OLIGOPOLY POWER IN THE CANADIAN DAIRY INDUSTRY

by

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Abstract

This study measures market power in the Canadian dairy industry, given the historically regulated marketing system. In doing so, this study is the first to simultaneously test for oligopoly power at more than one market level. To this end, an econometric model of the fluid milk production, processing and retail sectors is estimated. Results indicate that oligopoly power; of varying degrees, exists in each sector of the dairy industry. For example, over the period 1976 to 1994, farmers on average were able to elevate marginal cost price 31 percent above their actual marginal cost. The presence of market power suggests that researchers should be cautious when making the assumption of perfect competition in the Canadian dairy industry. Incorrect characterization of perfect competition may bias the results, and interpretation of agricultural policy analysis.

Introduction

The Canadian dairy industry operates under a supply management system. This system insulates producers, processors, retailers and consumers from the volatility of the world dairy market. The principal objective of supply management is to provide efficient producers with a fair and equitable return to labour and investment. To accomplish this, supply management is based on cost of production pricing, provincial production quotas, and binding import restrictions.

Agricultural policy analysis typically makes the simplifying assumption that market participants operate in a perfectly competitive environment. However, research has shown that Canadian dairy processors possess oligopoly power, or the ability to influence output price (Rude, 1992; Cranfield et al, 1994). As such, the assumption of perfect competition may bias policy results.

To prevent bias and inappropriate policy analysis, it is also important to consider whether there is also oligopoly power in the farm and retail sectors of the Canadian dairy industry. With the trend toward industry concentration in both sectors there is a strong possibility that market power may have developed; market power over and above that generated from the regulations of supply management. Moreover, the imposition of binding import restrictions may have enhanced the environment for market power.

The purpose of this study is to measure the oligopoly power of Canadian dairy farmers, processors, and retailers given the historically regulated market structure. To this end, an econometric model; which accounts for potential oligopoly power in each sector of the Canadian fluid milk industry is estimated for historical periods. In doing so, this study is the first to simultaneously test for oligopoly power at more than one market level. Fluid milk is isolated from the rest of the market because of the formidable time, data and technical requirements of also incorporating industrial milk. The impact of oligopoly power on marketing decisions throughout

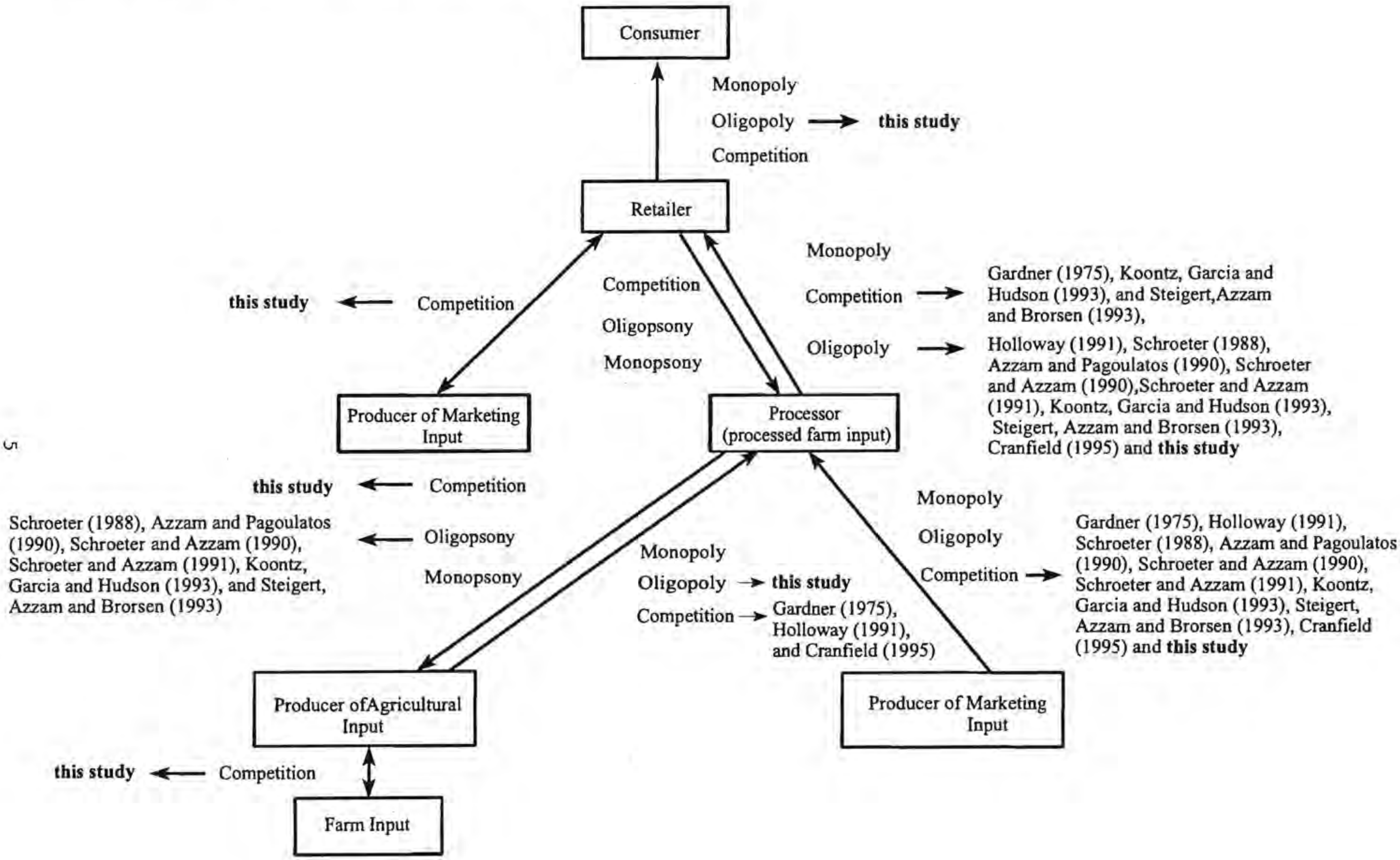
Table 1. Summary of Previous Market Power Studies

