IMPACT OF THE EUROPEAN UNION'S SMP INTERVENTION PROGRAM ON THE UNITED STATES: 2016-19

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IDFA International Dairy Foods Association

NMPF NATIONAL MILK PRODUCERS FEDERATION

USA U.S. Dairy Export Council. Ingredients | Products | Global Markets

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EXECUTIVE SUMMARY

EU SETS EXPANSION PLANS IN MOTION

In 2003 the EU government began to phase out their quota program which capped annual milk production growth in the EU. The EU wanted greater access to a growing world market. Quotas were increased by 1% per year starting in April 2009 in order to create a "soft landing" for producers. On April 1, 2015 quotas were abolished. From 2012 to 2016 EU milk production grew at an annual rate of 2.1%.

EU Responds to Milk Crisis in 2016

Strong EU milk production growth coupled with reduced dairy imports from China and a Russian trade embargo in 2014 resulted in a dramatic decline in EU farm-gate milk prices, from €40/100 kg at the beginning of 2014 to a low of €25.7/100 kg by July 2016. The EU government responded in two ways. [1] First, by releasing a €500 million aid package consisting of both coupled subsidies and a supply control scheme.[2] Second, they tripled the annual ceiling of SMP Intervention purchases in 2016 from 109,000 mt at the beginning of the year to 350,000 mt by June 24, 2016.

EU Government Accumulates a Mountain of SMP

The EU government purchased 335,586 mt of SMP in 2016 under the Intervention program, equivalent to 22% of total EU SMP production that year. By the end of 2017 they had accumulated 378,051 mt in government inventory. Using data from Global Trade Atlas, the size of the global SMP market in 2017 was estimated to be 2,354,640 mt. Therefore, the EU was holding the equivalent of 16% of the global market in government storage. Thereafter, the EU Commission set the ceiling for SMP purchases to zero for 2018 and 2019 to avoid further accumulation.

Intervention Program and Exports

As global demand for SMP began to improve in 2018, the EU unleashed their stockpile of aging SMP onto the commercial market. During the 18-month period January 2018 to June 2019 the EU sold, via a tendering process, 379,453 mt of intervention product at a weighted average price of €1,337/mt. The EU government spent approximately €190 million in the process of purchasing, storing, and ultimately disposing of this inventory. The EU government implemented no restrictions to prevent the product from entering the global market. The SMP Intervention product entered export channels since the domestic market was not capable of handling this volume without an adverse impact on the domestic

[1] Marie-Laure Augère-Granier, "The EU Dairy Sector: Main Features, Challenges and Prospects," European Parliamentary Research Service, December 2018.
[2] Alan Matthews, "Milk Policy in the EU-A Rare Case of Policy Incoherence," April 25, 2016, www.capreform.eu .

price of SMP, and hence the farm-gate milk price. The conclusion from this report is that the EU Intervention Program as operated in 2016-19 adversely impacted the global market.

Method of Analysis

A global annual econometric model for skim milk powder was developed for this study. A baseline was developed for 2016-19 which includes the activities of the EU's Intervention program (purchase and disposition). The model was simulated to reflect a "no Intervention" scenario over the same time period. The "impact" or "results" of the **model scenario** evaluates the change from the baseline to the scenario results for each year (i.e. US farm-gate milk prices would have been higher under a "no Intervention" scenario). To assess and conclude the impact of the **Intervention policy** on the global market, this study starts with the counterfactual "no Intervention" model scenario results, then calculates the change to the baseline (i.e. Intervention caused EU exports to expand in 2018 and 2019 greater than they otherwise would have been without the program).

Model Results for the US

The EU Intervention Program had a significant global market impact. In addition, this study estimates that over 94% of the variation in the US farm-gate milk price is ultimately explained by butter and nonfat dry milk prices. Thus, as the price of nonfat dry milk changes, it drives the value of protein in the US, and this has a significant impact on farm-gate milk prices. This analysis shows that had there been **no Intervention Program**, the global price of SMP and the US farm value of milk would have initially been lower in 2016, but would have recovered and been much higher in 2018 and 2019 when compared to the baseline. The model results compared to the baseline are,

- US farm-gate milk price would have fallen $0.42/cwt in 2016, but would have exceeded the baseline by $0.27/cwt in 2018 and $0.73/cwt in 2019 under the "no Intervention" scenario.
- farm value of US milk would have initially declined 2.6% in 2016, but then would have increased by 1.7% by 2018 and 4.0% in 2019 under the "no Intervention" scenario.
- value of US exports of NFDM/SMP would have fallen 6.7% in 2016, but then would have increased by 4.7% in 2018 and 10.1% in 2019 under the "no Intervention" scenario.
- global price of SMP would have initially declined 5.4% in 2016, but then would have increased by 3.6% in 2018 and 8.7% in 2019 under the "no Intervention" scenario.

EU's Intervention Program for SMP

In summary, the US was economically harmed by the EU's Intervention program for SMP in two ways. First, the program depressed the global price of SMP below what it otherwise would have been in 2018 and 2019. This had an adverse impact on the US farm value of milk. Second, the program allowed the EU to garner a higher global export market share and resulted in the US and other SMP exporters realizing lower export market shares relative to what they otherwise would have been. The EU domestic SMP market prior to 2016 was estimated to be approximately 580 thousand mt per year. This study demonstrates that the disposal of low-quality Intervention SMP in 2018-19 was too large to be absorbed by the domestic market without adversely impacting the domestic market price. Also, based on the results of the global econometric SMP model developed for this study, the EU increased their global market share of SMP above what it otherwise would have achieved without the Intervention program in 2018 and 2019.

The global coronavirus pandemic is creating adverse marketing conditions that significantly increase the probability that both SMP and butter could enter the EU's Intervention program in 2020 and possibly 2021. A significant reduction in EU domestic demand for cheese and butter and reduced export opportunities will likely negatively impact EU farm-gate milk prices and internal EU butter and SMP prices. Instead of cutting back on the EU milk supply, excess product will enter the EU Intervention program creating an overhang on the global market for SMP and butter.

The EU Intervention program has adversely impacted the US dairy market by lowering the global price of SMP and the US farm gate milk price, and the US share of the global SMP export market. This study concludes that the EU Intervention program has adversely impacted global trade in SMP. Therefore, the EU must either alter the Intervention Program by consuming all surplus SMP internally or end the program.

Table 1. **Summary Impacts of the "No Intervention" Scenario**[a]

	Units	*Purchase Period:* 2016	2017	*Disposition Period:* 2018	2019
European Union:					
Milk deliveries	thou MT	-528	-115	425	1,015
	% chng	-0.3%	-0.1%	0.3%	0.6%
EU Farm milk price	€/100 kg	-0.4	-0.1	0.3	0.8
	% chng	-1.5%	-0.3%	1.0%	2.3%
Internal SMP price	€/100 kg	-8.4	-1.5	4.7	15.6
	% chng	-4.7%	-0.8%	3.1%	7.4%
SMP production	thou MT	-32	-7	26	63
	% chng	-2.1%	-0.4%	1.6%	3.9%
SMP exports	thou MT	71	11	-51	-120
	% chng	12.3%	1.4%	-6.2%	-12.4%
Value of exports	mil $	$72.4	$6.2	-$46.8	-$124.5
	% chng	6.3%	0.4%	-2.9%	-4.9%
United States:					
Milk production	thou mt	-34	-6	22	53
	% chng	0.0%	0.0%	0.0%	0.1%
Farm-gate milk price	$/cwt	-0.42	-0.08	0.27	0.73
	% chng	-2.6%	-0.4%	1.7%	3.9%
Value of producer milk	Mil $	-897	-172	599	1,618
	% chng	-2.6%	-0.5%	1.7%	4.0%
NFDM/SMP production	thou mt	-3	-1	2	6
	% chng	-0.3%	-0.1%	0.2%	0.5%
NFDM/SMP exports	thou mt	-8	3	7	10
	% chng	-1.3%	0.5%	1.0%	1.4%
Value of exports	mil $	-$79.3	-$6.2	$66.6	$187.0
	% chng	-6.7%	-0.5%	4.7%	10.1%
Global SMP price	$/mt	-$108	-$20	$73	$228
	% chng	-5.4%	-1.0%	3.6%	8.7%

[a] The "impact" is defined as the scenario results minus the baseline. In other words, it looks at the change from the "baseline," which reflects the activities of the EU Intervention program, to the "no Intervention" scenario.

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INTRODUCTION AND BACKGROUND

Objectives of the Report

The objective of this report is to analyze the economic impact of the EU's Intervention program for SMP on the US dairy industry over the period 2016-19. More specifically, analyze the impact of this policy on US farm-gate milk prices, the value of US farm milk, US export volume and value for SMP, and US export market share for SMP. It is hypothesized that the EU's Intervention Program contributed to an expansion in EU milk and SMP production. And the availability of subsidized EU intervention stocks entered global markets and depressed the market price of SMP in both 2018 and 2019. ***This hypothesis will be tested in this report by use of an econometric model.***

The WTO's Agreement on Agriculture required both the EU and US to reduce spending on domestic agricultural subsidies and to end the use of export subsidies (the Nairobi Agreement). Today, the EU and US are permitted to spend up to €72 bil and $19 bil, respectively, on non-exempt agricultural subsidies which are tallied in the annual "Aggregate Measurement of Support," or AMS, as detailed in the Agreement on Agriculture (AoA). Many commodity programs are reflected in that calculation, including price support programs. The US dairy price support program was discontinued in the 2014 Farm Bill, but the EU continues to use their legacy program called "Intervention".

A dynamic partial equilibrium model of the global SMP market was developed for this study. The model reflects what occurred in the global market (called the baseline) and simulates what would have occurred (the scenario) had there been no intervention program. The annual difference between the baseline and the scenario estimates the impact of the EU Intervention program on global prices and market shares. Thus, the model simulation quantifies the policy impact (the EU Intervention program).

EU Dairy Expansion and Market Correction

The EU historically set high internal milk prices and import duties, and capped milk production via production quotas as part of the Common Agriculture Policy (CAP). The EU began to notice in the early 2000's that global demand for dairy was growing steadily. So, in 2003 the process began to phase out production quotas by 2015. This was accomplished by raising the annual production quotas by 1% each year starting in April 2009 over 5 years in order to generate "a soft landing." On April 1, 2015 milk quotas were abolished.[3] But the EU price support program (called Public Intervention) which historically worked in concert with production quotas, was left in place.

