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Implications of Dairy Imports: The Case of Milk Protein Concentrates

Kenneth W. Bailey

Imports of milk protein concentrates (MPCs) are increasingly entering the United States with minimal trade restrictions. MPC is a general reference to a dried protein product derived from milk using a technology known as "ultra filtration." Two questions are addressed in this article. First, did the combination of relaxed import restrictions, low world prices for protein, and relatively high domestic support levels for nonfat dry milk encourage imports of MPCs? Second, did increased imports of MPC displace domestic use of nonfat dry milk and thereby increase government purchases under the dairy price support program? This study has implications for U.S. trade policy.

Key Words: dairy imports, milk protein concentrates, price supports

Imports into the United States of milk protein concentrates (MPCs) have grown rapidly in recent years despite the presence of a tariff-rate quota system for dairy products adopted under the Uruguay Round of the General Agreement on Tariffs and Trade (GATT). At the time of this agreement, Section 22 import quotas for specific dairy products were replaced by tariff-rate quotas (TRQs). The quota levels were expanded and tariffs lowered over a six-year implementation period. This procedure was designed to provide a delicate balance between the need to protect the domestic dairy industry, while at the same time improve market access to global trade.

MPC is a general reference to a dried protein product derived from milk using a technology known as "ultra filtration." MPC is produced from skim milk, which is passed through a membrane with minute pores that retains larger molecules (such as protein) and allows smaller molecules, such as water, lactose, and some minerals, to pass through (Chandan, 1997). The resulting product, called "retentate," is mostly protein and is either used in liquid form to make cheese, or is spray dried.

MPCs were not considered a significant trade issue during Uruguay Round negotiations since the

product was not sold at the time in international markets. Thus MPCs were not subjected to the same import licensing rules as other dairy products (such as cheese, butter, nonfat dry milk, etc). Only after implementation of the new World Trade Organization (WTO) rules in 1995 did trade in MPCs become significant. MPC imports into the United States surged in the latter half of the 1990s at a time when domestic use of dry protein (nonfat dry milk) fell and government purchases of nonfat dry milk under the dairy price support program increased.

The National Milk Producers Federation (NMPF), a trade association representing U.S. dairy cooperatives and their members, estimated that imports of MPC and casein (another protein-based product derived from milk) have reduced U.S. dairy farm income by \$157 million per year (NMPF, 2001). Implicit in this argument is that MPC imports substitute for domestic sources of milk proteins and thereby reduce domestic milk prices. In contrast, the International Dairy Foods Association (IDFA), a trade group representing U.S. dairy processors, asserts the high level of MPC imports is due to an unmet demand for this new product in food manufacturing, and that these imports "are not substitutable with nonfat dry milk" (IDFA, 2001).

Two questions are addressed in this article. First, did the combination of relaxed import restrictions, low world prices for protein, and relatively high

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domestic support levels for nonfat dry milk encourage imports of MPCs? Second, did increased imports of MPC displace domestic use of nonfat dry milk and thereby increase government purchases under the dairy price support program? These are important issues to address since Congress is considering legislation to impose higher tariffs on imports of MPC and casein (i.e., S. 847 and H.R. 1786). The latter question is important because relatively low U.S. tariffs on MPCs could be an issue in the upcoming WTO Round, launched in Doha, Qatar, in 2001.

The following section of this article reviews the history of dairy imports. A conceptual framework of the U.S. protein industry is then presented which accounts for imports. Next, the conceptual model is employed to graphically depict the impact of increased imports of MPCs on the U.S. dairy industry. The data are then reviewed and an econometric model is specified. Three equations are estimated to reflect domestic consumption of nonfat dry milk and imports of protein. In a section describing the model simulations, the econometric model is simulated over the historical period under two scenarios to reveal the impact of changing domestic and world prices. Concluding remarks are provided in the final section.

History of Dairy Import Controls

The United States has a long history of using import controls to protect domestic dairy producers. Section 22 of the Agricultural Adjustment Act of 1935 directed the Secretary of Agriculture to inform the President of the United States if foreign imports are affecting or interfering with the dairy price support program or domestic production of dairy products (Bailey, 1997, p. 234).

In 1981, the U.S. International Trade Commission (ITC) instituted an investigation of imports of casein¹ and lactalbumin.² The Commission cited the results of a 1981 U.S. Department of Agriculture/Economics and Statistics Service (USDA/ESS) study analyzing the implications of imposing either a 50% tariff on casein imports, or a quota equal to 50% of the amount imported during a representative period. The USDA/ESS study concluded a tariff or quota

would reduce casein imports and government purchases of nonfat dry milk under the dairy price support program, but would also increase consumer expenditures for protein. However, based on the findings of the ITC's investigation, it was determined that the high cost of the dairy price support program was not related to casein imports, but rather the escalating support price for milk (U.S. ITC, 1982). Due to this investigation, casein and lactalbumin imports are still not subject to import restrictions such as quotas or prohibitive tariffs.

Examining the impact of dairy imports on Wisconsin dairy farms, Salathe, Dobson, and Peterson (1977) reported Wisconsin farm milk prices would initially decline 18%, and 13% of Wisconsin farmers would eventually exit the industry. In a study of the impact of imports on the U.S. dairy industry, Novakovic and Thompson (1977) concluded a substantial increase in import levels would be required before any significant impact would be realized by the U.S. dairy industry.

