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Assessing the Impacts of Liberalization in World Dairy Trade

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Assessing the Impacts of Liberalization in World Dairy Trade*

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Abstract: A 25 region, 7 commodity hedonic spatial equilibrium model of the world dairy sector is developed and summarized. A unique aspect of this model is the explicit incorporation of milk fat and solids-not-fat in the spatial equilibrium structure. This model is then used to simulate the partial equilibrium impacts of free trade (complete trade liberalization) in the world dairy sector relative to observed 1989-92 average level of production, consumption, prices and trade flows. The free trade simulation results suggest average world market farm prices near current U.S. levels, while farm milk prices in Western Europe, Japan, Canada, and South America are simulated to fall 17%, 53%, 24% and 10%, respectively. In contrast, Eastern Europe, Australian and New Zealand farm milk prices are simulated to rise 140%, 43% and 105%, respectively.

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INTRODUCTION

In this paper, the spatial equilibrium model developed by Samuelson (1952) and Takayama and Judge (1964a, 1964b, 1971) is generalized to allow for several stages in the prodcution process. This conceptual model of hedonic spatial equilibrium is then used to build to an empirical model of the world dairy sector, the UW World Dairy Model (UW-WDM). In each stage, the commodities produced are destined as intermediate products for the production of new commodities in the next stage, being possible that one commodity keeps its form from one stage to another. In the last stage, all commodities are destined to final consumption. Also in each stage, commodities are assumed to be transportable between regions. As with previous studies dealing with intermediate products (Takayama and Judge, 1964b; Thore, 1992; Bishop, Pratt and Novakovic, 1993) we assume constant costs of processing, which may differ among regions.

The incorporation of stages of production with the presence of intermediate products brings a closer representation of reality. In the real world, final commodities are produced by using not only primary factors of production, but also intermediate products. Vanek (1963) introduces the issue of intermediate products by supposing that each product in the economy can be used both as an intermediate and as a final commodity. Samuelson (1966) suggests that the productive system can be considered as a "black box", with an input of primary factors of production and an output of the net quantity of final commodities. Using this approach, it has been demonstrated that the traditional theorems of the theory of international trade (Heckscher-Ohlin, Stolper-Samuelson, Rybczynski) are still valid even in the presence of intermediate products.

The next section presents the formulation of the spatial equilibrium framework with intermediate products following Chavas, Cox and Jesse (1993), Waquil (1995), and Waquil and Cox (1996). Next, data and specification issues required to empirically implement the model are presented and discussed. This discussion is followed by a presentation and summary of the results from a free trade (complete dairy trade liberalization) scenario that is simulated with the empirical model. The last section provides a summary and conclusions with some thoughts for further research.

CONCEPTUAL MODEL

The spatial equilibrium model with intermediate products developed in this paper is static and involves partial equilibrium. It assumes perfect competition and homogeneous products. It also considers that there are no structural changes in supply and demand in the transition from a starting position to the new equilibrium; that is, prices and quantities are determined along supply and demand functions which remain unchanged in the basic model. The model presented in this paper uses a quantity formulation (primal), in which the decision variables are quantities (production, consumption, trade flows). The associated Lagrange multipliers are interpreted as shadow prices.

Notation

This primal framework is developed with production occurring in a two-stage process involving the farm and processing sectors. However, it can be generalized for any number of stages of production. In this context, consider the allocation of a set of primary and secondary final commodities among spatially separated regions. The primary commodities can be produced and processed into secondary commodities in each of the regions. The final commodities can be consumed in each of the regions. Both primary and secondary commodities can be traded between regions.

Let N be the number of primary commodities (inputs). In the current context raw milk (MILK) is the primary commodity, i.e., $N = 1$. Let K be the number of secondary commodities (final products or outputs). In the current context the secondary outputs are cheese (CHE), whole milk powder (WMP), skim milk powder (SMP), butter (BUT), casein (CAS), and a residual products category (RESID) comprised of fluid, soft, frozen, evaporated/condensed and whey products, i.e., $K = 6$. Lastly, let $I = 25$ be the number of regions as defined in Appendix A. All the primary and final commodities can be traded among regions. The specific notation required for the conceptual model is as follows:

$\mathbf{w_{in}}$ quantity produced of the n-th primary commodity in region I, n = 1, ..., N, I = 1, ..., I.

$\mathbf{x_{in}}$ the quantity of the n-th primary commodity used as an input in the production of the secondary commodities in region I, n = 1, ..., N, I = 1, ..., I.

$\mathbf{y_{ik}}$ production level of the k-th secondary commodity in region I, k = 1, ..., K, I = 1, ..., I,

$\mathbf{z_{ik}}$ consumption level of the k-th commodity in region I, k = 1, ..., K, I = 1, ..., I.

$\mathbf{T_{ijn} \geq 0}$ represents the export of the n-th primary commodity from region I to region j (or alternatively the import of the n-th primary commodity into region j from region I);

$\mathbf{T_{iin} \geq 0}$ quantity of the n-th primary commodity that is both produced and used in the production of the secondary commodities within the I-th region (i.e. not exported to other regions).

$\mathbf{C_{ijn} \geq 0}$ unit cost of transportation of the n-th primary commodity from region I to region j. Assume $C_{iin} = 0$ (transportation costs are zero in the absence of trade).

$\mathbf{c_{ijk} \geq 0}$ The unit cost of transportation of the k-th secondary commodity from region I to region j. Assume $c_{iik} = 0$ (transportation costs are zero in the absence of trade).

$\mathbf{t_{ijk} \geq 0}$ The export of the k-th secondary commodity from region I to region j (or alternatively the import of the k-th secondary commodity into region j from region I).

$\mathbf{t_{iik} \geq 0}$ The quantity of the k-th secondary commodity that is both produced and consumed in the I-th region.

Production of Secondary Commodities (Outputs)

Following Chavas, Cox and Jesse (1993) assume that there are two kinds of inputs used to produce secondary commodities (outputs), y_{ik}: the primary commodities x, and other inputs denoted by the vector v. The production possibility set F_i defines technological relationship between inputs v_i and x_i and feasible outputs y_i in each region *I*. Thus define F_i as

$$(v_i, x_i, y_i) \in F_i, \tag{1}$$

where $x_i = \{x_{in}: n = 1, ..., N\}$ is the vector of primary inputs, $y_i = \{y_{ik}: k = 1, ..., K\}$ is the vector of secondary outputs, v_i = vector of other inputs (besides x_i). Efficient use of the inputs v_i, under competition, requires that they are chosen in a cost minimizing way as follows:

$$G_i(x_i,\ y_i)\ =\ \min_{v_i}\{r_i'v_i:\ (v_i,\ x_i,\ y_i)\ \in\ F_i\}, \tag{2}$$

where $G_i(x_i, y_i)$ is a (restricted) cost function measuring the cost of optimal input use v_i, conditional on primary commodities (inputs) x_i and on output levels y_i, I = 1, ..., I, r_i = vector of market prices for the inputs v_i, I = 1, ..., I. We assume throughout the paper that the cost function $G_i(x_i, y_i)$ is a decreasing function of x_i, and an increasing function of y_i. Thus, $G_i(x_i , y_i)$ measures the costs of transformation of primary into secondary commodities in region *I*. It is also assumed that primary inputs x_i and other inputs v_i are weakly separable.

Market Equilibrium

Samuelson (1952) shows that market equilibrium, using the primal approach, is achieved through the maximization of a net social payoff (NSP) function, given by the sum of producer surplus and consumer surplus. In a multi-commodity, multi-region dimension, an aggregate net social payoff function is obtained by summing the NSP functions across commodities and across regions, and subtracting the costs of transportation of commodities from one region to another. In the presence of intermediate products, it is also necessary to subtract the costs of transformation in each stage of production. In this context, consider the following quasi-welfare function:

$$V(w,\ x,\ y,\ z)\ =\ \sum_{i=1}^{J}\{D_i(z_i)\ -\ S_i(w_i)\ -\ G_i(x_i,\ y_i)\}, \tag{3}$$

where $G_i(x_i, y_i)$ is the cost function defined in equation (2), D is interpreted as a measure of the total benefits to the consumers purchasing the secondary goods z, and S is interpreted as the cost of producing the primary commodities w. Note that S + G is the total cost of production of the secondary goods z in the absence of trade. Hence, (3) is a measure of net social benefits (i.e., consumer benefits (D) minus total production cost (S + G)) in the absence of trade.

