, taking differential logarithmic approximation of an arbitrary set of demands. Alston and Chalfant (1993) show that the different forms of the AIDS models produce similar results. The form of the estimating equations for application to quarterly meat consumption data are

$$(1)\qquad \Delta w_{jt} = \alpha_j^0 + \sum_{k=2}^{4} \theta_{jk}^0 S_{kt} + \beta_j^0 \,\Delta\ln Q_t + \sum_{k=1}^{3} \gamma_{jk}^0 \Delta\ln p_{kt},$$

where Δw_{jt} and $\Delta \ln p_{kt}$ are changes in the ith expenditure share and the natural log of the jth price, respectively; $\Delta \ln Q_t = \Sigma_{k=1}^{3} \bar{w}_{kt} \Delta \ln q_{kt}$ represents the real expenditure effects and is specified in this manner to guarantee the demands add up; $\bar{w}_{it}$ is the average expenditure share for the ith meat in periods t and $t-1$; $\Sigma_{k=2}^{4} \theta_{jk}^0 S_{kt}$ represents the exogenous seasonal trends in the demand for meat j (S_{kt} are seasonal dummy variables); and β_j^0, γ_{jk}^0, and α_j^0 are coefficients of ordinary demands.

The inverse differential AIDS model was developed by Barten and Bettendorf in an application to monthly demand for fish. The derivation proceeds in a manner similar to that employed to develop the ordinary differential demand models except the differential logarithmic approximation is done to an arbitrary inverse demand system. The resulting estimating equations have the form:

$$(2)\qquad \Delta w_{jt} = \alpha_j^i + \sum_{k=2}^{4} \theta_{jk}^i S_{kt} + \beta_j^i \Delta\ln Q_t + \sum_{k=1}^{3} \gamma_{jk}^i \Delta\ln q_{kt},$$

where $\Delta \ln q_{kt}$ is the change in the natural log of the kth quantity consumed; $\Delta \ln Q_t$ now represents the "scale" effects (Anderson); the superscript i on the coefficients indicates they are from the inverse demands; and the others are as defined above. In what follows, these models will be referred to as "static."

Dynamics may be incorporated in either of the differential AIDS as follows. Let Y_t represent a vector of the changes in expenditure shares in period t; X_t represent the right-hand-side (RHS) variables in period t; $\Delta_k Z_t = Z_t - Z_{t-k}$; and A_k, B_k, and Φ represent coefficient matrices. Then a dynamic version of either differential AIDS is

$$(3)\qquad Y_t = \sum_{k=1}^{L} A_k \Delta_k Y_t + \Phi X_t + \sum_{k=1}^{L} B_k \Delta_k X_t + e_t.$$

Estimates of the long-run coefficient matrix, Φ, may be used to calculate long-run elasticities/flexibilities.[2] Note, the presence of Y_t in each $\Delta_k Y_t$ necessitates the use of three-stage least squares (3SLS) to estimate the system given by (3). However, an appropriate set of instruments exists as long as the current values of either meat prices (ordinary demands) or quantities (inverse demands) can be taken as predetermined.[3] Ensuing reference to these models will be as the "dynamic" models.

Finally, if current prices or quantities are not predetermined when estimating (3), then the instrument list must be augmented with variables exogenous to, but highly correlated with, Canadian meat demand. In the 1970s, researchers argued that Canadian meat prices are predetermined by U.S. livestock prices (for example, Tryfos and Tryphonopoulos; Hassan and Katz). Even though the Canadian chicken market has been federally protected

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[2] Wickens and Breusch favor this procedure over an "error-correction" approach because it avoids nonlinear estimation.

[3] Wickens and Breusch show that use of Z_{t-k} as an instrument for $\Delta_k Z_t$ (for both $Z=X$, Y) yields exactly the same results as solving for the long-run coefficients from a vector ARMAX approach. They also show the standard errors produced are appropriate. In demand systems, adding up requires that the column sums of the A_k and B_k must be zero. Additionally, since the associated variables sum to zero by construction, the rows of A_k are restricted to sum to zero (see Anderson and Blundell 1982, 1983).

since 1979, most Canadian meat demand estimates have maintained this assumption implicitly [again, with the exception of Moschini and Vissa (1993)]. Thus, U.S. prices for livestock and broilers are used as extra instruments to examine the predeterminedness of Canadian meat prices and quantities.[4] These models are subsequently referred to as the "consistent" models.