Author	Market Power Tested	Functional Form and Production Technology	Aggregation	Output(s)	Analytical Tool	Other	Results
Iwata (1976)	Oligopoly	Linear marginal cost and Const. Returns to Scale (CRS)	Firm level	Flat glass	NA	Proposes an econometric approach to price determination in oligopoly	Interdependent behaviour
Appelbaum (1979)	Monopoly	Generalized Leontief (GL) and CRS	Industry Level	Crude petroleum and natural gas	3SLS	Pioneering econometric study to test imperfect competition	Rejects price taking behaviour
Gollop and Roberts (1979)	Oligopoly	Translog prod'n function and unrestricted returns to scale (URS)	benchmark firm vs. non benchmark firm	Roasted coffee	Non-linear 3SLS	Estimated CV using firm level data	Interdependent behaviour
Appelbaum (1982)	Oligopoly	GL and CRS	indsutry	Rubber, textile, electrical machine, tobacco	FILM	First study to econometrically measure CV elasticity	Rubber is competitive, others are oligopoly
Roberts (1984)	Oligopoly	GL shadow price profit function and URS	leading firm and price taking firms	Roasted coffee	Zellner SUR	Estimated CV using firm level data and tested a dominant firm model	Interdependent behaviour
Lopez (1984)	Oligopoly	GL and CRS	Industry	Aggregate	Max. Likelihood	Linear version of Appelbaum (1982) model	Rejects price taking behaviour
Schroeter (1988)	Oligopoly and Oligopsony	GL and CRS	Industry	Beef	FIML	First to extend oligopoly model to oligopsony	Rejects price taking behaviour
Azzam and Pagoulatos (1990)	Oligopoly and Oligopsony	Translog prod'n function and unrestricted homotheticity, homogeneity and elasticity of substitution	Industry	Meat	Non linear 3SLS	Estimated oligopsony power without restricting CV to be equal	Market power in both meat and livestock markets
Schroeter and Azzam (1990)	Oligopoly and Oligopsony	GL and CRS	Industry	Beef and Pork	3SLS	Joint production of output which are demand related	Rejects price taking behaviour
Buschena and Perloff (1991)	Oligopoly	Linear and CRS	Firm	Coconut	3SLS	Application of CVelasticity at the export market	Rejects price taking behaviour
Schroeter and Azzam (1991)	Oligopoly and Oligopsony	GL and CRS	Industry	Pork	FIML	Extends market power under uncertainty	After 1980 Rejects price taking behaviour
Wann and Sexton (1992)	Oligopoly and Oligopsony	GL and CRS	Industry	Canned pears and fruit cocktail	Max. Likelihood	Extends to multiple outputs	Rejects price taking behaviour

Rude (1992)	Oligopoly	GL and increasing returns to scale (IRS)	Industry	Butter, cheese, concentrated and soft product	SUR	First to use CV elasticity in trade model	Rejects price taking behaviour
Karp and Perloff (1993)	Oligopoly	Constant marginal cost and Leontief	Brazil and Colombia as two large firms	Coffee	SUR	Uses a dynamic feed back model	Brazil and Colombia are closer to price taking than collusion
Koontz, Garcia and Hudson (1993)	Oligopsony	Leontief and CRS	Industry	Fed cattle	Max. Likelihood	Develops a non cooperative game theoretic model of meatpacker conduct	Rejects price taking behaviour
Powers (1993)	Oligopoly	CRS	Industry	California navel oranges	2SLS	Develops a structural model to measure market power when sellers can influence quantities sold to specific markets	Rejects price taking behaviour
Stiegert, Azzam and Brorsen (1993)	Oligopsony	GL and CRS	Industry	Fed Cattle	SUR	Develops a mark down function to to explain the wedge between fed cattle price and its MVP	Rejects price taking behaviour in most of the sample period
Hyde and Perloff (1994)	Monopsony	Cobb-Douglas, and decreasing, constant and increasing returns to scale	NA	NA	Estimation is not conducted, although simulations of the structural model are conducted	Uses Monte Carlo simulations to compare the strength of a structural model, and a nonstructural method in estimating monopsony power	Each method has specific weaknesses, proper specification and returns to scale are the most significant factors
Love and Shumway (1994)	Monopsony	Normalized quadratic restricted cost function	Simulated firm level data	Agricultural processing firms	Non - parametric techniques	Extends market power analysis to nonparametric techniques	Suggests nonparametric market power estimates are consistent with empirical estimates
Rogers and Sexton (1994)	Oligopsony	Cobb-Douglas and CRS	Industry	Agriculture	Estimation is not conducted	Develops a theoretical model to illustrate how high buyer concentration and transport cost, and noncompetitive buyer conduct effect the farm-retail price spread	Monopsony and oligopsony issues deserve evaluation in food industry debates
Cranfield (1995)	Oligopoly	GL and CRS	Industry	Beef	LSQ	Includes advertising and aggregation across countries	Rejects price taking behaviour

Bhuyan and Lopez (1995)	Oligopoly	Translog prod'n function and URS	Industry	39 products	Zellner SUR	Cover almost all the food processing industries	Rejects price taking behaviour in most industries
Sellen et al (1995)	Oligopoly and Oligopsony	GL and CRS	Industry	Roasted Coffee	FIML	Market power explained by advertising	Rejects price taking behaviour
Suzuki et al (1996)	Oligopoly	double and semi log demand and CRS	Industry	Fluid and industrial milk	2SLS	Estimates market power through algebraic expression rather than dual relationships to the cost function	Rejects price taking behaviour
Duff (1996)	Oligopoly	GL and CRS	Industry	Fluid milk	LSQ	First to measure market power at 3 levels simultaneously	Rejects price taking behaviour in each market

Figure 1. Vertical Market Structure from Selected Market Power Studies



output market and under perfect competition (θ=0) in the input market. Again, independence is invalid if the analysis utilizes simple technologies such as constant proportions and Cobb-Douglas with a single input or multiple inputs with perfect substitutability.

The framework for each sector is the jth firm's profit maximization decision. This produces the following first order condition: $P = (\partial C_j / \partial Q_j)/(1 + \theta_j/\eta_j)$ **(1)**. θ_j is the jth firm's conjectural elasticity, which measures the percentage change in industry output given a one percent change in the firm's output. η_j is the jth firm's price elasticity of demand. Thus, the output price for each dairy sector will be determined by a mark-up above marginal cost, as in (1), equal to θ_j/η_j. Because, for example, processor's output price is an input price facing retailers, the first order condition (1) for each sector is linked through the input price of milk which is a variable in the marginal cost function $(\partial C_j / \partial Q_j)$.

Using the above result, Appelbaum derives Lerner's index $L_j = \theta_j/\eta_j$ of oligopoly power. In a perfectly competitive market, θ_j equals zero, and L_j is also zero. Under monopoly, θ_j is one, and L_j is the inverse of the demand elasticity. $_j\theta$ may also lie between zero and one, suggesting an oligopoly.