Assume that the quasi-welfare function V(w, x, y, z) is differentiable and concave in (w, x, y, z), and satisfies $\partial S_i/\partial w_{in} = p_{in}^s \geq 0$, n = 1, ..., N, where p_{in}^s is the price received by the producers of the n-th primary commodity in region I. In addition, V(w, x, y, z) satisfies $\partial D_i/\partial z_{ik} = p_{ik}^d \geq 0$, k = 1, ..., K, where p_{ik}^d is the price paid by the consumers of the k-th secondary commodity in region I , I = 1, ..., I. The implications of these assumptions are that the quasi-welfare function is well-behaved; market prices of the primary commodities are equal to their marginal cost of production; and, market prices of the secondary commodities are equal to their marginal consumer benefit. Thus, these conditions are consistent with competitive market equilibrium, where prices reflect the marginal valuation of the corresponding commodities.

The maximization of the aggregate net social payoff function is subject to two sets of constraints: the trade flows and non-negativity constraints. The standard trade flow constraints are as follows:

$$w_{in} \geq \sum_{j=1}^{J} T_{ijn}, \tag{4a}$$

$$\sum_{j=1}^{J} T_{jin} \geq x_{in}, \tag{4b}$$

$$y_{ik} \geq \sum_{j=1}^{J} t_{ijk}, \tag{4c}$$

$$\sum_{j=1}^{J} t_{jik} \geq z_{ik}. \tag{4d}$$

These restrictions imply that exports plus domestic use cannot be larger than domestic production and that domestic consumption cannot exceed domestic production plus imports. This is true for primary commodities (equations (4a) and (4b)) as well as secondary commodities (equations (4c) and (4d)). As well, no region can produce, consume nor trade negative quantities.

The Samuelson-Takayama-Judge spatial equilibrium problem with vertical markets can now be written as:

$$\max_{w,x,y,z,T,t} \{V(w,\ x\ ,y,\ z) - \sum_{i,j,n} T_{ijn} C_{ijn} - \sum_{i,j,k} t_{ijk} c_{ijk} : \\ \text{equations (4)},\ w \geq 0,\ x \geq 0,\ y \geq 0,\ z \geq 0,\ T \geq 0,\ t \geq 0\}. \tag{5}$$

Hence, (5) maximizes the quasi-welfare function V(w, x, y, z) net of transportation cost, subject to the trade flow (4) and nonnegativity constraints, and generates a competitive spatial market equilibrium. Given the concavity of objective function and linear constraints, (5) is a standard concave programming problem, subject to linear constraints. Given the differentiability of the objective function (assumed) and constraints, the Kuhn-Tucker (K-T) conditions provide necessary and sufficient conditions for the solution to (5) (Sposito (1975); Takayama (1985, 1994)).

Lagrangean and Kuhn-Tucker Conditions

Provided (5) has a bounded solution, can alternatively characterize the spatial equilibrium as the saddle point of the following Lagrangean:

$$\begin{aligned} L = {} & V(w, x, y, z) - \sum_{i,j,n} T_{ijn} C_{ijn} - \sum_{i,j,k} t_{ijk} c_{ijk} \\ & + \sum_{i,n} \alpha_{in} \left[w_{in} - \sum_{j} T_{ijn}\right] \\ & + \sum_{i,n} \beta_{in} \left[\sum_{j} T_{jin} - x_{in}\right] \\ & + \sum_{i,k} \gamma_{ik} \left[y_{ik} - \sum_{j} t_{ijk}\right] \\ & + \sum_{i,k} \delta_{ik} \left[\sum_{j} t_{jik} - z_{ik}\right], \end{aligned}$$

where $\alpha \geq 0$, $\beta \geq 0$, $\gamma \geq 0$ and $\delta \geq 0$ are Lagrange multipliers corresponding to constraints (4). The K-T conditions associated with the primary (farm) sector are:

$$\frac{\partial L}{\partial w_{in}} = -\frac{\partial S_i}{\partial w_{in}} + \alpha_{in} \begin{cases} \leq 0, & w_{in} = 0, \\ = 0, & w_{in} > 0, \end{cases} \tag{6a}$$

$$\frac{\partial L}{\partial x_{in}} = -\frac{\partial G_i}{\partial x_{in}} - \beta_{in} \begin{cases} \leq 0, & x_{in} = 0, \\ = 0, & x_{in} > 0. \end{cases} \tag{6b}$$

Note that (6a) states, at the optimum, the marginal cost of the primary commodity ($\alpha_{in} \geq 0$) is equal to its marginal value ($-\partial S_i/\partial w_{in} \geq 0$) whenever w_{in} is positive. Given $w_{in} > 0$, (6a) implies $\alpha_{in} = p_{in}^s$ is the market supply price for w_{in}. (6b) states that, at the optimum, the marginal cost of the primary commodity ($\beta_{in} \geq 0$) is equal to its marginal value ($-\partial G_i/\partial x_{in} \geq 0$) whenever x_{in} is positive. Given $x_{in} > 0$, (6b) implies α_{in} is the market demand price for x_{in}.

The K-T conditions associated with the secondary (processing) sector are:

$$\frac{\partial L}{\partial y_{ik}} = -\frac{\partial G_i}{\partial y_{ik}} + \gamma_{ik} \leq 0,\ y_{ik} = 0 \qquad \text{(6c)}$$
$$= 0,\ y_{ik} > 0,$$

$$\frac{\partial L}{\partial z_{ik}} = \frac{\partial D_i}{\partial z_{ik}} - \delta_{ik} \leq 0,\ z_{ik} = 0, \qquad \text{(6d)}$$
$$= 0,\ z_{ik} > 0,$$

(6c) states that, at the optimum, the marginal cost of the secondary commodity ($\gamma_{ik} \geq 0$) is equal to its marginal value ($-\partial G_i/\partial y_{ik} \geq 0$) whenever y_{ik} is positive. Given $y_{ik} > 0$, (6c) implies γ_{ik} is the market supply price for y_{ik}. (6d) states that, at the optimum, the marginal cost of the secondary commodity ($\delta_{in} \geq 0$) is equal to its marginal value ($-\partial D_i/\partial z_{ik} \geq 0$) whenever z_{ik} is positive. Given $z_{ik} > 0$, (6d) implies $\delta_{ik} = p_{ik}^d$ is the market demand price for z_{ik}.

The K-T conditions associated with the transportation sector (spatial arbitrage constraints) are:

$$\frac{\partial L}{\partial T_{ijn}} = -C_{ijn} + \beta_{jn} - \alpha_{in} \leq 0,\ T_{ijn} = 0, \qquad \text{(6e)}$$
$$= 0,\ T_{ijn} > 0,$$

$$\frac{\partial L}{\partial t_{ijk}} = -c_{ijk} + \delta_{jk} - \gamma_{ik} \leq 0,\ t_{ijk} = 0, \qquad \text{(6f)}$$
$$= 0,\ t_{ijk} > 0,$$

These K-T conditions indicate that price differences between regions cannot differ by more than transportation cost (zero profit in transportation sector) and characterize trade efficiency. If $C_{iin} = c_{iik} = 0$, then (6e) and (6f) imply $\beta_{in} = \alpha_{in}$ (or $\gamma_{ik} = \delta_{ik}$) whenever $T_{iin} > 0$ ($t_{iik} > 0$); i.e., producer and consumer commodity prices are equal. In this case, β_{in} can be interpreted as the market price of the primary commodity x_{in} and γ_{ik} can be interpreted as the market price of the secondary commodity y_{ik}. More generally, when C_{iin} and c_{iik} are not zero, producer and consumer prices will differ by the cost of transformation (processing/marketing margin).