Tariffs and quotas on dairy products came under review in the Uruguay Round of the GATT, which was concluded in April 1994 and implemented over the six-year period 1995–2000. The Uruguay Round Agreement created the World Trade Organization (WTO), and specific trade disciplines for agriculture including improved market access, limits on export subsidies, and reduction of internal supports which lead to trade distortions. The U.S. government replaced Section 22 import quotas with tariff-rate quotas (TRQs) and increased market access. The government also began a gradual reduction in export subsidies, called the Dairy Export Incentive Program (DEIP), in both quantity and value (USDA/Foreign Agriculture Service, 2002a).

TRQs impose a low tariff rate, called the low-tier rate, on imports up to a specified quantity (called a quota). A higher tariff rate, denoted the high-tier rate, applies to any imports in excess of that amount. According to USDA, the high-tier tariff rates were reduced by 15% over the 1991–2000 implementation period, while quota levels subject to low-tier rates were increased gradually over the same period. In order to import dairy products at the low-tier tariff rate, importers must apply for a license from USDA. This requirement allows USDA to allocate the quota to specific dairy products and specific countries. Dairy products subject to this licensing system include “nearly all dairy products from cow’s milk, except for soft-ripened cheeses such as Brie” (USDA/Foreign Agriculture Service, 2002b). MPCs *are not* subject to the import licensing system.

¹ Casein is a dairy protein produced via a chemical process (acid or enzyme) that precipitates out the casein portion of protein from skim milk.

² In the early 1980s, whey protein was known commercially as “lactalbumin.”

Table 1. U.S. Imports of Chapter 4 Milk Protein Concentrate

Import Market	Calendar Year				
	1996	1997	1998	1999	2000
	<!!!!!!!!!!!!!!!!!!!! (Million Pounds)!!!!!!!!!!!!!!!!!!!!>				
New Zealand	10.8	17.3	24.8	32.2	42.7
Australia	2.3	2.5	5.0	10.9	15.3
Ireland	6.8	8.6	16.1	21.6	15.2
Germany	4.1	2.6	3.2	11.6	15.5
Netherlands	0.0	0.1	2.0	10.1	11.4
Canada	2.9	2.2	4.3	7.5	4.9
Hungary	0.3	0.4	0.9	0.9	2.8
Switzerland	0.0	0.0	0.0	0.1	2.7
France	0.1	0.7	0.0	0.7	2.1
Denmark	0.0	0.0	0.2	0.2	2.1
ROW ^a	4.1	3.1	7.3	3.1	1.4
Grand Total	31.4	37.5	63.8	98.9	116.1

Source: USDA/Foreign Agriculture Service (FAS Online); HTS Code 0404.90.10.

^aROW = rest of world.

In response to dairy producer concerns, the U.S. General Accounting Office (U.S. GAO, 2001) analyzed trends in MPC imports and domestic use. The analysis showed that MPC imports grew from 805 metric tons in 1990 to 44,878 metric tons in 1999. Further, the GAO study noted that exporters of MPC face no U.S. quotas, low duties,³ and a broadly defined classification system. The latter effectively limits the ability to track the quantity of protein in the form of MPCs entering the United States, or MPC end use.

There are two categories of MPCs in the Harmonized Tariff Schedule (HTS) codes adopted under the WTO. Chapter 4 MPC is a broad classification and includes any complete milk protein (casein plus lactalbumin) which is more than 40% "milk protein" by weight. This category of MPCs reflects a combination of both casein plus whey proteins. The second classification is Chapter 35 of the HTS, and includes milk proteins which are at least 90% "casein."

While imports of both classifications of MPC have increased in recent years, Chapter 4 imports experienced the greatest increase, growing 270%, from 31.4 million pounds in 1996 to 116.1 million pounds by 2000. U.S. MPC imports under Chapter 4 over the period 1996–2000 are detailed in table 1. The top 10 exporters to the United States in 2000 (ranked by value) include Oceania (New Zealand and Australia), the European Union (EU), and Can-

ada. It is hypothesized that Chapter 4 imports more closely compete with domestically produced nonfat dry milk since their protein contents are more closely matched. Over this same time period, Chapter 35 imports grew 208%, from 8.5 million pounds to 26.3 million pounds (USDA/Foreign Agriculture Service, FAS Online).

Imports of MPC directly and indirectly substitute for domestic sources of protein. Nonfat dry milk is a storable form of protein produced in the United States from skim milk. This product is used as an ingredient in both other dairy products (such as ice cream and cheese), and nondairy food products (e.g., candy and baked goods). In addition, nonfat dry milk is one of the products purchased under the dairy price support program.

The dairy price support program supports the manufacturing value of milk by providing a price floor under the wholesale market prices of cheese, butter, and nonfat dry milk. The U.S. government stands ready to purchase unlimited quantities of these products at announced prices. The Commodity Credit Corporation (CCC) purchase price of nonfat dry milk has declined steadily from \$1.0470 per pound in 1996 to \$1.01 by 2000. Annual government purchases of nonfat dry milk under this program rose from no purchases in 1996 to 558 million pounds in 2000. At the same time, domestic commercial disappearance of nonfat dry milk declined from 1,009.3 million pounds in 1996 to 770.8 million pounds in 2000. Government stocks of nonfat dry milk at the end of 2000 stood at 515.8 million

³ The tariff rate on MPCs in 2000 was \$0.0037 per kilogram.

pounds, equivalent to 67% of annual domestic use (USDA/Economic Research Service).

