A Demand System for Major Dairy Products in Ontario

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Abstract

Despite significant media and research interests drawn into the Canadian dairy sector in recent years, no study has estimated price and income elasticities of demand for major dairy products at the provincial level using longitudinal data. This article attempts to bridge this gap by estimating a demand system for seven major dairy products in Ontario. Employing Barten's General Model, four alternative demand systems were nested and the NBR demand system was found to be the most appropriate for the data set in Ontario on both theoretical and empirical grounds. The symmetry, homogeneity and concavity conditions are all supported by the data. Empirically, all own-price elasticities are negative and statistically significant. The expenditure elasticities of all dairy products are positive, less than unity and statistically significant. Finally, most dairy products are net substitutes in consumption.

Keywords: Demand Systems; Barten's General Model; Price and income elasticities; Dairy Products; Ontario.

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Introduction:

The dairy sector in Canada is governed by supply management. Under this policy, prices received by dairy producers are determined based on a ‘cost-of-production’ formula and for a given level of demand for milk, supply is restricted through binding production quotas at the farm level to achieve this price. To sustain this price, trade in dairy products is also regulated through tariff-rate-quotas. The over-quota tariffs for all dairy products are set at such high levels that it is impossible for anybody to make a profit by importing any dairy product into Canada beyond the minimum access quantities. The prices consumers pay, however, vary across locations and over time.

Supply management in the dairy sector invited controversy right from its inception in the 1960s (Barichello, 1981; Forbes et al., 1982). After almost half-a-century of its existence, supply management in dairy continues to receive significant attentions from the media, policy makers, trade negotiators and the academics (Clemens and Crowley, 2012; Gifford, 2005; Conference Board of Canada, 2009; Ivison, 2012; Wallece, 2011). While the issues entertained in many of these pieces are relevant for the dairy sector in Ontario and in Canada, the discussions often revolve around personal opinions.

The own-price elasticity and income elasticity of demand for different dairy products are used for a wide variety of policy analysis, discussions, dialogues and policy choices. For example, if one wishes to assess the effects of changes in domestic quota regulations, policy related to health and nutrition, trade liberalization under the WTO or Trans-Pacific Partnership (TPP) or trade disputes on the dairy sector, he/she would require reliable estimates of price and income elasticities of demand and the supply elasticities. To the best of our knowledge, no study has estimated a set of demand elasticities for major dairy products consumed in Ontario or in any other province in Canada. Most empirical studies rely on such parameters from previous studies and in many instances those from other countries (see Veeman, 1982; van Kooten, 1990; Meilke et al., 1998; Conference Board of Canada, 2009; Rude and An, 2013). As a consequence, the results from previous studies while informative may not be useful for meaningful policy dialogues and for long-term policy choices in supply managed sectors in Canada. Despite significant attention drawn into the dairy sector in recent years, little effort is invested to estimate these elasticities using longitudinal data. This article makes an attempt to bridge this gap by estimating a demand system for seven major dairy products in Ontario.

Ontario has the largest consumer base for various dairy products and enjoys the second highest share of national production, popularly known as the Market Sharing Quota (MSQ) in Canada. Although the market for manufactured dairy products such as butter, cheese, yogurt and ice cream account for about 66 percent of all dairy products consumed in Ontario, few studies attempted to estimate the price and income elasticities of demand for manufactured dairy products. Goddard and Tielu (1988) employed quarterly data from 1971 to 1984 and estimated the own-price elasticity of demand for fluid milk to be -0.25. Similarly, employing data from 1973 to 1984, Venkateswaran and Kinnucan (1990) estimated the price elasticity of demand for fluid milk to be -0.19. Finally, Goddard and McCutcheon (1993) employed data from 1981-1989 and estimated the price elasticity of demand for fluid milk to be -0.24. While these results suggest that the price elasticity of demand for fluid milk is low hovering around -0.22 and stable in Ontario, the estimated price elasticities are dated. In addition, none of these studies estimated the price elasticities of demand for other dairy products even though they account for over 60% of all dairy products consumed in Ontario. In light of these inadequacies, we selected seven major dairy products in this study: fluid milk, butter, cheese, yogurt, ice cream, cream and skim milk powder which accounted for about 98% of total dairy products consumed in recent years.

Substantial progress has been made in consumer demand analysis since the 1970s. An important segment of this progress focuses on the development of alternative specifications of demand systems which are theoretically consistent, amenable to econometric estimation and yield policy relevant price and income elasticities (Okarent and Alston 2011). The quality of the estimated elasticities from a demand system vary considerably depending on the choice of the functional form, the type of data used, assumed separability structure and the econometric technique used in estimation.

The Almost Ideal Demand System (AIDS) (Deaton and Muellbauer 1980) and the Rotterdam Model (RM) (Theil 1975a, b; Barten 1968, 1977) have been the two most popular demand systems used in agricultural economics. The popularity of these two demand systems is driven by the fact that both share desirable properties not possessed by other locally flexible functional forms such as the Translog (Christensen et al., 1975) and the Generalized Leontief (Diewert, 1971). They are also consistent with demand theory, linear and have identical data requirements. However, the two demand systems generated so different results in some applications that the appropriateness of either specification for a particular dataset has been questioned (Alston and Chalfant, 1993). Since economic theory provides little basis for *ex ante* discrimination between these two functional forms, the choice of an appropriate functional form for a particular demand system in agricultural economics has been '*adhoc*', often motivated by the personal familiarity of the researcher (Alston and Chalfant 1991a, 1991b; Lee et al., 1994).