EU farm-gate milk prices reached a historical high at the end of 2013 at over €40/100 kg ($US 25/cwt) due to rising world prices. Chinese imports of milk solids grew 19.4% per year during the period 2009-14. And New Zealand experienced a severe drought in their 2012/13 marketing year that negatively impacted milk production. But just as New Zealand milk production rebounded 9.5% in 2013/14 and as EU milk production grew 4.8% in 2014, both from the year before, global demand unexpectedly softened. The Russian embargo was implemented in 2014 and Chinese imports of milk solids fell 16.5% in 2015. As a result, average EU farm-gate milk prices fell to €30.6/100 kgs (US$15.41/cwt) in 2015 and further declined to €25.68 in July 2016. Internal EU skim milk powder (SMP) prices declined from

[3] Marie-Laure Augère-Granier, "The EU Dairy Sector: Main Features, Challenges and Prospects," European Parliament Research Service, December 2018.

€3,269/mt in Q1 2014 to €1,748/mt during the second half of 2015. Throughout the oscillations in milk prices, the EU continued to expand milk production (Figure 1).

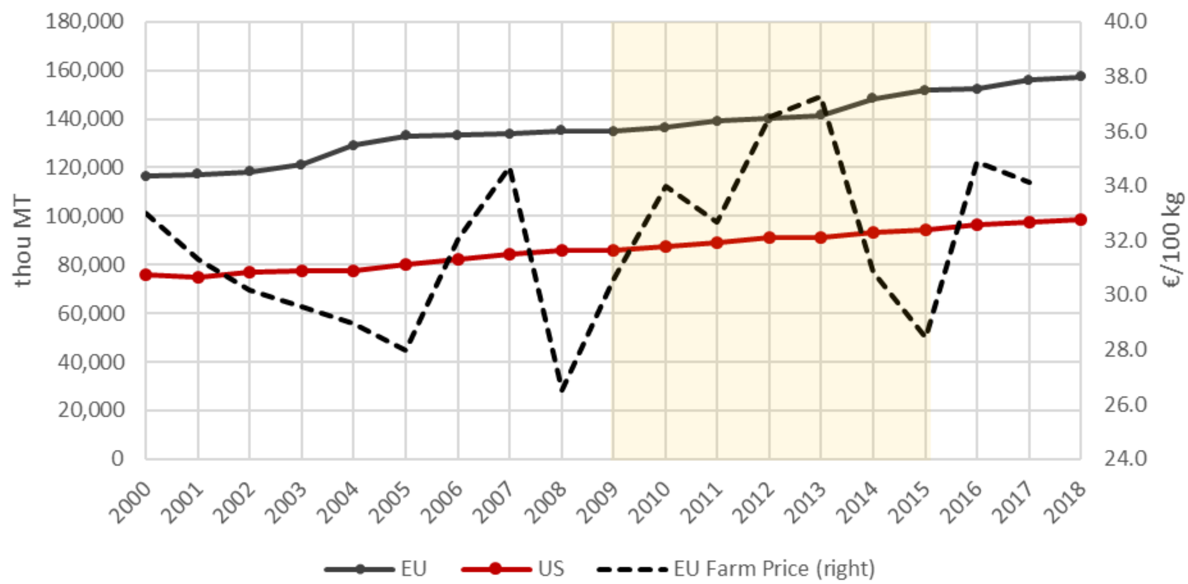


Figure 1. EU vs. US Milk Production and EU Farm-gate Milk Price

The EU responded to this milk crisis on July 18, 2016 with a €500 million aid package that consisted of three elements:

- An EU-wide voluntary milk reduction scheme of €150 million running from the last quarter of 2016 to January 2017.
- Conditional adjustment aid of €350 million for use at the member level.
- Other "technical adjustments" including a 3X expansion of the SMP Intervention program and advancements for direct payments and rural development payments.

The EU clearly expanded milk production beyond market demand. And just as global demand contracted, the EU responded to lower milk prices with more financial aid. That was to blunt the impact of market forces which would have curtailed internal EU milk production. Matthews noted that the EU's response to the crisis was to both reduce supply and to provide "coupled support" in the form of direct payments.[4] In their filing to the WTO's Committee on Agriculture for the 2016/17 marketing year, the EU reported "voluntary coupled support" payments to dairy of €876.6 million.[5] This spending was not included in the EU's estimate of their WTO-agreed spending cap (called Aggregate Measurement of Support, or AMS) because it was paid on a per head basis and considered production neutral (Blue Box spending). The EU also reported spending of €656.3 million consisting of "National Aid" (€207.3 million) and "Extraordinary Support Measures" (€448.9 million). This spending was "non-exempt direct payments" which by definition should have counted towards the EU's total spend on agricultural

[4] Alan Matthews, "Milk Policy in the EU-a Rare Case of Policy Incoherence," April 25, 2016, www.capreform.eu .
[5] WTO, Committee on Agriculture, "Notification," G/AG/N/EU/55, April 15, 2019.

programs. But, due to the *de minimis* provision in the WTO, it did not count towards the EU's total AMS calculation for that year.[6] Under WTO rules the EU could have spent up to €2.5 billion on direct payments that year for dairy before meeting the requirement to report toward their AMS cap of €72.378 billion. For 2016/17 the EU did report AMS spending of €2.99 billion on butter and €1.59 billion on SMP, assumed for the Intervention program, and €7 million for private storage aid for butter.

The EU has historically been a major dairy exporting region. The recent combination of quota elimination, direct and indirect farm support, and steadfast attention to negotiating, signing and implementing free trade agreements has enabled the EU to become a dairy export powerhouse. The trade figures in Table 2 indicate that with the exception of whole milk powder, the EU has seen significant expansion in their dairy sector over the last six years.

Hypothesis: EU Dairy Policy Adversely Affected Others

This report is focused solely on the economics of the EU Intervention program. Specifically, this study will analyze the impact of the EU SMP Intervention program on global markets, and in particular the United States market. That will include the "procurement phase" during 2016-17 when the EU amassed a large stockpile of approximately 378,000 mt of SMP, equivalent to roughly 16% of global annual trade in SMP. The EU Government in 2016 announced they were willing to purchase up to 350,000 mt of SMP inventory at a fixed price. ***This had the effect of creating government demand and raising prices above what it otherwise would have been.*** This study will also include the "disbursement phase" when that product was sold back to EU traders with no limitations on end use. ***Economically this would shift the EU's supply curve to the right, increasing supply, raising EU exports, and lowering world prices.*** It is hypothesized that a significant quantity of this product was exported during the disbursement phase in the form of SMP or fat-filled milk (SMP rehydrated and spray dried with vegetable oil), reducing the global price of SMP and expanding the EU's global market share for SMP. This study also reduced the export volume and value for SMP export competitors such as the United States. In particular, the EU's SMP Intervention program adversely impacted US nonfat dry milk (NFDM) and SMP export volume, value, and global export market share. Finally, since butter and NFDM/SMP prices ultimately drives the farm value of milk in the US, a decline in global SMP prices, and therefore US NFDM prices, adversely impacted the US farm-gate price of milk. This hypothesis will be tested in this study via use of an econometric model and policy simulations.

[6] The *de minimis* provision in the WTO reflects support which does not exceed 5% of the value of production. See Josling, Tangermann, and Warley, 1996, "Agriculture in the GATT," London: MacMillan Press Ltd., pg. 203.

Table 2. European Union External Exports of Dairy Products, 2012 - 19

Product	2012	2018	Six years	CAGR/year
	Metric Tons		% Change	
Milk and cream	486,775	961,690	97.6%	12.0%
Cheese	767,696	832,452	8.4%	1.4%
Skim milk powder	520,427	820,903	57.7%	7.9%
Whey products	543,738	693,834	27.6%	4.1%
Retail infant formula	324,399	587,567	81.1%	10.4%
Whole milk powder	379,248	328,077	-13.5%	-2.4%
Butter and other dairy fats	126,850	158,313	24.8%	3.8%

Source: Global Trade Atlas.

INTERVENTION PROGRAM

Background

The EU uses a number of programs to protect their dairy industry during periods of low milk prices. Two of the more prominent ones are Private Storage Aid (PSA) and Intervention. PSA supports part of the storage costs for butter and SMP while these products are temporarily removed from the market (typically 90-210 days). Public intervention has been the cornerstone of support for the EU's dairy industry since the formation of the Common Agricultural Policy (CAP). Public intervention involves purchasing surplus butter and SMP at fixed prices during a set period of time. Intervention buying occurs during March 1 - September 30 each year. The EU Commission has ongoing authority to buy up to 109,000 mt of SMP and 60,000 mt of butter at fixed prices of €1,698/mt for SMP and €2,217.5/mt for butter. If there is still an oversupply of product, the EU Commission can continue to buy product for intervention via a tendering process without a price guarantee. The product is stored at government expense in public warehouses, and later released back to the market when conditions improve.

The objective of the Intervention program is to directly support internal EU market prices for butter and SMP when market prices are declining below support prices. This indirectly supports farm-gate milk prices at roughly 27 euros/100 kgs. By putting a floor on the residual value of milk used to produce butter and SMP, it supports the entire price of milk.

Purchases in 2016-17

In 2016 the initial maximum ceiling of 109,000 mt of SMP was reached by March 31. The EU Commission then doubled the ceiling to 218,000 mt effective April 15, 2016. [7] In the meantime, the EU bought 27,038 mt of SMP on April 19, 2016 which did not count against the new ceiling. By May 2016 the new ceiling was maxed out. Thus, the EU Commission raised the ceiling a second time to 350,000 mt on June 24, 2016.[8] Before the second ceiling change was implemented, the EU Commission accumulated the following inventories via a tendering process: 36,361 mt on June 7 and 15,127 mt on June 21. In all, 78,526 mt was purchased via a tendering system and 257,060 mt was purchased under the fixed price system in 2016. The EU Commission reported 13,632 mt of Intervention stock was rejected in 2016. With carry-in stocks of 29,074 mt for 2016, EU Intervention stocks ended the year at 351,028 mt. An additional 27,203 mt of SMP was purchased under Intervention in late 2017 (net of published rejects/cancellations).

Given that the clear intent of the program was to support the farm price of milk, this study assumed that the 78,526 mt of product was purchased via the variable price tender at approximately €1,698/mt. Also, there was a process already underway to expand the ceiling on the fixed price system for SMP, thus tendering SMP intervention product below this price would make little sense.