The Lagrange multipliers associated with the trade flow constraints are:

$$\frac{\partial L}{\partial \alpha_{in}} = w_{in} - \sum_j T_{ijn} \geq 0, \ \alpha_{in} = 0 \qquad \text{(6g)}$$
$$= 0, \ \alpha_{in} > 0,$$

$$\frac{\partial L}{\partial \beta_{in}} = \sum_j T_{jin} - x_{in} \geq 0, \ \beta_{in} = 0 \qquad \text{(6h)}$$
$$= 0, \ \beta_{in} > 0,$$

$$\frac{\partial L}{\partial \gamma_{ik}} = y_{ik} - \sum_j t_{ijk} \geq 0, \ \gamma_{ik} = 0 \qquad \text{(6i)}$$
$$= 0, \ \gamma_{ik} > 0,$$

$$\frac{\partial L}{\partial \delta_{ik}} = \sum_j t_{jik} - z_{ik} \geq 0, \ \delta_{ik} = 0 \qquad \text{(6j)}$$
$$= 0, \ \delta_{ik} > 0.$$

Together with the complementary slackness conditions on the corresponding Lagrange multipliers, these trade flow constraints represent the feasibility conditions for interregional trade. (6h) and (6i) indicate β_{in} and γ_{ik} measure the marginal social cost of one unit of the primary commodity x_{in} and secondary commodity y_{ik}, respectively. But (6b) and (6c) yield the interpretation of β_{in} and γ_{ik} as the market price of x_{in} and y_{ik}, respectively. Thus, this model is consistent with a competitive market equilibrium both across commodities and over space, where market price is equal to the marginal cost of each commodity at the optimum (i.e., (6a) and (6d) establish this for primary commodity w_{in} and secondary commodity $z_{ik,}$, respectively).

Hedonic Spatial Equilibrium

Next, this conceptual model is generalized to include implicit (hedonic) characteristics (milkfat and nonfat solids) of the primary commodity (farm level milk). This yields a Lancasterian-type model with trade in a spatial equilibrium setting. Assume N primary commodities involve S characteristics, r_s, s = 1, ..., S. In the current context, S = 2 (milkfat and nonfat solids). Let $a_{ins} \geq 0$ denote the quantity of the s-th characteristic per unit of n-th primary (input) commodity x_{in}. Similarly, let $b_{iks} \geq 0$ denote the quantity of the s-th characteristic per unit of the k-th secondary (output) commodity y_{ik}. Lastly, assume that a_{ins} and b_{iks} are constant. A constant proportions production technology is represented as

$$y_{ik} = \min \{\sum_{n=1}^{N} x_{ink} \frac{a_{in1}}{b_{ik1}}, ..., \sum_{n=1}^{N} x_{ink} \frac{a_{inS}}{b_{ikS}}, f_{ik}(v_{ik}, x_{ik})\}, \forall i, \forall k, \tag{8}$$

where x_{ink} = quantity of n-th primary input used in to produce k-th secondary output in region I and $x_{in} = \sum_k x_{ink}$. While (8) assumes fixed proportions in each characteristics $\sum_n x_{ink} a_{ins}$, s = 1, ..., S, the general function $f_{ik}(v_{ik}, x_{ik})$ imposes no a priori restrictions on elasticities of substitution among the various inputs (v_{ik}, x_{ik}). A linear Lancasterian model where each commodity exhibits fixed component proportions, but components are perfect substitutes in their allocation among commodities.

The cost function associated with this constant proportions production technology that maps farm milk components into secondary products is

$$g_i(x_i, y_i) = \min_v \{r_i' v_i: y_{ik} \leq f_{ik}(v_{ik}, x_{ik})\}, \forall i, \tag{9a}$$

$$\sum_{k=1}^{K} y_{ik} b_{iks} \leq \sum_{n=1}^{N} x_{in} a_{ins}, \tag{9b}$$

subject tofor I = 1, ..., I, s = 1, ..., S. Equation (9b) ensures supply of components (production plus imports) must be greater than utilization (production of outputs). This is the key implication of the Lancasterian generalization and provides the basis for regional hedonic prices (i.e., shadow values of implicit component markets).

The primal, hedonic spatial equilibrium optimization problem (i.e, a generalized equation (5)) is written as

$$\max_{w,x,y,z,T,t} \{\sum_i [D_i(z_i)-S_i(w_i)-g_i(x_i,\ y_i)] - \sum_{i,j,n} T_{ijn}C_{ijn} - \sum_{i,j,k} t_{ijk}c_{ijk}$$
$$: \text{equations (4) and (9b)},$$
$$w\geq 0,\ x\geq 0,\ y\geq 0,\ z\geq 0,\ T\geq 0,\ t\geq 0\}, \tag{10}$$

with the corresponding primal Lagrangean:

$$\begin{aligned} L = & \sum_i [D_i(z_i)-S_i(w_i)-g_i(x_i,\ y_i)] \\ & -\sum_{i,j,n} T_{ijn}C_{ijn}-\sum_{i,j,k} t_{ijk}c_{ijk} \\ & +\sum_{i,s} \lambda_{is} [\sum_n x_{in}\ a_{ins}-\sum_k y_{ik}\ b_{iks}] \\ & + \sum_{i,n} \alpha_{in} [w_{in}-\sum_j T_{ijn}] \\ & + \sum_{i,n} \beta_{in} [\sum_j T_{jin}-x_{in}] \\ & + \sum_{i,k} \gamma_{ik} [y_{ik}-\sum_j t_{ijk}] \\ & + \sum_{i,k} \delta_{ik} [\sum_j t_{jik}-z_{ik}], \end{aligned} \tag{11}$$

All previous Kuhn-Tucker conditions hold except that:

$$\frac{\partial L}{\partial x_{in}} = -\frac{\partial g_i}{\partial x_{in}} + \sum_{s=1}^{S} \lambda_{is}a_{ins} - \beta_{in} \leq 0,\ x_{in} = 0, \qquad = 0,\ x_{in} > 0, \qquad (6b) \text{-->} (11a)$$

$$\frac{\partial L}{\partial y_{ik}} = -\frac{\partial g_i}{\partial y_{ik}} - \sum_{s=1}^{S} \lambda_{is}b_{iks} + \gamma_{ik} \leq 0,\ y_{ik} = 0 \qquad = 0,\ y_{ik} > 0. \qquad (6c)\text{-->}(11b)$$

$$\frac{\partial L}{\partial \lambda_{is}} = \sum_n x_{in}\ a_{ins}-\sum_k y_{ik}\ b_{iks} \geq 0,\ \lambda_{is} = 0 \qquad = 0,\ \lambda_{is} > 0, \tag{11c}$$

where λ_{is} is interpreted as the shadow price of the s-th component in region I. (11a) implies marginal value (β_{in}) of the n-th primary input x_{in} is equal to the marginal cost associated with inputs v_i ($-\partial g_i/\partial x_{in} \geq 0$), plus the marginal cost of the S components ($\sum_s \lambda_{is} a_{ins} \geq 0$). Similarly, (11b) implies the marginal value (γ_{ik}) of the k-the secondary product y_{ik} is equal to the marginal cost associated with inputs v_i ($\partial g_i/\partial y_{ik} \geq 0$), plus the marginal cost of the S components ($\sum_k \lambda_{ik} b_{iks} \geq 0$). (11c) provides the component balance constraint for component s in region I, I = 1, ..., I, s = 1, ..., S.

Note that this competitive market equilibrium satisfies the technology constraints (11a) - (11c), the trade flow constraints (6g) - (6j), and also efficiently allocates resources across commodities and across space via (6a), (6d) - (6f). Thus, this model provides a convenient characterization of spatial competitive equilibrium for component allocations and their implicit (hedonic) pricing. This generalization of the Samuelson-Takayama-Judge model, an hedonic spatial equilibrium model, is next applied to the world dairy sector.