Since these demand systems are not nested with each other, some analysts employed various non-nested tests for choosing between these two systems. The results of this exercise in many instances have been disappointing because the results of the non-nested tests were inconclusive (Okarent and Alston 2011). In this context, Barten's (1993) approach provides an empirically attractive alternative. This approach is based on a general model which not only nests the two most popular demand systems, the Rotterdam and the differential linear AIDS, but also two mixed demand systems, the Central Bureau of Statistics (CBS) demand system (Keller and Van Driel 1985) and the National Bureau of research (NBR) demand system (Neves 1987). Thus, it is useful for determining the most appropriate demand system for a given data set from this set of four alternative functional forms. The data driven nesting procedure introduced by Barten (1993) is employed in this study to determine the appropriate functional form for studying the demand for selected dairy products in Ontario.

Section two provides a brief exposition of Barten's general model and the nesting procedure. Section three focuses on data description, econometric issues and the estimation strategy. Estimation results are discussed in section four. The final section provides a summary of the main findings, highlights their policy implications and concludes the paper.

Barten's General Model: A Brief Exposition

To provide a brief exposition of the BGM, one can conveniently starts with the Rotterdam model which is specified as:

$$w_i d \ln q_i = b_i d \ln Q + \sum_j c_{ij} d \ln p_j \tag{1}$$

Where w_i is the budget share of the i^{th} commodity, p_i and q_i are the price and quantity of the i^{th} commodity respectively. The Divisia volume index for the change in real income is d ln Q which can be written as: $d \ln Q = \sum_j w_j d \ln q_j$. Thus, in the Roterdam model, b_is represent marginal budget shares, and c_{ij}s are the compensated price effects. Both income and price effects are assumed to be constant in the RM. However, there is no *a priori* reason that price and income effects both should be held constant.

The AIDS can also be expressed in differential form (Deaton and Muellbauer, 1980; Barten, 1993). For simplicity, if we replace b_i and c_{ij} in the Rotterdam model (eq.1) with $\beta_i + w_i$ and $\gamma_{ij} - w_i(\delta_{ij} - w_j)$ respectively, we obtain a differential version of the AIDS model as,

$$w_i d \ln q_i = (\beta_i + w_i) d \ln Q + \sum_j (\gamma_{ij} - w_i(\delta_{ij} - w_j)) d \ln p_j . \qquad (2)$$

Unlike those in the Rotterdam model, the marginal budget shares are, $\beta_i + w_i$, and the compensated price effects are, $\gamma_{ij} - w_i(\delta_{ij} - w_j)$ for the AIDS model. It is clear that both price and income effects in the AIDS model vary over time.

Since the dependent variables in equations (1) and (2) are the same, with appropriate re-definition of the unknown parameters one can specify a model which nests both the Rotterdam and differential AIDS models. This is the idea behind Barten's General Model which can be specified as:

$$w_i d \ln q_i = (d_i + \xi_1 w_i) d \ln Q + \sum_j (e_{ij} - \xi_2 w_i(\delta_{ij} - w_j)) d \ln p_j \qquad (3)$$

Where, d_i, ξ_1, e_{ij} and ξ_2 are the unknown parameters of BGM and can be estimated. In terms of the Rotterdam and differential AIDS parameters, d_i is defined as, $d_i = \xi_1 \beta_i + (1 - \xi_1) b_i$, while e_{ij} is defined $e_{ij} = \xi_2 \gamma_{ij} + (1 - \xi_2) c_{ij}$. The parameters ξ_1 and ξ_2 are called the nesting parameters. The values of these parameters determine whether one has the Rotterdam model or the differential AIDS model. If we set, $\xi_1 = \xi_1 = 0$ in eq. (3), the BGM becomes the Rotterdam model. Similarly, if we set $\xi_1 = \xi_1 = 1$ then the BGM becomes the differential AIDS model as in equation (2). However, if we set $\xi_1 = 0$ and, $\xi_2 = 1$, then the BGM becomes:

$$w_i d \ln q_i = d_i \ln Q + \sum_j (e_{ij} - w_j(\delta_{ij} - w_j)) d \ln p_j \qquad (4)$$

This is a mixed demand system which contains the Rotterdam income effects and the AIDS price effects. It is known as the National Bureau of Research (NBR) model and was developed in the mid-1980s (Neves, 1987). Finally, if we set $\xi_1 = 1$ and, $\xi_2 = 0$, then the BGM reduces to:

$$w_i d \ln q_i = (d_i + w_i) d \ln Q + \sum_j e_{ij} d \ln p_j \tag{5}$$

This model contains the AIDS income effects and Rotterdam price effects and is known as the Central Bureau of Statistics (CBS) model (Keller and van Driel, 1985). It was also developed in the mid-1980s.

Thus, by imposing simple restrictions on two nesting parameters of the BGM, ξ_1 and ξ_2 we can select one of the four alternative demand systems from the BGM by applying the likelihood ratio test (LRT). The likelihood ratio tests can also be used to test for homogeneity, symmetry and structural changes (Amemiya, 1985).