Insufficient data commonly makes firm level analysis difficult. Appelbaum achieves an industry specification, by assuming firm's possess a quasi-homothetic cost function, $C^j(w_i) = Q^j c(w_i) + G^j(w_i)$.[1] Thus, all firms face identical marginal costs, output price, own price demand elasticities, and conjectural elasticities. Subsequently, both (1) and the Lerner's index can be written without j subscripts, representing an industry average.

The first order condition **(1)**; also known as the pseudo-supply function, allows parametric

[1] Appelbaum uses a Gorman polar form of the Generalized Leontief cost function.

estimation of the conjectural elasticity, θ. Doing so holds the elasticity constant over the entire sample period. This restrictive assumption can be eliminated by specifying a structural equation for θ and substituting this into the pseudo-supply function. Past research has specified θ as a function of exogenous input prices, time and dummy variables (Appelbaum (1982), Lopez (1984), and Cranfield (1996)). Despite this example, there is no formal theory regarding the determinants of θ. As such, included variables are at the discretion of the researcher. While measures of concentration, and productivity appear to be theoretically consistent choices, again, there is no direct theory to either support or refute this practice. This presents a potential limitation in parametric estimation of firm conjectures.

To complete a model of the Canadian dairy industry, a farm level supply function must be estimated. With **supply management**, the cost of production farm price and supply are not related to the supply curve but to processor demand. Thus, the recorded market price can not be used to estimate underlying supply parameters. The difference between fluid milk price and static (one period) quota value should equal the marginal cost price (MCP). Static quota value (STQV) can be determined by discounting the capitalized value of fluid milk quota (Moschini, 1989). In discounting the value of quota, it is assumed that the chosen discount rate reflects the risk of the asset, nominal interest rates and expected capital gains.

MCP is theoretically consistent with the supply curve, assuming perfect competition in the farm sector. However, this study allows for farmer oligopoly power. In this case, the actual marginal cost (FMC) of dairy farmers, not MCP is consistent with the supply curve. Because of oligopoly power, MCP now includes a mark-up above FMC. Therefore, to derive the underlying supply equation; given farmer oligopoly power, it is necessary to first establish the relationship between MCP and FMC using the first condition discussed above, and then link quantity supplied with producer's actual marginal cost (FMC).

Figure 2 summarizes diagrammatically the conceptual model developed above. For simplicity, only the farm and retail markets are discussed here. Oligopoly power allows retail price (RP) to exceed marginal cost (RMC). Retail quantity is lower than under perfect competition, but higher than under monopoly. Farm production quota/supply (FSFM) is based on market demand at the cost of production price (FP). Thus, CDFM = FSFM allowing market equilibrium. The difference between FP and STQV should equal MCP. Marginal cost price is theoretically consistent with the supply curve under perfect competition. However, this framework accounts for producer oligopoly power. Thus, in Figure 2 MCP exceeds FMC because of producer market power, aside from that provided by supply management.

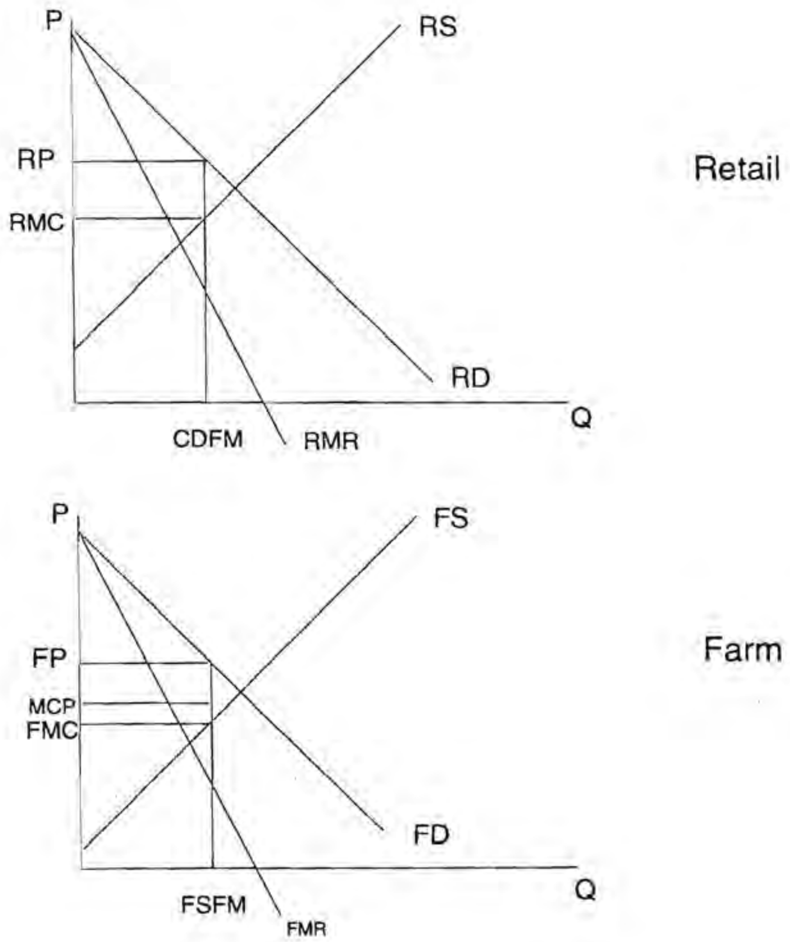
It is important to note that any estimated difference between MCP and FMC may be due in part to potential thinness or insufficient trading volume in the quota exchange market. While economic theory does not define a necessary volume of exchange to accurately reflect market valuation, a thin market has the potential to undervalue production quota. Undervaluation; if it occurs, may contribute to the empirical difference between MCP and marginal cost (FMC), thus overstating producer oligopoly power.

Empirical Framework

This section specifies an imperfect competition model of the Canadian dairy industry (see Figure 3)[2]. First, consumer fluid milk demand is specified below. Following Goddard and

[2] Figure 3 illustrates the determinants of each dependent variable, and where the linkages between market levels occur. Capitalized letters in the title of each equation box represent the acronym for the corresponding dependent variable. See also Appendix 1.