SPECIFICATION AND DATA ISSUES

Key data required to operationalize the UW-WDM hedonic spatial equilibrium model are:

1. ***Base level production, prices and consumption of both farm level raw milk and wholesale level (secondary) dairy products***. Consumption is generally computed from a supply/demand balance worksheet where consumption is taken as the residual of Production + Imports - Exports +Beginning Stock - Ending Stocks. These data are obtained from a variety of sources (see Appendix B). All quantities are measure in metric tonnes (MT) while prices are US$/MT.
2. ***Regional milk composition***. Milk from all sources (i.e., cow, sheep, goat, buffalo, etc.) is modeled as the dairy supply and demand in many regions comes from several different sources. Milk fat data are obtained from FAO data. Nonfat solids (SNF) are obtained from the following formula: %SNF = 6.535 + 0.6031*%FAT (see Pratt *et al.,* p.6).
3. ***Wholesale (secondary) level dairy product composition.*** While the current model allows farm level milk to vary in composition, the fat and SNF composition of dairy products are fixed at U.S. standards of identity following Selinsky *et al.*

4. ***Regional wholesale sector value added matrix (farm-wholesale processing and distribution costs).*** Quality information on these crucial data are scanty. The results presented here assume constant processing costs across regions based on U.S. data. Sensitivity analysis with the best information we could find on differential costs of processing indicate that while aggregate price and production changes are fairly robust to these assumptions, the interregional trade flows are clearly quite sensitive.
5. ***Interregional transportation costs.*** Distances between regions (ports) are obtained from Defense Mapping Agency data. In the absence of better information, we use the following flat transportation costs: $0.018/MT for non-refrigerated products (casein, WMP, SMP); $0.035 for refrigerated goods (products) and raw farm level milk.
6. ***Regional supply and demand elasticities.*** The model generates linear regional supply and demand curves using these elasticities and base level prices and quantities. The results presented here use elasticities derived from SWOPSIM (Sullivan *et al.*).
7. ***Regional trade distortions.*** These data (regional export subsidies, import tariffs and quotas, etc.)are also extremely tedious. The "free trade" results, presented do not require these parameters.

The empirical model identifies 25 separate regions comprised both of single countries as well as aggregates of countries. Appendix A summarizes these regions and provides a brief rational for their creation. Several regions (Former Soviet Union (North and South), China (East and South), Canada (East and West) and the U.S. (West, South, and East) have multiple ports to allow overland transhipment.

The FAO production and trade data allows identification of seven dairy products: cheese (CHE), whole milk powder (WMP), skim milk powder (SMP), butter (BUT), casein (CAS), and a residual products category (RESID) comprised of fluid, soft, frozen, evaporated/condensed and whey products.[1] Using U.S. standards of products identity and regional raw milk composition (as described above), a base level farm milk supply/wholesale processing demand component

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[1] There appears to be a good possibility to further disaggregate the residual category into fluid, whey, evaporated/condensed and perhaps frozen products with some additional assumptions.

balance is computed using equations (9b) to derive the fat and SNF composition of the residual category. That is, the total availability of fat and SNF from raw milk is balanced with component utilization associated with wholesale dairy production for all product except the residual category. This residual is then converted into total solids (40% fat, 60% SNF) milk equivalent basis. Thus, the regional base level starting values satisfy a supply demand component balance as do the resulting simulation solutions via equations (9b).

RESULTS

Tables 1-3 summarize the optimal production, price, and consumption results from the free trade simulation and provide percentage change comparison with the base level starting values (1989-92 averages) for several key regions in world dairy trade.[2] Table 4 summarize the regional component prices for fat and SNF generated by the hedonic spatial equilibrium, free trade solution. Table 5-9 summarize the optimal interregional trade flows associated with the free trade simulations.

Regional Production, Consumption, and Prices

The free trade simulations in Tables 1 and 2 suggest that complete trade liberalization in dairy would have minimal impacts on U.S. milk production (+1%) and price (+3%) relative to the 1989-92 average levels. In contrast, more heavily protected regions such as Western Europe, Japan, Canada, and South America are predicted to have declines in both milk production (-11%, -21%, -8% and -4%, respectively) and price (-17%, -53%, -24% and -10%, respectively). New Zealand and Australia, as lower cost production regions, are predicted to have sharp increases in both milk production (63% and 22%, respectively) and price (105% and 43%, respectively).[3] Note that farm price levels under this free trade scenario are in the neighborhood of the current

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[2] Full regional results are available on request from the authors.

[3] Conversations with New Zealand dairy researchers indicates that a 60% expansion over 3-5 years is not feasible and they suggest that 30%-40% is a more reasonable upper bound. We chose to leave the current model fully unconstrained in this regards. Future sensitivity analyses and more refined simulation scenarios will evaluate the impacts of this type of bounds on model results.

U.S. price -- roughly $US 290/MT. These farm price results are consistent with previous research (Dobson, OECD, etc.).

The underlying hedonic structure of the UW World Dairy Model is part of the reason for higher milk prices in regions other than the U.S. This reflects the higher milkfat and SNF content in these regions -- see Table 4. Thus, for example, while fat and SNF component prices are lower in Australia and New Zealand than in the U.S., the much higher solids content of their milk generates higher milk prices (Table 4). As expected under hedonic spatial equilibrium, the sum of the hedonic composition times characteristic prices yields the raw milk price.[4]

While U.S. farm level production and milk prices are relatively unchanged under the free trade scenario, the U.S. dairy processing/production profile changes quite sharply (Table 1): cheese (+41%); butter (-62%); whole milk powder (-64%); skim milk powder (-75%); and for casein, from a pure importer (no production) to self sufficiency (93,000 MT). Similarly, while changes in Western Europe, Japan, and South American milk production are considerably larger (-11%, -21%, and -4%, respectively), these regions show similar changes in their respective processing profiles: e.g., cheese (+15%, +50%, and +17%); butter (-39%, -100%, and -30%); whole milk powder (-100%, -100%, and -56%); and skim milk powder (-68%, -86%, and -70%). Thus these results suggest that, under free trade, the U.S., Western Europe, Japan and South America regions would reallocate milk solids from butter and milk powders to cheese (and casein in the case of the Japan and the U.S.). Similar results are found for India (IND), South East Asia (SEA), and Other South Asia (OSA) -- see below.

In contrast, Australia, New Zealand and Eastern Europe are simulated to considerably expand their production (and exports) of milk powders, and, with the exception of Eastern Europe, decrease cheese production and exports. This partially reflects the cheaper transportation costs for milk solids in powdered form versus as cheese. Somewhat surprisingly, these results suggest that Australia would produce no cheese (Table 1), importing all domestic consumption from New Zealand (Table 5)-- a highly unlikely occurrence. Canada, with the exception of the residual category, is simulated to decrease it's production of all dairy products

4 Similar results hold for the secondary/wholesale products with the addition of the value added costs of processing.

and to become a pure importer of whole milk powder (from Eastern Europe and New Zealand, Table 7) and skim milk powder (from Eastern Europe, Table 8).

Under this free trade scenario, cheese prices are simulated to fall (Table 2) while consumption rises (Table 3) sharply in most regions with the largest declines occuring in the most protected markets: Western Europe (-63%, +25%), Australia (-25%, +11%), New Zealand (-20%, +7%), Canada (-60%, +43%), and the U.S. (-39%, +23%). Average world prices are simulated to be in the $US 1,800/MT range, a 50% drop in average (not marginal !!!) world price. Aggregate world cheese consumption expands 18% over 1989-92 average levels. Apparently, these price results are somewhat counter to popular opinion. However, these results reflect the sharp drop in cheese prices in the major consuming regions who generally have substantial import protection on their domestic cheese markets. In the absence of this protection, cheese prices fall while consumption and production expand.

To some extent, cheese import barriers induce product and export substitution into milk powders (WMP, SMP and casein) and butter. With the considerable expansion of world cheese production (+18%) and the slight contraction in world milk supples (-1%) projected under this free trade scenario, world production and consumption of butter (-6%, -5%), WMP (-12%, -8%) and SMP (-2%, -5%) would decline. While butter, WMP, and SMP prices rise in many regions (e.g., Australia, New Zealand, U.S. South America), sharp price declines in the more protected markets (e.g., Western Europe, Eastern Europe and Canada) are sufficient to generate slight declines in average world prices for butter (-5%) and WMP (-1%). In contrast, average world SMP price rises +8%, and world casein production and consumption expand (+19%, +18%) as casein prices fall -41%.