BGM – Properties & Elasticities

The adding-up, homogeneity and symmetry properties can all be imposed using restrictions on the parameters of the BGM. In particular, testing for symmetry requires that $e_{ij} = e_{ji}$. Since the BGM already has real income effects, only the price related parameters are involved in testing the homogeneity property ($\sum_j e_{ij} = 0$). However, testing for adding-up is not as straightforward.

If we add up the equations in BGM, we obtain:

$$\sum_i w_i d \ln q_i = \sum_i (d_i + \xi_1 w_i) d \ln Q + \sum_i \sum_j \left(e_{ij} - \xi_2 w_i \left(\delta_{ij} - w_j\right)\right) d \ln p_j ,$$

which can be simplified as,

$$\sum_i w_i d \ln q_i = d \ln Q \left(\xi_1 + \sum_i d_i \right) + \sum_j d \ln p_j \sum_i e_{ij} - \xi_2 \sum_i w_i \sum_j \left(\delta_{ij} - w_j\right) d \ln p_j .$$

Therefore, the adding-up condition requires that $\sum_i d_i = 1 - \xi_1$ and, $\sum_i e_{ij} = 0$.

Income elasticities for the BGM are expressed as:

$$\eta_i = \frac{d_i + \xi_1 w_i}{w_i},$$

and, the compensated price elasticities are expressed as:

$$\eta'_{ij} = \frac{e_{ij} - \xi_2 w_i \left(\delta_{ij} - w_j\right)}{w_i}.$$

Uncompensated price elasticities can then be recovered using Slutsky's equation. Finally, depending upon the values of the nesting parameters, ξ_1 and ξ_2 the elasticity formulae will be different as they will pertain to either the Rotterdam model or the LA/AIDS model or the CBS or the NBR models.

Data Description

The data set used in this study consists of quarterly observations of consumer demand and corresponding prices of seven major groups of dairy products including fluid milk, cream, yogurt, ice cream, butter, cheese, and skimmed milk powder in Ontario from 1986:1 to 2010:4. The per capita disappearance of each of the selected dairy product is used as a proxy for its demand and is measured as a sum of initial stock, domestic production and imports, less exports and stocks at the end of the period. While it does not account for spoilage or other wastage of the product in question, it does incorporate away-from-home consumption and its use in processed foods. Quantities of cream, skimmed milk power, cheese, butter, and yogurt consumed were converted (from either litres or kilograms of product) into equivalent litres of fluid milk using conversion factors supplied by the Dairy Farmers of Ontario (DFO)[1]. Statistics Canada does not report nominal prices of the selected dairy products consumed in Ontario. Instead, monthly, quarterly and yearly price indices for different dairy products are reported. We obtained quarterly price indices for the selected dairy products and converted them into nominal prices following the procedure used by Moschini and Vissa (1993).[2]

Summary statistics of the data used to estimate the demand system are reported in Table 1. Fluid milk has the largest budget share followed by cream, cheese and yogurt in Ontario. Except for cheese, the real prices of dairy products are fairly stable. However, they are

[1] We wish to thank Phil Cairns and Kristin Benke of the Dairy Farmers of Ontario for several helpful discussions and for providing us the revised conversion factors for Ontario.

[2] Data from the Family Food Expenditure Surveys as reported by Statistics Canada were obtained for the years 1986, 1990, 1992, 1996, 2001 and 2006. From weekly family expenditures and quantities consumed, prices of the commodities were calculated by dividing expenditures by quantities. The prices were then regressed on the respective annual consumer price indices for Ontario. The estimated coefficients were then used to generate nominal prices for the entire period.

more variable than the corresponding budget shares which is indicative of adjustments in volumes consumed over time. Figure 1 shows changes in per capita consumption of selected dairy products in Ontario. While the consumption of fluid milk, butter and skim milk powder declined over time, the consumption of cheese, cream, ice cream and yogurt all have increased. This is reflected in the evolution of budget shares for these dairy products which is presented in Figure 2. Despite a declining trend, fluid milk still has the largest budget shares among dairy products, followed by cream, cheese, ice cream and yogurt. The budget shares for butter and SMP slowly declined and remained very low in Ontario (Table 1 and Figure 2).

This study assumes a two-step budgeting procedure in total expenditure allocations by the consumers. In this framework, total expenditure is allocated to broad group of commodities in the first stage and then the expenditures allocated to broad groups are allocated to individual commodities within each group. Therefore, it is assumed that dairy products as a group is weakly separable from other commodities consumed in Ontario. Thus, the dairy demand system we estimate is a conditional demand system and the elasticities are conditional on the expenditure allocated to the dairy products as a group.

Econometric Estimation and Empirical Results:

Barten's General Model and four alternative specifications of a demand system such as the Rotterdam, AIDS, CBS and NBR were estimated employing quarterly data from 1986:1 to 2010:4. Since we used quarterly data, log differences are computed between the same quarters in consecutive years instead of log differences between two contiguous quarters in the same year. Also the shares used to multiply each of the equations were averages for the same quarters. All five systems were estimated with homogeneity and symmetry conditions imposed on them for the ease of comparison. We also tested for structural stability of the estimated model by splitting the data set into two sub-periods and using the likelihood ratio test for all five demand systems. To avoid singularity of the estimated variance-covariance matrix, it was necessary to drop one of the demand equations from the system and estimate n-1 system of equations. As it does not matter to the estimated parameters which equation is deleted (Barten, 1969), we dropped the demand equation for butter from each of the system before estimation. The parameters of all five demand systems are computed using the iterated seemingly unrelated regression procedure of

SHAZAM 11. Iteration ensures that the estimated parameters asymptotically approach their maximum likelihood values (Judge et al., 1980).