Conceptual Framework

The two questions to be addressed require analysis of the wholesale markets for manufactured dairy products in the United States. The model employed here is based on work by Kaiser, Streeter, and Liu (1988), and Liu et al. (1991). These studies were based on a conceptual and an estimated econometric model of the U.S. dairy industry consisting of all three levels of the industry: farm, wholesale, and retail. The wholesale and retail markets for both fluid and manufactured dairy products were included.

The model used here is limited in focus to just the domestic supply of milk proteins, and the demand for protein in two key uses—cheese and nonfat dry milk. These are the two major applications for protein which is not used for fluid milk products. This model also includes protein purchased under the dairy price support program. By focusing on just the protein market, the model will clearly illustrate the impact of MPC imports on the manufactured dairy markets, and interactions between MPC imports and the dairy price support program.

In our conceptual framework, the domestic market for milk protein consists of four relationships: (a) the farm-level supply, (b) the import demand, (c) the derived demand for protein use, and (d) an equilibrium condition. Equations (1)–(4) represent these respective components of the conceptual model:

- (1) $S_{pr} = \alpha_{pr}^s \% \beta_{pr}^s P_{pr} \% \gamma_{pr}^s Z_{pr}^s \% \mu_{pr}^s$,
- (2) $ID_{mpc} = \alpha_{mpc}^d \% \beta_{mpc}^d P_{pr} \% \delta_{mpc}^d P_{mpc} \% \gamma_{mpc}^d Z_{mpc}^d \% \mu_{mpc}^d$,
- (3) $DD_{pr} / S_c \% S_{nf}$,
- (4) $S_{pr}(P_{pr}) \% ID_{mpc}(P_{pr}) / DD_{pr}(P_{pr})$.

The domestic supply of milk proteins (S_{pr}) is a function of its domestic price (P_{pr}) and a vector of supply shifters (Z_{pr}^s) which would include factors such as feed costs, weather variables, and the price of dairy replacements [equation (1)]. The import demand for milk proteins (ID_{mpc}) is inversely related to the international protein price (P_{mpc}), and positively related to the domestic price (P_{pr}). It is assumed that milk proteins produced domestically and imported milk proteins are perfect substitutes.

Z_{mpc}^d is a vector of demand shifters affecting import demand such as weather conditions for major dairy exporting countries, changes in global income and population, and policy changes in other countries.

Following Kaiser, Streeter, and Liu (1988), and Liu et al. (1991), the U.S. domestic derived demand for milk proteins (DD_{pr}) is equal to the sum of the wholesale supplies of cheese S_c , and nonfat dry milk S_{nf} [equation (3)]. Equation (4) is a market-clearing identity that equates the total supply of milk proteins (from domestic and international sources) with the derived demand. The α , β , δ , and γ notations are unknown coefficients to be estimated, and μ 's denote random error terms.

The conceptual model employs a derived demand equation to reflect domestic wholesale markets for cheese and nonfat dry milk. Multi-equation conceptual models for these two markets are described next.

The wholesale cheese market is represented by the following three equations:

- (5) $S_c = \alpha_c^s \% \beta_c^s P_c \% \lambda_c^s P_{pr} \% \sigma_c^s P_{mpc} \% \gamma_c^s Z_c^s \% \mu_c^s$,
- (6) $D_c = \alpha_c^d \% \beta_c^d P_c \% \gamma_c^d Z_c^d \% \mu_c^d$,
- (7) $S_c(P_c) / D_c(P_c)$.

The supply of cheese (S_c) is positively related to the wholesale cheese price (P_c), and inversely related to milk protein prices (P_{pr} and P_{mpc}), since milk proteins are considered inputs in cheese production [equation (5)]. It is hypothesized that the supply of cheese will increase if the global price of milk protein falls relative to the domestic price. The demand for cheese (D_c) is inversely related to the wholesale price of cheese (P_c) [equation (6)]. Both λ and σ are coefficients, and Z_c^s and Z_c^d represent supply and demand shifters, respectively. Equation (7) is the market-clearing identity.

Equations (8) through (11) describe the wholesale market for nonfat dry milk:

- (8) $S_{nf} = \alpha_{nf}^s \% \beta_{nf}^s P_{nf} \% \lambda_{nf}^s P_{pr} \% \sigma_{nf}^s P_{mpc} \% \gamma_{nf}^s Z_{nf}^s \% \mu_{nf}^s$,
- (9) $D_{nf} = \alpha_{nf}^d \% \beta_{nf}^d P_{nf} \% \lambda_{nf}^d P_c \% \gamma_{nf}^d Z_{nf}^d \% \mu_{nf}^d$,
- (10) $S_{nf}(P_{nf}) = D_{nf}(P_{nf})$ if $P_{nf}^{\text{sp}} \leq P_{nf}^{\text{sp}}$,
- or
- (11) $S_{nf}(P_{nf}^{\text{sp}}) = GP_{nf}^{\text{sp}} \% D_{nf}(P_{nf}^{\text{sp}})$ if $P_{nf}^{\text{sp}} > P_{nf}^{\text{sp}}$.

The supply of nonfat dry milk (S_{nf}) is positively related to the wholesale price of nonfat dry milk (P_{nf}), and inversely related to the domestic protein price (P_{pr}) and the international protein price (P_{mpc}) in equation (8). Recall the domestic and international milk proteins are being viewed as inputs and as perfect substitutes.

