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Estimating Endogenous Switching Systems for Government Interventions:

The Case of the Dairy Sector

by

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ABSTRACT

Government intervention in the agricultural sector has occurred since the 1930s, when the first price support programs were enacted as a means to improve farm incomes. Accordingly, commodity prices are determined by different forces depending on whether the price established by competitive supply and demand conditions is above or below the price floor set by the government. If the free market price is above the support price, a "market equilibrium" regime holds, and government intervention does not play a role in the price formation process. However, if the normal market price solution falls below the price floor, a "government support" regime holds and prices are determined by government intervention in the form of commodity purchasing.

Since there exist two potential solutions to the supply/demand system at any point in time, it is desirable to find a single econometric model which can accommodate both outcomes. The failure to account for the possibility that either regime can occur raises the potential for selectivity bias. To correct for the bias introduced by switching between regimes, Maddala outlined a Tobit two-stage least squares procedure for a single market. However, to investigate the effects of government programs on all sectors in the distribution system, the single market model, which focuses on the farm sector, must be extended to a multiple-market setting, which incorporates the wholesale and retail sectors.

This paper develops an estimation procedure which accounts for both market and government regimes in a multiple market setting. It is shown that selectivity bias is not only apparent in the component of the

system directly affected by government intervention, but also exists in those subsectors which are only indirectly affected by price support programs.

Furthermore, to test empirically whether the proposed procedure is an improvement over models currently used, the method is applied to the dairy sector, which is a classical example of government intervention. The dairy model consists of a wholesale and a retail market with each market containing a fluid and a manufactured product subsector. Selectivity bias is empirically significant in the reduced-form equations for the retail fluid price, the wholesale fluid price, the wholesale manufactured price, and the Class II price even though it is only the wholesale manufactured price that is subject to government intervention. The retail manufactured price was the only price not affected by selectivity bias.

Finally, comparisons are made between estimated elasticities from the proposed and conventional two-stage least squares models. While elasticities for other variables, such as income and advertising, were very similar for the two estimation methods, the results indicated that the price elasticity estimates from the conventional model were generally biased upward, i.e. more elastic. Therefore, ignoring selectivity bias in modeling government intervention may lead to serious biases in important policy parameters.

Estimating Endogenous Switching Systems for Government Interventions: The Case of the Dairy Sector

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INTRODUCTION

Government intervention in the agricultural sector has occurred since the 1930s, when the first price support programs were enacted as a means to improve farm incomes. Through price support programs, which now exist for dairy products and most major crops, the government sets a floor on market prices by making a commitment to buy unlimited quantities of the commodity at the support level. The intervention of the government has broad reaching effects, extending beyond the farm level to distribution and processing sectors of the food system.

When considering how prices of agricultural commodities are determined, the potential for government intervention introduces a special problem. Prices are determined by different forces depending on whether the price established by competitive supply and demand conditions is above or below the price floor set by the government. If the free market price is above the support price, the "market equilibrium" regime holds, and government intervention does not play a role in the price formation process.[1] However, if the normal market price solution falls below the price floor, the "government support" regime holds and prices are determined by government intervention in the form of commodity purchasing.

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1 Of course government programs still play a role in the price formation process in the sense that the existence of government support prices affect price expectations and the risk producers perceive. This holds under both regimes.

Since there exist two potential solutions to the supply/demand system at any point in time, it is desirable to find a single econometric model which can accommodate both outcomes. To date, studies of the impacts of government programs have not distinguished between regimes (Arzac and Wilkinson; Kaiser, Streeter and Liu; LaFrance and de Gorter). The failure to account for the possibility that either regime can occur raises the potential for selectivity bias. Specifically, conventional two-stage least squares estimates are biased because the endogenous price variable is, in reality, constrained to be no less than an exogenously determined level.

To correct for the bias introduced by switching between regimes, Maddala (pp. 326-335) outlines a Tobit two-stage least squares procedure for a single market. However, to investigate the policy impacts of government programs on all sectors in the distribution system, the single market model, which focuses on the farm sector, must be extended to a multiple-market setting which incorporates the wholesale and retail sectors.[2]

The purpose of this paper is twofold: (1) to develop an estimation procedure which accounts for both market and government regimes in a multiple market setting, and (2) to use the dairy sector to test empirically whether the proposed procedure is an improvement over models currently used. In the first section, a multiple-market switching system is presented and the technical aspects of the estimation procedure are discussed. It is shown that the selectivity correction procedure must be applied not only to the component of the

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2 In fact, for the dairy sector, the government intervention is made in the wholesale markets by supporting the prices of butter, cheese and nonfat dry milk.

system (the farm level) directly affected by government intervention, but also to those subsectors only indirectly affected (the retail level) by price support programs. A specific correction procedure is outlined in detail. The second section provides an empirical application of the model to the dairy sector. Finally, the estimation results are used to show that the proposed procedure produces significantly different results from models in which selectivity bias is ignored.

A SWITCHING SIMULTANEOUS SYSTEM

Consider a market consisting of a retail sector and a farm sector, with a predetermined quantity of farm supply at any given point in time. The retail sector is in equilibrium if retail supply and demand are solved simultaneously such that both quantities are equal. If the retail quantity is expressed on a farm commodity equivalent basis, the market as a system is in equilibrium when the retail quantity equals the fixed farm supply. Solutions to the equilibrium market system give the retail quantity, the retail price and the farm price. This type of model or its extension can be applied to agricultural markets which operate competitively in the absence of government regulations.

Suppose now that the government intervenes in this market by introducing a price support program, which consists of setting a price floor for the farm commodity. If the equilibrium farm price is above the support price, then the observed farm price is the equilibrium price. On the other hand, if the equilibrium farm price is below the support price, then the observed farm price equals the support level and the government buys the excess supply at that level. Solutions to the government support regime give the commercial retail quantity, the quantity of government purchases and the retail price.

Thus, depending on supply and demand conditions, the system has two possible solutions: a market equilibrium solution and a government support solution.

<u>Market Equilibrium Solution</u>:

The market equilibrium solution contains equilibrium values for the retail and farm sectors including the retail quantity, retail price, and farm price. In the retail sector, a general specification can be written:

$$(1.1) \qquad Q_s = \alpha_s P^r + \beta_s P^f + \gamma_s Z_s + \mu_s$$

$$(1.2) \qquad Q_d = \beta_d P^r + \gamma_d Z_d + \mu_d$$

$$(1.3) \qquad Q_s = Q_d \equiv Q^r$$

where Q_s and Q_d are the retail quantity supplied and demanded; P^r and P^f are the equilibrium retail and farm prices; Z_s and Z_d are vectors of exogenous supply and demand shifters and; Q^r denotes the equilibrium retail quantity. Throughout the paper, α's, β's and γ's are used to denote parameters associated with prices received, prices paid and all other exogenous variables, respectively.

For the farm sector, the following equilibrium condition holds:

$$(2) \qquad SBAR = Q^r$$

where SBAR is the "predetermined" farm supply. The assumption that SBAR is fixed simplifies the presentation. In the case where SBAR is endogenous, the farm supply equation would be added to the system but this does not change the essence of the discussion that follows.

After substituting (1.3) and (2) into (1.1) and (1.2), the reduced-form equations for the remaining two endogenous variables can be expressed as:

$$(3.1) \qquad P^f = \pi^f Z + \epsilon^f$$

$$(3.2) \qquad P^r = \pi^r Z + \epsilon^r$$

where Z is a column vector containing Z_s, Z_d and SBAR.

Government Support Solution:

With the government support price binding, the farm commodity price is set exogenously at the support level. Thus, (1.2) and (1.3) remain the same and (1.1) and (2) are replaced by

$$(1.1') \qquad Q_s = \alpha_s P^r + \beta_s P^g + \gamma_s Z_s + \mu_s$$

$$(2') \qquad SBAR = Q^r + Q^g$$

where P^g is the government support price and Q^g is the government purchase of the surplus farm commodity. With the government actively buying, the equilibrium farm price is replaced by the exogenous support price, but Q^g emerges as an additional endogenous variable. After substituting (1.3) and (2') into (1.1') and (1.2), the reduced-form equations for the remaining two endogenous variables can be expressed as:

$$(3.1') \qquad Q^g = \pi^g{}_* Z_* + \epsilon^g{}_*$$

$$(3.2') \qquad P^r = \pi^r{}_* Z_* + \epsilon^r{}_*$$

where Z_* is a column vector containing both Z = (Z_s, Z_d and SBAR) and P^g. Since the underlying market structures are different, depending on whether it is a market equilibrium solution or a government support solution, the reduced-form parameters and the error terms in (3.2') are different from those in (3.2). This is true even when the two underlying market structures contain the same exogenous variables (i.e. $Z = Z_*$).[3]

The Combined Model

The estimation problem is that, at any given point in time, either the market equilibrium or government support regime can prevail. A single model that entertains both possibilities is in order. Define the probability that the government support solution occurs as Φ and the probability that the market equilibrium solution occurs as $1-\Phi$. That is,

$$\Phi \equiv PROB\ \{P^f \leq P^g\}$$

$$1-\Phi \equiv PROB\ \{P^f > P^g\}$$

Then the unconditional expected retail quantity supplied is the following weighted average of (1.1) and (1.1'):

$$(4.1) \quad E[Q_s] = (1-\Phi)\ \{\alpha_s\ E[P^r|\ P^f > P^g] + \beta_s\ E[P^f|\ P^f > P^g] + \gamma_s\ Z_s + E[\mu_s|\ P^f > P^g]\} + \Phi\ \{\alpha_s\ E[P^r|\ P^f \leq P^g] + \beta_s\ P^g + \gamma_s\ Z_s + E[\mu_s|\ P^f \leq P^g]\}$$

Assuming that the joint density of μ_s and μ_d, and therefore of μ_s and ϵ^f, is bivariate normal, the two terms involving μ_s in (4.1) can be expressed as:

$$(4.2) \quad E[\mu_s|\ P^f > P^g] = E[\mu_s|\ \epsilon^f > P^g - \pi^f Z] = \{\ \sigma^\# / \sigma^f\ \}\ \{\ \phi(c^*) / (1-\Phi(c^*))\ \}$$

$$(4.3) \quad E[\mu_s|\ P^f \leq P^g] = E[\mu_s|\ \epsilon^f \leq P^g - \pi^f Z] = -\{\ \sigma^\# / \sigma^f\ \}\ \{\ \phi(c^*) / \Phi(c^*)\ \}$$

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[3] In the context of a reduced-form forecast, one would use (3) if the market is expected to be competitive, and (3') if the support price is expected to be binding. It is intuitively clear that such forecasts should be different for the two regimes.

where $\Phi(c^*)$ and $\phi(c^*)$ are the cumulative standard normal and the standard normal density, both evaluated at c^* ($c^* \equiv (P^g - \pi^f Z) / \sigma^f$), $\sigma^{\#} \equiv E[\mu_s \epsilon^f]$ and $(\sigma^f)^2 \equiv E[\epsilon^f \epsilon^f]$.

The first line in (4.2) and (4.3) follows from (3.1) while the second line is based on the results from Johnson and Kotz (pp. 111-113).[4]

From (4.2) and (4.3), it follows that

$$(1-\Phi)\ E[\mu_s |\ P^f > P^g] + \Phi\ E[\mu_s |\ P^f \le P^g] = 0$$

Thus, (4.1) becomes:

$$(5.1)\quad E[Q_s] = \alpha_s E[P^r] + \beta_s \{(1-\Phi)\ E[P^f |\ P^f > P^g] + \Phi P^g\} + \gamma_s Z_s$$

Applying a similar derivation to (1.2), the unconditional expected retail quantity demanded is:

$$(5.2)\quad E[Q_d] = \beta_d E[P^r] + \gamma_d Z_d$$

The result that (5.1) and (5.2) do not contain any additional bias terms indicates that the ordinary least squares estimator is appropriate if the unconditional expectations of $E[P^r]$ and the conditional expectation of $E[P^f |\ P^f > P^g]$ appearing on the right-hand-side are evaluated. These price expectations can be obtained from the reduced-form equations.