In mid-October 2017 EU's Agriculture and Rural Development Commissioner Phil Hogan announced publicly that the EU was considering changes to the Intervention Program.[9] They were considering

[7] Official Journal of the European Union, Council Regulation (EU) 2016/591, April 15, 2016. Source: https://eur-lex.europa.eu .

[8] ____. , Council Regulation (EU) 2016/1042, June 24, 2019. Source: https://eur-lex.europa.eu .

[9] MCT Dairies, "Weight of EU SMP Felt Globally," MCT Compass, October 31, 2017. http://www.mctdairies.com/Compass/2017/MCT-Dairies-Compass-2017-10.pdf .

reducing the ceiling on SMP from 109,000 mt to zero and setting up a tender buying system to allow the EU to decide on volume and price. Clearly the EU wanted to avoid purchasing more Intervention stocks in 2018 and was focusing instead on how to dispose of their massive inventory. Almost immediately, the global price for SMP declined. The CME spot price of nonfat dry milk (NFDM) fell from an average $1,843/mt ($0.8359/lb) in September 2017 to a low of $1,442/mt ($0.654/lb) by the week ending December 23, 2017. Ultimately, the EU decided to forego automatic buying of SMP Intervention and set the ceiling to zero, thus avoiding more stock accumulation.[10] In October 2018 the EU Council announced again they would continue to forego the automatic buy-in of SMP under the Intervention Program for 2019.[11]

Disposition in 2018-19

The purpose of the EU Intervention Program is to acquire inventory when prices were low, and to eventually release them back to the market when prices are higher. But by early 2018 the average age of EU Intervention stocks exceeded 900 days, or close to 2.5 years. Thus, the EU Commission was no doubt confronted with the reality that in order to monetize this inventory, given its advancing age, it was time to consider releasing it into the marketplace. The fact that global prices for SMP were starting to strengthen helped aide that decision.

To release EU Intervention stocks to the market, the EU Commission created a tendering process whereby only licensed EU traders could bid for a specific available quantity. A tender must be a minimum of 30 mt, and traders must post a security deposit of €50/mt. The EU offered a specific quantity at each event and traders provided a tender bid. For example, on Jun 19, 2018 the EU Commission offered 39,836 mt of SMP Intervention stocks to EU traders. A total of 23,532 mt was accepted, however only 20,632 mt was finally cleared from Intervention. The difference was offers not concluded by operators. In terms of acceptance, the successful bid will be the tender at the highest price (see EU regulation No. 1308/2013).[12]

The EU Commission orchestrated 37 tenders between December 13, 2016 and June 18, 2019 as part of a plan to liquidate aging intervention product into the market. The first successful tender was for 40 mt on December 13, 2016 at a reported price of €215/100 kg. Only 220 mt was liquidated in 2016-17. Then in 2018 the EU got aggressive at liquidating inventory as the age of the product became an issue and market prices stated improving. Between January 2018 and June 2019 the EU liquidated 379,453 mt at an average discount to the prevailing market of $374/mt.[13] Figure 2 clearly illustrates that as the global price of SMP rose, the EU Commission liquidated more and more intervention stocks at discounted prices.

[10] USDA, Foreign Agricultural Service, "EU Rescinds SMP Intervention Provisions Preventing Further Build-up." GAIN Report No. E17091, December 27, 2017. Source: www.fas.usda.gov .

[11] The European Council, "Skimmed Milk Powder: Public Intervention by Tendering Continues in 2019," Press Release, October 15, 2018. Source: www.consilium.europa.eu .

[12] Official Journal of the European Union, "Commission Implementing Regulation (EU) 2016/1240," May 18, 2016. Source: https://eur-lex.europa.eu .

[13] Data reference: EU Commission, Milk Market Observatory, table: tenders for fixing the minimum selling price for SMP, pg. 4, last update September 19, 2019. https://ec.europa.eu .

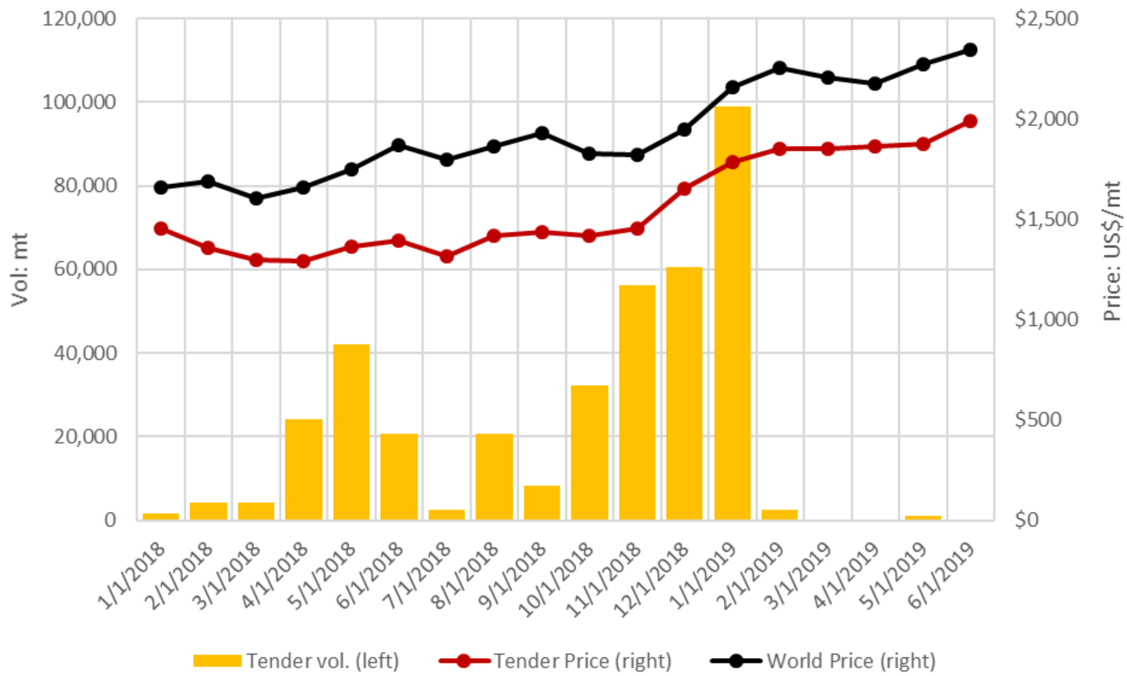


Figure 2. European Union Skim Milk Powder Intervention Tender vs. World Prices
Sources: EU Milk Market Observatory, USDA's Agricultural Marketing Service, and the St. Louis Federal Reserve.

Estimated Cost of the Program

The estimated cost of operating the EU Intervention Program for SMP during 2015-19 is provided in Table 3. The EU Commission spent an estimated €645 million acquiring SMP inventory during 2015-17 for both fixed and variable tenders. The acquisition cost for the variable tender was assumed to be at the maximum price of €1,698/mt since the objective of the program was income support. Next, the dispersion of SMP Intervention was carefully followed at each tender noting the recorded tender prices, the total accepted quantities, and the total sold quantities (net of rejects). Total revenue raised by the EU for these sales tenders through tender 37 on June 18, 2019 was estimated at €508 million. Figure 2 tracks the tender volumes and prices and compares them to the prevailing world price. The average spread or discount between the tender price and the prevailing world price over the period January 2018 – June 2019 was about $374/mt.

Storage costs for the program was estimated by calculating the age of the product sold (using first in, first out) and multiplying by a fixed storage cost of €1.10/mt per week.[14] Subtracting the cost of the program (acquiring inventory plus storage costs of roughly €54 million) from revenue (sales tenders) resulted in an estimated net loss of €191 million to the EU Commission, or roughly €503/mt of product handled under the program. AHDB Dairy estimated the cost at €220 million, close to the estimate from this report. **The point is, the EU Commission operated a dairy price support program that cost about €190 million.**

[14] This assumption was used in the analysis by AHDB, "No Profit for Commission on Intervention Scheme," January 30, 2019. https://dairy.ahdb.org.uk .

Table 3. Net Cost of Operating the European Union Intervention Scheme for SMP 2015-19

	2015	2016	2017	2018	2019	Total
Intervention Purchases:						
Fixed Price Tender:						
Vol. in mt	29,732	257,060	29,193			315,985
Price €/mt	1,698	1,698	1,698			1,698
Variable Tender						
Vol. in mt		78,526				78,526
Price €/mt		1,698				1,698
Intervention Net Purchases [a]						
Vol. in mt	29,074	321,994	28,605			379,673
Price €/mt	1,698	1,698	1,698			1,698
Value in mil €	(49)	(547)	(49)			**(645)**
Intervention Tenders: [b]						
Vol. in mt		40	180	276,883	102,570	379,673
Price €/mt		2,151	1,657	1,253	1,562	1,337
Value in mil €		0	0	347	160	**508**
Storage Costs in mil €						**(54)**
Net Gain/(Loss) in mil €						**(191)**
€/mt						**(503)**

[a] Source for purchases: Milk Market Observatory, EU Historical Intervention and Stocks, Intervention Stocks SMP, 2015-19, updated July 18, 2019, www.ec.europa.eu.

[b] Source for tenders: Milk Market Observatory, EU Internal Measures, Tenders For Fixing the Minimum Selling Price for SMP Under Regulation No (EU) 2016/2080 Historical Report, updated September 19, 2019, www.ec.europa.eu.

Note: Intervention net purchases are purchases net of rejects. All data as of December 2019.For 2017, net purchases were adjusted higher by 1,402 mt to account for the difference between published data for EU tenders and purchases.

The processors were able to sell SMP to the EU Commission at prices higher than the commercial market (prices would have been lower without the program). And EU traders were able to purchase product at an average discount of €503/mt relative to program cost, or at an average discount of $374/mt relative to the prevailing market price.

Trade Flows and Values

For the 12-month period September 2018-August 2019, Eurostat reported raw cow's milk delivered to dairies was up just 0.1% from the prior period to 157.8 million mt. Eurostat also reported SMP production up just 0.2% during the same 12-month period to 1,622 thousand mt relative to the prior period. In other words, no growth in milk or SMP production. And yet, data from Global Trade Atlas indicates that EU-28 exports of SMP beyond their borders over the period September 2018-August 2019 was up 29.4% relative to the prior 12-month period to 974,768 mt. So how could the EU expand SMP exports by 29% when production of SMP did not grow? The only reasonable answer is that the increase in exports was only made possible by using prior period inventory. In other words, SMP Intervention stock disposed of in 2018 and 2019 helped the EU expand SMP exports during this 12-month period.