The demand for nonfat dry milk has a unique specification because of its multiple uses. Due to its functional use and high protein content, nonfat dry milk is used as a finished dairy product, an input in the food processing industry, and as an input in other dairy products such as cheese.

Taking all of this into consideration, the demand for nonfat dry milk is inversely related to P_{nf} and positively related to P_{mpc} , since imported protein is considered a substitute for domestic protein [equation (9)]. Nonfat dry milk demand is also positively correlated with the wholesale price of cheese (P_c). The cheese price is expected to shift the demand curve for nonfat dry milk because a higher output price for cheese relative to the price of nonfat dry milk will increase the demand for nonfat dry milk in cheese production. Nonfat dry milk can partially substitute for raw milk as an alternative source of protein in cheese production (American Dairy Products Industry, 2001).

The market-clearing conditions for the wholesale nonfat dry milk market are expressed in equations (10) and (11), and are dependent on the operations of the dairy price support program. If the market-clearing wholesale price of nonfat dry milk (P_{nf}^c) is above the support price for nonfat dry milk (P_{nf}^{sp}), then equation (10) prevails. Otherwise, government purchases of nonfat dry milk (GP_{nf}^{sp}) are required in order to support the wholesale price of nonfat dry milk at P_{nf}^{sp} [equation (11)].

A final set of identities is required to link the supply of protein from the farm [equation (1) above] with the wholesale markets for cheese and nonfat dry milk:

$$(12) \quad P_c / Y_c P_{pr} \%MA_c,$$

$$(13) \quad P_{nf} / Y_{nf} P_{pr} \%MA_{nf}.$$

These identities, which are defined in federal milk marketing orders, use yield factors and make allowances. The yield factor (Y) reflects protein content in the finished product—cheese or nonfat dry milk. The make allowance (MA) is the unit cost of converting raw milk into the finished dairy products.

Impact of MPC Imports

The conceptual model, where MPC is assumed as a perfect substitute for nonfat dry milk, is used to identify the impact of increased MPC imports on the wholesale markets for cheese and nonfat dry milk. The impact of increased MPC imports is illustrated in figure 1.

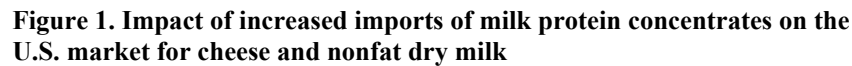
MPC imports are expected to increase if the international price of milk proteins (P_{mpc}) falls below the U.S. price of milk protein (P_{pr}) in the context of the conceptual model. Greater imports of MPC will increase the supply of milk proteins available in the United States. Given the derived demand curve (DD_{pr}), this will lower the domestic price of milk protein from P_{pr}^c to P_{pr}^N , and increase the quantity of protein on the domestic market from Q_{pr}^c to Q_{pr}^N (see top right panel of figure 1). A lower domestic price for protein will lower the input price for cheese production, thereby shifting the cheese supply function from S_c to S_c^N . For a given wholesale demand schedule of D_c , the wholesale price of cheese will fall from P_c^c to P_c^N ⁴.

The impact of increased MPC imports on the U.S. wholesale market for nonfat dry milk is a bit more complicated. In this illustration, the interaction between the demand curve for nonfat dry milk (D_{nf}) and the dairy price support program at the support price of P_{nf}^{sp} is represented by the “kinked” demand curve D_{nf}^{sp} (see lower right panel of figure 1). Currently, the operations of the dairy price support program may be reflected by the horizontal portion of this kinked demand curve since the support price of nonfat dry milk (P_{nf}^{sp}) is above the market-clearing level. This greatly simplifies the model because the domestic price of nonfat dry milk becomes exogenous.

Like the wholesale cheese market, the supply curve for nonfat dry milk is expected to shift from S_{nf} to S_{nf}^N due to the lower domestic input price for protein. In addition, it is hypothesized that the lower international protein price shifts the kinked demand curve for nonfat dry milk from D_{nf}^{sp} to D_{nf}^N , because lower priced MPC imports will substitute directly for domestically produced nonfat dry milk, thus reducing domestic nonfat dry milk use.

An increase in the supply of nonfat dry milk and a reduction in its domestic demand increases government purchases of surplus nonfat dry milk under the support price program (from G_{nf}^c to G_{nf}^N , lower

⁴ Note that in this example, the market-clearing price of cheese is well above the support price of cheese (P_c^{sp}).



The objectives of this study can be achieved by estimating only two of the structural equations outlined in the conceptual model: the equations that reflect

Table 2. Estimated Structural Equations for Wholesale Demand for Nonfat Dry Milk, Import Demand for Chapter 4 MPC, and Import Demand for Chapter 35 MPC**Wholesale Demand for Nonfat Dry Milk:**

$$\ln(NFCONS/POP) = 7.618 - 0.442 \ln(NFWPC/CPIFOOD) + 0.825 \ln(BCWP/CPIFOOD) + 0.599 \ln(EUNFDMPC/CPIFOOD) \\ (2.25) \quad (-0.77) \quad (2.44) \quad (2.47) \\ + 1.578 \ln((INCOME/POP)/CPIALL) + 0.213 DUMQ1 + 0.235 DUMQ2 + 0.134 DUMQ3 + 0.306 AR(1) \\ (1.87) \quad (3.42) \quad (3.49) \quad (2.09) \quad (1.73) \\ \text{Adjusted } R^2 = 0.44, \quad \text{Durbin-Watson} = 2.10$$