<u>Estimation of the Reduced-Form Equations</u>

Consider first the reduced-form equation for the farm commodity price, P^f, in order to obtain the conditional expectation $E[P^f |\ P^f > P^g]$ appearing in (5.1). This amounts to a censored sample problem since the

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4 Assuming that the joint density of x and y is bivariate normal with zero means, Johnson and Kotz show that
$E[x|\ y > z] = \{ cov[x,y] / sd[y] \} \{ \phi(\xi) / (1- \Phi(\xi)) \}$, and
$E[x|\ y < z] = - \{ cov[x,y] / sd[y] \} \{ \phi(\xi) / \Phi(\xi) \}$,
where cov and sd are the covariance and standard deviation operators and ξ is defined as $z/sd[y]$.

equilibrium farm price is constrained to be greater than the government support price. Applying ordinary least squares to (3.1) results in selectivity bias, and a Tobit type procedure is in order. This can be shown by taking the unconditional expectation of (3.1):

$$(6.1)\quad E[P^f] = (1-\Phi)\ E[P^f |\ P^f > P^g] + \Phi\ E[P^f |\ P^f \leq P^g]$$

$$= (1-\Phi)\ \pi^f Z + \sigma^f\ \phi + \Phi\ P^g$$

In comparing (3.1) to (6.1), it is clear that the error term in the former equation does not have a zero mean, verifying the biasedness of the ordinary least squares estimator. Using maximum likelihood Tobit procedure to estimate (3.1), however, one obtains consistent estimates of π^f, σ^f, ϕ and Φ. Then, the conditional expectation $E[P^f |\ P^f > P^g]$ in (5.1) can be computed from:

$$(7.1)\quad E[P^f |\ P^f > P^g] = \pi^f Z + \sigma^f\ [\phi\ /\ (1-\Phi)]$$

Next, consider the reduced-form equations for the retail price, P^r, to obtain the unconditional expectation $E[P^r]$ which appears in both (5.1) and (5.2). There are two reduced-form equations; one pertaining to the market equilibrium solution (i.e. (3.2)) and the other pertaining to the government support solution (i.e. (3.2′)). Combining the reduced-form equations for the two solution regimes weighted by their respective probabilities yields:

$$P^r = (1-\Phi)\ \{\pi^r\ Z + (\epsilon^r |\ P^f > P^g)\} + \Phi\ \{\pi^r_*\ Z_* + (\epsilon^r_* |\ P^f \leq P^g)\}$$

Then, the unconditional expectation of P^r is:

$$E[P^r] = \pi^r\ [(1-\Phi)\ Z] + \pi^r_*\ [\Phi\ Z_*] + (1-\Phi)\ \{\ (\sigma^{rf}\ /\ \sigma^f)\ (\phi\ /\ (1-\Phi))\ \}$$

$$-\ \Phi\ \{\ (\sigma^{rf}_*\ /\ \sigma^f)\ (\phi\ /\ \Phi)\ \}$$

where $\sigma^{rf} \equiv E[\epsilon^r\ \epsilon^f]$ and $\sigma^{rf}_* \equiv E[\epsilon^r_*\ \epsilon^f]$. From the above, it is clear that the reduced-form equation for P^r can be obtained by estimating

$$(6.2)\quad P^r = \pi^r\ [(1-\Phi)\ Z] + \pi^r_*\ [\Phi\ Z_*] + (\sigma^{rf} - \sigma^{rf}_*)\ [\phi\ /\ \sigma^f] + \xi^r$$

where ξ^r is an error term with a zero mean. Note that Φ, ϕ and σ^f are obtained from the Tobit estimation of (3.1) and Z and Z_* are data.

The first two terms in (6.2) reflect the weighted average of the reduced-form forecasts for the two solution regimes. If Z contains the same variables as Z_*, then (6.2) becomes:

(6.2') $P^r = \pi^r Z + (\pi^r{}_* - \pi^r) [\Phi Z] + (\sigma^{rf} - \sigma^{rf}{}_*) [\phi / \sigma^f] + \xi^r.$

Hence a standard F-statistic for the restrictions $\pi^r{}_* - \pi^r = 0$ can be used to test whether the reduced-form parameters are different for the two regimes. A significant F-statistic would indicate the need to weight each reduced-form forecast in accordance with the first two terms of (6.2). If Z is not the same as Z_*, an F test can be applied to those parameters which appear in both Z and Z_*.

Further, the appearance of the Heckman-like correction term $((\sigma^{rf} - \sigma^{rf}{}_*) [\phi / \sigma^f])$ in (6.2) indicates another source of selectivity bias. This correction term is due to the different correlations between ϵ^r and ϵ^f (i.e. σ^{rf}) and between $\epsilon^r{}_*$ and ϵ^f (i.e. $\sigma^{rf}{}_*$). This difference exists because the error terms ϵ^r in (3.1) and $\epsilon^r{}_*$ in (3.2) are not derived from the same structure. The importance of this additional correction term can be tested by examining the magnitude of the t-value associated with the estimated coefficient of $(\sigma^{rf} - \sigma^{rf}{}_*)$. The implication of a significant t-value is that selectivity bias exists even though the retail price is not subject to direct government intervention.[5]

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5 These tests are actually only approximations due to the fact that the covariance matrix is not homoscedastic for the two-stage Tobit estimator. However, deriving the asymptotic covariance matrix is complicated (see Lee et al).

With the estimates of π^r, π^r_* and $(\sigma^{rf} - \sigma^{rf}_*)$ obtained by applying ordinary least squares to (6.2), the unconditional expectation of P^r can be computed from:

(7.2) $E[P^r] = (1-\Phi)\, \pi^r Z + \Phi\, \pi^r_* Z_* + (\sigma^{rf} - \sigma^{rf}_*)\, [\phi / \sigma^f]$

<u>Estimation of the Structural Equations</u>

The combined structural equations are shown in (5.1) and (5.2). Substituting the price expectations obtained in (7.1) and (7.2) into (5.1) and (5.2) as "instruments" for the corresponding price variables and replacing $E[Q_s]$ and $E[Q_d]$ by Q_s and Q_d, one obtains:

(8.1) $Q_s = \alpha_s E[P^r] + \beta_s \{(1-\Phi)\, E[P^f | P^f > P^g] + \Phi P^g\} + \gamma_s Z_s + \tau_s$

(8.2) $Q_d = \beta_d E[P^r] + \gamma_d Z_d + \tau_d$

Since each of the two new error terms (τ_s and τ_d) in the above equations has a zero mean by construction and all the endogenous price variables on the right-hand-side of the structural equations have been replaced by their corresponding instruments, (8) can be estimated by ordinary least squares to obtain estimates of the structural parameters (α_s, β_s, γ_s, β_d and γ_d). The estimation sequence can be summarized in the following five steps:

1. Estimate the farm price reduced-form equation in (3.1) by a maximum likelihood Tobit procedure and obtain estimates of π^f and σ^f,
2. Compute Φ and ϕ for all observations.
3. Estimate the reduced-form equations for the retail price in (6.2) by ordinary least squares.
4. Calculate the conditional farm price expectation ($E[P^f | P^f > P^g]$) in (7.1) and the unconditional retail price expectation ($E[P^r]$) in (7.2) for all observations.
5. Estimate (8.1) and (8.2) by ordinary least squares.

APPLICATION TO THE DAIRY SECTOR

There are two major federal programs which affect the price of milk and manufactured dairy products: the dairy price support program and the federal milk marketing order program. The dairy price support program applies to milk utilized for manufactured (i.e., non-fluid) purposes while the federal order program applies to milk used for fluid purposes.[6]

Due to the fact that milk is highly perishable, the dairy price support program differs from price support programs for other agricultural commodities in that the government intervenes in wholesale markets for dairy products rather than supporting the price of the commodity directly at the farm level. Under the program, the government sets minimum wholesale prices for storable dairy products (i.e., cheese, butter, and nonfat dry milk) with the intent to assure dairy product manufacturers a price that is sufficient enough to cover their own manufacturing costs and still pay farmers a price for manufacturing milk (Class II price) equal to a targeted support level.

The federal milk market order program regulates processors of raw milk for fluid products. The federal order program authorizes a loose form of price discrimination through a system of classified pricing. Processors are required to pay minimum prices according to how the milk is utilized. Processors of manufactured dairy products pay the Class II price, which is an average market price for manufactured raw milk.

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6 There are two types of raw milk: Grade B and Grade A. Grade B milk can only be used for manufactured dairy products, e.g. cheese. Grade A milk can be used for fluid products. In addition, some Grade A milk is used in manufactured products since Grade A production exceeds demand for fluid products. The difference between Grade A and B is that Grade A milk is produced under stricter sanitary conditions.

Processors of fluid products pay the Class I price, which is equal to the Class II price plus the "Class I differential". The Class I differential is designed to enhance dairy farm income by exploiting the more price inelastic fluid market demand. Both the dairy price support and the federal marketing order program will be incorporated into the econometric model.

The econometric model of the dairy industry consists of two markets: a wholesale and a retail level. At each level there are two subsectors: a fluid milk and a manufactured dairy product subsector. In the wholesale market, fluid and manufactured dairy product processors buy raw milk from dairy farmers paying the Class I and II price, respectively. The wholesale fluid processors convert the raw milk into fluid products and receive wholesale prices from fluid retailers, who in turn sell to consumers. The wholesale manufactured dairy product processors convert the raw milk into non-fluid products and sell to either non-fluid retailers, or the government, depending upon the market price. If the market price is above the government minimum wholesale price, the wholesalers sell exclusively to manufactured product retailers and the market is therefore competitive.[7] On the other hand, if the market price is at the government minimum wholesale price, the wholesalers sell to both the government and to retailers at the minimum price, which is therefore binding.

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7 In the sense that the Class I price is obtained through government's superimposing the Class I differential on the Class II price, it should be understood that the solution is never genuinely competitive.

Market Equilibrium Solution:

In the case where the government purchase price is not binding, the market equilibrium solution is determined by the following specifications.

The retail fluid market supply, demand and equilibrium condition are:

(9.1) $Q^{rf}_s = \alpha^{rf}_s P^{rf} + \beta^{rf}_s P^{wf} + \gamma^{rf}_s Z^{rf}_s + \mu^{rf}_s$

(9.2) $Q^{rf}_d = \beta^{rf}_d P^{rf} + \gamma^{rf}_d Z^{rf}_d + \mu^{rf}_d$

(9.3) $Q^{rf}_s = Q^{rf}_d \equiv Q^{rf}$

where Q^{rf}_s and Q^{rf}_d are the retail fluid quantity supplied and demanded; P^{rf} and P^{wf} are the equilibrium retail fluid price and wholesale fluid price; Z^{rf}_s and Z^{rf}_d are vectors of exogenous supply and demand shifters pertaining to the retail fluid subsector and; Q^{rf} denotes the equilibrium retail fluid quantity.

The retail manufactured supply, demand and equilibrium condition can be written following the form of the retail fluid market as follows:

(10.1) $Q^{rm}_s = \alpha^{rm}_s P^{rm} + \beta^{rm}_s P^{wm} + \gamma^{rm}_s Z^{rm}_s + \mu^{rm}_s$

(10.2) $Q^{rm}_d = \beta^{rm}_d P^{rm} + \gamma^{rm}_d Z^{rm}_d + \mu^{rm}_d$

(10.3) $Q^{rm}_s = Q^{rm}_d \equiv Q^{rm}$

where superscripts rm's and wm's denote the retail and wholesale manufactured subsectors, respectively.