Figure 2. Canadian Retail and Farm Fluid Milk Markets



McCutcheon (1993) it is assumed that aggregate consumer demand for fluid milk (CDFM) can be represented by a linear functional form:

$$CDFM = \alpha_1 + \beta_{21}RP + \beta_{12}PCDI + \beta_{13}RPJCE + \beta_{14}T + \beta_{15}CDFM(-1) + \beta_{16}\,RPSDK \tag{1}$$

where: $\alpha_1, \beta_{11}, \beta_{12}, \beta_{13}, \beta_{14}, \beta_{15}, \beta_{16}$ ≡ parameters to be estimated
RPFM, RPJCE, RPSDK ≡ retail price of fluid milk, juice and soft drink
PCDI ≡ per capita income.
T ≡ time trend
CDFM(-1) ≡ lagged dependant variable allowing for habit persistence

Following Appelbaum (1982), this study uses a Gorman polar form of the Generalized Leontief (GL) cost function. The GL functional form permits linear aggregation, thus imposing constant returns to scale. The cost function used for each of the retail, processor and farm sectors is defined as:

$$C = \sum_i \sum_j \beta_{ij}(w_i w_j)^{1/2} Q + \sum_i \beta_i w_i \qquad i,j = K,L,F,M \tag{2}$$

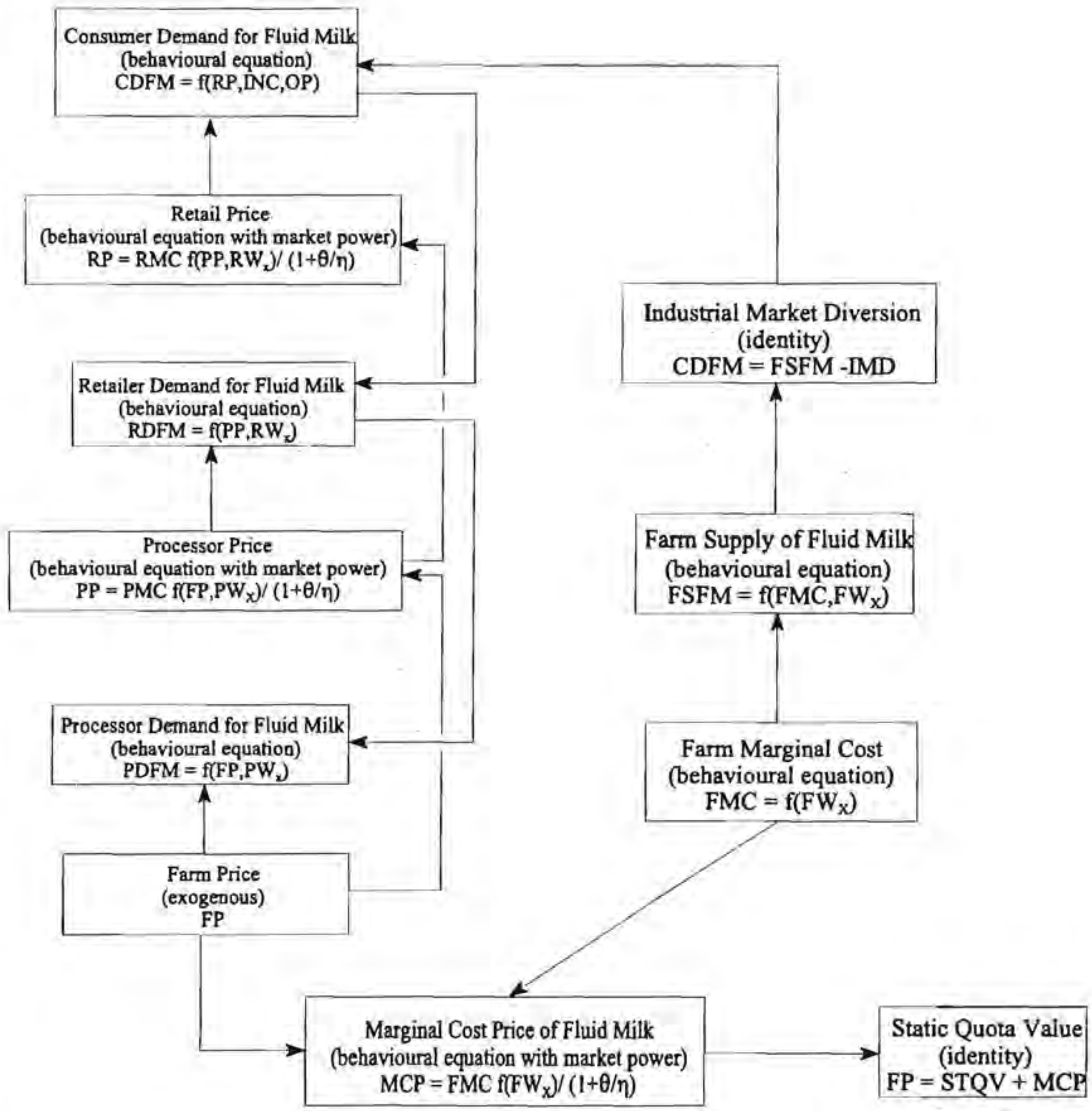
where: β_i, β_{ij} ≡ parameters to be estimated
w_i ≡ ith input's unit cost or price
Q ≡ output: **retailer** - Total Retail Food Sales; **processor** - retailer demand for fluid milk; **farmer** - processor demand for raw fluid milk
K,L,F,M, ≡ denote for: **retailer** - capital, labour, food sales other than fluid milk, packaged fluid milk; **processor** - capital, labour, fuel and electricity, raw fluid milk; **farmer** - capital, labour, direct cash inputs - including feed, building, crop and other cash costs, (no M input) - for a complete definition of each variable see Appendix 1

From this cost function, Shephard's Lemma permits derivation of conditional input demand functions:

$$\frac{\partial C}{\partial w_i} = \beta_i + (\sum_i \sum_j \beta_{ij}(w_i w_j)^{1/2} + \beta_{ii})Q \tag{3}$$

The final equation required to measure oligopoly power of retailers, processors and farmers is the first order condition of the firm's profit maximizing decision. Specifically this is defined as:

Figure 3. Model of the Canadian Fluid Milk Market [1]



[1] A separate estimate of θ and η is produced for each behavioural equation with market power presented above.

$$P = \frac{\sum_{i} \beta_{ii} w_i + 2\sum_{i=1}^{n}\sum_{j=1}^{k} \beta_{ij}(w_i w_j)^{1/2}}{(1+\frac{\theta}{\eta})} \tag{4}$$

where P is the output price of fluid milk and correspondingly the milk input price for some sectors, θ is the conjectural elasticity, and η is the demand elasticity facing the sector in question. In the farm sector, P is the marginal cost price, MCP. Determination of output price and other dependent variables in the model is further illustrated in Figure 3.