A more detailed look at EU exports during the period September 2018 – August 2019 indicates where that growth in EU exports went. Table 4 presents trade flows and landed CIF values for SMP exports as reported by Global Trade Atlas for key markets for the EU and US.

EU exports were ranked by partner based on two factors: volume and historical importance to the US. The EU realized a significant expansion of SMP exports to China over the period September 2018-August 2019, up 76% from the prior period to 126,383 mt. But that was largely due to a surge in demand from China and retaliatory tariffs against US imports. Mexico made the list, but was still a relatively small market for the EU at 31,390 mt. The US has a distinct geographical and zero duty tariff advantage in that market. The rest of the countries, representing SE Asia and Pakistan, realized significant expansions during this 12-month period at CIF values below that in the US. The Philippines, for example, had a 126% expansion in EU exports relative to the prior period at a CIF value of $1,932/mt, whereas the US lost 13% in exports and had a higher CIF value of $2,102/mt. Since both the EU and US face the same global market, how did the EU expand market share in traditional US markets and undercut the US on price? The most logical conclusion is the EU's Intervention program that provided EU traders with discounted SMP that allowed them to undercut the US and expand exports.

The data on EU production and exports suggests causality, that the subsidy implicit in the EU SMP Intervention program allowed the EU to undercut competitors and expand market share. To prove this, a more rigorous quantitative approach was developed—a partial equilibrium model.

Table 4. Comparison of Skim Milk Powder Export Volume and Value by Key Trade Partners for the European Union and United States.

Trade Partner	EU Exports			US Exports		
	Sep - Aug 2018/19			Sep - Aug 2018/19		
	Volume MT	% Change Year Ago	CIF Value $/MT	Volume MT	% Change Year Ago	CIF Value $/MT
China	126,383	76%	2,472	5,361	-81%	2,612
Indonesia	83,782	85%	2,065	50,713	0%	2,200
Philippines	68,068	126%	1,932	70,402	-13%	2,102
Malaysia	53,325	96%	1,965	22,898	-26%	2,084
Vietnam	34,118	36%	2,018	40,524	3%	2,155
Mexico	31,390	406%	2,328	336,202	4%	2,203
Pakistan	20,411	34%	2,078	8,231	-68%	2,286
Thailand	31,586	70%	2,128	5,815	60%	2,088
Total	**974,768**	**29%**	**2,160**	**641,216**	**-10%**	**2,190**

Source: Global Trade Atlas.

CONCEPTUALIZATION AND SIMULATION MODEL

The foundation for the economics of the EU's Intervention program is provided, and the global SMP econometric model that was developed for this analysis. The model focuses on the global protein market and solves for global SMP prices. Market prices for cheese, butter, whey and other dairy commodities are exogenous. Adynamic analysis was employed since the impact of the Intervention program has two phases: purchases and disposition. The bulk of the EU SMP purchases occurred in 2016 and the bulk of the disposition occurred in 2018 and 2019.

Theoretical Model

The EU's SMP Intervention program operates as a price support program. The objective of the program is to support the internal EU SMP and butter prices at or above a fixed level. This indirectly supports the farm-gate price of milk. The EU Intervention program for SMP is illustrated for the domestic EU market in Figure 3. S_{EU} and D_{EU} in the EU Market are EU domestic supply and demand curves, respectively. Without an EU price support program, the internal equilibrium price would be P_W. To support the internal price, the EU Government purchases a sufficient volume of SMP from the EU market in order to support the internal EU price of SMP to P_I. Not surprisingly, since the EU is a major global producer and exporter of SMP, the EU effectively supports the global price of SMP at P_I. This is illustrated for the World Market in Figure 3 where the EU is represented as an excess supply function ES_{EU}, which is defined as Supply – Demand at price P facing the global market. The excess demand for importers (net of other exporters) is represented as ED_{ROW}. The intersection of ES_{EU} and ED_{ROW} determines the world price, which in this case is P_W. However, with an Intervention program, the excess supply function for the EU becomes horizonal at the intervention price P_I. EU exports of fresh SMP declines from Q_W to Q_I as importers face higher prices. The volume of EU intervention stocks that are removed from the global market is represented by $Q_a - Q_I$.

Next, the economics of the disposition of EU Intervention stocks was conceptualized. This is illustrated in Figure 4. It starts by illustrating a shift in global demand for SMP from ED_{ROW} to ED'_{ROW}. This illustrates what occurred in 2018 and 2019 when global demand strengthened for SMP. That shift alone would have raised the global price of SMP from P_I to P'_W. The volume of intervention stocks accumulated from an earlier period is now disposed of in the current period. This is illustrated by shifting the EU supply curve from S_{EU} to S^*_{EU} by the volume of intervention stocks disposed of in the commercial market. This also shifts the EU excess supply function facing the global market to ES^*_{EU}. The global equilibrium price now declines from P'_W to P^*_W. Also, global trade increases from Q'_T to Q^*_T as the EU exports intervention stocks. For importers this is a good deal as they now face a lower world price P^*_W and imports rise from $Q_a$to Q_b. But it's not such a good deal for other major exporters such as the United States and New Zealand. Their export revenues, the world market price they face, export volumes and market share all decline. This is illustrated with a decline in export volume from Q_c to Q_d.

In summary, the EU's SMP Intervention program is hypothesized to support the internal EU SMP and farm milk price during the purchase or accumulation period, but depresses market prices in the disposition period (relative to what it otherwise would have been). In addition, the EU's Intervention program is hypothesized to adversely impact other exporters such as the United States and New Zealand. **The objective of this report is to build a dynamic global SMP model and test this hypothesis.**

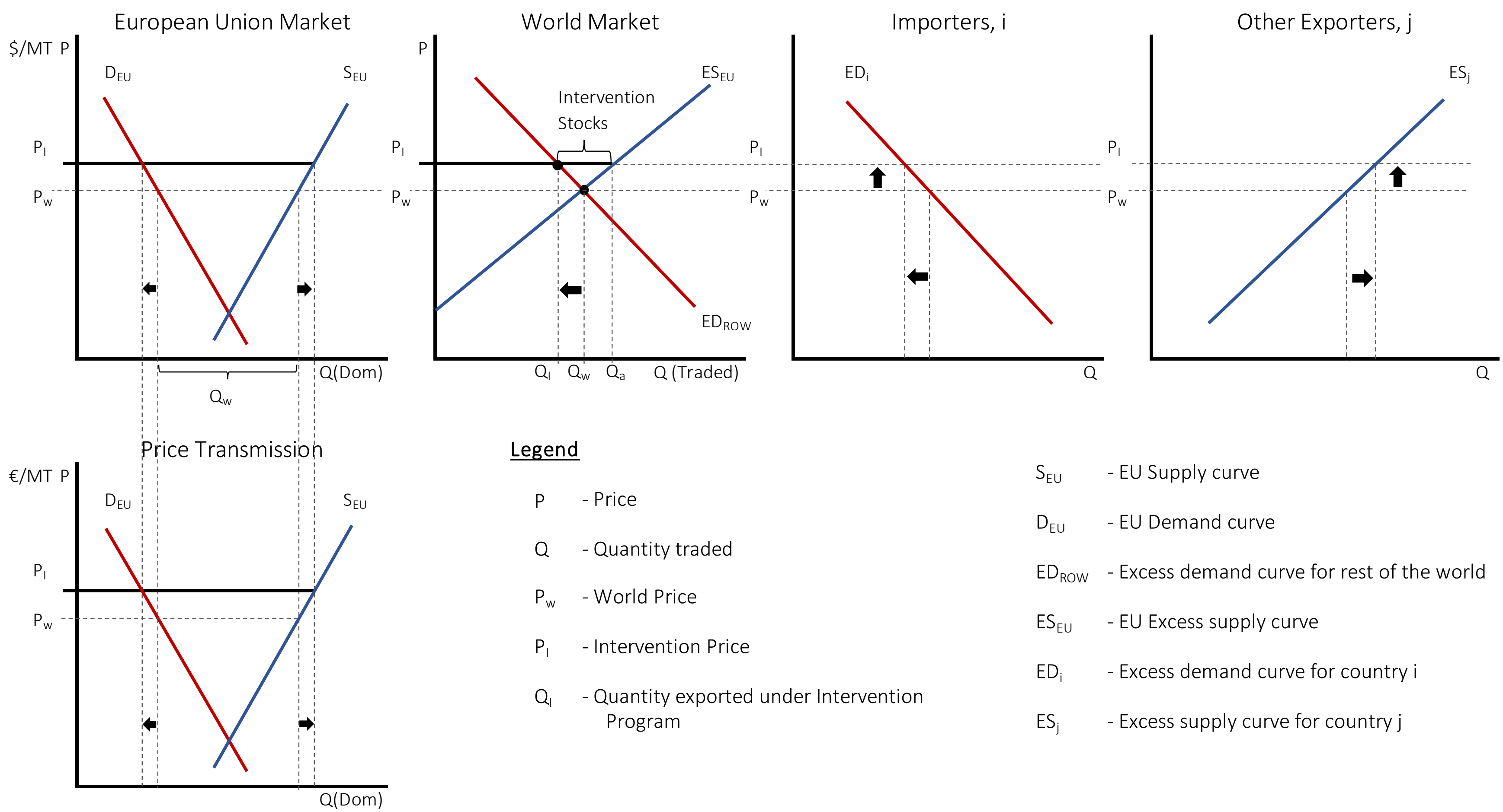
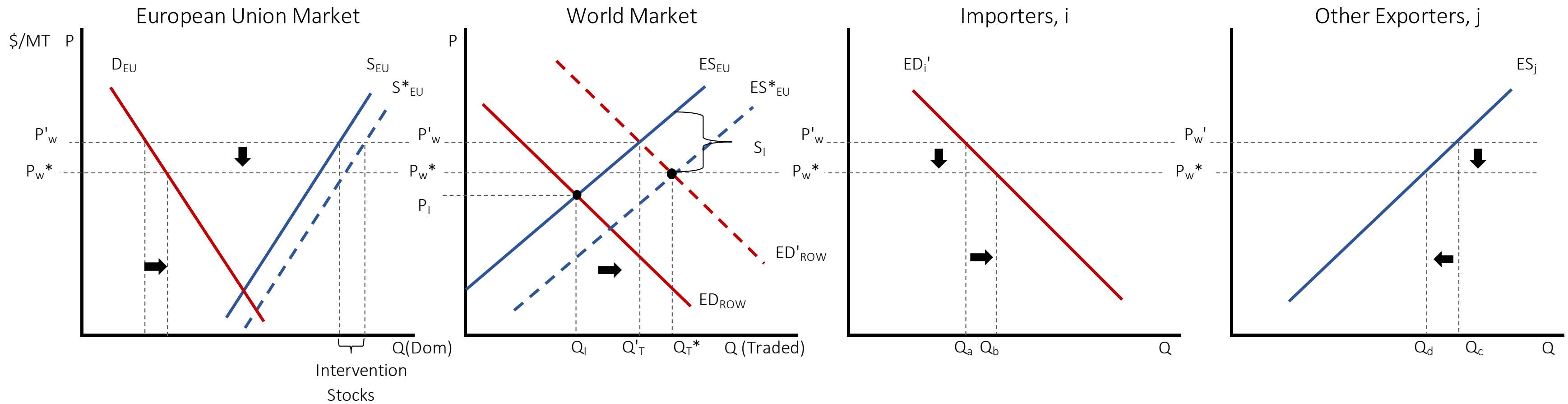


Figure 3. Impact of European Union Purchases of SMP Intervention Stocks on the Global Market for SMP.