The wholesale fluid supply, demand and equilibrium condition are:

(11.1) $Q^{wf}_s = \alpha^{wf}_s P^{wf} + \beta^{wf}_s (P^{II} + d) + \gamma^{wf}_s Z^{wf}_s + \mu^{wf}_s$

(11.2) $Q^{wf}_d = Q^{rf}$

(11.3) $Q^{wf}_s = Q^{wf}_d \equiv Q^{wf}$

where P^{II} and d are the Class II price and the Class I differential (i.e., the Class I price is $P^{II} + d$) and all other variables are similarly defined with superscript wf's denoting that the variables pertain to the wholesale fluid subsector. Equation (11.2) specifies that the wholesale fluid demand should equal the retail fluid quantity in equilibrium as all the quantity variables are expressed on a milk equivalent basis.

The wholesale manufactured supply, demand and equilibrium condition can be written following the form of the wholesale fluid market as follows:

$$(12.1) \qquad Q^{wm}{}_s = \alpha^{wm}{}_s P^{wm} + \beta^{wm}{}_s P^{II} + \gamma^{wm}{}_s Z^{wm}{}_s + \mu^{wm}{}_s$$

$$(12.2) \qquad Q^{wm}{}_d = Q^{rm}$$

$$(12.3) \qquad Q^{wm}{}_s = Q^{wm}{}_d \equiv Q^{wm}$$

where the variables defined with superscript wm's pertain to the wholesale manufactured subsector.

Finally, the farm level equilibrium condition is:

$$(13) \qquad SBAR = Q^{wf} + Q^{wm}$$

where SBAR is the "predetermined" raw milk supply. The farm supply is predetermined due to the assumption that dairy farmers respond to price expectations based on lagged prices only, which is a common assumption in dairy models (e.g., Chavas and Klemme; Kaiser, Streeter and Liu; LaFrance and de Gorter).

There are two levels of within-market equilibrium: the retail level (i.e. (9.3) and (10.3)) and the wholesale level (i.e. (11.3) and (12.3)). In addition, there are two levels of across-market equilibrium: the retail/wholesale linkages in (11.2) and (12.2) and the wholesale/farm linkage in (13). The retail level equilibrium conditions imply that the supply and demand in each of the two retail subsectors have to be solved simultaneously, and the wholesale level equilibrium conditions imply the same for the two wholesale subsectors. The retail/wholesale linkages imply that the wholesale and the retail markets for each of the two products be solved simultaneously. Finally, the wholesale/farm linkage indicates that the two wholesale subsectors have to solved simultaneously. Thus, equations (9) to (13) must be solved simultaneously to obtain the market equilibrium solution, and there is no way to decompose the solution into sub-systems.

Government Support Solution:

With the government purchase price binding, the wholesale manufactured price is set exogenously at the purchase price. Thus, (10.1) and (12.1) are replaced by

$$(10.1') \qquad Q^{rm}_s = \alpha^{rm}_s P^{rm} + \beta^{m}_s P^{g} + \gamma^{rm}_s Z^{rm}_s + \mu^{rm}_s$$

$$(12.1') \qquad Q^{wm}_s = \alpha^{wm}_s P^{g} + \beta^{wm}_s P^{II} + \gamma^{wm}_s Z^{wm}_s + \mu^{wm}_s$$

Also, the farm level equilibrium condition (13) is replaced by

$$(13') \qquad SBAR = Q^{wf} + Q^{wm} + Q^{g}$$

where P^g is the government purchase price of the manufactured product at the wholesale level and Q^g is government purchases in a milk equivalent measure. With the government buying, the wholesale manufactured price is replaced with the exogenous government purchase price. However, Q^g emerges as an additional endogenous variable balancing the number of unknowns with the number of equations.

The combined model that accommodates both the market equilibrium and the government support regimes will be estimated using the procedure discussed in the previous section. There are five reduced-form price equations: the retail fluid, the retail manufactured, the wholesale fluid, the wholesale manufactured, and the Class II prices. The wholesale manufactured price equation is estimated by a maximum likelihood Tobit procedure, and the corresponding conditional expectation ($E[P^{wm}| P^{wm} > P^{g}]$) is obtained in a fashion similar to that in (7.1). Then, the price instrument for the wholesale manufactured price is $(1 - \Phi) E[P^{wm}| P^{wm} > P^{g}] + \Phi P^{g}$ where Φ is now defined as *PROB* $\{P^{wm} \leq P^{g}\}$. The reduced-form equations for the other four price variables are estimated in a fashion similar to that in (6.2). The instruments for those variables are the unconditional expectations ($E[P^{rf}]$, $E[P^{rm}]$, $E[P^{wf}]$ and $E[P^{II}]$) which are obtained in a fashion similar to that in (7.2). Finally, the structural equations in (9.1), (9.2), (10.1), (10.2), (11.1), and (12.1) are estimated by ordinary least squares with the right-hand-side endogenous price variables being represented by their corresponding "instruments". The derivations of the reduced-form and the structural equations estimated are in Appendix 1.

THE EMPIRICAL RESULTS

In this section, the results of the estimation of the structural equations are presented, and the empirical relevancy of the selectivity-bias correction for the reduced-form estimation is tested. Specifically, these tests are conducted for the price equations not subject to any direct censoring process. Finally, the results of the structural equations estimated using the conventional two-stage least squares are presented and compared with the equations accounting for selectivity bias.

The Estimated Structural Equations

The estimated structural equations are presented in Table 1 and the variables are defined in Table 2. The estimated coefficients of all

Table 1. Estimated Structural Equations for the Wholesale and Retail Sectors Using the Proposed Bias Correction Two-Stage Least Squares Procedure*

Retail Fluid Demand

$$\ln RFD = -\underset{(-1.50)}{0.413}\ln(RFP/PFOOD) + \underset{(1.94)}{0.258}\ln RFD_{-1} + \underset{(5.14)}{0.447}\ln(INC/CPI) + \underset{(2.03)}{0.014}\ln(GFA/CPI)$$

$$-\underset{(-1.69)}{0.005}\,TREND + [1/(1 - \underset{(10.40)}{0.825}L^{4})]\,U \qquad \bar{R}^2 = 0.80;\ D.W. = 1.95$$

Retail Fluid Supply

$$\ln RFS = \underset{(19.51)}{2.637} + \underset{(4.76)}{0.535}\ln(RFP/WFP) + \underset{(3.40)}{0.150}\ln RFS_{-1} - \underset{(-7.19)}{0.132}\ln(PFE/CPI) - \underset{(-7.84)}{0.163}\ln UNEMP$$

$$+ [(1 + \underset{(4.05)}{0.702}L)/(1 + \underset{(-1.87)}{0.232}L + \underset{(-7.63)}{0.582}L^{2})]\,U \qquad \bar{R}^2 = 0.78;\ D.W. = 1.93$$

Retail Manufactured Demand

$$\ln RMD = -\underset{(-1.72)}{0.478}\ln(RMP/PFOOD) + \underset{(2.93)}{0.246}\ln RMD_{-1} + \underset{(9.02)}{0.435}\ln(INC/CPI) + \underset{(3.22)}{0.005}\ln(GMA/CPI)$$

$$+ \underset{(1.72)}{0.035}\ln TREND + \underset{(3.45)}{0.051}\,DUM1 + \underset{(12.66)}{0.163}\,QTR2 + \underset{(7.60)}{0.103}\,QTR3 + U \qquad \bar{R}^2 = 0.96;\ D.W. = 1.75$$

Retail Manufactured Supply

$$\ln RMS = \underset{(2.51)}{0.167}\ln(RMP/WMP) + \underset{(8.42)}{0.578}\ln RMS_{-1} - \underset{(-1.91)}{0.094}\ln(RWAGE/CPI)$$

$$+ \underset{(6.78)}{0.085}\ln TREND - \underset{(-2.99)}{0.050}\,DUM2 + [1/(1 + \underset{(-1.08)}{0.080}L + \underset{(-11.80)}{0.795}L^{2})]\,U \qquad \bar{R}^2 = 0.92;\ D.W. = 2.44$$

Wholesale Fluid Supply

$$\ln WFS = \underset{(2.35)}{0.093}\ln(WFP/P1) + \underset{(16.49)}{0.938}\ln WFS_{-1} - \underset{(-12.04)}{0.888}\ln WFS_{-2} + \underset{(15.96)}{0.861}\ln WFS_{-3}$$

$$-\underset{(-1.50)}{0.017}\ln(PFE/CPI) + [1/(1 + \underset{(-2.46)}{0.317}L)]\,U \qquad \bar{R}^2 = 0.84;\ D.W. = 1.88$$

Wholesale Manufactured Supply

$$\ln WMS = -\underset{(-3.35)}{2.077} + \underset{(2.28)}{0.475}\ln(WMP/P2) + \underset{(7.96)}{0.568}\ln WMS_{-1} - \underset{(-3.86)}{0.793}\ln(MWAGE/CPI)$$

$$+ \underset{(6.91)}{0.097}\ln TREND + [1/(1 + \underset{(-0.78)}{0.058}L + \underset{(-11.61)}{0.790}L^{2})]\,U \qquad \bar{R}^2 = 0.92;\ D.W. = 2.35$$

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* $\bar{R}^2$ is adjusted coefficient of determination, D.W. is the Durbin-Watson statistic, and t-values are given in parentheses.

Table 2. Definition of Variables

Quantity Variables

RFD, RFS, WFS - Quantity of raw milk in fluid sector (billion pounds of raw milk equivalent). Retail demand is equal to retail supply which is equal to wholesale supply.

RMD, RMS, WMS - Quantity of raw milk in manufacturing sector (billion pounds of raw milk equivalent). Retail demand is equal to retail supply which is equal to wholesale supply.

Price Variables

RFP, RMP - Retail fluid and manufacturing price indices (1967 = 100).

WFP - Wholesale fluid price index (1967 = 100).

WMP - Wholesale manufacturing price ($/ cwt. of raw milk equivalent).

P1, P2 - Class I and II price ($/cwt).

PFOOD - Retail consumer price index for all food (1967 = 100).

PFE - Producer price index for fuel and energy (1967 = 100).

Other Variables

INC - U.S. personal disposable income (billion $).

GFA, GMA - Generic fluid and manufacturing advertising expenditures (thousand $).

UNEMP - U.S. civilian unemployment rate (%).

RWAGE, MWAGE - Hourly wage in food retailing and food manufacturing ($/hour).

TREND - Trend variable, for retail fluid and manufactured demand equals 1975 (quarter 1) = 1, ..., 1987 (quarter 4) = 52; for other equations equals 1970 (quarter 1) = 1, ..., 1987 (quarter 4) = 72.

QRT2 - Seasonal dummy variable equal to 1 for quarter 2, 0 otherwise.

QRT3 - Seasonal dummy variable equal to 1 for quarter 3, 0 otherwise.

DUM1 - Dummy variable, equal to 1 for 1981 through 1983, 0 otherwise.

DUM2 - Dummy variable, equal to 1 for 1972 through 1974, 0 otherwise.

U, L, ln - White noise, lag operator, and natural logarithm, respectively.

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predetermined variables have the expected signs, and all t-values are statistically significant at conventional levels. All equations, except for the retail fluid and manufactured demand equations, were estimated using quarterly data from 1970 through 1987. Due to data limitations, the two retail demand equations were estimated with quarterly data from 1975 through 1987.[8]

The retail market consists of four equations: supply and demand for fluid products and supply and demand for manufactured dairy products.