Each sector's conjectural elasticity θ, is expressed as a function of the following variables: 1) industry concentration, 2) time trend, representing technological progress, and 3) input prices, representing changes in market conditions not determined by the model. This specification follows the work of Appelbaum (1982), Lopez (1984), and Cranfield (1996).

Demand elasticities are calculated from the demand equation facing each sector. For example, the demand elasticity facing retailers is derived by from the consumer demand function (1). Conversely, the demand elasticity facing processors and farmers is derived from the fluid milk input demand functions of retailers and processors, respectively.

To close the model, a few equations and identities are required. First, an identity establishing the cost of production farm price[3] as the sum of marginal cost price and static quota value, is needed. This equality links dairy producers' first order condition to the processing sector through the farm (input) price of raw milk.

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[3] The price farmers receive is based on a cost of production formula which includes cash costs (feed, electricity, etc), interest on non-quota debt, depreciation on cattle, buildings and machinery, and a return to labour and equity. Each component comprises a fixed percentage of the base price. As individual components change, the base price is altered accordingly.

$$FP = MCP + STQV \quad (5)$$

The farm fluid milk supply function is defined as

$$FSFM = \alpha_2 + \beta_{21}FMC + \beta_{22}FSFM(-1) + \beta_{23}T \quad (6)$$

where: $\alpha_2, \beta_{21}, \beta_{22}, \beta_{23}, \equiv$ parameters to be estimated
FMC ≡ farm marginal cost (see Figure2).
FSFM(-1) ≡ lagged dependant variable
T ≡ time trend

Finally, an identity is required to establish diversion of excess fluid milk production to the industrial market; assuming zero trade with the U.S. This identity is the difference between farm supply and consumer demand: $IMD = FSFM - CDFM$ **(7).**

Results

Equations 1 through 7 were estimated simultaneously using the LSQ option in TSP version 4.2b. This estimator produces maximum likelihood parameter estimates because more than one equation is being estimated. Initial values for equation 1 and 6 were estimated using OLS. The sample period was annual from 1976 to 1994.

Estimation results for the consumer fluid milk demand equation are shown in Table 2. This equation had a very good fit, as indicated by the R^2 value. Durbin's h statistic suggested no auto-correlation was present. All variables, except income, exhibited theoretically valid signs and were statistically significant.

Tables 3, 4 and 5 present estimation results for the retailer, processor and farmer input demand equations and first order conditions (FOC)[4]. In general, most of the equations had a good fit. The Durbin Watson statistics suggest auto-correlation may have been present in some of the

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[4] Each variable is defined in Appendix 1.

Table 2. Regression Results - consumer fluid milk demand

	Canada
Estimator	ML
Sample	1976-1994
Constant	1903000000
	(83.677)*
Retail Milk Price	-155413000
	(-39.323)*
Per Capita Income	-0.0010039
	(-6.085)*
Lagged demand	0.16173
	(27.989)*
Retail Juice Price	-192202
	(-17.163)*
Time Trend	11263900
	(9.789)*
Retail soft drink price	3182800
	(176.657)*
R^2	0.898510
Durbin's h	3.04
Log of likelihood	-4232.62

Table 3. Regression Results - retailer input demand equations and CE equation

	Processed Milk(m)	Labour(l)	Capital(k)	Other Product(O)	FOC
Estimator	ML	ML	ML	ML	ML
Sample	1976-1994	1976-1994	1976-1994	1976-1994	1976-1994
Constant	2370530000 (93.672)*	150843000 (4.427)*	3327320000 (27.566)*	1.631E+11 (43.679)*	
Time	14311400 (10.174)*	2073520 (2.184)*	186555000 (28.331)*	644017000 (29.358)*	
Wm					-0.00284 (-24.126)*
Wl					-0.0229 (-9.698)*
Wk					-0.0943 (-58.958)*
Wo					0.00642 (16.051)*
Wl*Wk					-0.00469 (-26.176)*
Wl*Wm					-0.000266 (-4.287)*
Wm*Wk					0.0662 (32.338)*
Wo*Wl					0.00874 (15.854)*
Wo*Wk					0.00234 (35.331)*
Wo*Wm					-0.000274 (-14.953)*
Θ					0.010353 (4.384)*
R^2	0.74784	0.89181	0.98268	0.97739	0.59120
D.W.	0.38379	1.36542	0.83012	0.88353	0.55537

Note: W denotes an input price corresponding to either milk (m), labour (l), capital (k) or other product (o).

Table 4. Regression Results - processor input demand equations and CE equation

	Raw Milk(m)	Labour(l)	Capital(k)	Fuel(f)	FOC
Estimator	ML	ML	ML	ML	ML
Sample	1976-1994	1976-1994	1976-1994	1976-1994	1976-1994
Constant	1951730000	-67783100	115267000	57561600	
	(69.589)*	(-77.477)*	(12.703)*	(35.596)*	
Time	6326010	-544064	129151000	-1154580	
	(4.887)*	(-11.729)*	(27.492)*	(-11.852)*	
Wm					0.01456
					constant
Wl					0.0336
					(89.888)*
Wk					-0.1856
					(-10.445)*
Wf					-0.00141
					(-9.496)*
Wl*Wk					-0.02616
					(-33.767)*
Wl*Wf					0.00065
					(9.218)*
Wf*Wk					0.0428
					(107.121)*
Wl*Wm					0.01581
					(50.719)*
Wf*Wm					0.00492
					(8.071)*
Wk*Wm					0.02871
					(12.606)*
Θ					0.00002088
					(3.661)*
R^2	0.16669	0.51642	0.98431	0.66294	0.19248
D.W.	0.22731	0.21642	0.64503	0.55137	0.85233

Note: W denotes an input price corresponding to either milk (m), labour (l), capital (k) or fuel (f).