Canadian Meat Demand Data

To estimate ordinary and inverse differential AIDS models of Canadian meat demand per capita, consumption and price indexes for beef, pork, and chicken were obtained from Agriculture and Agri-Food Canada, quarterly from 1970-Q1 through 1992-Q4 (H. Huang).[5] Price indexes are converted to prices as follows. Base-year weights, used in computing the consumer price index, are used to combine base-year prices for beef and pork cuts into a beef and pork price in the base year, 1986 (Robbins).

For example, the 1986 beef price is calculated by taking weights for beef cuts in the Canadian consumer price index: hip cuts, 0.25; loin cuts, 0.22; rib cuts, 0.08; chuck cuts, 0.15; stewing cuts, 0.05; ground beef, 0.39; combined with the 1986 prices of representative cuts: round steak, $9.24; sirloin steak, $10.06; prime rib roast, $9.14; blade roasts, bone out and bone in, ($5.36+5.22)/2; stewing beef, $5.81; and hamburger, $3.30. The weights and prices are combined, summed, and divided by the sum of the weights, resulting in a 1986 beef price of $6.69 per kilogram. The 1986 pork price was generated in a similar fashion as $6.79 per kilogram. The only price reported for chicken is a broiler price $3.83 per kilogram (Robbins). These are used to convert the consumer price indexes for beef, pork, and chicken to price series.

Instruments employed in estimation of consistent models are U.S. slaughter steers price, choice, 900–1100 lbs., Omaha; U.S. barrows and gilts price, 7 markets; and U.S. broilers price, farm level. Canadian instruments are obtained from the Cansim database (Statistics Canada). Variables representing the cost of livestock production are Canadian farm workers' hourly wages (Cansim matrix #2016; d 605901), consumer price index for fuel oil and other liquid fuel (Cansim matrix #2201; p 484179), and consumer price index for electricity (Cansim matrix #2201; p 484181). Those representing the health of the Canadian economy are composite index of 10 leading indicators (Cansim matrix #191; d 99947), consumer price index, all items (Cansim matrix # 2201; p 484000), personal consumption expenditures (Cansim matrix # 6707; d 10113), and population from Agriculture and Agri-Food Canada (series revised as of May 1994). Those which have aspects of both are exchange rate-Canadian cents per U.S. dollar (Cansim matrix #933; b 40001) and government of Canada 91-day treasury bill tender (Cansim matrix #2560; b 14001).

[4] Since national supply control was implemented in 1979, it seems unlikely that U.S. broiler prices will predetermine Canadian chicken price over the entire sample. This suggests other instruments are needed. Variables representing Canadian livestock production costs and the Canadian macro economy are, therefore, included as instruments. Details are given, below.

[5] The per capita consumption series for beef, pork, and chicken were revised in May 1994, primarily because of a revision of the population series by Statistics Canada. Pork consumption was revised again to account for manufacturing and waste as of February 1995 (H. Huang). Agriculture and Agri-Food Canada consumption figures are in carcass weight and so they were adjusted using the conversion factors given in Hewston for beef and in Hewston and Rosien for pork.

Canadian Meat Demand Estimates

To develop plausible estimates of Canadian meat demand, six models are estimated using the seemingly unrelated regressions and three-stage least squares estimators in the SHAZAM program (White). The six models are ordinary and inverse differential AIDS [equations (1) and (2), the static models], ordinary and inverse differential AIDS augmented with dynamics [equation (3) assuming current quantities or prices are predetermined, the dynamic models], and ordinary and inverse differential AIDS augmented with dynamics and estimated with instruments for current prices or quantities (consistent models). All models fit reasonably well and produced mostly significant coefficients.[6] Detailed presentation of the coefficients and summary statistics is foregone. Each model is employed for several purposes. First, extensive diagnostics are employed to gauge model adequacy. Second, each is used to examine the impact of considering potential endogeneity. This is done using Durbin-Wu-Hausman tests which are calculated as suggested by Hausman and Taylor. The symmetric approach, that is, use of both differential AIDS and IAIDS models, allows a further test of model adequacy, a generalization of the multivariate nonnested tests of DM. Finally, each model is used to calculate elasticities or flexibilities for comparison.