Retail fluid demand (RFD) is a function of the ratio of retail fluid price index (RFP) to the consumer price index for food (PFOOD), and other demand shifters including demand in the previous period, disposable personal income (INC) deflated by the consumer price index for all items (CPI), generic fluid advertising expenditures (GFA) deflated by the CPI, and a trend variable (TREND). The variable PFOOD is used as a proxy for the price of fluid milk substitutes, GFA accounts for the influence of contemporaneous fluid advertising on demand, the lagged dependent variable is used to capture the consumption effect of habit formation, and the trend variable reflects the increase in health concerns regarding the possible link between milk consumption and heart

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[8] Data on generic advertising expenditures for fluid and manufactured dairy products are not available on a quarterly basis prior to 1975. These variables are demand shifters in the two retail demand equations. Because of this, two sets of reduced-form equations are estimated (one set uses 1975 through 1987 with all the exogenous variables included, and the other uses the entire sample with the advertising variables excluded). The first set is used to generate price instruments (from 1975 through 1987) for the estimation of the two retail demand equations and the second set is used to generate price instruments (from 1970 through 1987) for the estimation of the remaining four equations. The data set is listed in Appendix 2.

disease. An autoregressive term involving only the fourth lag is added to account for the strong seasonal pattern of fluid product consumption.

Retail fluid supply (RFS) is estimated as a function of the ratio of RFP to the wholesale fluid price index (WFP), which represents the major variable cost in the retail supply function. Other explanatory variables include: lagged fluid supply, producer price index for fuel and energy (PFE) deflated by the CPI, and the unemployment rate (UNEMP). The lagged dependent variable captures the short-run capacity constraint on retail fluid supply, PFE reflects the variable cost of energy, and the unemployment rate is used as a proxy for the state of the economy. To correct for seasonality, an autoregressive-moving average error structure is imposed.

Retail demand for manufactured dairy products (RMD) is a function of the ratio of the retail manufactured product price index (RMP) to PFOOD. Other demand shifters include lagged demand, income, generic manufactured dairy product advertising expenditures (GMA), a time trend variable, a dummy variable (DUM1), and two quarterly dummy variables (QTR2 and QTR3). The advertising variable accounts for the contemporaneous effect of advertising, the lagged demand variable is used to capture the impact of habit formation on consumption, and the time trend reflects the increase in demand from increases in away-from-home consumption (e.g. increase in away-from-home pizza consumption). The variable DUM1 is included to account for a period of greater instability during the period of 1981 to 1983, and the two quarterly dummy variables reflect the seasonal pattern of manufactured demand.[9]

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9 Using the estimated retail demand equations, the fluid and manufactured price elasticities are simulated by a one period shock. The short run elasticities are -0.413 for fluid and -0.478 for

Retail supply for manufactured dairy products (RMS) is estimated as a function of the ratio of RMP to the wholesale manufacturing price (WMP), which is the major variable cost in the retail supply function. Other supply shifters include: lagged supply, average hourly wage among retail workers in the food industry (RWAGE), a time trend variable (TREND), and a dummy variable (DUM2). Lagged supply is included to reflect capacity constraints in the retail manufacturing supply, RWAGE represents another major variable cost in the supply function, the trend variable is a proxy for technological improvements in manufactured product subsector, and the dummy variable may explain the impact of higher energy prices in the early 1970's. To account for serial correlation, a second-order autoregressive error structure is imposed.

The wholesale market consists of two equations: supply for fluid products and supply for manufactured dairy products.

The wholesale fluid supply (WFS) is estimated as a function of the ratio of WFP to the Class I price for raw milk (P1), which is the major variable cost for the fluid processors. Other explanatory variables include: supply in previous periods and the deflated fuel and energy price index. A first order autoregressive error structure is imposed to account for serial correlation.

The wholesale manufactured supply (WMS) is expressed as a function of the ratio of WMP to the Class II price for raw milk (P2). In addition, the following supply shifters are included: lagged supply accounting for capacity constraint, deflated average hourly wages in food manufacturing (MWAGE), and a trend variable to capture

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manufactured products. The long run elasticities (which converge after four quarters) are -0.552 and -0.653 for fluid and manufactured dairy products, respectively.

technological change.[10] To correct for serial correlation in the error term, a second order autoregressive term is imposed.

Test for Selectivity Bias

The wholesale manufactured price is constrained by the government purchase price in the model. Hence, the reduced-form equation for this price variable is estimated by a maximum likelihood Tobit procedure. It was shown in (6.2) that other prices (the retail fluid, the retail manufactured, the wholesale fluid and the Class II prices) are also subject to selectivity bias and the Heckman-like correction term has to be incorporated in the reduced-form estimation of those prices even though they are not subject to direct government intervention (see the third term in (6.2) and (A3.2) to (A3.5) in Appendix 1). In order to determine whether this correction procedure matters in an empirical setting, the significance of the Heckman-like correction term is tested. Also, F-tests on the reduced-form parameters under both regimes are conducted to determine whether the reduced-form forecasts for the two regimes need to be weighted in a fashion similar to the first two terms in (6.2) for the four price variables (also see (A3.2) to (A3.5) in Appendix 1).

Table 3 presents the test results. With respect to the Heckman-like correction term, three of the four price reduced-form equations are statistically significantly different from zero, suggesting selectivity bias is present if the correction is not made in the estimation.

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10 It is interesting to note that the time trend variable was initially included in the fluid supply functions to capture technological change, but was not significant. This is not surprising because while production of non-fluid products has undergone substantial technological improvements, the fluid technology has not (Putnam, et. al.).

Selectivity bias is found to exist in the equations for the retail fluid price, the wholesale fluid price, and the Class II price, but not in the retail manufactured price equation. Furthermore, the F-tests suggest that the reduced-form parameters are significantly different for the two regimes for the retail fluid price and the Class II price equations. Judging from the test results, it is important to note that selectivity bias exists for prices that are not subject to direct government intervention.

Table 3. Hypothesis Tests on the Reduced-Form Parameters

Equation	Ho: $\beta_{HLC} = 0^{\#}$ (t-value)	Ho: $\pi_{*} - \pi = 0^{*}$ (p-value)
Retail Fluid Price (RFP)	3.07	0.087
Retail Manufactured Price (RMP)	0.38	0.834
Wholesale Fluid Price (WFP)	2.16	0.212
Class II Price (P2)	2.53	0.005

β_{HLC} is to denote the coefficient of the Heckman-like correction term.
* Test is conducted for the common components of π_{*} and π.

Comparison to Alternative Estimation Results

The test above provides statistical evidence that the selectivity-bias correction procedure is necessary for policy models of government intervention. While this procedure has been shown to be important in a statistical sense, it is also important to examine the actual magnitudes of these differences for important policy parameters. To do this, the model was re-estimated using two-stage least squares assuming the government price is always binding. The results appear to be fairly similar with respect to goodness of fit, t-values, and Durbin-Watson statistics (see Table 4). The main differences between models are found in the magnitudes of the price coefficients.

Table 4. Estimated Structural Equations for the Wholesale and Retail Sectors Using the Conventional Two-Stage Least Squares Procedure*

Retail Fluid Demand

$$\ln RFD = -\ 0.572 \ln (RFP/PFOOD) + 0.218 \ln RFD_{-1} + 0.467 \ln (INC/CPI) + 0.016 \ln (GFA/CPI)$$

(-1.61) (1.62) (5.39) (2.28)

$$-\ 0.006\ TREND + [1/(1 - 0.823\ L^4)]\ U$$

(-1.85) (10.26)

$\bar{R}^2 = 0.79$; D.W. = 1.87

Retail Fluid Supply

$$\ln RFS = 2.662 + 0.631 \ln (RFP/WFP) + 0.139 \ln RFS_{-1} - 0.139 \ln (PFE/CPI) - 0.163 \ln UNEMP$$

(23.67) (5.42) (3.76) (-7.74) (-8.07)

$$+\ [(1 + 0.796\ L) / (1 + 0.316\ L + 0.553\ L^2)]\ U$$

(4.50) (-2.44) (-7.14)

$\bar{R}^2 = 0.77$; D.W. = 2.05

Retail Manufactured Demand

$$\ln RMD = -\ 0.506 \ln (RMP/PFOOD) + 0.235 \ln RMD_{-1} + 0.436 \ln (INC/CPI) + 0.004 \ln (GMA/CPI)$$

(-1.82) (2.82) (9.10) (2.97)

$$+\ 0.042 \ln TREND + 0.052\ DUM1 + 0.162\ QTR2 + 0.103\ QTR3 + U$$

(2.14) (3.53) (12.53) (7.59)

$\bar{R}^2 = 0.95$; D.W. = 1.80

Retail Manufactured Supply

$$\ln RMS = 0.170 \ln (RMP/WMP) + 0.607 \ln RMS_{-1} - 0.072 \ln (RWAGE/CPI)$$

(1.66) (8.66) (-0.96)

$$+\ 0.083 \ln TREND - 0.061\ DUM2 + [1/(1 + 0.090\ L + 0.786\ L^2)]\ U$$

(6.26) (-2.58) (-1.18) (-11.61)

$\bar{R}^2 = 0.91$; D.W. = 2.46

Wholesale Fluid Supply

$$\ln WFS = 0.090 \ln (WFP/P1) + 0.939 \ln WFS_{-1} - 0.887 \ln WFS_{-2} + 0.862 \ln WFS_{-3}$$

(2.24) (16.41) (-11.98) (15.83)

$$-\ 0.018 \ln (PFE/CPI) + [1/(1 + 0.318\ L)]\ U$$

(-1.46) (-2.47)

$\bar{R}^2 = 0.84$; D.W. = 1.87

Wholesale Manufactured Supply

$$\ln WMS = -\ 1.960 + 0.406 \ln (WMP/P2) + 0.464 \ln WMS_{-1} - 0.838 \ln (MWAGE/CPI)$$

(-3.41) (3.91) (6.17) (-4.34)

$$+\ 0.105 \ln TREND + [1/(1 + 0.070\ L + 0.782\ L^2)]\ U$$

(7.77) (-0.90) (-11.13)

$\bar{R}^2 = 0.92$; D.W. = 2.48

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* $\bar{R}^2$ is adjusted coefficient of determination, D.W. is the Durbin-Watson statistic, and t-values are given in parentheses.

In econometric analyses of agricultural policy, analysts are usually interested in estimated price elasticities. For instance, it is important to have various elasticity measures in the retail market so as to evaluate the impacts of alternative farm policies on consumers. Table 5 shows the estimated demand and supply elasticities for the retail market from both models. While the conventional two-stage least squares results in similar income and advertising elasticities, it consistently overestimates the price elasticities compared with the bias corrected two-stage least squares method.

Table 5. Comparison of Elasticities*

	Corrected Two-Stage Least Squares		Conventional Two-Stage Least Squares	
	Short-run	Long-run	Short-run	Long-run
Retail Fluid Demand				
w.r.t. RFP:	-0.413	-0.552	-0.572	-0.724
w.r.t. INC:	0.447	0.600	0.467	0.594
w.r.t. GFA:	0.014	0.018	0.016	0.020
Retail Fluid Supply				
w.r.t. RFP:	0.535	0.622	0.631	0.723
Retail Manufactured Demand				
w.r.t. RMP:	-0.478	-0.653	-0.506	-0.681
w.r.t. INC:	0.435	0.597	0.436	0.589
w.r.t. GMA:	0.005	0.007	0.004	0.006
Retail Manufactured Supply				
w.r.t. RMP:	0.167	0.403	0.170	0.439

* Elasticities are simulated by a one-period shock at the first quarter of 1985. The short-run elasticities are the instantenous responses. The long-run elasticities reflect the new equilibrium levels which converge within 4 to 6 quarters.