Regional Trade Flows

Optimal cheese trade flows from the free trade simulations are summarized in Table 5. New Zealand, a major cheese exporter, is found to totally supply domestic consumption in Japan and Australia as well as export to Eastern China (CHNE). The east (USAE) and west (USAW) coasts of the U.S. export cheese to the coasts of Canada (supplying roughly 40% of Canadian consumption) as well as completely supplying cheese consumption in Mexico (MEX) and the

Central America (CAM) region. India (IND, supplying 14% and 11% of total world fat and SNF in this free trade simulation), South East Asia (SEA), and Other South Asia (OSA) are also simulated to be major exporters to both East and South China (from South East Asia) and the Middle East (from India and Other South Asia). Since milk production changes are quite small in these regions (+2% IND, -2% SEA, and +4% OSA), these results indicate that considerable changes in regional processing profiles would occur under free trade. In these regions, for example, cheese production and exports expand while production of butter and milk powders declines sharply with an associated increase in imports, mainly from Australia and New Zealand.

World butter trade under the free trade simulation (Table 6) suggests similar realignments and reciprocal trade flows. Western Europe (WEU) imports roughly 1/3 of it's butter consumption from Eastern Europe (EEU) while Japan imports 91% of it's butter consumption from Australia (with minor amounts (11,000 MT) from China). As well, Australian butter exports completely satisfy domestic consumption in South East Asia (SEA). New Zealand supplies 52% and 17% of U.S. and Canadian butter consumption, respectively -- the shipments are to the west coasts, as expected. Note that Table 6 indicates transhipments of west coast U.S. butter (USAW) to the east coasts of both Canada (CANE) and the U.S. (UASE). These U.S. exports account for roughly 18% of total butter consumption in Canada. Lastly, as further evidence of reciprocal, two-way trade under free markets, Mexico ships small amounts of butter to the U.S. through New Orleans (USAS).

The free trade trade flows in whole milk powder (WMP), Table 7, indicate that both Eastern Europe (EEU) and New Zealand (NZ) would be major exporters. The EEU supplies 90% of the domestic consumption in Western Europe (WEU-- the remainder is imported from the south of the Former Soviet Union (FSUS)) as well as 33% of the aggregate U.S. market (100% of USAE consumption). New Zealand supplies total domestic WMP consumption in China (CHNE, CHNS), Japan (JAP), South East Asia (SEA), Other South Asia (OSA), and Central America (CAM) as well as supplying providing a majority of the domestic consumption in Canada (CAN, 50%), the Western U.S. (USAW, 100%, 33% of total U.S.), Mexico (MEX, 94%), and South America (SAM 56%). In addition to supplying 10% of WMP consumption in Western Europe (WEU), the Former Soviet Union (FSU) also exports to the Middle East (MDE, 27% of consumption) and North Africa (NAF, 100% of consumption). South Africa (SAF) exports WMP to the Middle East (MDE, 73% of consumption) and Australia supplies 59% of the consumption in South East Asia (SEA). The only U.S. exports of WMP are to Mexico: these are 6% of Mexican consumption and 31% of total U.S. production.

The free trade trade flows in skim milk powder (SMP), Table 8, indicate that both Eastern Europe (EEU), Australia (AUS), and New Zealand (NZ) would be major exporters, with the EEU clearly dominant. EEU exports completely satisfy SMP domestic consumption in India (IND), North Africa (NAF), Canada (CANE and CANW), eastern and southern U.S. (USAE and USAS), Mexico (MEX), Central America (CAM) and the rest of World (ROW). As well, the EEU supplies large shares of domestic consumption in the Middle East (MDE, 68%), Western Europe (WEU, 61%), and South America (SAM, 73%). The next largest exporter, New Zealand, supplies 77% of Japanese consumption, with Australia supplying the remainder. As well, total SMP consumption in China and South East Asia are supplied by Australian exports.

Lastly, Table 9 indicates a complete lack of casein trade under this free trade scenario. To the extent that the casein trade evolved to circumvent trade barriers (e.g., import quotas in the U.S.), the removal of these barriers is simulated to result in self sufficiency in the major casein consuming regions (Western Europe, Eastern Europe, Japan, and the U.S.). With the continued growth and development of highly specialized, value added milk powders in world dairy trade, and given the absence of trade barriers assumed in this simulation, these results are quite reasonable.

SUMMARY AND CONCLUSIONS

This paper summarizes an hedonic, spatial equilibrium conceptual framework and it's empirical implementation in a model of the world dairy sector. The UW World Dairy Model (UW-WDM) provides a static partial equilibrium representation of the world dairy sector with 3-5 year (intermediate run) adjustment horizons, 25 regions, 7 dairy products, and 2 milk components. Simulation results for a complete liberalization, free trade scenario are summarized and discussed.

Summary

The simulation results suggest that average world milk prices under free trade would be in the neighborhood of current U.S. prices, i.e., $US 300/MT ($13.50/cwt). Farm milk prices in Western Europe, Japan, Canada, and South America are simulated to fall 17%, 53%, 24% and 10%, respectively while Eastern Europe, Australian and New Zealand prices would rise 140%, 43% and 105%, respectively, under the free trade simulation. In most heavily protected regions (e.g. Western Europe, Japan, United States, and South America -- Canada is the exception here), the production (and exports) of milk, milk powders and butter would decline while cheese production expands sharply. Similar results are found for India, South East Asia, and Other South Asia.

The free trade simulation suggests that average world cheese price would fall 50% (to $US 1,800/MT) while world production and consumption would expand 18% (to 17,000 MT). Conversely, this simulation suggests that world production, consumption and the price of butter and milk powders (with the exception of casein) would decline (production, 2%-12%; consumption, 5%-8%; prices, 5%-8%). Clearly, the free trade simulation indicates major adjustments in the world cheese sector, with associated adjustments to the butter and milk powder sectors being induced by underlying hedonic spatial equilibrium structure of the model. Since cheese represents the largest utilization (demand for) of world milk solids (and usually at a premium price), the model allocates solids to cheese first and then allocates the remaining regional component availability among the remaining products (butter, milk powders and other products).

With respect to dairy exports, both New Zealand and the U.S. are major exporters of cheese in the free trade simulations. New Zealand exports mainly to Asian markets (China and Japan, as well as Australia) while the U.S. exports to the Western hemisphere (Canada, Mexico and Central America). India, South East Asia, and the Other South Asia regions also export cheese, particularly to the Middle East and China. Both New Zealand and Australia are major exporters of butter in the free trade simulation with New Zealand completely satisfying butter consumption in the western and southern regions of the U.S. As well, Mexico ships a small amount of butter through New Orleans to the U.S.

The simulations suggest that New Zealand, Eastern Europe and the Former Soviet Union would be major exporters of whole milk powder (WMP) under free trade in dairy. New Zealand is simulated to supply the total WMP domestic consumption in China, Japan, South East Asia, Other South Asia, and Central America as well as a majority of the domestic consumption in Canada, the Western U.S., Mexico, and South America. Results also suggest some WMP moving from Eastern Europe to both Canada and the U.S. With respect to the skim milk powder (SMP) export market, the free trade simulations indicate that Eastern Europe would be the dominant exporter, followed by Australia and New Zealand. Eastern Europe is simulated to completely satisfy domestic consumption in India, North Africa, Canada, Eastern and Southern U.S., Mexico, Central America and the Rest of World region. As well, the Eastern Europe would supply large shares of domestic consumption in the Middle East, Western Europe, and South America.

In summary the free trade simulation results indicate considerable realignment in the world dairy sector, particularly in cheese production and consumption and dairy product trade flows. Results also suggest regions such as Eastern Europe, the Former Soviet Union, South Africa, India, South East and Other South Asia could become significant dairy exporters under free trade in the world dairy sector.

Pro's/Con's Partial Equilibrium

Commodity level trade policy tends to be product specific and comprised of both price (tariffs and subsidies) and quantity (quota) instruments. Emerging growth markets in dairy trade (i.e., whey proteins, pharmaceutical lactose, specialized (valued added) milk powders) can be difficult to model using time-series based models and/or highly aggregated computable general equilibrium (CGE) models due to data limitations and aggregation constraints. Partial equilibrium models allow for a more micro oriented policy evaluation of these instruments compared to producer subsidy equivalents (PSE's) or consumer subsidy equivalents (CSE's) on an aggregate dairy sector. Conversely, the partial equilibrium results will be useful to the extent they meaningfully incorporate relevant "exogenous" shocks (i.e., outside the partial equilibrium) induced by trade liberalizations. This suggests the use of more general equilibrium type results as a means to calibrate alternative partial equilibrium trade scenarios.