The diagnostic tests employed are those suggested by McGuirk, Driscoll, Alwang, and Huang (MDAH). These are designed to check the "statistical adequacy" of the models. Results are given in table 2 in terms of p-values or marginal significance levels of the tests, small values indicate rejection of the corresponding underlying assumption and suggest a statistically inadequate model. Tests given in the first five columns are as described in MDAH (including Rao's small sample correction). The multivariate normality test is the one suggested by Lutkepohl and Theilen. As suggested by MDAH, diagnostics are performed on the reduced forms for dynamic and consistent models rather than on their structural forms. None of the models appears misspecified in terms of functional form, heteroskedasticity, or normality. Static models appear to suffer from unincorporated dynamics and parameter instability. Dynamic and consistent models appear adequate in terms of diagnostics given in table 2.

Next, two further tests of model adequacy are examined. Results are given in table 3. The static and dynamic models are estimated assuming that current prices or quantities are predetermined. This assumption is tested using the instruments described in the previous section. In all four models the hypothesis that current RHS variables are predetermined is rejected. These results may be confounded in the static models since there appear to be other violations of statistical assumptions in these models. For example, if chicken quantities, beef prices, and pork prices are predetermined, rejection of the predeterminedness of all prices or of all quantities would be expected. This issue was examined further by estimating the mixed demand system of Moschini and Vissa (1993) and testing endogeneity of the RHS variables in a system similar to theirs, again employing the same set of instruments. The marginal significance level of the test statistic

[6] All estimates are calculated with homogeneity and symmetry imposed, currently in the static models and in the long run in the dynamic and consistent models, that is, on the matrix Φ in (3). The Slutsky and Antonelli matrices corresponding to each of the models are negative semidefinite at sample mean shares, again in the long run for the dynamic and consistent models. Implementation of the dynamic differential AIDS models, as in (3), requires prior specifying the lag length, L. This was done empirically, using the technique suggested by Simms assuming a maximum lag length of six periods. One lag is found appropriate for the inverse demands, while two lags are required for the ordinary demands.

Table 2. *p*-Values for Diagnostic Tests of Differential AIDS and IAIDS Models

	Ff[a]	Het[b]	ARCH[c]	Chow[d]	Indep[e]	Norm[f]
Static AIDS	0.582	0.551	0.002	0.005	0.000	0.177
Static IAIDS	0.229	0.364	0.946	0.015	0.047	0.060
Dynamic AIDS	0.545	0.497	0.990	1.000	0.092	0.932
Dynamic IAIDS	0.979	0.536	0.461	1.000	0.319	0.052
Consistent AIDS	0.425	0.533	0.852	0.468	0.252	0.822
Consistent IAIDS	0.918	0.496	0.679	0.274	0.298	0.722

Notes: Tests of functional form, heteroskedasticity, and autoregressive conditional heteroskedasticity employ only the squares of predicted values and residuals, as appropriate, due to lack of degrees of freedom. Models are Static AIDS, equation (1) in the text; Static IAIDS, (2) in text; Dynamic AIDS, (1) augmented with dynamics as in (3) and taking current prices and real meat expenditures as predetermined; Dynamic IAIDs, (2) augmented with dynamics as in (3) and assuming current quantities and the scale variables are predetermined; Consistent AIDS, same as the Dynamic AIDS but estimated with instruments for current prices and real meat expenditures; and Consistent IAIDS, same as the Dynamic IAIDS but estimated with instruments for current quantities and the scale variables.

[a] Functional form test [McGuirk et al. (MDAH)].

[b] Heteroskedasticity test (MDAH).

[c] Autoregressive conditional heteroskedasticity test (MDAH).

[d] Multivariate Chow test (MDAH).

[e] Multivariate Breusch-Godfrey test (MDAH).

[f] Multivariate normality test (Lutkepohl and Theilen).

was 0.015. This suggests that it is not the predeterminedness of the chicken price that is being rejected in the differential AIDS while the predeterminedness of beef and pork quantities are rejected in the differential IAIDS model. Thus, neither the static models nor the dynamic models appear to be statistically adequate based on the results of the diagnostic specification tests, while both the consistent models appear adequate.