The greatest divergence in estimated elasticities between models is in the retail fluid demand and supply price elasticities. With respect to retail fluid demand, correcting for selectivity-bias yields a long-run price elasticity of -0.552 compared to -0.724 for the conventional two-stage least squares model. With respect to the retail fluid supply, the corrected model also yields a more price inelastic result than the conventional model (0.622 vs. 0.723). Similar differences exist in the price elasticities in the retail manufactured demand and supply equations, but they are not as large as the differences in the fluid market.

Insights as to why the conventional two-stage least squares method consistently yields higher estimates (in absolute values) of price elasticities than the corrected model may be gained by considering a single market example. Figure 1 illustrates the bias which arises from the censored problem. The possible price-quantity values for supply and demand are denoted by "+" and "-", respectively. Since the observations never fall below the support price, the estimated supply and demand curves using the method without accounting for the censoring problem results in smaller slopes (in absolute values) than the slopes of the true supply and demand. Consequently, estimated price elasticities from the conventional model are more elastic than the true values.

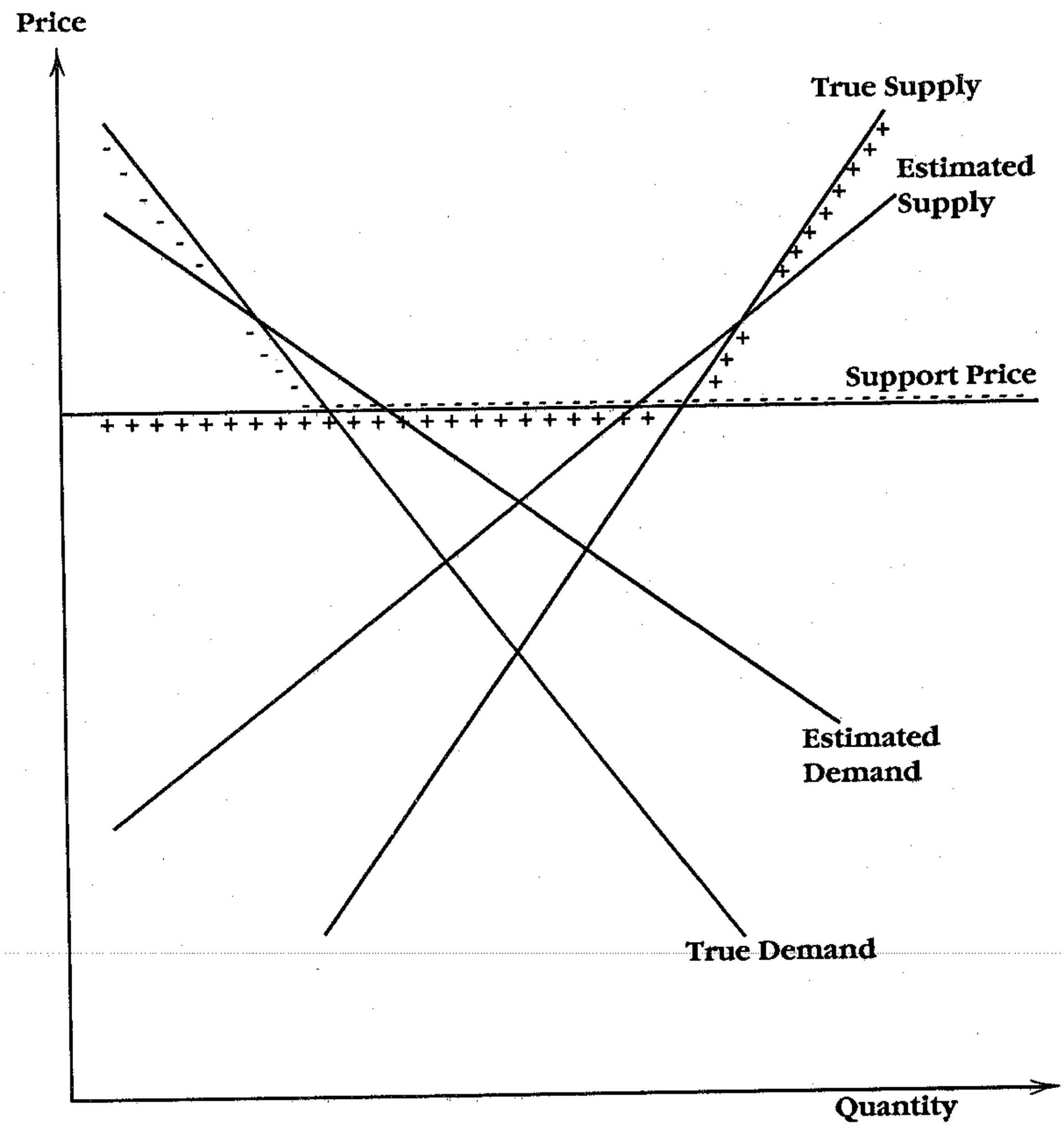

Figure 1: Censored Supply and Demand Model

CONCLUSION

This paper developed a bias corrected two-stage least squares estimation procedure in a multiple market setting to deal with selectivity bias. Selectivity bias may occur in markets where government price intervention exists. The procedure was applied to the U.S. dairy sector, which is a classical example of a switching system: government support regime when the price determined by competitive supply and demand conditions is below the government stipulated price, and market equilibrium regime otherwise.

In the context of a multiple market switching system, it was shown theoretically and empirically that selectivity bias is not only apparent in the component of the system directly affected by government intervention, but also exists in those subsectors which are only indirectly affected by price support programs. The dairy model used in the analysis consists of a wholesale and a retail market with each market containing a fluid and a manufactured product subsector. Selectivity bias was empirically significant in the reduced-form equations for the retail fluid price, the wholesale fluid price, the wholesale manufactured price, and the Class II price even though it is only the wholesale manufactured price that is subject to government intervention. The retail manufactured price was the only price not affected by selectivity bias.

Finally, comparisons were made between estimated elasticities from the corrected and conventional two-stage least squares models. While elasticities for other variables, such as income and advertising, were very similar for the two estimation methods, the results indicated that the price elasticity estimates from the conventional model were generally biased upward, i.e. more elastic. Therefore, ignoring selectivity bias in modeling government intervention may lead to serious biases in important policy parameters.

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APPENDIX 1:

Derivations of the Reduced-Form and Structural Equations: The Dairy Sector

The dairy model for the market equilibrium regime is presented in equations (9) to (13). Making use of (11.2), (11.3), (12.2), (12.3) and (13), one can express $Q^{wf}{}_{s} = Q^{rf}$, $Q^{wm}{}_{s} = Q^{rm}$ and $Q^{rf} = SBAR - Q^{rm}$. Using these results and substituting (9.3) and (10.3) into (9.1), (9.2), (10.1), (10.2), (11.1) and (12.1), the reduced-form for the remaining six endogenous variables can be expressed as:

$$(A1.1) \qquad P^{wm} = \pi^{wm} Z + \epsilon^{wm}$$

$$(A1.2) \qquad P^{rf} = \pi^{rf} Z + \epsilon^{rf}$$

$$(A1.3) \qquad P^{rm} = \pi^{rm} Z + \epsilon^{rm}$$

$$(A1.4) \qquad P^{wf} = \pi^{wf} Z + \epsilon^{wf}$$

$$(A1.5) \qquad P^{II} = \pi^{II} Z + \epsilon^{II}$$

$$(A1.6) \qquad Q^{rm} = \pi^{rm}{}_{q} Z + \epsilon^{rm}{}_{q}$$

where Z is a column vector containing $Z^{rf}{}_{s}$, $Z^{rf}{}_{d}$, $Z^{rm}{}_{s}$, $Z^{rm}{}_{s}$, $Z^{wf}{}_{s}$, $Z^{wm}{}_{s}$, d and SBAR.

Now, with the government purchase price binding, the wholesale manufactured price is set exogenously at the purchase price. Thus, (10.1) and (12.1) are replaced by (10.1') and (12.1'), respectively. Also, the farm level equilibrium condition (13) is replaced by (13'). From (13'), express $Q^{wf} = SBAR - Q^{wm} - Q^{g}$. Making suitable substitutions of this result and other equilibrium conditions into the rest of the equations, the reduced-form equations for the remaining six endogenous variables can be expressed as:

(A1.1') $Q^g = \pi^g_* Z_* + \epsilon^{wm}_*$

(A1.2') $P^{rf} = \pi^{rf}_* Z_* + \epsilon^{rf}_*$

(A1.3') $P^{rm} = \pi^{rm}_* Z_* + \epsilon^{rm}_*$

(A1.4') $P^{wf} = \pi^{wf}_* Z_* + \epsilon^{wf}_*$

(A1.5') $P^{II} = \pi^{II}_* Z_* + \epsilon^{II}_*$

(A1.6') $Q^{rm} = \pi^{qrm}_* Z_* + \epsilon^{qrm}_*$

where Z_* is a column vector containing $Z = (Z^{rf}_s, Z^{rf}_d, Z^{rm}_s, Z^{rm}_s, Z^{wf}_s, Z^{wm}_s$, d and SBAR) and P^g.

The Combined Model

Again, one seeks a single model that entertains both the possibility of market equilibrium solution and that of government support solution. Define the probability for the government support solution to occur as Φ and the probability for the market equilibrium solution to occur as $1-\Phi$. That is,

$\Phi \equiv$ *PROB* $(P^{wm} \leq P^g)$

$1-\Phi \equiv$ *PROB* $(P^{wm} > P^g)$

Following the procedure in the text, the unconditional expected retail fluid quantity supplied and demanded can be derived from (9.1) and (9.2):

(A2.1) $E[Q^{rf}_s] = \alpha^{rf}_s E[P^{rf}] + \beta^{rf}_s E[P^{wf}] + \gamma^{rf}_s Z^{rf}_s$

(A2.2) $E[Q^{rf}_d] = \beta^{rf}_d E[P^{rf}] + \gamma^{rf}_s Z^{rf}_s$

Similarly, from (10.1) and (10.1') and from (10.2), the unconditional expected retail manufactured quantity supplied and demanded are:

(A2.3) $E[Q^{rm}_s] = \alpha^{rm}_s E[P^{rm}] + \{(1-\Phi) \beta^{rm}_s E[P^{wm} | P^{wm} > P^g]$
$+ \Phi \beta^{rm}_s P^g]\} + \gamma^{rm}_s Z^{rm}_s$

(A2.4) $E[Q^{rm}_d] = \beta^{rm}_d E[P^{rm}] + \gamma^{rm}_s Z^{rm}_s$

Finally, from (11.1) and from (12.1) and (12.1'), the unconditional expected wholesale fluid and manufactured supply quantities are:

$$\text{(A2.5)} \qquad E[Q^{wf}{}_s] = \alpha^{wf}{}_s \, E[P^{wf}] + \beta^{wf}{}_s \, (E[P^{II}] + d) + \gamma^{wf}{}_s \, Z^{wf}{}_s$$

$$\text{(A2.6)} \qquad E[Q^{wm}{}_s] = \{(1-\Phi) \, \alpha^{wm}{}_s \, E[P^{wm} | \, P^{wm} > P^g] + \Phi \, \alpha^{wm}{}_s \, P^g]\} + \beta^{wm}{}_s \, E[P^{II}] + \gamma^{wm}{}_s \, Z^{wm}{}_s$$

Estimation of the Reduced-Form Equations

It is clear that the reduced-form equation for wholesale manufactured price in (A1.1) has to be estimated by a Tobit type procedure as the unconditional price expectation is:

$$\text{(A3.1)} \qquad E[P^{wm}] = (1-\Phi) \, E[P^{wm} | \, P^{wm} > P^g] + \Phi \, E[P^{wm} | \, P^{wm} \leq P^g] = (1-\Phi(c^*)) \, \pi^{wm} \, Z + \sigma^{wm} \, \phi(c^*) + \Phi(c^*) \, P^g$$

where $\Phi(c^*)$ and $\phi(c^*)$ are the cumulative standard normal and the standard normal density, both evaluated at c^* ($\equiv (P^g - \pi^{wm} Z) / \sigma^{wm}$) and $(\sigma^{wm})^2 \equiv E[\epsilon^{wm} \, \epsilon^{wm}]$.