The hypotheses of homogeneity, symmetry and both homogeneity and symmetry are tested using the Wald test. To implement these tests, each demand system was estimated without imposing symmetry and homogeneity conditions. Then, we imposed these conditions separately and jointly on each of the five demand systems. Based on the Wald test, the maintenance of homogeneity and symmetry conditions either separately or jointly could not be rejected at 5 percent level of significance only for the NBR demand system (Table 2). These findings suggest that only the results from this functional specification are theoretically consistent with homogeneity and symmetry conditions. The acceptance of the homogeneity condition can be interpreted as an acceptance of the exogeneity of changes in income (Attfield, 1985).

Based on a number of discussions with DFO personnel, we explored the structural stability issues in the demand for major dairy products in Ontario by estimating the models with the full sample and with 1986:1-1996:4 and 1997:1-2010:4 sub-samples. Then, we examined if the estimated parameters from the sub-samples were significantly different from those of the full sample. The results of the likelihood ratio tests are presented in Table 3a and 3b. The results demonstrate that the estimated parameters from all five models are structurally stable over the study period. The results of the model selection test presented in Table 4 indicate that all but the NBR model are rejected at 5 percent level of significance. Thus, the NBR model can best explain the demand for major dairy products in Ontario. Accordingly, the NBR model is estimated with both homogeneity and symmetry conditions imposed on it prior to estimation. The estimated parameters of the NBR model also satisfy monotonicity and concavity conditions of the underlying cost function. Monotonicity is satisfied at each data point since all budget shares in this model are strictly positive.

The estimated parameters of the NBR model are presented in Table 5. The explanatory power of the model is satisfactory as indicated by the system's R^2 of 0.98. All estimated parameters are jointly significant as indicated by the test of overall significance which rejects the null hypothesis that the slope coefficients are jointly zero. The likelihood ratio statistics of the diagonal covariance matrix reveals that the model does not suffer from heteroskedasticity. Over 83% of the coefficients are statistically significant at 5% level of error probability. All expenditure coefficients are positive and statistically significant indicating that the budget shares for all dairy products would increase if total expenditure is increased.

Table 6 presents the estimated Marshallian elasticities of demand for seven major dairy products in Ontario. All but one of the estimated price elasticities and all expenditure elasticities appear to be inelastic. All own-price elasticities are negative and except that for the skim milk powder, all are statistically significant at the 5 percent level of error probability. The Marshallian own-price elasticity of demand for fluid milk, butter, cheese, yogurt, ice cream, cream and skim milk powder respectively are -0.71, -0.41, -0.73, -0.87, -1.15, -1.40 and -0.82. The negative and statistically significant own-price elasticity of demand for all dairy products suggest that the corresponding demand curves are downward sloping and hence, satisfy the law of demand. All expenditure elasticities are positive and statistically significant at the 5 percent level. Since the expenditure elasticities of all dairy products considered in this study are less than unity, they can be considered as necessary goods in Ontario.

Since the Hicksian elasticities of demand can capture only the substitution effect and leave out the income effect, they can be used to shed lights on the substitutability of major dairy products in consumption. The Hicksian elasticities of demand are negative but smaller than their Marshallian counterparts (Table 7). In particular, the Hicksian own-price elasticity of demand for fluid milk, butter, cheese, yogurt, ice cream, cream and skim milk powder are -0.57, -0.41, -0.72, -0.84, -1.08, -1.24 and -0.79 respectively. The concavity of the cost function at the sample mean is ensured since all own-price Hicksian elasticities are negative. Since all own-price Hicksian elasticities are statistically significant at 5% level, the underlying Slutsky matrix is negative semi-definite. The cross-price Hicksian elasticities suggest that over 76% are net substitutes in consumption in Ontario (Table 7).

How consistent are the estimated elasticities of demand for dairy products in Ontario with other studies? The estimated elasticity of demand for fluid milk in Ontario presented in this article is much higher than those reported in previous studies (Table 8). These differences can be attributed to differences in purposes, data, periods covered and methods employed. While Goddard and Tielu (1988) used the Linear Expenditure System to measure elasticity of demand for fluid milk, both Venkateswaran and Kinnucan (1990) and Goddard and McCutcheon (1993) used single equation demand functions to estimate the price elasticity of demand for fluid milk in Ontario. None of these studies either estimated the Hicksian demand for fluid milk or estimated demand for butter, cheese, yogurt, ice cream, cream and skim milk powder consumed in Ontario. Therefore, this article makes an important empirical contribution by being the first study to estimate and report the elasticity of demand for seven major dairy products in Ontario employing a theoretically consistent demand system. While the use of time series econometrics may generate a different set of estimated price and income elasticities, they are less likely to be very different from the results presented in this paper because we estimated a differential demand system.