Major Data Gaps

Key limitations of the current model include:

1. Lack of detailed information on interregional transportation costs: differences in negotiated versus published rates; volume discounts; discounts due to back hauls; discounts/premiums due to market power; etc. The current model assume flat rates across all regions.
2. Lack of detailed information on regional differences in milk production, processing and distribution costs: size economies due to new plants, agglomeration, etc.; vintage and mix of processing technology; regional differences in non-milk processing inputs (labor, energy, capital, etc.). The current model assume flat costs across all regions.
3. Accurate characterization of current and emerging trade policies (subsidies, tariffs, quotas and tariff-rate quotas, etc.): legislated versus implemented policies; aggregation of country policies into regions.
4. Refined linkages into more general equilibrium modeling results: linkages to the livestock, grain and oilseeds sectors (supply and demand effects); linkages into the non-agricultural sectors (labor, capital, transportation sectors, etc.); macroeconomic linkages (regional growth and distribution of income due to trade liberalization, impacts of exchange rates, etc.).

Current and Future Research

Current research is focussed on addressing the data gaps identified above, generating a BASE scenario which models the current distorted trade context, and evaluating a variety of specific dairy trade proposals with a focus on the impacts for the U.S. dairy sector. Clearly, raw milk costs, processing costs and transportation costs are key elements of regional comparative advantage in world dairy markets. Sensitivity analysis on these costs, supply/demand elasticities, etc. are in progress to assess the robustness of model results to these key assumptions. Lastly, further disaggregation of fluid milk, whey products, and evaporated amd condensed products from the residual category are in progress.

Future research plans include: augmenting a detailed U.S. dairy sector model with a 9 province, regional model of the Canadian dairy sector as well as adding a detailed Mexican dairy sector model; and expanding a multi-market (grains, oilseeds, and livestock) partial equilibrium model of the MERCOSUR (Waquil; Waquil and Cox) to the Western Hemisphere by adding the U.S., Mexico, Canada and other South and Central American regions (Chile is already added in). As well, it appears essential for this type of partial equilibrium modeling to further develop and refine "exogenous" linkages to more general equilibrium type results in order to enhance the usefulness of results. These linkages require considerable additional research and collaboration with other trade modelers.

Conclusion

The commodity and regional disaggregation allowed by the partial equilibrium framework developed here allows for detailed analysis of both quantity (e.g., quotas) and price (subsidies, tariffs, transportation and processing costs) related trade distortions. Hence, despite the well known limitations of partial equilibrium (Blandford; Hertel; Thompson; Winters), the UW-WDM will hopefully provide a useful additional analytical tool to complement our analysis of current and emerging world dairy trade issues.

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Table 1. Summary of Free Trade Simulation Results Compared to 1989-92 Average Levels: Production.

OPTIMAL PRODUCTION (1000 MT)							
	MILK	**CHEESE**	**BUTTER**	**WMP**	**SMP**	**CASEIN**	**RESID**
Western Europe	120,118	6,851	1,272		517	124	74,150
Eastern Europe	49,414	1,052	1,241	441	1,825	15	19,273
Australia	8,042		254	65	349	1	3,420
New Zealand	12,616	392	297	702	295	2	2,002
Canada	7,190	244	76	0	0	0	5,318
United States	67,867	4,404	238	26	108	93	42,388
South America	31,396	645	107	168	14		26,099
WORLD	534,923	16,952	6,908	1,947	3,778	265	361,806

% CHANGE From 1989-92 AVERAGES							
	MILK	**CHEESE**	**BUTTER**	**WMP**	**SMP**	**CASEIN**	**RESID**
Western Europe	-10.7	15.3	-38.6	-100.0	-68.2	-0.8	2.5
Eastern Europe	41.3	4.7	151.7	472.7	421.4	-42.3	-17.6
Australia	21.5	-100.0	146.6	3.2	142.4	-75.0	-4.7
New Zealand	63.3	208.7	19.3	212.0	63.9	-97.1	-11.4
Canada	-8.3	-15.3	-24.0	-100.0	-100.0	-100.0	8.4
United States	1.4	41.0	-61.5	-63.9	-75.0	3000.0	0.0
South America	-4.0	17.1	-30.1	-55.8	-69.6	-100.0	1.7
WORLD	0.9	17.6	-5.9	-11.7	-1.9	18.8	-0.1

Table 2. Summary of Free Trade Simulation Results Compared to 1989-92 Average Levels: Prices.

OPTIMAL PRICES (US $/MT)

	MILK	CHEESE	BUTTER	WMP	SMP	CASEIN	RESID
Western Europe	311	1,801	2,715	2,549	2,316	2,599	369
Eastern Europe	309	1,785	2,681	2,531	2,298	2,583	367
Australia	313	1,755	2,429	2,504	2,343	2,640	373
New Zealand	316	1,710	2,417	2,490	2,335	2,632	375
Canada	310	1,840	2,679	2,603	2,396	2,673	375
United States	298	1,795	2,667	2,606	2,398	2,674	362
South America	310	1,793	2,599	2,601	2,429	0	369
WORLD	327	1,798	2,618	2,529	2,317	2,636	393

% CHANGE From 1989-92 AVERAGES

	MILK	CHEESE	BUTTER	WMP	SMP	CASEIN	RESID
Western Europe	-16.5	-62.9	-33.7	-18.9	-8.7	-42.2	-20.8
Eastern Europe	137.6	-46.0	-37.8	69.5	85.1	-42.6	125.6
Australia	43.0	-25.3	30.0	14.6	19.0	-41.3	36.3
New Zealand	105.4	-19.9	33.1	22.7	38.3	-38.6	94.7
Canada	-23.8	-59.5	-40.0	-22.5	-14.3	-40.6	-26.4
United States	2.8	-38.8	17.5	-6.7	3.2	-40.6	-0.1
South America	-10.3	-28.2	47.9	28.3	44.1	-100.0	-14.4
WORLD	-1.8	-50.2	-5.4	-0.6	8.4	-40.6	-6.2

Table 3. **Summary of Free Trade Simulation Results Compared to 1989-92 Average Levels: Consumption.**

OPTIMAL CONSUMPTION (1,000 MT's)						
	CHEESE	BUTTER	WMP	SMP	CASEIN	RESID
Western Europe	6,851	2,031	347	1,335	124	74,150
Eastern Europe	1,052	503	55	135	15	19,273
Japan	243	128	118	363	28	5,525
Australia	156	50	5	40	1	3,420
New Zealand	29	32	23	16	2	2,002
Canada	427	117	6	52	0	5,318
United States	3,995	473	54	363	93	42,388
South America	645	107	384	51		26,099
WORLD	16,952	6,908	1,947	3,778	265	361,806

% CHANGE From 1989-92 AVERAGES						
	CHEESE	BUTTER	WMP	SMP	CASEIN	RESID
Western Europe	25.2	14.5	7.8	3.6	17.0	2.5
Eastern Europe	7.3	5.7	-27.6	-33.8	7.1	-17.6
Japan	19.1	37.6	29.7	25.6	27.3	7.2
Australia	10.6	-13.8	-16.7	-7.0	0.0	-4.7
New Zealand	7.4	-13.5	-8.0	-20.0	0.0	-11.4
Canada	43.3	27.2	0.0	8.3	29.2	8.4
United States	23.3	-10.9	5.9	-1.6	24.0	0.0
South America	17.1	-34.0	-22.1	-33.8	-100.0	1.7
WORLD	18.3	-4.6	-8.1	-5.0	16.7	-0.1

Table 3. **Summary of Regional Component Prices Under Free trade Simulation.**

	COMPONENT PRICES ($US/MT)		RAW MILK COMPOSITION (%)	
	FAT	SNF	FAT	SNF
Western Europe	3,048	2,122	0.041	0.088
Eastern Europe	3,006	2,104	0.041	0.088
Japan	3,217	2,232	0.037	0.086
Australia	2,714	2,174	0.043	0.090
New Zealand	2,681	2,166	0.047	0.088
Canada: East	3,054	2,320	0.037	0.086
Canada: West	2,944	2,311	0.037	0.086
U.S. East	2,995	2,186	0.037	0.086
U.S. West	2,878	2,237	0.037	0.086
U.S. South	2,956	2,205	0.037	0.086
South America	2,903	2,242	0.039	0.087
WORLD	2,847	2,316	0.044	0.088

Table 4. Summary of Free Trade Simulation Results: Optimal Cheese Trade Flows (1,000 MT) For Major Exporters/Importers.