Import Demand for Chapter 4 MPC:

$$\ln(MPC4IMPS) = 61.655 + 5.670 \ln(NFWPC/CPIFOOD) - 0.304 \ln(EUNFDMPC/CPIFOOD) - 0.323 \ln(EUNFDMPC_1/CPIFOOD_{-1}) \\ (3.52) \quad (6.20) \quad (-1.00) \quad (-2.07) \\ - 0.342 \ln(EUNFDMPC_2/CPIFOOD_{-2}) - 0.361 \ln(EUNFDMPC_3/CPIFOOD_{-3}) + 20.30 \ln((INCOME/POP)/CPIALL) \\ (-2.03) \quad (-1.11) \quad (2.72) \\ + 0.000195 TSQ - 0.0486 DUMQ1 + 0.357 DUMQ2 + 0.319 DUMQ3 \\ (1.02) \quad (-0.29) \quad (2.15) \quad (1.91) \\ \text{Adjusted } R^2 = 0.92, \quad \text{Durbin-Watson} = 1.56$$

Import Demand for Chapter 35 MPC:

$$\ln(MPC35IMPS) = 15.758 + 0.831 \ln(NFWPC/CPIFOOD) + 0.214 \ln(EUNFDMPC/CPIFOOD) - 0.391 \ln(EUNFDMPC_1/CPIFOOD_{-1}) \\ (1.84) \quad (0.79) \quad (0.35) \quad (-1.63) \\ - 0.997 \ln(EUNFDMPC_2/CPIFOOD_{-2}) + 8.412 \ln((INCOME/POP)/CPIALL) - 0.0466 DUMQ1 + 0.0492 DUMQ2 \\ (-1.48) \quad (3.51) \quad (-0.35) \quad (0.33) \\ + 0.134 DUMQ3 - 1.011 DUMQ1Q296 + 0.496 AR(1) \\ (1.08) \quad (-3.06) \quad (3.06) \\ \text{Adjusted } R^2 = 0.72, \quad \text{Durbin-Watson} = 2.09$$

Note: Numbers in parentheses below the parameter estimates are student *t*-statistics.

MPC import demand (HTS Chapter 4 and Chapter 35 imports), and domestic use of nonfat dry milk. An analysis of the impact of MPC imports on the dairy price support program is limited to just the market for nonfat dry milk because there have been only limited cheese purchases during the period of study. The farm supply of milk was not endogenized in the econometric model because the farm supply of milk in year *t* is related to farm milk prices in year *t* - 1. This study is interested in the impact of MPC imports in year *t* only, so farm supply is considered exogenous to the model.

Quarterly data over the 1990/Q1 through 2000/Q4 period were used for model estimation. The source of data for MPC imports (both Chapters 4 and 35) was USDA's Foreign Agriculture Service (FAS Online). The fob Northern Europe price for nonfat dry milk, also available from FAS, was used as a proxy for the international market price of MPC. The U.S. GAO (2001) reported that MPC was priced according to two factors: protein content, which varied from 40–90%, and the global price of protein. The Northern Europe nonfat dry milk price is quoted at a set protein level, represents a significant portion of the world trade in protein, and is highly correlated with the New Zealand price of nonfat dry milk.

New Zealand, another major exporter of nonfat dry milk, is the EU's major competitor in the international market for nonfat dry milk. Data for commercial disappearance of nonfat dry milk in the United States were taken from various issues of the USDA/Economic Research Service's *Livestock, Dairy, and Poultry Situation and Outlook Report*.

The three structural demand equations were estimated and simulated using SAS Econometric Time Series (ETS) software (SAS Institute, Inc., 1999). Because the equations have a similar specification and are not simultaneous, the Seemingly Unrelated Regression (SUR) estimator was selected to account for any cross-equation correlations between error terms. In addition, all three equations were estimated in double-log form following Kaiser, Streeter, and Liu (1988). The parameter estimates are presented in table 2 (with student *t*-statistics in parentheses below the individual parameter estimates). A list of the variables and their definitions is provided in table 3.

In the first equation of table 2 (wholesale demand for nonfat dry milk), commercial disappearance of nonfat dry milk (*NFCONS*) is divided by population (*POP*) and estimated as a function of the deflated prices for domestic nonfat dry milk (*NFWPC*),

Table 3. List of Variables and Definitions

Variable Name	Definition
Endogenous Variables:	
<i>NFCONS</i>	U.S. commercial disappearance of nonfat dry milk (mil. lbs.)
<i>MPC4IMPS</i>	U.S. imports of Chapter 4 milk protein concentrate (mil. lbs.)
<i>MPC35IMPS</i>	U.S. imports of Chapter 35 milk protein concentrate (mil. lbs.)
Exogenous Variables:	
<i>BCWP</i>	Wholesale block cheese price, Chicago (\$/lb.)
<i>CPIALL</i>	Consumer Price Index, all items (1982–84 = 100)
<i>CPIFOOD</i>	Consumer Price Index, food (1982–84 = 100)
<i>EUNFDMP</i>	Nonfat dry milk price, fob Northern Europe (US\$/lb.)
<i>DUMQ(i)</i>	Quarterly dummy variable ($i = 1, 2, 3$)
<i>DUMQ1Q296</i>	Dummy variable, = 1 for 1996/Q1 and 1996/Q2, = 0 otherwise
<i>INCOME</i>	U.S. personal disposable income (\$ bil.)
<i>POP</i>	Total U.S. population (mil. persons)
<i>NFWPC</i>	Wholesale nonfat dry milk price, Central States (\$/lb.)
<i>TSQ</i>	Trend squared, where trend = 61 for 1990/Q1, = 62 for 1990/Q2, etc.

domestic cheese (*BCWP*), and the Northern Europe price of nonfat dry milk (*EUNFDMP*). Deflated per capita income and three quarterly dummy variables are also included. The original model showed signs of autocorrelated residuals, which was corrected using a first-order autoregressive error correction model, AR(1).