As the final diagnostic of statistical adequacy, the consistent models are compared using the multivariate nonnested test of DM. Results are given in table 3. Even though the static and dynamic models failed previous tests of statistical adequacy, they are compared, as well. In each case models are compared with their counterparts, that is, the static AIDS is tested against the static IAIDS and vice versa. Application of this test requires some care in the present circumstances. For the static models, the test as described in DM must be modified. Both the AIDS and IAIDS models are estimated using 3SLS employing U.S. livestock prices and variables representing costs of livestock production and the health of the Canadian economy as instruments. These instruments are used to estimate DM's nonnested-test regression, as well. The structural form of the dynamic models are just identified. This means that the augmented equation used in DM's test is unidentified. So the tests are performed using the unrestricted vector autoregressive representation of the dynamic models, which omits current changes of RHS variables. This certainly results in some loss of power. The consistent models are over identified. Thus, the nonnested tests are performed on their structural forms. The additional variable required for the test, an adjusted difference in the predictions of the null and alternative models, is still likely to be correlated with the errors, implying that the estimates of the nonnested-test regression will be biased and inconsistent. To account for this the instruments of the null model are used in estimation of the nonnested-test regression to generate the test statistic. Other approaches could have been taken, such as

Table 3. *p*-Values for Endogeneity of Current Prices or Quantities and Nonnested Tests of the Forms of the Differential AIDS and IAIDS Models

Test	Static AIDS	Static IAIDS	Dynamic AIDS	Dynamic IAIDS	Consistent AIDS	Consistent IAIDS
DWH[a]	0.003	0.003	0.000	0.000	NA[c]	NA[c]
NNT[b]	0.000	0.000	0.042	0.000	0.875	0.000

Notes: Model definitions are given in the notes to table 2.
[a] Durbin-Wu-Hausman specification test (Hausman and Taylor).
[b] Multivariate nonnested hypothesis tests (Davidson and MacKinnon). In each case the test was between similar nonnested models, i.e., static vs. static. The dynamic models are just identified, which means the augmented equation used in Davidson and MacKinnon's P-test would be unidentified, so the test was conducted using the unrestricted vector ARMAX form. Consistent models are both over identified so the tests are conducted by employing the null model's instruments to calculate instrumental variable estimates for the nonnested test. This means the consistent model tests are conditional on the instruments used. To assess the effect of the instruments, tests were recomputed each time omitting one of the instruments. In all but two cases the consistent AIDS was not rejected by the consistent IAIDS while the consistent IAIDS was always rejected by the consistent AIDS. In two cases, when CPI or T-bill yield were dropped, the consistent AIDS was rejected by the consistent IAIDS. This suggests that while the consistent AIDS model appears the most "statistically adequate" of the models explored other better models may exist.
[c] Not Applicable.

using instruments from both models. The difficulty with these other approaches is that the check described by DM is lost; that is, regressing the null model's residuals on the null model's RHS variables will not produce zero coefficients unless the null model's instruments are used. As pointed out by MacKinnon, White, and Davidson, this means that the results are conditional on the instrument sets, as well as the models themselves.

Results in table 3 indicate that in each case the null model is rejected by its counterpart (at a 5% confidence level) with one exception, the consistent AIDS model is not rejected by the consistent IAIDS. As indicated above, this result may be sensitive to the instruments used to construct the test statistic. This sensitivity is examined by reestimating the models and conducting the nonnested test, dropping each of the instruments one at a time. In every case, the consistent IAIDS model is rejected. The consistent AIDS model was rejected twice, when either the consumer price index for all items or the 91-day treasury bill tender dropped from the instruments. Thus, while the results are more fragile than one would desire, the consistently estimated, dynamic differential AIDS model is the most "statistically adequate" of the models examined.

While statistically significant differences in the adequacy of the six demand models is evident, whether such statistical differences are economically relevant is a separate question. To examine this issue, demand sensitivities for all six models are given in table 4. To facilitate comparison between ordinary and inverse demand models, own-price and expenditure elasticities are given for ordinary demands, but reciprocals of own-price flexibilities and negative reciprocals of scale flexibilities are given for inverse demands.[7]

[7] One would prefer to use the result that the inverse of the matrix of flexibilities is the matrix of elasticities and vice versa (Houck; Anderson). Unfortunately, this holds only for the unconditional demands, in general. It would also hold for conditional demands if the elasticity/flexibility matrices were block triangular or diagonal, i.e., at least one set of off-diagonal blocks of the elasticity/flexibility matrices between meats and all other commodities are zero. However, this imposes restrictions on preferences that are not supported empirically, see George and King or Blanciforti, Green, and King for estimates