<u>Legend</u>

P	- Price	S_{EU}	- EU Supply curve
Q	- Quantity traded	D_{EU}	- EU Demand curve
P_w	- World Price	ED_{ROW}	- Excess demand curve for rest of the world
P_I	- Intervention Price	ES_{EU}	- EU Excess supply curve
Q_I	- Quantity exported under Intervention Program	ED_i	- Excess demand curve for country i
S_I	- Subsidy of Intervention Program	ES_j	- Excess supply curve for country j

Figure 4. Impact of European Union Disposition of SMP Intervention Stocks on the Global Market for SMP.

Specification of the Global Econometric Model

For this study a dynamic annual non-spatial partial equilibrium model of the global SMP market was estimated. The supply, demand, and price of SMP, as well as milk and dairy product production, was endogenized (estimated and solved for) in this model for major importers and exporters. Since the focus of this study was the global protein market, market prices for cheese, butter and whey were held constant (exogenous). It is termed "non-spatial" since it reflects exports from and imports to a country, but not trade between countries. Using the conceptual model outlined earlier, this study specified and estimated excess supply functions for major exporters, and excess demand functions for major importers. Each country uses domestic prices in their specification when available. Price linkage or transmission equations are then estimated to ensure that one global price for SMP solves the world market in a given year.

The mathematical model and estimated econometric model are provided in the Appendix. Excess supply for global exporters is defined as follows:

ES = PRD + IMP – DUSE - ΔSTKS = EXP

where ES = excess supply, PRD = production, IMP = imports, DUSE = domestic use, ΔSTKS = change in ending stocks, and EXP = exports.

Excess demand for global importers is defined as follows:

ED = EXP + DUSE – PRD + ΔSTKS = IMP

where ED = excess demand.

These equations form the identities for excess supply and demand. They also incorporate the estimated equations for production, domestic use, stocks, etc.

For the world price of SMP the USDA's Oceania price was used which is highly correlated with the US and EU prices for NFDM/SMP.[15] Both the EU and US NFDM/SMP prices were connected to the Oceania price via price transmission equations. SMP trade data from IHS's Global Trade Atlas was used in this study. Country level income and inflation was sourced from the International Monetary Fund's World Economic Outlook database. Nominal per capita GDP denominated in US dollars was used, as well as inflation indexes. The World Bank's Population Estimates and Projections was used for annual country-level population data. The USDA Economic Research Service's annual nominal exchange rate database was used for exchange rates. In terms of other data, it was taken from country level sources for milk production, farm-gate milk prices, dairy product production, and internal prices.

Global Trade Balance

As stated earlier, global trade data from Global Trade Atlas was used. Generally speaking, Global Trade Atlas does not account for trade from every country in the world, accounting for roughly 98% of global trade. But for this study, available country data was used when available. Exports and imports were sourced by country/region for SMP for 2000-19. For example, total SMP exports for 2018 were 2,531,211 mt. The top countries/regions that accounted for 85% of SMP exports were then identified

[15] Using monthly data 2010-19, USDA's Oceania price for SMP had a correlation coefficient of 0.969 with the W. European SMP price and a correlation coefficient of 0.935 with the USDA monthly federal order NFDM price.

and specified as exporters for this study (US, EU-28, New Zealand, Australia, and Belarus). For total imports of SMP, Global Trade Atlas accounted for 1,699,381 mt of SMP in 2018, far less than total exports. The top 12 importing countries in 2018 accounted for 84% of total imports (Mexico, China, five members of SE Asia, Algeria, Egypt, Russia, Japan and Pakistan). The difference between total exports and total imports was assumed to be due to non-reported countries that were likely to be SMP importers. Thus, total exports of SMP from Global Trade Atlas was assumed to represent the volume of global trade (for both exports and imports). It was also taken into consideration that the major exporters also had some imports, and the major importers had some exports. That is the nature of global trade.

For global SMP exports, the difference between total global exports and exports from the top five exporting countries/regions plus "exports from major importers" was defined as ROW exports. For global SMP imports, the difference between total global trade (defined earlier as global exports) and imports from the top 12 importing countries plus "imports from major exporters" was defined as ROW imports.

The final calculations were to determine a dataset for excess supply, excess demand, and net ROW demand. Excess supply was calculated as exports for major exporters less their imports. Excess demand was calculated as imports for major importers less their exports. The net ROW demand was finally specified by subtracting ROW exports from ROW imports. That completes the global supply and demand balance. Table 5 provides a summary of how the data was computed for 2012-19.

Table 5. Global Trade Balance for Skim Milk Powder, Thousand MT

		--------Exports--------			--------Imports--------					
Year	Global Trade	Major Exporters	Major Importers	ROW	Major Importers	Major Exporters	ROW	Excess Supply	Excess Demand	ROW Demand
2012	1,793	1,598	31	164	1,135	13	646	1,585	1,104	481
2013	1,860	1,569	46	246	1,271	16	574	1,553	1,225	328
2014	2,105	1,832	64	209	1,363	18	724	1,813	1,299	514
2015	2,199	1,986	60	153	1,429	21	749	1,965	1,369	596
2016	2,164	1,891	56	216	1,474	14	675	1,877	1,418	459
2017	2,355	2,053	64	237	1,563	14	777	2,039	1,499	540
2018	2,531	2,163	131	238	1,559	21	952	2,142	1,428	714
2019	2,573	2,287	94	192	1,570	25	978	2,261	1,475	786

Source: Global Trade Atlas.

EU SMP Supply and Demand

The EU does not publish a SMP supply and demand table as is done by the USDA's Economic Research Service for NFDM/SMP. That is unfortunate as the supply and use is complex in the EU. This is a necessary tabulation for this study, so it was approximated in Table 6. One should start with what is know: SMP production, imports and exports to and from the EU (excluding intra-EU trade between members), and ending stocks for public intervention and private storage. What is not reported by the EU are skim solids exported as fat-filled milk (discussed below), commercial inventory, and domestic consumption.

Table 6. European Union Supply and Demand for Skim Milk Powder, Thousand MT

	2015	2016	2017	2018	2019
Production	1,619	1,546	1,617	1,600	1,608
YOY% change	15.1%	-4.5%	4.6%	-1.1%	0.5%
Beginning Government Stocks	16	62	417	380	175
Imports (external trade)	3	4	2	3	6
Exports (external trade)	1,020	887	1,156	1,227	1,390
SMP[a]	695	579	780	816	962
Fat-filled Milk Estimate[b]	325	308	376	411	428
Government Ending Stocks:	62	417	380	175	0
Public Intervention	29	351	378	175	0
Private Storage	33	66	2	0	0
Domestic consumption plus change in commercial stocks (estimate)	556	308	501	581	398

[a] HS Code 040210.

[b] SMP equivalent of HS 1901.90.99 sorted by CIF value in relation to global SMP prices.

Source: Global Trade Atlas.

Exports are defined here as the sum of SMP exports and the SMP equivalent of fat-filled milk. The methodology for approximating fat-filled milk exports is discussed below. Ending stocks were broken out into three categories: public intervention, private storage, and commercial traders. The EU publishes data for Public Intervention and Private Storage. Inventory held by commercial traders was approximated. The reason is twofold. First, it is unreasonable to expect the large volume of SMP Intervention disposition to be immediately purchased and sold commercially by EU trading companies. This product must first be "repurposed."[16] Thus effectively inventory held by commercial traders was separated from government inventory and implied domestic consumption. The calculation for "implied consumption" was deemed to be reasonable. For the period 2012-15, when there was very little activity for public intervention, EU per capita consumption of SMP averaged 2.5 pounds. That compares to US estimates of 3.3 pounds per capita of NFDM. The US consumes more dried skim milk than the EU since more is used for mozzarella production. For the period 2017-18 the estimates from this report of EU implied consumption of SMP was 2.1 pounds. Thus, the approximation of commercial inventory and derived implied consumption appear reasonable.

The purchase, disposition, and stocks for the EU SMP Intervention program are reflected in Table 7. Ending intervention stocks grew from 29,075 mt in 2015 to 378,051 mt at the end of 2017. Disposition of SMP Intervention stocks ramped up in 2018 and 2019. Ending stocks were zero at the end of 2019.

[16] The assumption used in this report is that SMP Intervention stock that was 2-3 years old when disposed of was either liquified and reprocessed into fat-filled milk, sold for casein or other dairy/food processing, or repackaged and re-certified for export sale. According to Article 16 of Common Market Organization Regulation No. 1308/2013, the EU is eventually required to publish details on the purchases and disposition of intervention stock.

Table 7. Intervention Stocks for Skim Milk Powder, MT

	2015	2016	2017	2018	2019
Beginning stocks	0	29,074	351,028	378,051	175,428
Purchases	29,732	335,586	29,193	0	0
Disposition	658	13,632	2,170	202,624	175,428
Ending Stocks	29,074	351,028	378,051	175,428	0

Source: EU Commission.