Table 5. Regression Results - farm input demand equations and CE equation

	Cash Costs(f)	Labour(l)	Capital(k)	MC	FOC
Estimator	ML	ML	ML	ML	ML
Constant	4760580000 (18.819)*	355294800 (9.158)*	61217200000 (28.380)*		
Time	60480000 (4.071)*	-17813100 (-9.911)*	-1933880000 (-15.015)*		
Wf				-0.02278 (-14.408)*	
Wl				0.17170 (5.256)*	
Wk				-590859 (-38.786)*	
Wl*Wk				-1.4654 (-33.198)*	
Wl*Wf				0.01692 (2.542)*	
Wf*Wk				0.59085 (38.756)*	
Farm #'s					-0.00000001 (-0.211)*
Time Trend					0.00126 (4.734)*
Farm Output					-0.0000149 (-4.377)*
Cow Output					0.0000022 (1.563)*
Labour Rate					-0.009223 (-2.586)*
Capital Rate					0.18232 (5.184)*
Cash Costs					-0.000775 (-4.036)*
R^2	0.23174	0.11553	0.86149	0.60029	0.19035
D.W.	2.24156	0.76253	0.49748	1.06000	0.31231

Note: W denotes an input price corresponding to either cash costs (f), labour (l) or capital (k).

equations. Concavity and monotonicity of the underlying cost function was not satisfied for any sector. A time trend variable was also included in the intercept of each input demand equation, enabling each function to fit the data much better.

In the processing sector FOC, the milk price co-efficient B_{MM} was held constant at 0.01456 because of estimation difficulties. In the estimated model processor demand (PDFM) and retailer demand (RDFM) are equivalent volumes (see Figure 3). This caused an arithmetic error, preventing the empirical estimation of B_{MM}. An appropriate constant value for B_{MM} was chosen by estimating the retail market power model on its own, and retrieving a similar co-efficient B_{MM}. It was hypothesized that the retail milk price co-efficient should provide a proxy for the processor co-efficient. To further test the validity of this constant, it was compared to a similar co-efficient estimated for Canadian dairy processors by Cranfield et al 1994. Although the estimate of Cranfield et al was higher, the constant included here appears reasonable and enhances the statistical significance of the model.

In both the retail and processing sectors, an endogenous conjectural elasticity equation was not included because of estimation difficulties which prevented convergence of the model. Instead, the conjectural elasticity was estimated as a single parameter. Although this is a restrictive practice, the conjectural elasticity was statistically significant. Conversely, a conjectural equation was estimated for the farm sector. Most variables were significant, although some suggest an intuitively questionable affect on θ. For example, the results indicate that declining farm numbers and increasing production have a negative impact on producer conjectures. Although the co-efficient for farm numbers was insignificant, neither result meets *a priori* expectations.

Table 6 shows estimation results for the farm supply of fluid milk. As indicated by the R^2, the equation had a good fit. The first order auto-regressive co-efficient was statistically significant. All other variables exhibited theoretically valid signs and were statistically significant.[5] In the long run, farm supply is inelastic as indicated by a long run elasticity of 0.32 (see Table 7). This estimate is reasonable in comparison to other studies, such as McCutcheon (1992) which presents farm supply elasticities of 0.39 and 0.45 for Ontario and Quebec respectively.

Table 8 shows mean values of the conjectural and demand elasticities, and Lerner indices for each sector. The conjectural elasticity for the retail, processor and farm sector was 0.010353, 0.000020881, ands 0.026152 respectively. Thus, for example, a one percent increase in the average retailer's production increased industry output 0.010353 percent.

The demand elasticity facing the processor and farm sector was -0.00574, and -0.08348, respectively. The consumer demand elasticity was -0.07106. This estimate is lower than elasticities of -0.24, -0.21, -0.2 to -0.26, -0.34, and -0.334, and presented by Curtin et al (1987), Al-Zand and Andriamanjay (1988), Goddard and McCutcheon (1993), Moschini and Moro (1993), and Goddard and Tielu (1995).

Retailers, processors, and farmers possessed a Lerner index of 0.1467, 0.04861, and 0.313 respectively. Thus, for example, farmers on average, have been able to elevate marginal cost price 31.30 percent above their actual marginal cost. This result is illustrated graphically in Figure 2. Because of producer market power, MCP exceeded actual marginal cost (MC) by approximately 30 percent. Over the sample period, retailer and processor market power increased, while farm market

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[5] Production theory suggests input prices (eg. cash costs) act as supply curve shifters. As such, input prices are often included as explanatory variables in supply curve estimation. In this study, input and specifically cash costs did not produce statistically significant parameters in either OLSQ or simultaneous estimation. For this reason, these variables were excluded.

Table 6. Regression Results - farm fluid milk supply

	Canada
Estimator	ML
Sample	1976-1994
Constant	1623800000
	(65.754)*
Marginal Cost	22175500
	(2.921)*
Lagged Milk Supply	0.31242
	(37.473)*
Time Trend	10601900
	(9.826)*
Autocorrelation (AR1)	-0.50013
Co-efficient	(-47.185)*
R^2	0.76341
Durbin's h	3.35

Table 7. Long Run Elasticity Estimates from Fluid Milk Supply Studies

Author	Study Area and Period	Supply Elasticity (Number in parentheses denotes the supply response of the model)	Supply Parameter Calculated with Farm Price or Marginal Cost Price - **For Canadian Supply Management Only**
Chavas and Klemme (1986)	U.S. 1960-1982	0.89 (5) - 2.46 (10)	farm price
Chyc (1992)	Canada 1979-1990	provinces range from 0.53 to 0.73	marginal cost price
Dahlgran (1985)	U.S. 1953-1983	1.0 (6) - 2.0 (16)	farm price
This Study: Duff and Goddard (1997)	**Canada 1976-1994**	**0.32**	**marginal cost price**
Elterich and Masud (1980)	U.S. 1966-1978	2.8	farm price
Fang (1996)	Canada	1.408	marginal cost price
Fox, Roberts and Brinkman (1992)	Canada	0.492	farm price
Goddard and Tielu c (1995)	Canada 1984-1994	Fluid Milk 0.757 Industrial Milk 0.862	marginal cost price
Helmberger and Chen (1994)	U.S. 1966-1990	0.58	farm price
Kaiser (1996)	U.S. 1975-1995	0.076	farm price
Kaiser et al (1988)	U.S. 1949-1985	0.8 (5)	farm price
Kaiser et al (1992)	U.S.	0.059	farm price
Lafrance and de Gorter (1985)	U.S. 1950-1980	4.8 - 8.0	farm price
McCutcheon (1992)	Ontario and Quebec 1981-1989	Ontario 0.39 Quebec 0.45	marginal cost price
Thraem and Hammond (1983)	U.S. 1949-1978	1.15	farm price

Table 8. Demand and Conjectural Elasticities, and Lerner Indices

Sector	Conjectural Elasticity	Demand Elasticity	Lerner Index
Retail	0.010353 (4.38)	-0.07106	0.14670 (7.72)
Processor	0.00002088 (3.71)	-0.000574	0.04861 (2.31)
Farm	0.026152 (12.27)	-0.08348	0.313 (7.45)

Numbers in parentheses are t-statistics

power declined slightly.