Table 4. Ordinary and Inverse Differential AIDS Estimates of Elasticities/Flexibilities

		Ordinary Demands			Inverse Demands[a]		
	Elasticities/ Flexibilities	Static Models	Dynamic Models	Consistent Models	Static Models	Dynamic Models	Consistent Models
Beef	Own price	−0.88	−0.84	−0.81	−1.43	−1.01	−1.02
		(0.07)	(0.07)	(0.08)	(0.10)	(0.09)	(0.11)
	Expenditure/ scale	1.19	1.02	0.98	1.04	0.94	1.12
		(0.08)	(0.13)	(0.15)	(0.09)	(0.12)	(0.23)
Pork	Own price	−0.79	−0.78	−0.86	−1.37	−1.15	−0.93
		(0.07)	(0.07)	(0.08)	(0.09)	(0.13)	(0.10)
	Expenditure/ scale	1.01	1.19	1.27	0.88	1.32	1.01
		(0.11)	(0.16)	(0.20)	(0.07)	(0.35)	(0.27)
Chicken	Own price	−0.30	−0.35	−0.45	−2.94	−1.08	−0.96
		(0.10)	(0.09)	(0.11)	(0.87)	(0.17)	(0.23)
	Expenditure/ scale	0.40	0.51	0.43	1.22	0.74	0.74
		(0.13)	(0.18)	(0.11)	(0.21)	(0.12)	(0.19)

Notes: Calculated at the sample mean shares. Asymptotic standard errors, in parentheses, are calculated assuming the mean shares are constant and should be considered lower bounds.
[a] These three columns give reciprocals of own-price flexibilities or negative reciprocals of scale flexibilities. Roughly, they are interpreted as own-price and expenditure elasticities (see footnote 7).

All are calculated at the sample means along with asymptotic standard errors (Greene, p. 75, equation 3-94, with mean shares assumed constant) given in parentheses.

Three things in table 4 are worthy of note. First, the consistent differential AIDS model produces estimates for beef and chicken which are not extreme relative to those summarized in table 1. However, pork is both more own-price and expenditure elastic than has been found in recent studies. This is probably due to the redefinition of pork disappearance to account for manufacturing and waste. These new pork data have only been used by Moschini and Vissa, who do not include dynamics.

Second, the estimates from the different forms of the differential AIDS models are in fair agreement. For example, even though both the static and dynamic AIDS show significant statistical deficiencies, neither produces point estimates which differ from those of the consistent differential AIDS by more than 2 standard errors (except the static AIDS estimate of own-price elasticity of chicken). As gross characterization of demand, all three AIDS models produce similar pictures.

If the consistent AIDS model is used as a standard for comparison, incorporating dynamics and consistency has moved the IAIDS models estimates toward agreement; however, differences persist in terms of the gross characterization of the sensitivities of Canadian meat demands. That is, all three meats are more elastic from the inverse side.

of unconditional elasticity matrices and K.S. Huang for an unconditional flexibility matrix. Thus, use of reciprocals of own-price flexibilities is for gross comparisons of the sensitivities of inverse demands. Likewise, one would expect the expenditure elasticity and scale flexibility for the same good to be approximately negative reciprocals of each other. This would be true if the own-price elasticity/flexibility were reciprocals and cross-price elasticity/flexibilities were zero. In this case one would have

$$e_i = -\Sigma_j e_{ij} = -e_{ii} = -1/f_{ii} = -1/\Sigma_j f_{ij} = -1/f_i,$$

where e and f represent elasticities and flexibilities, respectively. Single subscripts refer to expenditure elasticities or scale flexibilities; while double subscripts represent prices.

This is probably why the consistent AIDS model rejects the consistent IAIDS model in the nonnested test, but the consistent AIDS is not rejected when their roles are reversed.

Finally, since the consistent AIDS model was the most "statistically adequate" of the models examined, it is their characterization of Canadian meat demand which is to be preferred among the estimates developed here.