For the "no Intervention" scenario, both purchases and disposition was set to zero and the global SMP model was resolved. If there were no purchases of public intervention stocks in 2016 and 2017, it's clear from the supply and demand schedule in Table 6 that EU exports of SMP would have been much higher than actual exports. Thus, one would expect lower global SMP prices in this period under a "no Intervention" scenario since EU excess supply of SMP would have been greater. Likewise, if there were no disposition of EU Intervention stocks in 2018 and 2019, EU exports of SMP would have been much lower. Thus, one would expect higher global SMP prices in this period under this scenario.

Fat-Filled Milk

Since the elimination of quotas and expansion of milk production, the EU has developed a new export market for "fat-filled milk powder," or FFMP for short. It's difficult to track the trade data because FFMP is classified as an industrial export or "food preparation" under HS 1901.90.99 and is lumped in with other products, including flour, groats, meal, starch or malt extract, etc. FFMP is basically a cheaper alternative to whole milk powder.[17] It substitutes butterfat with vegetable oil, namely palm oil or soy oil. Most of this product is exported by the EU to West Africa and Asia. FFMP mimics the functionality of whole milk powder, has a longer shelf life, and contains roughly 26% vegetable fat and 70% nonfat dairy solids. The expansion in EU exports of FFMP has not been without controversy. It has been linked to domestic subsidies and the lifting of production quotas.[18,19]

To approximate the volume of EU exports of skim solids used in FMMP, EU export data for HS 1901.90.99 was sorted by unit export value (CIF price) for each trade partner for the period 2008-19. This data was then compared to the EU export price of SMP. FFMP is priced in relation to the prevailing global price of SMP. To approximate the range of pricing, the data was sorted for unit export values that were within a premium of $500 and a discount of $500 per mt relative to the annual average EU export SMP price. For example, the prevailing EU export price of SMP in 2017 was $2,335/mt. Total EU exports of food preparations under HS 1901.90.99 was 743,831 mt. All of the data was sorted by export value ($/mt) by trading partner that fell into a range of $2,835-$1,835/mt. That data sort derived an export volume of 515,842 mt which was conservatively estimated to be FFMP exports from the EU. Since FFMP is 70% skim solids, and since SMP contains roughly 96% skim solids, an SMP equivalent of the FFMP

[17] AHDB Dairy, "The Rise of Fat-Filled Milk Powders." October 19, 2018. www.dairy.ahdb.org.uk .
[18] Simon Marks and Emmet Livingstone, "Brussels to Africa: Don't Cry Over Our Spilt Milk," Politico, April 23, 2019.
[19] EPA Monitoring, "Strong Expansion of EU Fat Filled Milk Powder Exports to West African Markets Resumes," April 19, 2018. www.epamonitoring.net .

exports of 376,135 mt was derived. Starting in January 2020 the EU has begun to track exports of fat-filled SMP using HS code 1901.90.95.

Counterfactual Scenario and Policy Impacts

Economists analyze the impact of specific policies by employing structural econometric models and economic theory. In this study the impacts of the EU's SMP Intervention program were isolated by first estimating a global dynamic partial equilibrium model (see the Appendix for the model). That model was calibrated (equation intercepts adjusted) to a "baseline" over the period 2016-19. The baseline included the actual details of the operations of the EU's Intervention program, both purchases and dispositions. Once the model and baseline were in place, a "no Intervention" scenario was simulated for the period 2015-19. This scenario was constructed by eliminating both the purchases and disposition of Intervention stocks. It also assumed there was no buildup in the commercial inventory of EU traders in 2018 which was sold in 2019. It's as if the policy no longer existed. This increased the excess supply (exports) of SMP from the EU for 2016 and 2017, and reduced the availability of SMP exports for 2018 and 2019. The model was then solved iteratively for a new equilibrium price in each period until global excess supply was equal to global excess demand. **Once a dynamic equilibrium was reached for 2015-19, the results of the "no Intervention" scenario could then be compared to the baseline for each year. These results effectively isolate the impact of the EU's Intervention program on global SMP.**

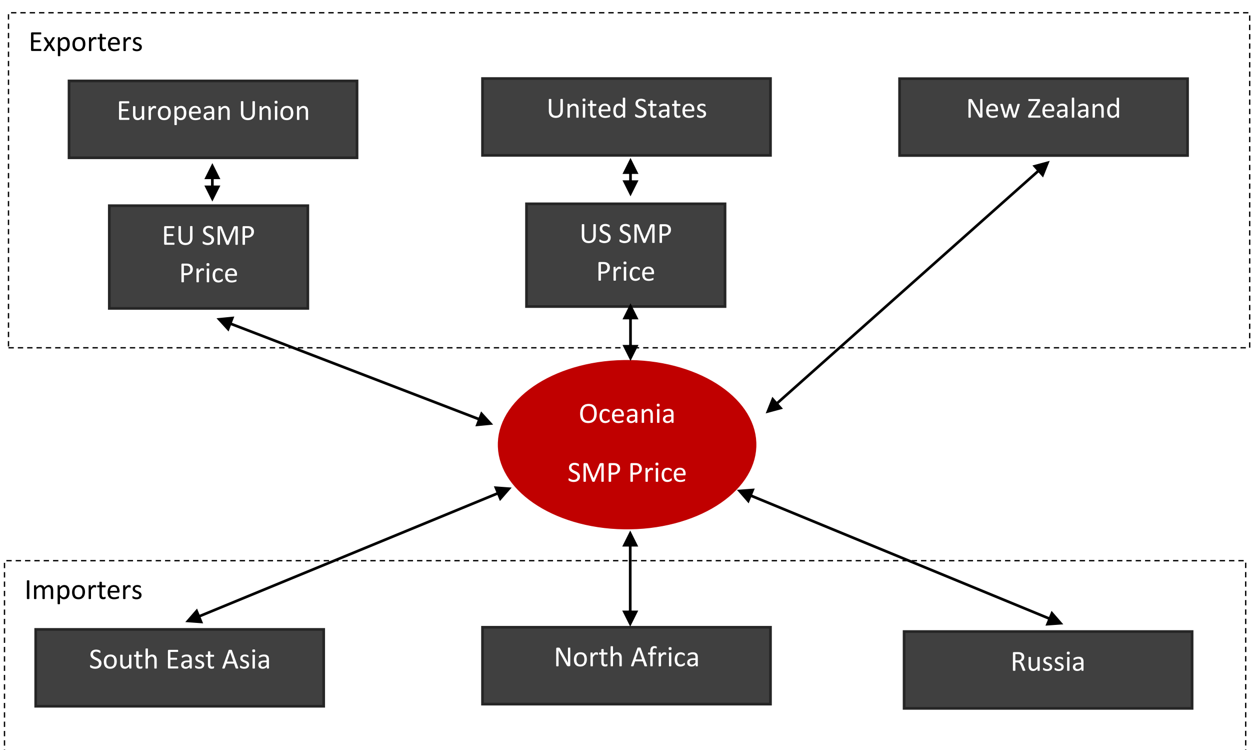


Figure 5. Schematic of the Global Skim Milk Powder Model

MODEL SIMULATION RESULTS

In the results below, the "no Intervention" scenario will be discussed in terms of its **change relative to the baseline.** This illustrates **what would have happened** had there been no EU Intervention program. For example, EU SMP exports "increased" in 2016 under the "no Intervention" scenario. This represents the counterfactual scenario results. To reach a conclusion regarding the impact of the EU Intervention program, the change from the "no Intervention" scenario to the baseline is calculated. So, the impact of the EU Intervention program was to "decrease" EU exports of SMP in 2016 by 71 thousand mt. The counterfactual scenario results are used to quantify what happened under the baseline as a direct result of the EU Intervention Program.

European Union

The results from the "no Intervention" scenario for the EU is provided in Table 8. In 2016, the internal EU SMP price declined €8.4/100 kg relative to the baseline under the "no Intervention" scenario. SMP that entered the Intervention program would have instead been exported under this scenario. Exports rose 71 thousand mt under the "no Intervention" scenario and this lowered the world price of SMP by $108/mt in 2016. The farm-gate price of milk in the EU, which was €28.4/100 kg under the baseline, fell to €28/100 kg under the "no Intervention" scenario. A lower farm price in 2016 under this scenario reduced EU milk deliveries by 0.3% relative to the baseline. That is not a big decline. EU dairy farmers received other forms of financial support from the EU government which was outlined earlier. A decline in internal and global prices for SMP, coupled with a decline in milk production, would have also resulted in fewer skim solids. Thus, SMP production in 2016 under the "no Intervention" scenario declined 2.1% relative to the baseline. As stated earlier, SMP exports in 2016 increased by 71 thousand mt in 2016 relative to the baseline. The reason is SMP which entered the Intervention program in 2016 under the baseline would have instead been directed to the export market under a "no Intervention" scenario. Finally, an additional 184 thousand mt of SMP would have been consumed internally due to the 4.7% decline in internal SMP prices, and greater availability of product.[20]

Beginning government stocks of EU SMP in 2017 would have been just 66 thousand mt under the "no Intervention" scenario, consisting solely of private storage aid. Without a huge government store of inventory overhanging the market, the EU SMP market would have recovered in 2017-19. The internal SMP price under the "no Intervention" scenario decreased slightly relative to the baseline. EU milk production changed very little, and SMP production decreased 0.4% in 2017 but increased 1.6% in 2018 due to greater availability of surplus skim solids. EU exports of SMP increased 1.4% in 2017 and decreased 6.2% in 2018 under the "no Intervention" scenario relative to the baseline. That's because the EU government would not have had large stores of Intervention stock to unleash onto the world market under this scenario in 2018. And SMP "other uses" declined 8 thousand MT in 2018 under the "no Intervention" scenario due to a higher internal SMP price under this scenario, resulting in lower domestic use.

The largest impacts of a "no Intervention" scenario occurred in 2019. The internal SMP price rose 7.4% to €225/100 kg and the farm-gate milk price rose 2.3% to €35.2/100 kg. That drove EU milk deliveries up

[20] Baseline data indicates that "other uses" of SMP fell a dramatic 39.2% in 2016 from the year before when the Intervention program purchased 335,586 mt of SMP.