Canada is a vast country with significant regional differences in soil and climatic conditions, resource endowments and consumption behaviours. These differences are likely to influence the nature of dairy consumption across provinces in Canada. The differences in the allocations of dairy production entitlements across provinces under the Supply Management system and the discovery of differences in dairy consumption patterns across provinces can have significant policy implications. It is likely that the incorporation of province-specific price and income elasticities of demand for major dairy products in economic analysis will generate different set of welfare consequences for Canada as a whole and for different provinces. The province-specific estimates can also be used to generate the impacts of future trade agreements and how those impacts would be distributed across provinces. It is hoped that the new results will better inform long-term policy choices in Canadian agriculture.

Concluding Remarks:

Supply management as a policy tool in the dairy sector in Canada has been controversial since its introduction in the mid 1960s. A number of factors churned up the controversies in recent years. While there are strong proponents and opponents of supply management in the dairy sector, the arguments are often filled with guesstimates because no one has estimated a set of reliable price and income elasticities of demand for major dairy products consumed in Ontario or in any other provinces in Canada. An attempt is made in this article to bridge this gap by estimating a demand system for seven major dairy products in Ontario employing quarterly data from 1986:1 to 2010:4. Barten’s (1993) General model and the data driven approach has been used to determine the most appropriate functional specification of the demand system, given the data set for seven major dairy products in Ontario.

The estimated model (the NBR demand system) fits the data well. In additional, standard statistical tests of model adequacy were satisfactory. In particular, the NBR model supported the theoretical properties of homogeneity and symmetry. It also satisfies the montonicity and concavity conditions. Thus, the estimated price and income elasticities of demand for dairy products in Ontario reported in this article are theoretically consistent, reliable and valid for policy analysis.

All own-price elasticities have the expected negative sign and all are statistically significant at the 5% level. All Hicksian elasticities are smaller than their Marshallian counterparts as expected. All expenditure elasticities are positive and significant at the 5% level indicating that all dairy products are considered necessary goods in Ontario. All but two estimated own-price elasticities are less than unity. While cross-price elasticities of demand for dairy products vary across commodities, more than three-quarter of those are positive. Previous elasticity estimate of demand for fluid milk in Ontario are much lower than those reported in this article. It is hoped that the price and income elasticities of demand reported in this article will lead to interesting policy analysis and contribute to more informed policy choices in the long-run in Canadian agriculture.

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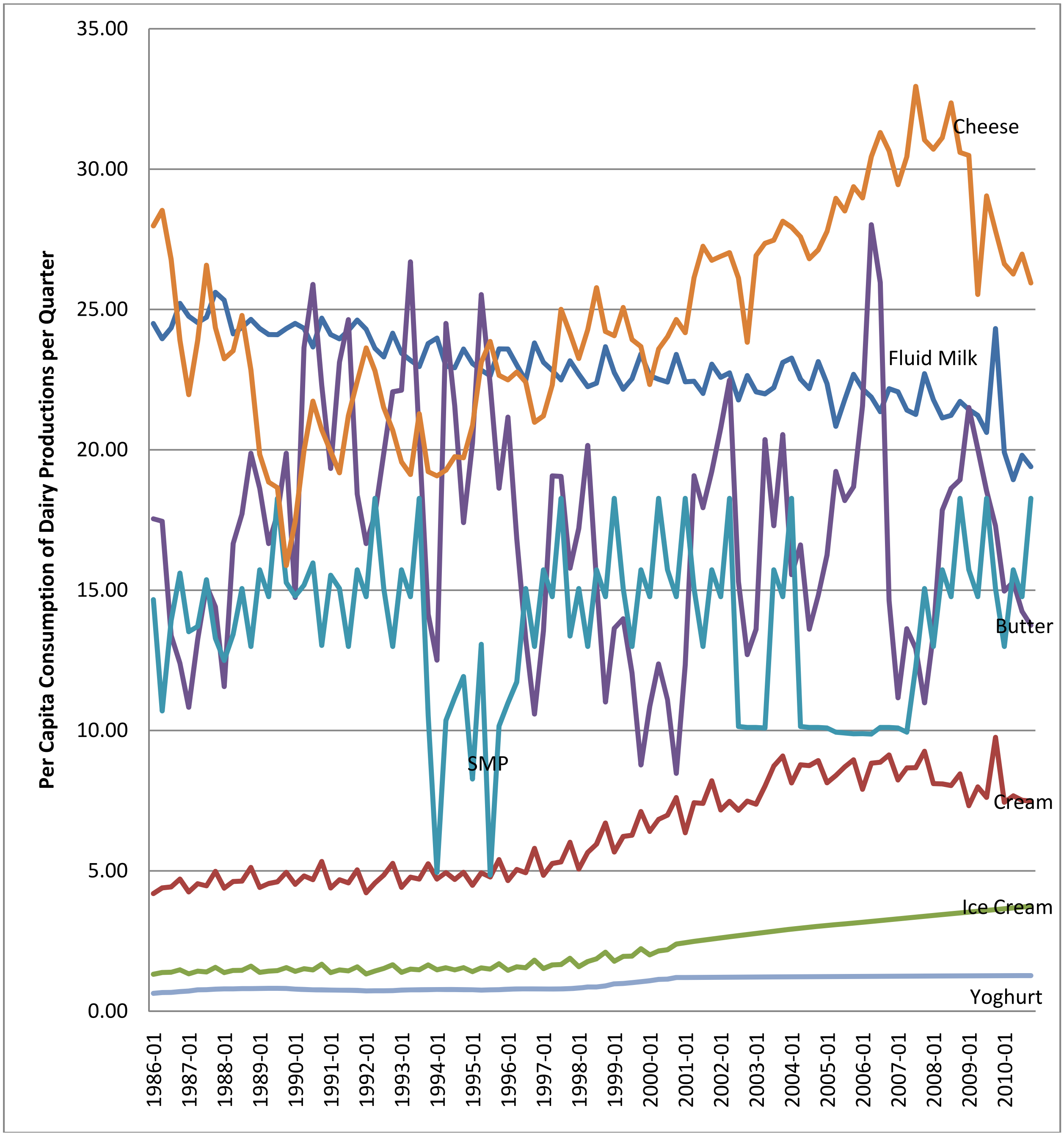