The econometric results for this equation indicate an adjusted R^2 of 0.44 (table 2). The parameter estimate for the wholesale price of nonfat dry milk, while having the correct sign, was not statistically significant. This may be because the wholesale price of nonfat dry milk over the period of estimation fluctuated little above the support price floor. The cheese price and the Northern Europe price of nonfat dry milk both have the correct signs and are statistically significant. In addition, the deflated per capita income variable and quarterly dummy variables had statistically significant parameter estimates and correct signs. Thus the estimated equation was judged satisfactory for simulation purposes.

The next two equations from table 2 specified the U.S. imports of MPCs (both Chapters 4 and 35) as a function of the deflated prices of *NFWPC* and *EUNFDMP*, deflated per capita income, and quarterly dummy variables. Trend squared (*TSQ*) was used to reflect the impact of new technology on the demand for MPC as a protein ingredient. Advances

in membrane filter materials made the widespread adoption of ultra filtration technology economically possible, which in turn has made MPC production commercially viable. This adoption was followed by significant increases in world trade in MPC.

Both import demand equations contain distributed lag terms reflecting the impact of changes in the international price of MPC imports. It was hypothesized that because MPCs are a relatively new product, and imports faced more price risk relative to domestic milk protein sources, a period of reduced international prices was required before traders took action and arranged for imports. A four-quarter distributed lag model structure (quarters t through $t - 4$) was specified.

As seen from table 2, Chapter 4 MPC imports (*MPC4IMPS*) had correct signs and strong student t -statistics for the domestic deflated price of nonfat dry milk (*NFWPC*) and per capita income, and had a strong adjusted R^2 of 0.92. The distributed lag model had correct signs for the world price of protein (*EUNFDMP*), and most parameter estimates were significant through three periods. Prior specifications with more or fewer lags produced incorrect signs and low student t -statistics. *TSQ*, the trend square variable, did not have a statistically significant parameter estimate, but was retained because it had the correct sign and was theoretically important. The model estimates produced a Durbin-Watson estimate of 1.56, which is considered borderline for autocorrelation of error terms. However, an earlier AR(1) correction proved statistically insignificant.

For the third equation in table 2, Chapter 35 MPC imports (*MPC35IMPS*) had less robust parameter estimates and an adjusted R^2 of only 0.72. For example, the parameter estimate for domestic nonfat dry milk was not statistically significant. However, the specification produced the proper signs, some of the parameter estimates were statistically significant (such as the income variable), and the AR(1) correction was statistically valid. The distributed lag model was not particularly robust, but two of the three parameter estimates had student t -statistics above 1.0 and correct signs.

The model was validated by simulating it over the historical period 1991/Q1 through 2000/Q4. The simulation period was reduced a year relative to the estimation period to allow for the distributed price lags in the estimated model. Following Pindyck and Rubinfeld (1981, p. 362), the mean percent error (MPE) and the root mean square percentage (RMSP) error were estimated over the simulation period in order to measure the deviation of the simulated

variables from the actual time path. The MPE was 0.6% for *NFCONS*, 6.8% for *MPC4IMPS*, and 6% for *MPC35IMPS*. The RMSP error was 14.6% for *NFCONS*, 39.5% for *MPC4IMPS*, and 37.2% for *MPC35IMPS*. Based on these results, some large positive simulation errors appear to have canceled out large negative errors. Thus the high values for RMSP indicate the model may have limitations for forecasting purposes. However, the significant parameter estimates suggest the model is reasonable for simulation purposes.

Model Simulations

Two scenarios were developed in order to answer the questions posited previously. The simulation period was 1996/Q1 through 2000/Q4, a period when MPC imports grew significantly. The two scenarios, identified below, were then compared to the baseline derived using historical data to compute the model validation statistics:

- SCENARIO 1. Set the Northern Europe nonfat dry milk price at \$0.99 per pound.
- SCENARIO 2. Reduce the CCC purchase price of nonfat dry milk to \$0.80 per pound.

The Northern Europe price of nonfat dry milk, a proxy for the international protein price, fell from a peak of \$0.96 per pound in the first quarter of 1996 to a low of \$0.55 per pound by the second quarter of 1999. The first scenario was thus simulated over the period 1996/Q1–2000/Q4. It maintains the relatively high international price of protein and examines the impact on domestic nonfat dry milk consumption and imports of MPC. When compared to the simulated baseline, this scenario would effectively estimate the impact of low world prices (what actually occurred) on domestic consumption of nonfat dry milk and MPC imports.