	CHNE	CHNS	JAP	SEA	OSA	MDE	AUS	NZL
IND	0	0	0	0	0	228	0	0
SEA	4	99	0	22	0	0	0	0
OSA	0	0	0	0	19	275	0	0
MDE	0	0	0	0	0	224	0	0
NZL	94	0	113	0	0	0	156	29
	CANE	CANW	USAE	USAW	USAS	MEX	SAM	CAM
CANE	126	0	0	0	0	0	0	0
CANW	0	118	0	0	0	0	0	0
USAE	88	0	1,330	0	0	0	0	0
USAW	0	96	0	1,334	0	0	0	0
USAS	0	0	0	0	1,331	143	0	83
SAM	0	0	0	0	0	0	645	0

Table 5. **Summary of Free Trade Simulation Results: Optimal Butter Trade Flows (1,000 MT) For Major Exporters/Importers.**

	WEU	EEU	FSUS	CHNE	CHNS	JAP	IND	SEA	OSA	MDE
WEU	1,272	0	0	0	0	0	0	0	0	0
EEU	738	503	0	0	0	0	0	0	0	0
CHNE	0	0	0	37	0	6	0	0	0	0
CHNS	0	0	0	0	37	5	0	0	0	0
IND	0	0	0	0	0	0	956	0	0	0
OSA	21	0	22	0	0	0	0	0	149	11
MDE	0	0	0	0	0	0	0	0	0	295
AUS	0	0	0	0	0	117	0	76	0	0

	AUS	NZL	NAF	CANE	CANW	USAE	USAW	USAS	MEX
IND	0	0	14	0	0	0	0	0	0
OSA	0	0	84	0	0	0	0	0	0
AUS	50	0	0	0	0	0	0	0	0
NZL	0	32	0	0	20	0	141	104	0
CANE	0	0	0	37	0	0	0	0	0
CANW	0	0	0	0	39	0	0	0	0
USAE	0	0	0	0	0	99	0	0	0
USAW	0	0	0	21	0	55	19	0	0
USAS	0	0	0	0	0	0	0	44	0
MEX	0	0	0	0	0	0	0	10	46

Table 6. **Summary of Free Trade Simulation Results: Optimal Whole Milk Powder Trade Flows (1,000 MT) for Major Exporters/Importers.**

	WEU	EEU	FSUS	FSUN	CHNE	CHNS	JAP	SEA	OSA	MDE	AUS
EEU	313	55	0	0	0	0	0	0	0	0	0
FSUS	0	0	157	0	0	0	0	0	0	21	0
FSUN	34	0	0	158	0	0	0	0	0	0	0
AUS	0	0	0	0	0	0	0	59	0	0	5
NZL	0	0	0	0	35	35	118	41	63	0	0
SAF	0	0	0	0	0	0	0	0	0	57	0

	NZL	NAF	SAF	CANE	CANW	USAE	USAW	USAS	MEX	SAM	CAM
EEU	0	0	0	3	0	18	0	0	0	0	0
FSUS	0	112	0	0	0	0	0	0	0	0	0
NZL	23	0	0	0	3	0	18	0	118	216	32
SAF	0	0	6	0	0	0	0	0	0	0	0
USAS	0	0	0	0	0	0	0	18	8	0	0
SAM	0	0	0	0	0	0	0	0	0	168	0

Table 7. **Summary of Free Trade Simulation results: Optimal Skim Milk Powder Trade Flows (1,000 MT) for Major Exporters/Importers.**

	WEU	EEU	FSUN	CHNE	CHNS	JAP	IND	SEA	OSA	MDE	AUS
WEU	517	0	0	0	0	0	0	0	0	0	0
EEU	817	135	0	0	0	0	5	0	9	92	0
FSUN	0	0	295	0	0	0	0	0	0	43	0
AUS	0	0	0	21	21	58	0	209	0	0	40
NZL	0	0	0	0	0	278	0	0	0	0	0

	NZL	NAF	CANE	CANW	USAE	USAW	USAS	MEX	SAM	CAM	ROW
EEU	0	127	26	26	122	12	121	131	37	51	116
NZL	16	0	0	0	0	0	0	0	0	0	0
USAE	0	0	0	0	0	54	0	0	0	0	0
USAW	0	0	0	0	0	54	0	0	0	0	0
SAM	0	0	0	0	0	0	0	0	14	0	0

Table 8. Summary of free Trade Simulation Results: Optimal Casein Trade Flows (!,000 MT) for Major Exporters/Importers.

	WEU	EEU	JAP	AUS	NZL	USAE	USAW	USAS
WEU	124	0	0	0	0	0	0	0
EEU	0	15	0	0	0	0	0	0
JAP	0	0	28	0	0	0	0	0
AUS	0	0	0	1	0	0	0	0
NZL	0	0	0	0	2	0	0	0
USAE	0	0	0	0	0	31	0	1
USAW	0	0	0	0	0	0	31	0
USAS	0	0	0	0	0	0	0	30

APPENDIX A: UW WORLD DAIRY MODEL REGIONS

CRITERIA FOR THE CREATION OF DAIRY REGIONS

The following criteria was followed for the creation of dairy regions and the inclusion or exclusion of countries in these regions:

1) Geographical proximity.
2) Common Dairy Policies.
3) Cultural proximity which supports assumptions regarding similar consumption patterns.
4) Similar economic or development status.
5) Significant producer, consumer, importer or exporter of dairy products.
6) Data availability.
7) Large population or economy.

1) WESTERN EUROPE: WEU (17)

Austria	Belgium-Lux.	Denmark	Finland
France	Germany	Greece	Iceland
Ireland	Italy	Netherlands	Norway
Portugal	Spain	Sweden	Switzerland
United Kingdom			

The majority of these countries are members of the EU and have a common agricultural policy. The latest members of the EU are Austria, Sweden, and Finland. Iceland Switzerland and Norway are also included in this group because together their supply and demand for dairy products are not sufficiently large to be a separate region, but are large enough so as to not be overlooked. In addition, these countries have similar dairy industry structure and are geographically, economically, and culturally close to the rest of the countries in this group.

2) EASTERN EUROPE: EEU (11)

Albania	Bosnia & Herzegovina	Bulgaria	Croatia
Czech Rep.	Hungary	Macedonia	Poland
Romania	Slovakia	Slovenia	Yugoslavia

These countries are geographically close and in the middle of economic and political reform. As a group and individually their production and consumption of dairy products is steadily declining and along with the former Soviet Union, is one of the regions with greater uncertainties for the future of their dairy industries. In the late 1980's Poland and Czechoslovakia became important dairy exporters. While the size of their exports has fallen in recent years they remain active in world markets due to the need to obtain hard currencies.

In spite of the break up of some republics such as the Czech Rep. and Slovakia, and Macedonia, Croatia, Bosnia Herzg, and Yugoslavia, FAO has data for all these east European countries as one region from 1989.

3) FORMER USSR: FSU (15)

Ukraine	Belarus	Estonia	Latvia
Lithuania	Moldova	Russia	Armenia
Azerbaijan	Georgia	Kazakhstan	Kyrgyzstan
Tajikistan	Turkmenistan	Uzbekistan	

This is probably the region with the most dramatic changes in the production and consumption of dairy products in recent years. Due to the size and importance in world dairy trade (specially on butter) it would be ideal to separate these countries in at least three regions. Russia, North and South Former Soviet Union. Russia, Ukraine and the Northern Republics are probably going to follow a different development pattern than the Southern Republics whose economic structure is less developed.

However, FAO data does not separate these countries until 1993. Before 1993 all trade and production information is presented as USSR. Therefore, if we are to disagregate this region, we can only do it starting on 1993. In addition, the FAO data for the southern countries is incomplete making it virtually impossible to create a region for these countries. Since all these countries were once part of one country we can assume a similar demand behavior and since all are in a process of economic and political adjustments we can expect that their supply and demand for dairy products will be declining in the short run.