Figure 1. Changes in the Consumption of Seven Dairy Products in Ontario

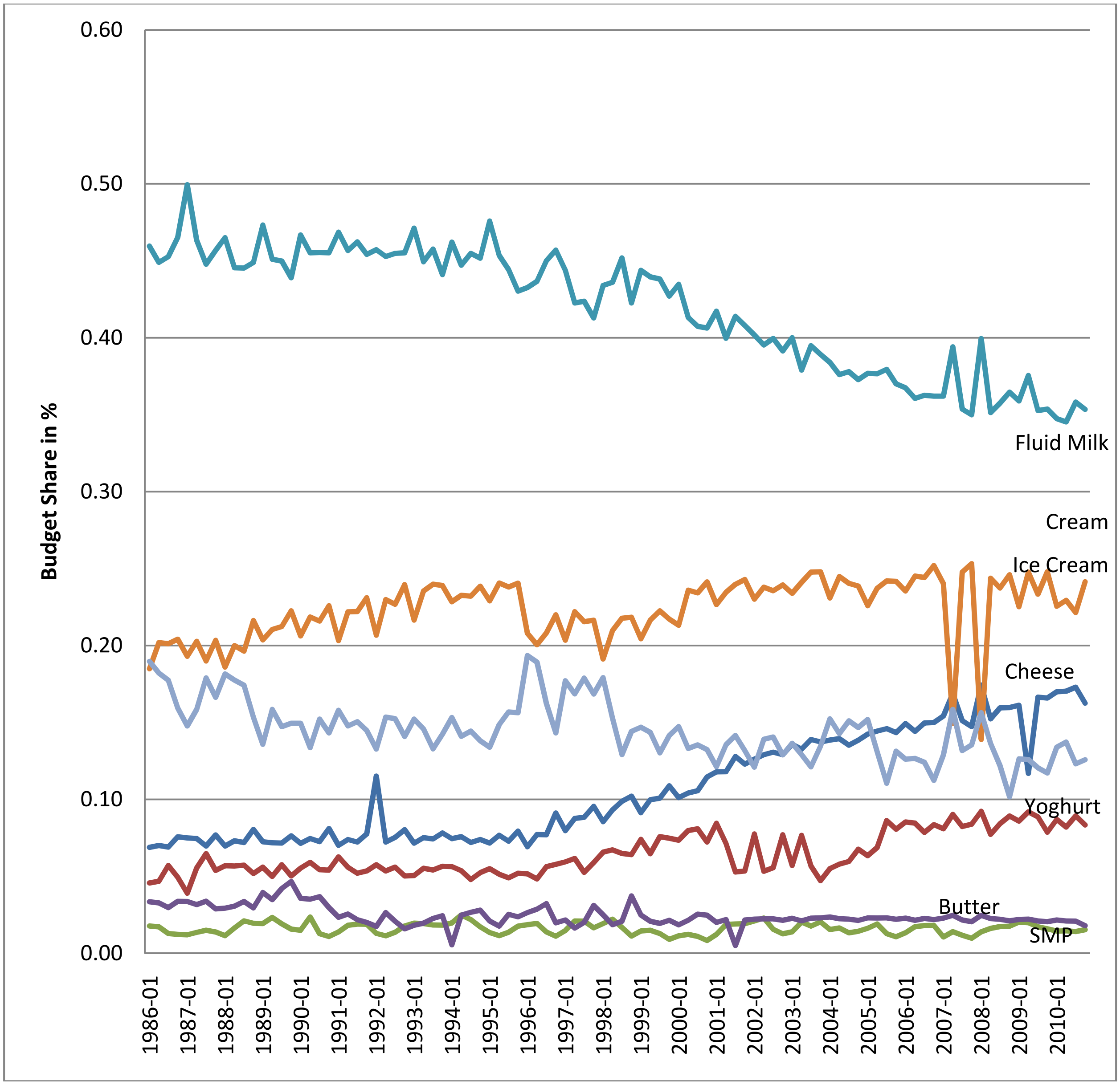

Figure 2. Evolution of Budget/Expenditure Shares of Major Dairy Products in Ontario

Table 1. Summary Statistics of Prices and Budget Shares of Major Dairy Products in Ontario

Variable	Mean	Standard Dev.	Min	Max
Real Prices				
Cream	4.08	0.12	3.89	4.43
Yogurt	4.38	0.36	3.81	5.28
Butter	0.92	0.07	0.80	1.10
Cheese	14.10	2.10	10.66	19.14
SMP	7.34	0.14	7.07	7.65
Ice Cream	1.82	0.18	1.54	2.29
Fluid Milk	2.81	0.37	2.21	3.68
Budget Shares				
Cream	0.2200	0.0200	0.1400	0.2500
Yogurt	0.0600	0.0140	0.0400	0.0900
Butter	0.0200	0.0040	0.0100	0.0200
Cheese	0.1500	0.0187	0.1000	0.1900
SMP	0.0200	0.0060	0.0100	0.0500
Ice Cream	0.1100	0.0350	0.0700	0.1700
Fluid Milk	0.4200	0.0390	0.3500	0.5000