Conclusions

Recent Canadian meat demand elasticity estimates in the literature vary widely. These differences may have resulted from a number of sources, but two were singled out for examination in this study, demand dynamics and slope of the supply. Since a symmetrical approach to such problems was advocated, this required the specifying six demand systems, which varied according to the consideration of dynamics and endogeneity of RHS variables. Differential ordinary and inverse almost ideal demand systems (AIDS and IAIDS, respectively) were chosen for the exercise, because their linearity made incorporating dynamics simple and since both have differences of shares as dependent variables, allowed using nonnested tests. Even so this choice is arbitrary, so all of the models were subjected to diagnostic tests suggested by McGuirk et al. The static versions of the AIDS and IAIDS models showed parameter instability and omitted dynamics. Dynamic and consistent versions of the models showed no such model inadequacy.

Static and dynamic models were tested for endogenous RHS variables. All showed significant endogeneity, although in the static models these results may be confounded with other model inadequacies. Because of the symmetric approach to estimation taken here, a final statistical test was possible. Each of the models was tested against its partner, so to speak, that is, the static AIDS was tested against the static IAIDS, and vice versa, using the multivariate nonnested test of Davidson and MacKinnon. Both static models rejected each other. Similarly, both dynamic models rejected each other. Finally, the consistent AIDS rejected the consistent IAIDS, but the consistent IAIDS did not reject the consistent AIDS (although this result was somewhat sensitive to the instruments used to correct for endogeneity of RHS variables).

Finally, elasticities or flexibilities are calculated for all six models. Those of the consistent AIDS model were approximately average for beef and chicken but more elastic for pork. All the AIDS estimates were in agreement as to the responsiveness of demands. IAIDS models were more "elastic" than AIDS models and were moved toward less elastic by the inclusion of dynamics and endogenous quantities.

Careful treatment of dynamics and endogeneity seems to be warranted when modeling Canadian meat demand with quarterly, time-series data. A natural extension of these results would be to examine U.S. demands for beef, pork, and chicken. As to dynamics, this presents no difficulty, but to examine endogeneity in the U.S. market would require specifying a set of instruments for prices or quantities. The sensitivity of results to the instrument set is likely to be large. How to proceed when results are sensitive to the instrument set is an open question, worthy of further research.

Finally, the symmetric approach to demand estimation is a fairly low-cost diagnostic which for many currently popular systems, that is, those where both ordinary and inverse demands have expenditure shares or their changes as dependent variables, can be augmented by a nonnested test. Although in most cases application of these tests requires some care, they do appear to be fairly powerful.

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Appendix

Table A1. Previous Estimates of Canadian Meat Demand Elasticities

Study	Data Frequency	Year Published	Commodities Included	Functional Form	Own-Price Elasticities			Expenditure Elasticities		
					Beef	Pork	Chicken	Beef	Pork	Chicken
Tryfos and Tryphonopoulos	Annually	1973	B, P, C, L, V	Linear	−0.521	−1.049	−0.087	0.835	−0.004	1.129
Hassan and Katz	Annually	1975	B, P, C, L, V, T	Log-log	−0.767	−0.955	−0.564	0.553	0.257	0.730
Hassan and Johnson	Quarterly	1979	B, P, C, T, V	Box-Cox	−0.453	−0.836	−0.732	0.355	0.437	0.622
Young	Quarterly	1987	B, P, C, T	Box-Cox	−0.480	−0.660	−0.470	0.880	0.390	0.260
Alston and Chalfant	Annually	1991	B, P, PO, F	Rotterdam	−0.660	−0.740	−0.740	0.820	0.850	0.440
Chalfant, Gray, and White	Annually	1991	B, P, PO, F	LA/AIDS	−0.403	−0.591	−0.769	1.575	0.537	0.832
Chen and Veeman	Quarterly	1991	B, P, C, T	Dyn. AIDS	−0.770	−0.820	−0.950	0.930	1.010	1.040
Reynolds and Goddard	Quarterly	1991	B, P, C	LA/AIDS	−0.736	−0.676	−0.334	1.136	1.139	0.183
Goddard and Cozzarin	Annually	1992	B, P, C	Dyn. Translog	−1.080	−0.100	−0.320	1.880	0.310	0.190
Moschini and Vissa	Quarterly	1993	B, P, C	Mixed Rot.	−0.885	−0.641	−0.804	1.075	1.021	0.766

Notes: Abbreviations for included commodities are B = beef, P = pork, C = chicken, L = lamb, V = veal, T = turkey, PO = poultry, F = fish.