With the result from a maximum likelihood Tobit estimation of (A1.1), the conditional expectation of $E[P^{wm} | \, P^{wm} > P^g]$ can be obtained from:

$$\text{(A4.1)} \qquad E[P^{wm} | \, P^{wm} > P^g] = \pi^{wm} \, Z + \sigma^{wm} \, [\phi \, / \, (1-\Phi)]$$

There are two reduced-form equations for the retail fluid price ((A1.2) and (A1.2')). The combined reduced-form equation is:

$$P^{rf} = (1-\Phi) \, \{\pi^{rf} \, Z + (\epsilon^{rf} | \, P^{wm} > P^g)\} + \Phi \, \{\pi^{rf}{}_* \, Z_* + (\epsilon^{rf}{}_* | \, P^{wm} \leq P^g)\}$$

As the derivation in the text, taking unconditional expectation on both sides of the above equation, the reduced-form equation for P^{rf} can be obtained by regressing

$$\text{(A3.2)} \qquad P^{rf} = \pi^{rf} \, [(1-\Phi) \, Z] + \pi^{rf}{}_* \, [\Phi \, Z_*] + (\sigma^{rfwm} - \sigma^{rfwm}{}_*) \, [\phi \, / \, \sigma^{wm}] + \xi^{rf}$$

where $\sigma^{rfwm} \equiv E[\epsilon^{rf} \; \epsilon^{wm}]$ and $\sigma^{rfwm}{}_{*} \equiv E[\epsilon^{rf}{}_{*} \; \epsilon^{wm}]$ and ξ^{rf} is a newly appended error term and it has a zero mean by construction. Note that Φ, ϕ and σ^{rf} are obtained from the Tobit estimation of (A1.1) and Z and Z_{*} are data. From (A3.2), the unconditional expectation of P^{rf} is:

(A4.2) $$E[P^{rf}] = (1-\Phi) \; E[P^{rf} | \; P^{wm} > P^{g}] + \Phi \; E[P^{rf} | \; P^{wm} \leq P^{g}])$$
$$= \pi^{rf} \; [(1-\Phi) \; Z] + \pi^{rf}{}_{*} \; [\Phi \; Z_{*}] + (\sigma^{rfwm} - \sigma^{rfwm}{}_{*}) \; [\phi \; / \; \sigma^{wm}]$$

The combined reduced-form equations for the retail manufactured price, the wholesale fluid price and the Class II price can be similarly derived from (A1.3)-(A1.3') pair to (A1.5)-(A1.5') pair. They can be estimated by regressing

(A3.3) $$P^{rm} = \pi^{rm} \; [(1-\Phi) \; Z] + \pi^{rm}{}_{*} \; [\Phi \; Z_{*}] + (\sigma^{rmwm} - \sigma^{rmwm}{}_{*}) \; [\phi \; / \; \sigma^{wm}] + \xi^{rm}$$

(A3.4) $$P^{wf} = \pi^{wf} \; [(1-\Phi) \; Z] + \pi^{wf}{}_{*} \; [\Phi \; Z_{*}] + (\sigma^{wfwm} - \sigma^{wfwm}{}_{*}) \; [\phi \; / \; \sigma^{wm}] + \xi^{wf}$$

(A3.5) $$P^{II} = \pi^{II} \; [(1-\Phi) \; Z] + \pi^{II}{}_{*} \; [\Phi \; Z_{*}] + (\sigma^{IIwm} - \sigma^{IIwm}{}_{*}) \; [\phi \; / \; \sigma^{wm}] + \xi^{II}$$

where $\sigma^{rmwm} \equiv E[\epsilon^{rm} \; \epsilon^{wm}]$, $\sigma^{rmwm}{}_{*} \equiv E[\epsilon^{rm}{}_{*} \; \epsilon^{wm}]$, $\sigma^{wfwm} \equiv E[\epsilon^{wf} \; \epsilon^{wm}]$, $\sigma^{wfwm}{}_{*} \equiv E[\epsilon^{wf}{}_{*} \; \epsilon^{wm}]$, $\sigma^{IIwm} \equiv E[\epsilon^{II} \; \epsilon^{wm}]$ and $\sigma^{IIwm}{}_{*} \equiv E[\epsilon^{II}{}_{*} \; \epsilon^{wm}]$. As before, each of the appended error terms (ξ^{rm}, ξ^{wf}, ξ^{II}) has a zero mean by construction.

Moreover, the unconditional expectation of P^{rm}, P^{wf} and P^{II} are:

(A4.3) $$E[P^{rm}] = (1-\Phi) \; E[P^{rm} | \; P^{wm} > P^{g}] + \Phi \; E[P^{rm} | \; P^{wm} \leq P^{g}])$$
$$= \pi^{rm} \; [(1-\Phi) \; Z] + \pi^{rm}{}_{*} \; [\Phi \; Z_{*}] + (\sigma^{rmwm} - \sigma^{rmwm}{}_{*}) \; [\phi \; / \; \sigma^{wm}]$$

(A4.4) $$E[P^{wf}] = (1-\Phi) \; E[P^{wf} | \; P^{wm} > P^{g}] + \Phi \; E[P^{wf} | \; P^{wm} \leq P^{g}])$$
$$= \pi^{wf} \; [(1-\Phi) \; Z] + \pi^{wf}{}_{*} \; [\Phi \; Z_{*}] + (\sigma^{wfwm} - \sigma^{wfwm}{}_{*}) \; [\phi \; / \; \sigma^{wm}]$$

(A4.5) $$E[P^{II}] = (1-\Phi) \; E[P^{II} | \; P^{wm} > P^{g}] + \Phi \; E[P^{II} | \; P^{wm} \leq P^{g}])$$
$$= \pi^{II} \; [(1-\Phi) \; Z] + \pi^{II}{}_{*} \; [\Phi \; Z_{*}] + (\sigma^{IIwm} - \sigma^{IIwm}{}_{*}) \; [\phi \; / \; \sigma^{wm}]$$

Estimation of the Structural Equations

The combined structural equations are shown in (A2.1) to (A2.6). Substituting (A4.1) to (A4.5) into (A2) for the relevant price expectations and replacing $E[Q^{rf}_s]$, $E[Q^{rf}_d]$, $E[Q^{rm}_s]$, $E[Q^{rm}_d]$, $E[Q^{wf}_s]$ and $E[Q^{wm}_s]$ by Q^{rf}_s, Q^{rf}_d, Q^{rm}_s, Q^{rm}_d, Q^{wf}_s and Q^{wm}_s, one obtains:

(A5.1) $$Q^{rf}_s = \alpha^{rf}_s E[P^{rf}] + \beta^{rf}_s E[P^{wf}] + \gamma^{rf}_s Z^{rf}_s + \tau^{rf}_s$$

(A5.2) $$Q^{rf}_d = \beta^{rf}_d E[P^{rf}] + \gamma^{rf}_d Z^{rf}_d + \tau^{rf}_d$$

(A5.3) $$Q^{rm}_s = \alpha^{rm}_s E[P^{rm}] + (1-\Phi) (\beta^{rm}_s E[P^{wm}| P^{wm} > P_g) + \Phi (\beta^{rm}_s P_g) + \gamma^{rm}_s Z^{rm}_s + \tau^{rm}_s$$

(A5.4) $$Q^{rm}_d = \beta^{rm}_d E[P^{rm}] + \gamma^{rm}_d Z^{rm}_d + \tau^{rm}_d$$

(A5.5) $$Q^{wf}_s = \alpha^{wf}_s E[P^{wf}] + \beta^{wf}_s (E[P^{II}] + d) + \gamma^{wf}_s Z^{wf}_s + \tau^{wf}_s$$

(A5.6) $$Q^{wm}_s = (1-\Phi) (\alpha^{wm}_s E[P^{wm}| P^{wm} > P_g]) + \Phi (\alpha^{wm}_s P_g) + \beta^{wm}_s E[P^{II}] + \gamma^{wm}_s Z^{wm}_s + \tau^{wm}_s$$

Since each of the six newly appended error terms in (A5) has a zero mean by construction and all the price variables in the right-hand-side of the equations have been "instrumented", the equations can be estimated by ordinary least squares to obtain estimates of the structural parameters (α^{rf}_s, β^{rf}_s, γ^{rf}_s, β^{rf}_d, γ^{rf}_d, α^{rm}_s, β^{rm}_s, γ^{rm}_s, β^{rm}_d, γ^{rm}_d, α^{wf}_s, β^{wf}_s, γ^{wf}_s, α^{wm}_s, β^{wm}_s and γ^{wm}_s)

The sequence for estimating the dairy system can be summarized as the following. 1. Estimate the wholesale manufactured price reduced-form equation in (A1.1) by a maximum likelihood Tobit procedure and obtain estimates of π^{wm} and σ^{wm}. 2. Compute Φ and ϕ for all observations. 3. Estimate the reduced-form equations for the retail fluid price, the retail manufactured price, the wholesale fluid price and the Class II price in (A3.2) to (A3.5) by ordinary least squares. 4. Calculate the conditional expectation of the wholesale manufactured price ($E[P^{wm} | P^{wm} > P^{g}]$) in (A4.1) and the unconditional expectations of the retail fluid price ($E[P^{rf}]$), retail manufactured price ($E[P^{rm}]$), wholesale fluid price ($E[P^{wf}]$) and the Class II price ($E[P^{II}]$) in (A4.2) to (A4.5) for all observations. 5. Estimate (A5.1) to (A5.6) by ordinary least squares.

APPENDIX 2:

The Data and Sources

The data used to estimate the structural and reduced form equations of the dairy industry are presented in Table A.1. The time series is quarterly data from 1970 through 1987. The sources for the data are listed below. In the table, the number in parentheses corresponds to the sources that the data were collected from.

(1) Bureau of Economic Statistics, Inc., Economic Statistics Bureau of Washington, D.C., ***Handbook of Basic Economic Statistics***. Washington, D.C., 1970-88.

(2) U.S. Department of Labor, Bureau of Labor Statistics, ***Consumer Price Index***. Washington D.C., 1970-88.

(3) U.S. Department of Labor, Bureau of Labor Statistics, ***Employment and Earnings***. Washington D.C., 1970-88.

(4) U.S. Department of Labor, Bureau of Labor Statistics, ***Producer Price Index (and Wholesale Price Index)***. Washington D.C., 1970-88.

(5) Leading National Advertisers, Inc., ***Leading National Advertisers***. Expenditures include network television, cable network television, spot television, network radio, magazine, newspaper, and outdoor advertising for the following generic dairy promotion units: American Dairy Association, California Milk Producers Advisory Board, National Dairy Promotion and Research Board, Oregon Dairy Products Commission, United Dairymen of Arizona, Washington Dairy Products Commission, and Wisconsin Milk Marketing board. Expenditures also include joint venture of the COW Group.

(6) U.S. Department of Agriculture, Economic Research Service, ***Dairy Situation and Outlook***. Washington D.C., 1970-88.

(7) U.S. Department of Agriculture, Agricultural Marketing Service, ***Federal Milk Order Market Statistics***. Washington D.C., 1970-88.

(8) The retail manufacturing price index was constructed as a weighted average of the retail cheese, butter, and ice cream price indices reported in ***Dairy Situation and Outlook***, 1970-88.