T statistics were calculated for each year to determine if the Lerner index was statistically different from zero and one. The Lerner index for each sector was significant at the 5 percent level, for both hypotheses, in all years of the sample. This result confirmed that retailers, processors, and farmers have acted neither competitively nor monopolistically, but rather as oligopolists.

Implications

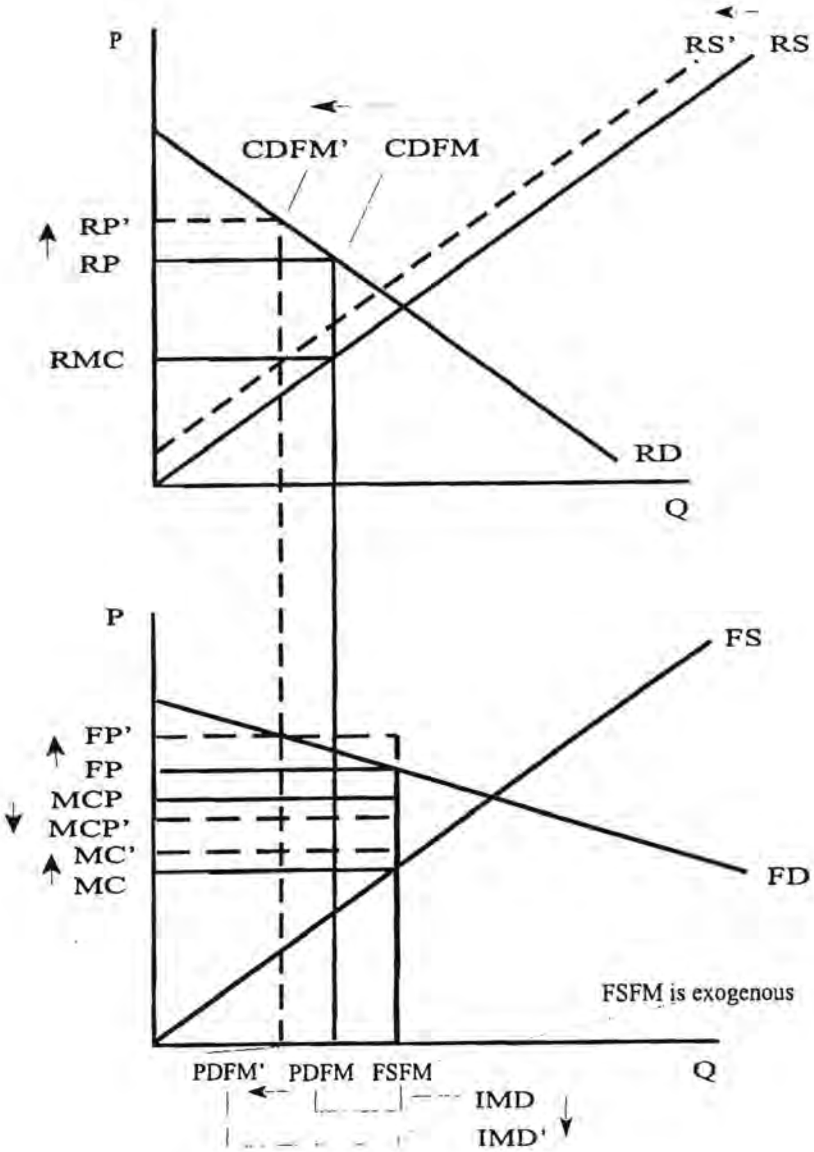
The results presented here suggest that researchers should be cautious when assuming perfect competition in the Canadian dairy industry. The implications of incorrectly characterizing the Canadian dairy industry as perfectly competitive can be illustrated by simulating the estimated model under various exogenous policy changes. Table 9 presents the impact of a 25 percent increase in farm cash costs and the resulting change in the cost of production farm price, under both perfect and imperfect competition. In these simulations, farm supply is held constant (exogenous) at base levels, which is realistic given the restriction of production quotas. The impact of higher feed and producer prices on the dairy industry is also represented diagrammatically in Figure 4. This diagram extends Figure 2 to include industrial market diversion and exogenous farm supply as is the case in the simulation discussed here. The supply curve does not shift in Figure 4, to correspond with the exclusion of cash costs (as a supply shifter) from the supply function, as discussed in Footnote #5.

The cash cost price index is represented by Wf in the farmer's FOC and conjectural elasticity equation (see Table 5). As discussed in footnote 3, each component of the formula price comprises a fixed percentage of the base price. Cash costs comprise approximately 40 percent of the base price (Dairy Farmers of Ontario, 1995). Thus, a 25 percent increase in cash costs will also increase the cost of production price 10 percent (25%*40%).

Table 9. Mean Percentage Changes in Key Variables for a 25 Percent Increase in Cash Costs which also Results in a 10 Percent Increase in the Cost of Production Farm Price:1980-1994

Variable	Units	Perfect Competition	Imperfect Competition
Consumer Demand	mil. l	-0.00231	-0.00195
Retail Price	$/l	+0.0239	+0.0204
Processor Price	$/l	+1.167	+1.163
Marginal Cost Price	$/l	+24.51	-7.01
Farm Marginal Cost	$/l	+24.51	+24.51
Static Quota Value	$/l	-3.56	+49.05
Farm Price	mil. l	+10.00	+10.00
Industrial Market Diversion	mil. l	+74.0	+44.2
Producer Surplus	mil. $	+25.75	-6.89
Farm Revenue (after quota cost)	mil. $	+25.43	-6.24
Consumer Surplus	mil. $	-0.00369	-0.00331

Figure 4. Impact of an Increase in Cash Costs and Farm Price
on the Canadian Retail and Farm Dairy Sectors



The results indicate that the structure of competition throughout the market effects the impact of an exogenous increase in cash costs. Under both competition scenarios, higher cash costs cause marginal cost to rise 24.5 percent. Given a negative relationship with the farm conjectural elasticity, increased cash costs cause farm market power to decline (see Table 5). Under imperfect competition, marginal cost price falls 7 percent, also pushing farm revenue and producer surplus downwards. Static quota values rise 49 percent as farm price increases, and marginal cost price decreases. With perfect competition, marginal cost price and marginal cost are equivalent. Thus, marginal cost price rises 24.5 percent as discussed above, pushing static quota value down 3.56 percent. As marginal cost price increases, farm revenue and producer surplus rise 25.43 and 25.75 percent respectively. A higher farm price translates into higher processor and retail prices, under both competition scenarios. In the process, consumer demand and surplus fall. Imperfect competition throughout the market slightly reduces the transmission of higher farm prices to other sectors. As such, processor and retail prices do not increase, and consumer demand and surplus do not decline to the extent shown with perfectly competitive markets. Because farm supply is fixed, as demand falls industrial market diversion rises. Imperfect competition reduces the increase in diversion to the industrial sector.