Table 2. Statistical Test for Homogeneity and Symmetry Conditions

Models	**LLV^{U}**	**LLV^{H}**	**LRT^{H}**	**LLV^{S}**	**LRT^{S}**	**LLV$^{S\$H}$**	**LRT$^{S\$H}$**
Barten's	1927.54	1896.71	61.66	1916.46	22.16	1897.72	59.64
AIDS	1791.87	1765.53	52.68	1759.65	64.44	1768.00	47.74
Rotterdam	1850.54	1832.03	37.02	1844.88	11.32	1836.30	28.48
CBS	1873.62	1868.15	10.94	1846.07	55.10	1854.58	38.08
NBR	1724.75	1720.51	8.48	1713.35	22.80	1710.11	29.28
Degrees of Freedom		6	6	15	15	21	21
Critical value[1] ($\boldsymbol{x^2}$)		12.59	12.59	24.99	24.99	32.67	32.67

[1]At the 5% level of significance

Notes: LLV^{U} : Unrestricted; LLV^{H} : Homogeneity; LLV^{S} : Symmetry

Table 3a. Statistical Test for Structural Stability

Sub-Period	**1986-1996**			
Models	**Unrestricted Likelihood Ratio Test**	**Homogeneity Likelihood Ratio Test**	**Symmetry Likelihood Ratio Test**	**Symmetry and Homogeneity Likelihood Ratio Test**
Barten's (Unrestricted)	4.12	4.10	4.12	4.14
AIDS	3.90	3.89	3.89	3.89
Rotterdam	4.12	4.09	4.11	4.13
CBS	3.80	3.80	3.80	3.79
NBR	3.98	3.99	3.98	3.98
Critical value (x^2)[1]	37.65	37.65	37.65	37.65

[1]At the 5% level of significance with 35 degrees of freedom

Table 3b. Statistical Test for Structural Stability

Sub-Period	**1997-2010**			
Models	**Unrestricted Likelihood Ratio Test**	**Homogeneity Likelihood Ratio Test**	**Symmetry Likelihood Ratio Test**	**Symmetry and Homogeneity Likelihood Ratio Test**
Barten's (Unrestricted)	5.14	5.11	5.12	4.09
AIDS	4.85	4.85	4.85	3.82
Rotterdam	5.12	5.10	5.11	4.07
CBS	4.75	4.74	4.74	3.74
NBR	4.97	4.97	4.97	3.94
Critical x^2 value[1]	24.99	24.99	24.99	24.99

[1]At the 5% level of significance with 15 degrees of freedom

Table 4. Statistical Test for Model Selection

Models	**Log of Likelihood Values**	**Likelihood Ratio Test**	**Critical Value[1] (x^2)**
Barten's (Unrestricted)	1751.51		
AIDS	1741.38	20.26	
Rotterdam	1744.19	14.64	5.99
CBS	1734.41	34.2	
NBR	1749.05	4.92	

[1] Because the functional form restrictions are based on two parameters in the general model, the Likelihood Ratio Test is distributed as x^2 with two degrees of freedom. The critical value is 5.99 at the 5% level of significance.

Table 5 Parameter Estimates of the NBR Model for Seven Dairy Products in Ontario

	C_i	a_{iFM}	a_{iCS}	a_{iYO}	a_{iIC}	a_{iCM}	a_{iSMP}	a_{iBU}	β_i	DW_i	System R^2
FM	0.2163	-0.2291	0.0400	0.0065	0.0262	0.0205	-0.0088	0.0053	0.1394	1.8783	
	(0.0073)	(0.0125)	(0.0109)	(0.0060)	(0.0104)	(0.0122)	(0.0044)	(0.0009)	(0.0114)		
CS	0.2587	0.0400	-0.2315	0.0010	0.0322	0.0112	-0.0120	-0.0359	0.1949	1.6820	
	(0.0109)	(0.0109)	(0.0191)	(0.0007)	(0.0127)	(0.0014)	(0.0051)	(0.0124)	(0.0143)		
YO	0.0472	0.0065	0.0010	-0.0882	0.0022	0.0307	0.0018	0.0121	0.0339	1.7226	0.98
	(0.0035)	(0.0006)	(0.0007)	(0.0112)	(0.0075)	(0.0097)	(0.0005)	(0.0053)	(0.0093)		
IC	0.0234	0.0262	0.0322	0.0022	-0.1413	0.0203	0.0128	-0.0156	0.0632	1.2635	
	(0.0080)	(0.0104)	(0.0127)	(0.0075)	(0.0171)	(0.0103)	(0.0053)	(0.0103)	(0.0139)		
CM	0.2597	(0.0205)	0.0112	0.0307	0.0203	-0.2415	-0.0078	0.0059	0.1608	1.6191	
	(0.0085)	(0.0102)	(0.0043)	(0.0097)	(0.0014)	(0.0240)	(0.0068)	(0.0110)	(0.0178)		
SMP	0.0240	-0.0088	-0.0120	0.0018	0.0128	-0.0078	-0.0130	-0.0056	0.0326	1.5443	
	(0.0027)	(0.0044)	(0.0051)	(0.0005)	(0.0053)	(0.0068)	(0.0045)	(0.0038)	(0.0058)		