Table 8. Impact of a "No Intervention" Scenario on the EU Milk and Skim Milk Powder Market

	Units	2015	*Purchase Period:* 2016	2017	*Disposition Period:* 2018	2019
Milk deliveries:						
baseline	thou MT	151,872	152,235	156,015	157,382	158,223
scenario	thou MT	151,765	151,706	155,899	157,808	159,238
change	thou MT	-107	-528	-115	425	1,015
% change	%	-0.1%	-0.3%	-0.1%	0.3%	0.6%
Farm-gate milk price						
baseline	€/100 kg	30.8	28.4	34.9	34.1	34.4
scenario	€/100 kg	30.7	28.0	34.8	34.4	35.2
change	€/100 kg	-0.1	-0.4	-0.1	0.3	0.8
% change	%	-0.3%	-1.5%	-0.3%	1.0%	2.3%
Internal SMP price						
baseline	€/100 kg	185.6	178.5	178.0	149.1	209.6
scenario	€/100 kg	184.0	170.1	176.6	153.7	225.2
change	€/100 kg	-1.6	-8.4	-1.5	4.7	15.6
% change	%	-0.9%	-4.7%	-0.8%	3.1%	7.4%
SMP production						
baseline	thou mt	1,619	1,546	1,617	1,600	1,608
scenario	thou mt	1,613	1,514	1,610	1,626	1,671
change	thou mt	-6	-32	-7	26	63
% change	%	-0.4%	-2.1%	-0.4%	1.6%	3.9%
SMP implied consumption						
baseline	thou mt	506	308	501	491	488
scenario	thou mt	509	491	503	483	469
change	thou mt	3	184	2	-8	-19
% change	%	0.5%	59.6%	0.5%	-1.7%	-4.0%
SMP ending stocks						
baseline	thou mt	112	467	430	315	50
scenario	thou mt	83	116	52	50	50
change	thou mt	-29	-351	-378	-265	0
% change	%	-26.0%	-75.2%	-87.9%	-84.1%	0.0%
SMP exports						
baseline	thou mt	695	579	780	816	962
scenario	thou mt	708	650	790	765	842
change	thou mt	14	71	11	-51	-120
% change	%	2.0%	12.3%	1.4%	-6.2%	-12.4%

[a]Domestic use plus change in commercial stocks.

in 2019 by 0.6%, resulting in a greater supply of skim solids. As a result, SMP production rose 63,000 mt or 3.9% under the "no Intervention" scenario relative to the baseline. But that increase in fresh powder production was largely offset by the loss of EU Intervention dispositions under this scenario. Thus, SMP exports declined by 120,000 mt relative to the baseline, or 12.4%. That significant decline in EU SMP exports relative to the baseline had a significant positive impact on the global price of SMP which rose by $228/mt or 8.7%.

United States

The results from the "no Intervention" scenario on the US is provided in Table 9. For the US, the Federal Order NFDM price fell four cents/lb or 5.0% under the "no Intervention" scenario (relative to the baseline), and the US farm-gate milk price fell $0.42/cwt or 2.6% in 2016. The US value of producer milk declined $897 million under the "no Intervention" scenario relative to the baseline. There were minimal impacts on milk production and NFDM/SMP production and consumption. US exports of NFDM/SMP declined in 2016 by 8,000 mt under the "no Intervention" scenario relative to the baseline. There were little changes in 2017 under the "no Intervention" scenario relative to the baseline. The Federal Order NFDM price fell just one cent/lb, the farm-gate milk price declined eight cents/cwt, and the value of producer milk fell just 172 million. US exports were basically unchanged under this scenario.

The results of this scenario were much greater in 2018 and 2019. The Federal Order NFDM price rose three cents and eight cents/lb in 2018 and 2019, respectively, under this scenario relative to the baseline. The impact on the farm-gate milk price was significant; prices rose 27 cents/cwt in 2018 and 73 cents/cwt in 2019 under this "no Intervention" scenario relative to the baseline. The EU had less product to export and global prices rose. While the higher prices had little impact on milk production, SMP production rose marginally by two thousand mt in 2018 and six thousand mt in 2019. Some of this increase was offset by reduced domestic consumption due to higher internal nonfat dry milk prices. Exports rose under the "no Intervention" scenario by 1.0% in 2018 and 1.4% in 2019 relative to the baseline due in some part by lower stock levels.

So why would a change in NFDM prices have such a large impact on the US farm-gate milk price? That's because butter and NFDM prices sets the floor for the farm value of milk in the US. The statistical model indicates that 94.3% of the variability in the annual farm-gate milk price is explained by butter and NFDM prices. As NFDM prices rise, the value of protein in cheese, fresh dairy products, and fluid milk all rise.

The biggest impact of the "no Intervention" scenario for the US was on the farm-value of milk. Had the EU not implemented the Intervention program during 2016-19, the US farm value of milk would have been $600 million higher in 2018 and $1.6 billion higher in 2019. US dairy farmers lost earnings, equity, and in some cases possibly went out of business because of this EU policy. The most dramatic results were in 2019 when global demand increased and EU commercial traders aggressively exported Intervention stocks. In 2019 a "no Intervention" scenario would have resulted in a $0.73/cwt increase in the farm-gate milk price. **Stated another way, the EU Intervention program depressed US farm-gate milk prices by $0.73/cwt in 2019.**

Table 9. Impact of a "No Intervention" Scenario on the United States Milk and Nonfat Dry Milk Market

	Units	2015	*Purchase Period:* 2016	2017	*Disposition Period:* 2018	2019
Milk production						
baseline	thou mt	94,579	96,367	97,762	98,691	99,030
scenario	thou mt	94,572	96,333	97,756	98,714	99,083
change	thou mt	-6	-34	-6	22	53
% change	%	0.0%	0.0%	0.0%	0.0%	0.1%
Farm-gate milk price						
baseline	$/cwt	17.10	16.30	17.70	16.30	18.60
scenario	$/cwt	17.02	15.88	17.62	16.57	19.33
change	$/cwt	-0.08	-0.42	-0.08	0.27	0.73
% change	%	-0.5%	-2.6%	-0.4%	1.7%	3.9%
Fed Order NFDM price						
baseline	$/lb	0.90	0.83	0.87	0.79	1.04
scenario	$/lb	0.89	0.79	0.86	0.82	1.13
change	$/lb	-0.01	-0.04	-0.01	0.03	0.08
% change	%	-1.0%	-5.0%	-0.9%	3.4%	8.0%
Value of producer milk						
baseline	Mil $	35,655	34,630	38,148	35,465	40,608
scenario	Mil $	35,482	33,733	37,976	36,064	42,226
change	Mil $	-173	-897	-172	599	1,618
% change	%	-0.5%	-2.6%	-0.5%	1.7%	4.0%
NFDM/SMP production						
baseline	thou mt	1,029	1,049	1,073	1,061	1,072
scenario	thou mt	1,028	1,046	1,072	1,063	1,078
change	thou mt	-1	-3	-1	2	6
% change	%	-0.1%	-0.3%	-0.1%	0.2%	0.5%
NFDM implied consumption						
baseline	thou mt	489	446	425	370	385
scenario	thou mt	489	447	425	370	384
change	thou mt	0	1	0	-1	0
% change	%	0.0%	0.2%	0.0%	-0.2%	-0.1%
NFDM/SMP exports						
baseline	thou mt	558	594	606	712	701
scenario	thou mt	557	586	609	719	711
change	thou mt	-1	-8	3	7	10
% change	%	-0.2%	-1.3%	0.5%	1.0%	1.4%

Rest of the World

The "No Intervention" scenario results compared to the baseline for the other major exporters, New Zealand and Australia, are presented in Table 10. The results show minimal impacts on production and exports, but more significant impact on the farm price and export revenues. Before discussing the results, it's important to understand that New Zealand and Australia report their annual data on a marketing year basis. New Zealand has a June-May marketing year, whereas Australia has a July-June marketing year. So the challenge in this study was how to structure an annual econometric model that reports trade on a calendar year basis. This was discussed in more detail in the Appendix. The approach used was to model production, internal farm prices, and exports on a marketing year, and then convert the trade results from a marketing year to a calendar year. All results in Table 10 are reported on a marketing year basis except trade which is presented on a calendar year basis.

The results of the "no Intervention" scenario show little impact on internal production and exports of SMP in both New Zealand and Australia. To some extent that should be expected since in both countries SMP production accounts for a relatively small percent of their overall dairy portfolio. That said, the biggest impact of the "no Intervention" scenario appears to be on the farm gate price of milk. In New Zealand, the farm milk payout would have declined almost 3.0% in 2015/16 had there been no EU Intervention program. However, in the following years the payout would have been much higher. That is particularly true in 2018/19 when the New Zealand farm milk payout would have been 4.7% higher. The same is true in Australia. In both countries farm-gate milk prices are estimated as a function of the global prices of butter and SMP. This provided a statistically significant specification. The hypothesis, which was proven by the statistical results, is that butter and SMP prices provides the foundation for farm pricing of fat and protein in both countries. Another result, to be seen later, is the impact of a "no Intervention" scenario on global SMP prices had a very significant impact on New Zealand and Australian SMP export earnings and relative market shares.

Global Price and Market Share

In this section the impact that the "no Intervention" scenario had on the global price of SMP and export market shares will be reviewed. When computing market shares, the numerator is the value for a country's excess supply or demand, and the denominator is global excess supply. Recall that the equilibrium condition for the model is that global excess supply is equivalent to global excess demand. Export market share for a major exporter was not compute by simply dividing exports for the country/region by total global trade. The reason is that calculation would not account for the small offsetting effect of imports for that country. Most major exporters also have some small volume of imports. In any event, the major point of interest is the "change" in market share from the baseline to the "no Intervention" scenario.

The results of the "no Intervention" scenario and the baseline are presented in Table 11. First the baseline, scenario, and change from baseline for the Global SMP price are shown. From there the baseline and the "change from baseline" for global market shares and value of exports under the "no Intervention" scenario are shown. Note that the change from baseline is simply the "no Intervention" scenario results minus the baseline. It shows what would have happen had there been no EU Intervention program.