The CCC purchase price for nonfat dry milk remained at \$1.0470 per pound over the historical period from 1996 through 1997. Thereafter, it was reduced to \$1.03 per pound in 1998, and \$1.01 per pound in 1999–2000. The domestic wholesale price of nonfat dry milk for Central States fluctuated from \$1.07 to \$1.29 per pound during 1995–1996, and from \$1.01 to \$1.14 during 1997–2000.⁵ Thus, with the exception of a few quarters, the wholesale

price of nonfat dry milk (adjusted to the West Coast prices) over the 1997–2000 period was within a few pennies of the announced CCC purchase price of nonfat dry milk.

The second scenario was designed to simulate the impact of a lower CCC purchase price for nonfat dry milk under the dairy price support program. This scenario was designed to analyze the market impacts of a lower CCC purchase price during a time period when the operations of the price support program, combined with import controls, historically propped up wholesale market prices. Thus, to reflect the impact of a lower CCC purchase price on the domestic market for nonfat dry milk, the model was estimated with the domestic wholesale price of nonfat dry milk at the higher of the Northern Europe price, or \$0.80 per pound. Given this rule, the model determined that the wholesale price of nonfat dry milk was equal to the Northern Europe price over the 1996/Q1–1997/Q1 period, and the Central States price of \$0.80 per pound during the 1997/Q2–2000/Q4 period.

The simulation results for the first scenario are reported in table 4. The results indicate that fixing the Northern Europe price of nonfat dry milk at the peak level of \$0.99 per pound would effectively raise the international protein price 18–79% relative to the historical baseline over the period 1997/Q1–2000/Q2 (the results were similar, but lower in 1996). The results in table 4 confirm the higher world protein price resulted in greater use of domestic nonfat dry milk in the United States and reduced imports of MPC. Domestic consumption of nonfat dry milk increased 10–42% during the period 1997/Q1–2000/Q2, and imports of MPC declined 14–51%, both relative to the simulated baseline.

Increased domestic consumption of nonfat dry milk in the first scenario resulted in an equal reduction in CCC purchases of nonfat dry milk. Over the simulation period 1996/Q1–2000/Q4, CCC purchases of nonfat dry milk would have been reduced by 810 million pounds due to greater domestic commercial use and higher international protein prices. Given monthly CCC purchase prices of \$1.01 to \$1.05 per pound over this time period, high international prices for nonfat dry milk would have reduced the cost of operating the dairy price support program by about \$829 million.

The simulation results for the second scenario are provided in table 5. Lowering the domestic price of nonfat dry milk to the higher of the Northern Europe price, or \$0.80 per pound, resulted in a reduction in the domestic price of nonfat dry milk

⁵ Over this time period, the Western price of nonfat dry milk averaged 2¢ per pound under the Central States price. The majority of nonfat dry milk over this time period entered the CCC via the West Coast.

Table 4. Simulated Impact of Raising the Northern Europe Price of Nonfat Dry Milk to \$0.99 per Pound (Scenario 1)

Year/ Quarter	Commercial Use Nonfat Dry Milk	U.S. Imports of MPC		N. Europe Nonfat Dry Milk Price
		Chapter 4	Chapter 35	
<!!!! (% Change Relative to Baseline) !!!!!>				
1996/Q1	2.1	! 1.6	0.1	3.5
1996/Q2	8.8	! 5.8	0.0	15.1
1996/Q3	10.0	! 10.6	! 5.4	17.2
1996/Q4	8.7	! 14.3	! 15.9	14.9
1997/Q1	10.3	! 18.1	! 16.3	17.7
1997/Q2	14.1	! 20.1	! 14.3	24.7
1997/Q3	17.3	! 22.8	! 17.4	30.6
1997/Q4	16.8	! 25.9	! 23.6	29.7
1998/Q1	22.1	! 30.0	! 25.6	39.7
1998/Q2	26.1	! 33.7	! 26.4	47.4
1998/Q3	29.6	! 37.2	! 32.4	54.2
1998/Q4	33.1	! 41.6	! 36.5	61.2
1999/Q1	36.9	! 45.2	! 39.7	69.0
1999/Q2	41.9	! 48.7	! 42.6	79.4
1999/Q3	38.3	! 50.6	! 47.0	71.9
1999/Q4	29.0	! 50.0	! 50.5	53.1
2000/Q1	24.3	! 47.5	! 46.6	43.9
2000/Q2	17.2	! 41.7	! 39.9	30.3
2000/Q3	1.3	! 30.9	! 37.0	2.1
2000/Q4	0.0	! 20.5	! 23.8	0.0

equal to 14–35% over the period 1996/Q1–2000/Q4. This simulates the impact of a lower CCC purchase price for nonfat dry milk. The results in table 5 show increased consumption of domestic nonfat dry milk and reduced imports of MPC. Domestic consumption of nonfat dry milk rose 7–21% relative to the baseline over the period 1996/Q1–2000/Q4. Chapter 4 MPC imports fell 59–91%, and Chapter 35 imports fell 12–30% over the same time period, both relative to the simulated baseline.

The increased domestic consumption of nonfat dry milk under scenario 2 had a direct impact on the operation of the dairy price support program. A reduced CCC purchase price for nonfat dry milk would have reduced government purchases under the dairy price support program by 555 million pounds, and reduced program procurement costs by about \$572 million over the period 1996/Q1–2000/Q4.