In summary, false characterization of perfect competition has three noteworthy implications. First, oligopoly power effects price transmission between dairy sectors. Second, market power enables retailers and/or processors to incur some of the benefits from producer marketing activities such as advertising. Analysis assuming perfect competition will overstate the "actual" return to producer marketing programs if in fact retailers and/or processors exercise market power. Third, producer welfare estimates are larger under oligopoly than perfect competition. Incorrect assumptions with regard to market structure, may bias the estimated welfare return to producer marketing activities such as advertising, or policy changes such as trade liberalization.

Conclusions

The purpose of this study was to measure the market power of Canadian dairy producers, processors and retailers given the historically regulated environment. In doing so, this study was the first to simultaneously test for oligopoly power at three market levels. Results indicated that Canadian dairy farmers, processors and retailers have operated as oligopolists. For example, on average, farmers have been able to elevate marginal cost price 31.3 percent above marginal cost. Processors, and retailers have been able to raise price 4.09, and 14.67 percent respectively, above marginal cost.

The presence of market power suggests that researchers should be cautious when assuming perfect competition in the Canadian dairy industry. Incorrect characterization of perfect competition has three noteworthy implications for the interpretation of agricultural policy analysis. First, oligopoly power effects price transmission between dairy sectors. Second, market power enables retailers and/or processors to incur some of the benefits from producer marketing activities such as advertising. Third, producer welfare estimates are larger under oligopoly than perfect competition.

This study possesses a number of limitations. First, the possibility of processor and retailer oligopsony power should also be addressed. This would improve the comprehensiveness and accuracy of the price structures developed here. In addition, the inclusion of farmer oligopsony power in their respective feed, labour and capital markets would further the richness of the model.

Another limitation is data availability. The data used in this study was annual. Thus, much of the seasonal variation; which can enhance the quality of estimation results, was lost. If quarterly data on farm production costs were collected, then a quarterly model of the Canadian fluid milk market could have been be developed. In doing so, the data limitations discussed above would be eliminated and the explanatory power of the model greatly improved.

A final limitation is that the model does not include the industrial milk market. This was not undertaken because of the enormous time, data and estimation resources that would have been required. However, industrial products are a significant segment of the Canadian dairy industry at each market level. Thus, inclusion of the industrial market could also enhance the richness of this model.

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Appendix 1
Data Definition and Sources

Variable names used in the empirical model and sources of these data are presented in this Appendix. All prices, income and advertising expenditure variables were deflated by the all item CPI.

Farm Sector

FSFM - farm sales of fluid milk, also corresponds to processor demand for fluid milk; litres; CANSIM matrix D230979

FP - farm price of fluid milk - processor input price for raw milk (W_M), weighted average of provincial prices based on provincial share of total fluid production; \$/litre; Agriculture Canada Dairy Market Review

CANQV - aggregate fluid quota value, weighted average of provincial quota values based on provincial share of total fluid production; \$/litre; Agriculture Canada Dairy Market Review

STQV - static fluid quota value, CANQV multiplied by the prime business loan rate; \$/litre/year

FNUM - farm numbers; farms; Canadian Dairy Commission

FAVGPRD - average farm production; kilolitres/farm; Canadian Dairy Commission

FAVGCW - average per cow production; kilolitres/cow; Canadian Dairy Commission

X_L - total farm labour using Ontario statistics as a proxy for Canadian farm labour use, average labour hours/litre multiplied by industry production; hours; Ontario Dairy Farm Accounting Project

W_L - farm worker hourly wage; \$/hour; Statistics Canada

X_F - direct cash cost quantity index, index including feed, artificial insemination, machinery repairs, custom work, fertilizer, pesticides, seed, building repairs, porperty tax, and electricity; Ontario Dairy Farm Accounting Project

W_F - direct cash cost price index; index including feed, artificial insemination, machinery repairs, custom work, fertilizer, pesticides, seed, building repairs, porperty tax, and electricity; Statistics Canada Catalogue 62-004

X_K - capital stock; index; Ontario Dairy Farm Accounting Project

W_K - user cost of capital; percent;

Processing Sector

PP - processor price of fluid milk - retailer input price for milk (W_M), generated by dividing 1986 total value of fluid manufacturing sales by total volume -this price was multiplied by a 1986=100 processor price index to create a price series; \$/litre; CANSIM matrix D691046

RDFM - retailer demand for fluid milk, also corresponds to processor supply and consumer demand, sum of commercial sales of standard, 2%, skim, butter, chocolate and 1% milk; litres; CANSIM matrices D223125-29

PNUM - fluid processor numbers; processors; Statistics Canada Catalogue 31-203

X_L - fluid processing worker hours; hours; Cansim matrix D662366

W_L - fluid processing worker hourly wage; \$/hour; CANSIM matrix D662365

X_F - fluid processor fuel and electricity quantity index; index; Statistics Canada Catalogue 31-203

X_K - capital stock; index;

W_K - user cost of capital; percent;

Retail Sector

RP - retail price of fluid milk, generated by multiplying the 1986 average Canadian city retail milk price by a 1986=100 retail price index to create a price series; \$/litre; CANSIM matrix P490510

RAVGSLE - average retail food store sales; thousand dollars per store; Statistics Canada

TRSLE - total quantity of food sold at the retail level, generated by dividing the total value of sales by the all food item consumer price index 1986=100

X_L - retail food labour; hours; CANSIM matrix L57052

W_L - retail food labour hourly wage; \$/hour; Statistics Canada Catalogue 72-002

W_O - input price index for other food products, generated from price indexes for meat and fish, and other food products; 1986=100; Statistics Canada

X_O - retailer demand for food products other than fluid milk;

X_K - capital stock; index;

W_K - user cost of capital; percent;