(9) The wholesale and retail manufacturing supply and demand was constructed by subtracting fluid use and net CCC purchases from commercial disappearance. All data used in this construction are reported in ***Dairy Situation and Outlook***, 1970-88.

(10) The manufacturing purchase price and wholesale price were constructed using data reported in ***Dairy Situation and Outlook***, 1970-88. See Appendix 3 for the procedures of constructing these two prices.

Table A.1. Data Used in Econometric Estimation of the Structural and Reduced Form Equations of the Dairy Industry, 1970-87, Quarterly.

QUARTER AND YEAR	MILK PRODUCTION (BIL LBS)	CLASS 2 PRICE ($/CWT)	CLASS 1 PRICE ($/CWT)	CLASS 1 DIFFER-ENTIAL ($/CWT)	WSALE & RET FLUID SUPPLY AND DEMAND (BIL LBS)	WSALE & RET MANF SUPPLY AND DEMAND (BIL LBS)	NET CCC REMOVAL (MIL LBS)	MANF PURCHASE PRICE ($/CWT)	MANF WHOLESALE PRICE ($/CWT)	FLUID WHOLESALE PRICE (67=100)
NAME	SBAR	P2	P1	D	RFD, RFS, WFD, WFS	RMD, RMS, WMD, WMS	CCC	PP	WMP	WFP
I 1970	28.36	4.63	6.73	2.10	17.1	8.4	1.3	4.89	5.25	107.9
II	32.06	4.60	6.67	2.07	15.2	9.2	2.9	5.29	5.34	108.8
III	29.15	4.62	6.70	2.07	16.9	9.8	1.2	5.29	5.34	108.8
IV	27.44	4.81	6.84	2.03	18.0	8.8	0.5	5.29	5.36	109.6
I 1971	28.80	4.81	6.91	2.10	15.6	7.1	2.7	5.29	5.57	108.3
II	32.41	4.79	6.91	2.12	15.1	10.5	2.7	5.29	5.57	108.9
III	29.48	4.79	6.86	2.07	16.4	10.2	1.4	5.57	5.63	111.1
IV	27.88	4.86	6.92	2.06	17.7	9.1	0.5	5.57	5.63	111.6
I 1972	29.59	4.99	7.04	2.04	16.5	8.7	2.0	5.56	5.68	111.6
II	32.82	4.95	7.09	2.14	15.1	10.5	2.8	5.56	5.80	111.7
III	29.89	5.06	7.06	2.00	17.2	11.0	0.7	5.56	5.74	110.5
IV	27.75	5.30	7.21	1.91	18.7	9.8	-0.2	5.56	5.89	112.1
I 1973	28.67	5.48	7.48	2.01	16.9	8.4	1.6	5.56	6.19	111.9
II	31.80	5.67	7.64	1.97	16.0	12.8	0.5	5.98	6.40	114.3
III	28.40	6.36	7.96	1.60	17.4	10.8	0.1	6.22	6.59	115.0
IV	26.63	7.69	9.02	1.33	18.7	9.4	0.0	6.36	7.43	115.0
I 1974	28.09	8.13	9.99	1.86	16.8	11.1	0.1	6.39	8.21	117.7
II	31.60	6.99	10.11	3.12	14.6	13.2	0.5	7.21	8.63	126.2
III	29.02	6.46	8.60	2.15	16.4	11.7	0.6	7.21	7.95	128.7
IV	26.88	6.66	8.73	2.06	17.8	10.1	0.2	7.21	7.46	125.6
I 1975	28.13	6.84	8.90	2.07	16.1	9.9	1.1	7.87	7.70	126.6
II	31.34	7.02	8.99	1.96	15.1	12.8	1.2	8.01	7.75	128.0
III	28.56	7.77	9.25	1.47	17.2	12.4	-0.3	8.01	8.10	128.4
IV	27.35	8.84	10.27	1.43	17.8	10.5	0.0	8.61	8.93	129.5
I 1976	29.18	8.58	11.03	2.45	16.4	12.0	0.0	8.60	10.10	132.7
II	32.36	8.35	10.53	2.18	14.9	14.6	0.1	9.06	9.40	137.5
III	30.14	8.72	10.54	1.82	15.8	13.7	0.1	9.06	9.51	137.9
IV	28.50	8.26	10.66	2.41	17.0	10.7	1.1	9.27	10.04	138.7
I 1977	29.74	8.22	10.34	2.12	14.9	10.2	2.1	9.28	9.31	140.7
II	33.06	8.61	10.47	1.86	13.5	12.5	2.6	9.94	9.32	139.5
III	30.85	8.68	10.73	2.05	16.0	13.4	1.1	9.94	9.89	140.7
IV	29.00	8.80	10.81	2.01	17.1	12.4	0.3	9.94	9.91	142.1
I 1978	29.69	9.00	10.96	1.96	15.4	11.7	1.2	9.94	10.02	143.1
II	32.58	9.25	11.22	1.97	15.4	12.6	1.9	10.47	10.12	144.6
III	30.36	9.64	11.39	1.75	16.0	14.7	-0.1	10.47	10.40	148.6
IV	28.82	10.41	12.02	1.61	17.0	13.2	-0.2	10.79	10.87	151.6
I 1979	29.76	10.55	12.63	2.07	15.8	12.8	0.2	10.79	11.69	158.5
II	32.78	10.69	12.68	2.00	14.2	14.9	1.1	11.76	11.80	165.1
III	31.06	11.09	12.87	1.78	15.4	15.4	0.0	11.76	12.13	167.2
IV	29.75	11.29	13.32	2.03	16.8	12.8	0.8	12.58	12.70	170.8
SOURCES:	(6)	(7)	(7)	(7)	(7)	(9)	(6)	(10)	(10)	(4)

Table A.1. Data Used in Econometric Estimation of the Structural and Reduced Form Equations of the Dairy Industry, 1970-87, Quarterly.

QUARTER AND YEAR	MILK PRODUCTION (BIL LBS)	CLASS 2 PRICE ($/CWT)	CLASS 1 PRICE ($/CWT)	CLASS 1 DIFFER-ENTIAL ($/CWT)	WSALE & RET FLUID SUPPLY AND DEMAND (BIL LBS)	WSALE & RET MANF SUPPLY AND DEMAND (BIL LBS)	NET CCC REMOVAL (MIL LBS)	MANF PURCHASE PRICE ($/CWT)	MANF WHOLESALE PRICE ($/CWT)	FLUID WHOLESALE PRICE (67=100)
NAME	SBAR	P2	P1	D	RFD, RFS, WFD, WFS	RMD, RMS, WMD, WMS	CCC	PP	WMP	WFP
I 1980	31.20	11.44	13.44	2.00	15.1	12.9	1.5	12.58	12.78	178.9
II	34.04	11.67	13.65	1.98	12.8	11.5	4.4	13.44	13.26	181.4
III	32.19	11.89	13.79	1.91	14.9	14.4	1.5	13.44	13.40	183.5
IV	30.98	12.52	14.22	1.70	15.7	13.1	1.4	14.16	14.19	188.0
I 1981	32.47	12.66	14.70	2.05	13.4	10.2	4.3	14.15	14.10	194.0
II	35.17	12.61	14.77	2.15	12.9	12.6	4.8	14.15	14.08	193.9
III	33.09	12.49	14.69	2.20	14.6	15.0	2.1	14.15	14.11	194.2
IV	32.04	12.53	14.62	2.09	15.0	13.9	1.6	14.23	14.20	195.6
I 1982	33.17	12.49	14.69	2.21	13.1	10.8	4.7	14.15	13.99	196.8
II	35.58	12.43	14.61	2.17	12.8	13.4	4.9	14.15	13.95	197.7
III	33.92	12.44	14.57	2.13	14.0	15.1	2.7	14.15	14.00	198.1
IV	32.83	12.58	14.64	2.06	14.8	14.2	2.1	14.15	14.20	198.9
I 1983	34.17	12.58	14.76	2.18	12.2	10.1	5.6	14.15	14.01	199.8
II	36.83	12.51	14.70	2.19	12.1	13.0	5.8	14.15	13.98	199.8
III	34.94	12.49	14.65	2.17	13.7	15.1	3.1	14.15	14.02	199.5
IV	33.73	12.40	14.64	2.25	14.6	14.7	2.3	13.99	14.10	199.6
I 1984	33.95	12.06	14.40	2.33	13.3	11.5	4.5	13.66	13.72	199.7
II	35.59	12.08	14.23	2.15	13.5	16.1	2.8	13.66	13.77	199.4
III	33.49	12.37	14.27	1.90	15.0	17.3	0.8	13.66	14.18	200.2
IV	32.45	12.63	14.71	2.08	15.8	15.8	0.6	13.66	14.21	203.8
I 1985	33.63	12.19	14.73	2.54	13.5	11.8	4.1	13.66	13.60	205.4
II	37.39	11.43	14.10	2.67	13.0	15.4	4.2	13.08	13.06	203.8
III	36.68	11.10	13.41	2.31	14.5	17.5	2.6	12.60	12.66	201.9
IV	35.43	11.19	13.30	2.10	15.4	16.4	2.2	12.61	12.60	204.2
I 1986	36.17	11.06	13.33	2.27	14.2	11.6	5.0	12.68	12.66	200.9
II	36.17	10.99	13.45	2.46	13.4	16.0	4.2	12.68	12.70	201.0
III	35.61	11.31	13.56	2.25	14.6	19.4	0.9	12.68	13.07	202.3
IV	33.72	11.83	14.07	2.24	15.7	18.4	0.5	12.68	13.29	206.0
I 1987	34.82	11.33	14.39	3.06	14.2	14.7	2.7	12.42	12.34	209.3
II	37.40	11.02	13.66	2.64	13.9	19.1	1.5	12.42	12.43	206.1
III	35.51	11.29	13.55	2.26	14.6	19.9	0.7	12.42	12.75	206.0
IV	34.73	11.27	13.91	2.64	14.9	17.1	1.8	12.17	12.11	208.8
SOURCES:	(6)	(7)	(7)	(7)	(7)	(9)	(6)	(10)	(10)	(4)

Table A.1. Data Used in Econometric Estimation of the Structural and Reduced Form Equations of the Dairy Industry, 1970-87, Quarterly (Continued).