FM=Fluid Milk, CS=Cheese, YO=Yoghurt, IC=Ice Cream, SMP=Skim Milk Powder, BU=Butter

Table 6. Marshallian Elasticities of Demand for Major Dairy Products in Ontario

	Fluid Milk	Butter	Cheese	Yoghurt	Ice Cream	Cream	Skim Milk Powder	Expenditure Elasticity
Fluid Milk	-0.7118	-0.1222	-0.0542	-0.2528	-0.0904	-0.1637	-0.8272	0.3483
	(0.1158)	(0.0717)	(0.1855)	(0.1204)	(0.1201)	(0.1344)	(0.2924)	(0.0284)
Butter	-0.1805	-0.4148	-0.5957	0.5652	-0.7129	0.0592	-0.4433	0.3760
	(0.1256)	(0.0314)	(0.0128)	(0.2789)	(0.1270)	(0.0046)	(0.0657)	(0.0206)
Cheese	1.2869	-0.0614	-0.7264	0.1152	0.2482	0.0134	0.0792	1.146
	(0.1222)	(0.0797)	(0.2114)	(0.1152)	(0.2238)	(0.1462)	(0.3189)	(0.1149)
Yoghurt	-0.1592	0.2228	0.0198	-0.8745	0.0820	0.1487	0.1622	0.5650
	(0.0329)	(0.0649)	(0.0525)	(0.0232)	(0.0268)	(0.0934)	(0.0887)	(0.1636)
Ice Cream	-0.1648	0.0538	0.1517	0.1096	-1.1485	0.0207	0.2209	0.5745
	(0.0121)	(0.1810)	(0.0084)	(0.0842)	(0.0955)	(0.2833)	(0.2118)	(0.1622)
Cream	0.8872	0.1642	-0.1084	0.2291	0.0667	-1.4021	0.0836	0.7310
	(0.2157)	(0.0135)	(0.3390)	(0.1529)	(0.1683)	(0.2364)	(0.0155)	(0.1438)
Skim M.P.	-0.3883	0.0833	-0.1977	0.0757	0.0531	-0.2603	-0.8238	0.6630
	(0.0402)	(0.0254)	(0.0728)	(0.0291)	(0.0346)	(0.0460)	(0.0627)	(0.1510)

Notes: Standard errors in parenthesis

Table 7. Hicksian Elasticities of Demand for Major Dairy Products in Ontario

	Fluid Milk	Butter	Cheese	Yoghurt	Ice Cream	Cream	Skim Milk Powder
Fluid Milk	-0.5724	-0.1153	0.0050	-0.2319	-0.0521	-0.0871	-0.8203
	(0.0201)	(0.0485)	(0.0236)	(0.0194)	(0.0103)	(0.0283)	(0.0469)
Butter	-0.1153	-0.4115	-0.5680	0.5750	-0.6950	0.0950	-0.4400
	(0.1200)	(0.2653)	(0.1273)	(0.2092)	(0.0054)	(0.1462)	(0.2057)
Cheese	1.2915	-0.0612	-0.7244	0.1159	0.2494	0.0159	0.0794
	(0.1102)	(0.2813)	(0.0949)	(0.0740)	(0.0058)	(0.0971)	(0.1426)
Yoghurt	0.0670	0.2341	0.1159	-0.8406	0.1441	0.2730	0.1735
	(0.0842)	(0.0211)	(0.0955)	(0.1810)	(0.2833)	(0.1121)	(0.0183)
Ice Cream	0.0651	0.0653	0.2494	0.1441	-1.0853	0.1471	0.2324
	(0.0934)	(0.3114)	(0.0209)	(0.0736)	(0.1584)	(0.0086)	(0.1649)
Cream	1.1797	0.1788	0.0159	0.2730	0.1471	-1.2413	0.0982
	(0.0842)	(0.2118)	(0.0955)	(0.1810)	(0.2833)	(0.1121)	(0.1837)
Skim Milk Powder	0.2641	0.1159	0.0794	0.1735	0.2324	0.0982	-0.7912
	(0.1102)	(0.2813)	(0.0949)	(0.0740)	(0.1518)	(0.0371)	(0.1426)

Notes: Standard errors in parenthesis.

Table 8. Comparison of Own-Price Elasticities of Demand for Major Dairy Products in Ontario

Study	Area	Period	Marshallian Estimates							Hicksian Estimates						
			FM	BU	CS	YO	IC	CM	SMP	FM	BU	CS	YO	IC	CM	SMP
Goddard and Tielu	Ontario	1971-84	-0.25													
Venkateswa-ran & Kinnucan	Ontario	1973-84	-0.19													
Goddard & McCutcheon	Ontario	1981-89	-0.24													
This Study	Ontario	1986-2010	-0.71	-0.41	-0.73	-0.87	-1.15	-1.4	-0.82	-0.57	-0.41	-0.72	-0.84	-1.09	-1.24	-0.79

FM=Fluid Milk, BU=Butter, CS= Cheese, YO=Yogurt, IC=Ice Cream, CM= Cream and SMP= Skim Milk Powder