Conclusions

Dairy producers in the United States consider the current lack of tariff rate quotas on MPC imports as a “loophole” that survived the Uruguay Round Agreement on Agriculture. Through their trade associations, the producers are pressing for legislation which will increase the tariff on MPC imports, or include MPC imports as part of the negotiations in

Table 5. Simulated Impact of Reducing the CCC Purchase Price of Nonfat Dry Milk to \$0.80 per Pound (Scenario 2)

Year/ Quarter	Commercial Use Nonfat Dry Milk	U.S. Imports of MPC		Central States Nonfat Dry Milk Price
		Chapter 4	Chapter 35	
<!!!! (% Change Relative to Baseline) !!!!!>				
1996/Q1	7.1	! 58.6	! 12.1	! 14.4
1996/Q2	15.4	! 83.9	! 23.5	! 27.6
1996/Q3	20.6	! 90.9	! 29.7	! 34.5
1996/Q4	17.6	! 87.5	! 26.2	! 30.7
1997/Q1	14.4	! 82.2	! 22.3	! 26.2
1997/Q2	15.1	! 83.4	! 23.2	! 27.2
1997/Q3	13.5	! 80.2	! 21.2	! 24.9
1997/Q4	13.0	! 79.0	! 20.4	! 24.1
1998/Q1	12.6	! 78.0	! 19.9	! 23.4
1998/Q2	11.9	! 76.3	! 19.1	! 22.4
1998/Q3	12.8	! 78.6	! 20.2	! 23.8
1998/Q4	15.8	! 84.7	! 24.1	! 28.2
1999/Q1	12.6	! 78.1	! 20.0	! 23.5
1999/Q2	11.0	! 73.7	! 17.8	! 21.0
1999/Q3	11.9	! 76.2	! 19.0	! 22.3
1999/Q4	12.0	! 76.7	! 19.2	! 22.7
2000/Q1	10.9	! 73.3	! 17.6	! 20.8
2000/Q2	10.7	! 72.7	! 17.3	! 20.5
2000/Q3	11.3	! 74.6	! 18.2	! 21.5
2000/Q4	11.6	! 75.4	! 18.6	! 21.9

the new WTO round launched in Doha, Qatar, in 2001. One issue considered here was whether MPC imports were due to relatively low international milk protein prices in relation to high supports in the United States. The other issue addressed was whether MPC imports substituted for domestically produced milk protein, thereby increasing the cost of operating the dairy price support program.

The results of this study provide the following three conclusions.

- First, imported MPC clearly substitutes to some degree for domestically produced nonfat dry milk. When this occurs, CCC purchases under the dairy price support program increase if the wholesale price of nonfat dry milk is at or below the support price.
- Second, increased imports of MPC occur whenever the Northern Europe price of nonfat dry milk falls below the U.S. price, creating an economic advantage to the importers of the product.
- Third, some level of MPC imports is inelastic relative to the domestic and international protein prices. MPC imports did not fall to zero whenever the relative price advantage between domestic and world prices was eliminated in model simulations. Thus one can conclude that some MPC imports do occur because of its functional properties in food processing, not its substitutability for nonfat dry milk.

Based on the model simulation of Scenario 1 (the Northern Europe nonfat dry milk price is set at \$0.99/pound), MPC imports increased when the international price of protein fell below U.S. protein prices. Under this first scenario, model results indicate that had the Northern Europe nonfat dry milk price remained constant at \$0.99 per pound over the period 1996–2000, Chapter 4 and Chapter 35 MPC imports would have fallen 14–51% relative to the baseline, and consumption of nonfat dry milk in the United States would have been significantly higher. In other words, the availability of a protein source (MPC) under little or no tariffs at a relatively low price increased imports of MPC and reduced domestic consumption of nonfat dry milk. Any nonfat dry milk not used commercially was purchased under the dairy price support program.

The model simulation of Scenario 2 (the CCC purchase price of nonfat dry milk is reduced to \$0.80/pound) reveals that a high CCC purchase price for nonfat dry milk under the dairy price support program, combined with the opportunity to import lower-priced MPC, contributed to reduced domestic consumption of nonfat dry milk and higher CCC purchases. Based on this scenario, had the CCC purchase price been reduced to \$0.80 per pound over the period 1996–2000, MPC imports would have been significantly lower, and domestic consumption of nonfat dry milk would have been higher, thus reducing the cost of operating the dairy price support program, relative to the baseline. Stated another way, the opportunity to import MPCs in the face of relatively high internal support prices for nonfat dry milk effectively increased the cost of operating the dairy price support program by about \$572 million over the period of study.

A number of limitations should be considered when reviewing these results. First, the question of what impact MPC imports had on farm-gate milk prices in the United States is not addressed. Such an estimate would show the monetary damages to domestic milk producers. However, to address this question, a complete U.S. dairy industry model would be required that could simultaneously solve for cheese, butter, nonfat dry milk, and whey prices. Another limitation of this study is that no estimate was made of the impact of a lower domestic protein price on the supply of nonfat dry milk to the wholesale market. Again, such an estimate would require the use of a much larger multiple-component pricing model of the U.S. dairy industry.

Finally, the model results provide very little information about the impact of MPC imports on

consumers. One would expect that changes in domestic milk protein prices would have significant welfare implications for consumers. Milk protein is a major component in many dairy products, is an ingredient in a number of processed foods, and in some cases may substitute directly with other plant-based proteins. Thus, modeling consumer demand for milk proteins is complex and would require a number of simplifying assumptions. Given the economic gravity of the results estimated so far, however, a more comprehensive dairy industry model and analysis should be considered for future research.

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