QUARTER AND YEAR	MANU FOOD HOURLY WAGE ($/HOUR)	RET FOOD HOURLY WAGE ($/HOUR)	PRODUCER PRICE FOR FUEL&ENERGY (67=100)	UNEMP RATE (%)	RETAIL FLUID PRICE (67=100)	RETAIL MANU. PRICE (67=100)	CPI ALL ITEMS (67=100)	CPI FOOD (67=100)	DISPOS PERSONAL INCOME (BIL $)	CIV POP (MIL)	GENERIC FLUID ADVERT ($1000)	GENERIC MANF ADVERT ($1000)
NAME	MWAGE	RWAGE	PFE	UNEMP	RFP	RMP	CPI	PFOOD	INC	POP	GFA	GMA
I 1970	3.09	2.64	102.6	4.20	111.03	106.94	113.90	114.20	7,882	203.2	NA	NA
II	3.14	2.68	104.8	4.80	111.13	108.24	115.73	115.20	6,924	204.1	NA	NA
III	3.16	2.73	107.1	5.20	111.47	109.01	117.03	115.70	7,058	205.0	NA	NA
IV	3.24	2.78	112.8	5.90	112.63	109.82	118.57	115.30	7,115	205.9	NA	NA
I 1971	3.33	2.85	112.8	5.90	113.30	110.89	119.47	117.00	7,327	206.8	NA	NA
II	3.38	2.92	114.4	6.00	114.73	111.32	120.83	119.20	7,493	207.4	NA	NA
III	3.37	2.98	115.3	6.00	115.23	112.02	122.13	119.10	7,576	208.1	NA	NA
IV	3.43	3.02	115.0	5.90	115.23	112.01	122.77	120.30	7,674	208.7	NA	NA
I 1972	3.54	3.10	116.5	5.80	116.33	112.89	123.67	121.63	7,822	209.3	NA	NA
II	3.59	3.15	118.2	5.70	116.59	113.17	124.67	122.57	7,945	209.8	NA	NA
III	3.58	3.20	120.3	5.60	115.77	113.15	125.80	124.53	8,156	210.3	NA	NA
IV	3.69	3.26	121.9	5.30	116.37	265.26	126.93	125.43	8,490	210.8	NA	NA
I 1973	3.78	3.31	126.7	5.00	119.63	116.47	128.70	131.40	8,789	211.4	NA	NA
II	3.83	3.35	142.8	4.90	121.70	117.94	131.53	138.07	9,035	211.9	NA	NA
III	3.85	3.39	144.8	4.70	125.93	122.46	134.43	146.20	9,253	212.3	NA	NA
IV	3.95	3.48	201.3	4.70	141.80	135.81	137.57	149.90	9,503	212.8	NA	NA
I 1974	4.05	3.62	189.0	5.20	150.63	147.46	141.43	156.80	9,639	213.3	NA	NA
II	4.15	3.68	210.5	5.10	155.93	142.42	145.57	159.53	9,886	213.9	NA	NA
III	4.23	3.79	225.0	5.50	151.30	138.63	150.13	162.77	10,127	214.4	NA	NA
IV	4.35	3.87	229.0	6.60	151.93	143.15	154.30	167.87	10,281	214.9	NA	NA
I 1975	4.49	3.98	233.0	8.40	153.90	144.36	157.03	171.27	10,352	215.5	3,523	0
II	4.56	4.05	243.0	8.80	151.07	145.38	159.50	172.47	11,052	216.0	3,504	0
III	4.63	4.09	254.9	8.60	150.20	150.14	162.90	178.17	11,094	216.5	2,618	0
IV	4.73	4.19	258.0	8.50	155.60	164.93	165.50	179.83	11,345	217.0	3,502	0
I 1976	4.86	4.30	255.7	7.60	160.37	174.23	167.10	179.83	11,637	217.6	3,356	0
II	4.92	4.37	260.3	7.40	159.83	172.45	169.17	180.03	11,808	218.1	3,859	0
III	5.01	4.43	270.9	7.80	159.83	178.12	171.87	182.03	12,033	218.7	3,320	0
IV	5.10	4.53	279.0	7.90	162.73	179.35	173.80	181.47	12,296	219.2	4,064	0
I 1977	5.24	4.65	293.7	7.40	161.63	177.33	176.87	186.57	12,552	219.8	4,087	0
II	5.31	4.73	304.3	7.10	161.77	181.60	180.67	192.07	12,919	220.3	4,044	0
III	5.40	4.80	309.9	6.90	162.33	184.55	183.30	194.77	13,355	220.9	3,463	0
IV	5.52	4.94	312.0	6.60	163.63	186.94	185.33	195.43	13,735	221.5	4,828	0
I 1978	5.67	5.11	315.3	6.20	165.53	190.70	188.47	201.80	14,057	222.1	4,426	0
II	5.74	5.18	323.2	6.00	169.93	195.70	193.37	210.53	14,513	222.7	3,940	0
III	5.83	5.26	326.7	6.00	172.67	200.56	197.93	215.33	14,962	223.3	2,633	0
IV	5.96	5.41	334.3	5.80	178.70	209.50	201.93	218.00	15,427	223.9	5,361	0
I 1979	6.10	5.56	350.9	5.70	185.33	216.52	206.97	227.50	15,875	224.6	4,081	0
II	6.20	5.62	393.7	5.80	188.00	221.25	214.07	234.00	16,240	225.1	5,892	0
III	6.29	5.68	454.8	5.90	192.73	226.61	221.13	236.77	16,743	225.8	4,651	0
IV	6.47	5.80	487.9	5.90	199.73	234.10	227.60	239.67	17,149	226.4	5,329	0
SOURCES:	(1)	(1)	(4)	(3)	(1)	(8)	(2)	(2)	(3)	(1)	(5)	(5)

Table A.1. Data Used in Econometric Estimation of the Structural and Reduced Form Equations of the Dairy Industry, 1970-87, Quarterly (Continued).

QUARTER AND YEAR	MANU FOOD HOURLY WAGE ($/HOUR)	RET FOOD HOURLY WAGE ($/HOUR)	PRODUCER PRICE FOR FUEL&ENERGY (67=100)	UNEMP RATE (%)	RETAIL FLUID PRICE (67=100)	RETAIL MANU. PRICE (67=100)	CPI ALL ITEMS (67=100)	CPI FOOD (67=100)	DISPOS PERSONAL INCOME (BIL $)	CIV POP (MIL)	GENERIC FLUID ADVERT ($1000)	GENERIC MANF ADVERT ($1000)
NAME	MWAGE	RWAGE	PFE	UNEMP	RFP	RMP	CPI	PFOOD	INC	POP	GFA	GMA
I 1980	6.64	5.93	553.5	6.10	203.17	238.19	236.47	245.33	17,717	227.1	4,492	0
II	6.80	6.07	576.5	7.40	207.33	245.26	245.00	250.50	17,898	227.7	5,722	88
III	6.91	6.34	593.5	7.50	209.63	252.99	249.63	258.20	18,460	228.2	4,896	74
IV	7.04	6.58	615.7	7.50	213.60	261.79	256.17	264.43	19,080	228.8	7,593	50
I 1981	7.23	6.75	696.5	8.50	219.13	268.05	262.93	270.53	19,725	229.3	3,381	10
II	7.39	6.84	707.6	7.90	220.63	270.77	269.03	273.00	20,060	229.8	3,269	60
III	7.50	6.96	703.5	8.00	220.30	271.98	276.73	277.20	20,786	230.4	4,457	5
IV	7.60	6.87	702.5	8.60	220.73	273.25	280.70	277.50	21,098	230.9	5,887	119
I 1982	7.78	7.03	689.7	10.30	221.47	276.17	283.00	282.43	22,072	231.5	3,775	140
II	7.92	7.17	677.3	10.30	221.83	277.49	287.33	285.73	22,418	232.0	4,756	19
III	7.88	7.27	700.4	10.80	221.20	279.03	292.77	287.83	22,786	232.5	3,968	19
IV	7.98	7.35	703.4	11.30	221.20	279.57	293.37	286.63	23,181	233.0	8,372	76
I 1983	8.14	7.43	670.1	12.30	223.50	281.16	293.23	289.20	23,457	233.7	722	76
II	8.21	7.47	654.1	11.10	223.20	282.54	296.90	292.10	23,954	234.2	659	86
III	8.16	7.54	670.9	10.30	222.87	282.89	300.47	292.27	24,432	234.7	641	4
IV	8.25	7.60	663.7	9.30	222.10	283.73	303.07	293.10	25,279	235.3	596	1
I 1984	8.37	7.64	655.6	9.40	222.97	282.94	306.37	301.23	26,118	236.1	3,208	532
II	8.41	7.66	660.4	8.40	223.30	283.18	309.73	301.90	26,428	236.7	8,411	1,927
III	8.36	7.63	658.4	8.40	223.73	288.69	313.07	304.07	26,911	237.2	1,054	563
IV	8.40	7.66	652.7	8.00	228.37	292.30	315.37	304.53	27,286	237.8	16,764	946
I 1985	8.54	7.54	629.1	8.70	229.70	293.92	317.43	308.83	27,622	238.4	17,579	20,153
II	8.60	7.38	640.6	8.30	228.83	292.51	321.23	309.27	28,484	238.9	15,394	14,035
III	8.53	7.27	630.5	8.30	227.57	294.01	323.60	309.70	28,472	239.5	11,007	3,958
IV	8.61	7.24	634.1	7.80	226.23	293.70	326.50	311.33	29,066	240.1	15,505	16,235
I 1986	8.73	7.23	566.5	8.70	225.85	294.07	327.95	315.45	29,660	240.6	17,052	15,545
II	8.76	7.08	483.6	8.40	225.73	293.00	326.50	316.73	30,224	241.2	16,951	16,854
III	8.70	6.96	445.1	8.20	226.47	295.20	328.93	322.00	30,382	241.7	8,393	3,119
IV	8.79	6.98	439.0	7.70	228.55	297.73	330.65	324.15	30,616	242.4	20,390	17,339
I 1987	8.91	6.95	468.8	8.40	230.30	302.10	334.47	329.67	31,259	242.9	14,750	14,786
II	8.94	6.94	485.3	7.40	229.90	302.70	338.83	332.53	31,306	243.4	15,334	19,474
III	8.88	6.86	506.2	7.10	230.10	303.80	342.63	334.10	31,935	244.0	8,991	6,888
IV	8.95	6.86	506.4	7.20	233.90	305.50	345.55	335.20	32,576	244.6	12,129	19,710
SOURCES:	(1)	(1)	(4)	(3)	(1)	(8)	(2)	(2)	(3)	(1)	(5)	(5)

APPENDIX 3:

Construction of the Aggregate Purchase Price and Wholesale Price of Manufactured Dairy Products

Because the model aggregates all non-fluid dairy products into one product (Class II), an aggregate purchase price and wholesale manufactured price needed to be constructed. The aggregate purchase price (PP) and aggregate wholesale manufactured price (WMP) were constructed using the following procedures.

First, purchase prices and wholesale prices for cheese, butter, and nonfat dry milk were converted from a price per pound of product basis to a value of product per hundred pounds of raw milk basis. This resulted in all prices being measured on a milk equivalent basis. The following formulas were used to make these conversions:

$P^{me}{}_{chs}/cwt = P^{w}{}_{chs}/lb * 10.1$

$P^{me}{}_{but}/cwt = P^{w}{}_{but}/lb * 4.48$

$P^{me}{}_{nfm}/cwt = P^{w}{}_{nfm}/lb * 8.13$

where:

$P^{me}{}_{chs}$ = wholesale value (purchase price or wholesale price) of 100 pounds of raw milk used in cheese,

$P^{w}{}_{chs}$ = purchase price or wholesale market price of cheese per pound,

10.1 = yield factor for cheese (100 pounds of raw milk yields 10.1 pounds of cheese),

$P^{me}{}_{but}$ = wholesale value (purchase price or wholesale price) of 100 pounds of raw milk used in butter wholesale value (purchase price or wholesale price) of 100 pounds of raw milk used in butter,

$P^{w}{}_{but}$ = purchase price or wholesale market price of butter per pound,

4.48 = yield factor,

$P^{me}{}_{nfm}$ = wholesale value (purchase price or wholesale price) of 100 pounds of raw milk used in nonfat dry milk wholesale value (purchase price or wholesale price) of 100 pounds of raw milk used in nonfat dry milk,

P^{w}_{nfm} = purchase price or wholesale market price of nonfat dry milk per pound,

8.13 = yield factor.

Next, P^{me}_{but} and P^{me}_{nfm} were added together because they are joint products in order to obtain $P^{me}_{but+nfm}$. Then, the aggregate purchase price and wholesale price was computed by taking the weighted average of P^{me}_{chs} and P^{me}_{but}. The weights were equal to the market shares of cheese (w_1) and butter plus nonfat dry milk (w_2). The formulas used in calculating the two price aggregates are:

$$PP = w_1\ PP^{me}_{chs} + w_2\ PP^{me}_{but+nfdm}, \text{ and}$$

$$WMP = w_1\ WP^{me}_{chs} + w_2\ WP^{me}_{but+nfdm}.$$

where:

PP = aggregate government purchase price per cwt. of raw milk, and

WMP = aggregate wholesale price per cwt of raw milk.

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