4) OTHER NORTH ASIA: CHN (5)

China	Taiwan	Hong Kong	Macao	Mongolia

FAO reports data for P. R. China and Taiwan as one country. These countries or regions are very close geographically and culturally. Hong Kong should be included also in this group since it is a significant importer of dairy products in Asia and because on July 1 1997 it will be reunited with China. Macao will be reunited with China in 1999. FAO will probably report China, Taiwan and Hong Kong as one country after 1997 and add in Macao after 1999. Mongolia on the other hand does not have a significant trade activity of dairy products, but has a large production of milk and their agriculture and livestock conditions are similar to those of Inner Mongolia which is an important dairy region in China. Although dairy products are not in the traditional diet for China, both demand and supply of dairy commodities will increase significantly along with rapid economic growth.

5) JAPAN: JAP

Japan is a large economy with over 100,000 million inhabitants, a major consumer and importer of dairy products. Japan historically protected its domestic agriculture, thus in light of the GATT agreement, Japan is expected to provide wider access to its market for dairy products.

6) SOUTH EAST ASIA: SEA (6)

Indonesia	South Korea	Malaysia	Philipines
Singapore	Thailand		

These countries are geographically close and belong to ASEAN (with the exception of South Korea). All of these countries are experiencing very rapid economic growth, increasing productivity and income. Currently these cointries are important importers of milk and dairy products. Both supply and demand for dairy products are expected to increase in this region.

7) INDIA: IND

India has more than 900,000 inhabitants, is one of the biggest producers of milk (60,000 MT/ year), from which almost half is non-cow milk. India's cow milk production increased by almost 6,000 MT from 1990 to 1995. This amount is close to the annual production of Canada, Australia or Argentina. In addition, India is the biggest consumer of butter and ghee with more than 20% of the world's butter and ghee consumption.

8) OTHER SOUTH ASIA: OSA (4)

Bangladesh	Pakistan	Afghanistan	Sri Lanka

These countries are close geographically and are large importers of dry milk. Bangladesh and Pakistan were once one country with India and are culturally close, thus we expect similar demand patterns. Afghanistan is a large milk producer but with rather small trade. Sri Lanka on the other hand is experiencing rapid economic growth and is a significant importer of dairy products.

9) AUSTRALIA: AUS

Australian milk production has grown significantly over the last ten years and has become a major exporter of dairy products with about 10% of the international market share. Australian exports are specially significant to the ASEAN countries and Japan.

10) NEW ZEALAND: NZL

In spite of producing only 2% of the worlds milk, New Zealand's dairy exports represent approximately 21% of the world's market. New Zealand's temperate weather and grazing conditions makes it a low cost milk producer and very competitive in international markets. Trade liberalizing policies are expected to have large favorable impact on New Zealand's dairy industry.

11) MIDDLE EAST: MDE (15)

Bahrain	Cyprus	Iran	Iraq
Israel	Jordan	Lebanon	Kuwait
Oman	Qatar	Saudi Arabia	Syria
Turkey	Un. Arab Emirates	Yemen	

All these countries are close geographically and are major importers of dairy products. Their economies are mainly based on oil exports. With the exception of Israel they are Arab countries with many cultural similarities.

12) NORTH AFRICA: NAF (5)

Algeria	Egypt	Lybia	Morocco	Tunisia

These Arab/Muslim countries are located in North Africa and are major importers of dry milk. Since these countries do not have comparative advantages for milk production, it is expected that they will remain net importers of dairy products.

13) SOUTH AFRICA: SAF

South Africa is a relatively large milk producer and a net exporter of dairy products. However, its export volumes are not significant relatively to the world's total exports. It is the only significant producer and exporter of milk in the South of Africa.

14) CANADA: CAN

Canada is a traditional producer and exporter of milk products. Like EEC and other west European countries, Canada's dairy exports are subsidized. Even though Canada's economy and dairy industry is similar to the United States, they have different dairy policies such as supply management and other trade restrictions. Canada is also a member of NAFTA and GATT agreements.

15) UNITED STATES: USA

The USA is the largest producer and consumer of dairy products in the world. However its exports represent only 9% of the worlds dairy market.

16) MEXICO: MEX

Mexico's population is approximately 90 million and it is the largest importer of dry milk. Mexico's overall economy and dairy industry has been growing due to structural adjustment policies. Mexico is also part of NAFTA and GATT.

17) CENTRAL AMERICA & CARIBBEAN: CAM (12)

Belize	Costa Rica	Cuba	Dominican Republic
El Salvador	Guatemala	Haiti	Honduras
Jamaica	Nicaragua	Panama	Trinidad and Tobago

Central America and Caribbean countries are generally small economies and net importers of milk. They are culturally and geographically close and could become an important market for dairy products from North and South America.

18) SOUTH AMERICA: SAM (14)

Argentina	Bolivia	Brazil	Chile
Colombia	Ecuador	Falkland I.	French Guiana
Guyana	Paraguay	Peru	Suriname
Uruguay	Venezuela		

South American countries are close geographically and culturally. It's a region experiencing economic growth and political stability. As a region South America is a net importer of dairy products, however some countries such as Argentina, Paraguay and Uruguay are net exporters and have comparative advantages for growth in dairy and other agricultural products. Brazil is a the largest consumer and producer of milk in South America and its growth potential as a producer is underscored by the fact that only 10% of its dairy farms are technically efficient and capital investments are being made due to a more stable economic environment.

Also, Argentina, Chile, Brazil, Uruguay and Paraguay are members of MERCOSUR a successful custom union agreement that plans to expand to other countries in South America.

19) REST OF THE WORLD: ROW

All other countries

Mostly sub-Saharan African countries, small countries in Europe, the Pacific and Caribbean regions, and some Asian countries with small milk production and trade. The rest of the world is calculated by subtracting the sum of the 18 previous regions from the total world production and trade.

APPENDIX B: UW WORLD DAIRY MODEL DATA SOURCES

DAIRY TRADE AND PRICES.

5. ***Regional trade of dairy products***. Contains volume and total value of imports and exports of dry milk, butter and cheese.

6. ***Regional fresh milk trade and prices***: Contains volume, total value and calculated price of imports and exports of fresh milk.

7. ***Regional prices for dairy products***. Contains calculated import and export prices of dry milk, butter and cheese.

Sources:

OECD: *Statview v.2.0 Documentation.*

Australian Dairy Corporation: *Dairy Compendium 1994, 1995.*

FAO: *FAOSTAT PC, FAO Yearbook* (various issues, years)

USDA, Foreign Agricultural Service: *Dairy, Livestock, and Poultry: World Dairy Situation* Various Issues.

DAIRY PRODUCTION.

1. ***Regional dairy production and Composition.*** Contains total milk, cow milk, dry whole milk, dry skimmed milk, cheese, and butter production.

Sources:

FAO: *FAOSTAT PC.*

OECD: *Statview v.2.0 Documentation*

Robert, G. Jensen, Editor. *Handbook of Milk Composition.* San Diego: Academic Press, 1995.

DAIRY CONSUMPTION.

1. Regional consumption.

FAO: *FAOSTAT PC.*

2. ***Regional demand shifters.*** Contains population, GNP per capita, CPI, population growth rate, and income elasticity estimates.

WORLD BANK: *World Development Report* (various years).

REGIONAL SUPPLY AND DEMAND PRICE ELASTICITIES.

Source: John Sullivan, et al. *A 1989 Global Database for the Static World Policy Simulation (SWOPSIM) Modeling Framework.* U.S. Department of Agriculture, Economic Research Service, Agriculture and Trade Analysis Division, Washington, DC, 1992.

DISTANCES BETWEEN PORTS.

1. ***Main regional ports.*** List of regions, countries and ports for each region.
2. ***Distances between ports***. Contains a matrix with distances between ports in nautical miles.
3. ***Main travel routes bwtween ports***. List of some travel routes used to calculate the distances between ports .

Source: Defense Mapping Agency. *Distances between Ports*. Hydrographic/Topographic Center, Fifth Edition, 1985.