Table 10. Impact of a "No Intervention" Scenario on New Zealand and Australia

			Purchase Period:		*Disposition Period:*	
	Units	2015	2016	2017	2018	2019
New Zealand: 1/						
Milk Production						
baseline	thou mt	21,568	21,341	21,372	21,864	22,192
scenario	thou mt	21,557	21,277	21,321	21,867	22,283
change	thou mt	-11	-64	-51	4	92
% change	%	0.0%	-0.3%	-0.2%	0.0%	0.4%
NZ farm milk payout						
baseline	NZ$/kgMS	4.30	6.52	6.79	6.35	6.20
scenario	NZ$/kgMS	4.17	6.49	6.93	6.65	6.20
change	NZ$/kgMS	-0.13	-0.03	0.14	0.30	0.00
% change	$	-3.0%	-0.5%	2.0%	4.7%	0.0%
SMP exports 2/						
baseline	thou mt	411	444	401	358	373
scenario	thou mt	411	443	400	358	374
change	thou mt	0	-1	-1	-1	1
% change	%	0.0%	-0.1%	-0.3%	-0.1%	0.2%
Australia: 3/						
Milk Production						
baseline	mil liter	9,681	9,016	9,325	8,795	8,681
scenario	mil liter	9,678	9,000	9,322	8,805	8,705
change	mil liter	-3	-16	-3	10	24
% change	%	0.0%	-0.2%	0.0%	0.1%	0.3%
Farm-gate milk price						
baseline	AU c/liter	44.90	40.90	45.80	48.50	51.00
scenario	AU c/liter	44.77	40.28	45.68	48.98	52.18
change	AU c/liter	-0.13	-0.62	-0.12	0.48	1.18
% change	%	-0.3%	-1.5%	-0.3%	1.0%	2.3%
SMP exports 2/						
baseline	thou mt	201	163	157	155	128
scenario	thou mt	200	162	156	155	129
change	thou mt	0	-1	-1	0	1
% change	%	0.0%	-0.4%	-0.5%	0.1%	0.8%

[a] June/April marketing year.
[b] Exports converted to a calendar year basis.
[c] July/June marketing year.

Table 11. Impact of the "No Intervention" Scenario on Global Skim Milk Powder Prices and Trade

	Units	2015	*Purchase Period:* 2016	2017	*Disposition Period:* 2018	2019
Global SMP price (Oceania)						
baseline	$/mt	$2,168	$1,998	$2,045	$2,012	$2,633
scenario	$/mt	$2,145	$1,890	$2,025	$2,085	$2,861
change	$/mt	-$22	-$108	-$20	$73	$228
% change	%	-1.0%	-5.4%	-1.0%	3.6%	8.7%
Baseline Market Share:						
EU-28	%	35.2%	30.6%	38.1%	37.9%	42.3%
US	%	28.3%	31.6%	29.7%	33.2%	31.0%
New Zealand	%	20.7%	23.5%	19.6%	16.6%	16.3%
Australia	%	9.7%	8.3%	7.3%	6.6%	5.0%
Belarus	%	6.2%	5.9%	5.4%	5.7%	5.4%
Change from Baseline 1/						
EU-28	%	0.5%	2.8%	0.3%	-1.7%	-3.6%
US	%	-0.2%	-1.4%	0.0%	1.0%	1.9%
New Zealand	%	-0.1%	-0.7%	-0.2%	0.3%	0.8%
Australia	%	-0.1%	-0.3%	-0.1%	0.1%	0.3%
Belarus	%	-0.1%	-0.4%	-0.1%	0.3%	0.6%
Baseline Value of Exports: 2/						
EU-28	mil $	$1,498	$1,150	$1,589	$1,635	$2,518
US	mil $	$1,205	$1,186	$1,236	$1,430	$1,844
New Zealand	mil $	$880	$882	$816	$715	$971
Australia	mil $	$414	$312	$305	$286	$297
Belarus	mil $	$262	$222	$223	$244	$323
Change from Baseline 2/						
EU-28	mil $	$13.9	$72.4	$6.2	-$46.8	-$124.5
US	mil $	-$15.3	-$79.3	-$6.2	$66.6	$187.0
New Zealand	mil $	-$9.2	-$49.0	-$10.1	$24.9	$86.1
Australia	mil $	-$4.4	-$18.0	-$4.6	$10.6	$28.8
Belarus	mil $	-$4.6	-$20.2	-$3.6	$15.3	$49.3

[a] Change in the "no Intervention" scenario relative to the baseline.

[b] Uses the global SMP price (USDA's Oceania priced of SMP).

The Global price of SMP under the "no Intervention" scenario would have been $108/mt lower relative to the baseline in 2016 had there been no EU Intervention program. Recall that under the baseline the EU in 2016 removed SMP from the internal market and placed it in Intervention. That effectively shorted the global market. Thus, under the "no Intervention" scenario, that product would have instead entered EU export channels. That had the impact of expanding EU exports in 2016 under this scenario and lowering the global price of SMP. But a lower SMP price in 2016 would have lowered milk production and SMP production in major exporting countries/regions including the EU and US.

In 2017 the global price of SMP under the "no Intervention" scenario fell by $20/mt relative to the baseline. That was due mainly to the EU which would have exported more under this scenario. In 2018 and 2019 global SMP prices rose dramatically by $73/mt and $228/mt, respectively, under the "no Intervention" scenario relative to the baseline. The EU produced marginally more SMP due to a higher internal SMP price, but exported much less since there were no dispersions of EU SMP Intervention stocks into the market. So, compared to the baseline, the EU overall exported less. Reduced excess supply from the EU onto the global market had the impact of driving global market prices higher. SMP production and exports in the US, New Zealand, and Australia only marginally increased.

Export market shares also changed under the "no Intervention" scenario as illustrated in Table 11. The impact of the "no Intervention" scenario was a decline in EU market share for SMP in 2018-2019 and a relative increase in market share for other major exporters including the US, New Zealand, Australia, and Belarus. The EU held in government storage the equivalent of 16% of the global market of SMP in 2016-17. Then in 2018 and 2019 the EU unloaded that product (at a discount) and effectively expanded their exports and market share to the detriment of others. The counterfactual scenario ("no Intervention") provides the analytical framework from which one can conclude this. Without the dispersion of inventory from the EU Intervention program, EU exports and hence market share would have been lower during the period 2018-19. US exports under a "no Intervention" scenario would have been higher during 2018-19.

Finally, the value of exports changed under the "no Intervention" scenario as illustrated in Table 11. The value of exports are computed by multiplying excess supply (exports less imports) times the global price of SMP (the USDA Oceania price of SMP). The analysis indicates that over the period 2016-19, the EU would have realized a total of $93 million ***less*** in export value under a "no Intervention" scenario when compared to the baseline. Under a "no Intervention" scenario global prices were higher, but the EU would have exported much less. Thus the value of their exports would have declined. But the opposite is true for the other major exporters. A "no Intervention" scenario would have resulted in much ***greater*** export values for the other major exporters since exports marginally increased, but global prices significantly increased under this scenario. For the US and New Zealand, total export values for 2016-19 under the "no Intervention" scenario would have been $168 million and $52 million higher, respectively. For Australia and Belarus, total export values for 2016-19 would have been $17 million and $41 million higher, respectively.

SUMMARY AND CONCLUSIONS

The EU decided in 2003 to expand their dairy sector in order to capitalize on a growing global market for dairy products. They did this by phasing out milk production quotas over a 5-year period, increased direct and indirect government expenditures for dairy, and negotiated numerous bi-lateral free trade agreements which increased their market access for dairy products. Even after they ended the milk quota system in 2015 they maintained their dairy price support program. This was a deliberate policy to increase rural economic activity and to expand global dairy market share. This study focused exclusively on the economic impacts of the EU's public intervention program as it relates to SMP.

The following methodology was used:

A global SMP econometric model was developed for this study. The model was **calibrated** to a "baseline" over the period 2016-19 that reflected activities under the EU's Intervention program. The model was then used to **simulate** a "no Intervention" scenario. The **model results** discussed earlier in this report looked at the change in the "no Intervention" scenario relative to the baseline. But to reach **conclusions** about the Intervention program, one does the opposite. Start with the "no Intervention" scenario results, then calculate the change back to the baseline. The difference is the economic impact of the EU Intervention program. This is the standard approach used in economic policy studies.

This study shows the following:

The EU's SMP Intervention program initially supported the EU and global price of SMP when the EU government purchased 335,586 mt of SMP in 2016 and 29,193 mt in 2017. The program had the effect of raising the global price of SMP by $108/mt in 2016 and $20/mt in 2017 above what it otherwise would have been without the program. EU dairy farmers benefitted marginally since the farm-gate milk price rose €0.40/100 kg in 2016. But the operations of the Intervention program dramatically reduced EU exports by 71 thousand mt in 2016 and 11 thousand mt in 2017 below what it otherwise would have been. SMP was basically diverted from the domestic and export markets to government inventories.

But any benefit to the world market was short lived. In 2018 and 2019 the EU unleased the equivalent of 16% of the global market of SMP from government storage. Of the 378,051 mt of SMP in the EU Intervention program at the end of 2017, this study indicates that almost 50% was exported by the EU in 2018-19 as SMP (HS 040210). The model simulation indicates that EU SMP exports increased by a total of 171 thousand mt in 2018 and 2019 due solely to the EU's Intervention program. The rest of the Intervention stock was likely used for fat-filled milk exports, for use in other dairy and food products, or in commercial inventories. All of the discounted low quality SMP from the Intervention program was consumed and/or sold by the end of August 2019, after which internal EU SMP prices began to rise from €207/100 kg at the end of August to €250/100 kg by the first week of December 2019.

The EU's Intervention program had devastating effects on other major exporters including the US. This study shows that while the US farm-gate milk price was initially supported by $0.42/cwt in 2016 by the program, it reduced the farm-gate milk price by $0.27/cwt in 2018 and $0.73/cwt in 2019. In addition, the US lost global market share due to the EU's Intervention program. **All told, the US lost a combined $168 million in export value during 2016-19.**

The following conclusions are reached:

The EU disposed of Intervention stocks at below cost in 2018-19, effectively creating a subsidy for EU traders. The EU government knowingly sold Intervention stocks, with no restrictions on end use, to trading houses that exported the product abroad. The EU Intervention program also adversely impacted other major SMP exporters, including the US. Economic damages to the US were estimated in this study, including a loss of export market share from 33.5% in 2018-19 (under the "no Intervention" scenario) to 32.1% with Intervention in key US dairy export markets. In addition, there was a quantifiable loss of $168 million in export value for 2016-19.

This has the following implications:

The purpose of the Uruguay Round was to phase out and eventually end all trade distorting domestic subsidies. The EU Intervention program represents a hold out for policy reform. This study clearly demonstrates that this program distorted the thin global market for SMP and caused economic harm to the United States. This has had devastating implications for the US since the actions of the EU SMP Intervention program have made the US less competitive. The EU's dairy Intervention program should either be reformed by internalizing all surplus SMP purchases, or simply ended. The EU could internalize all SMP surpluses and avoid exporting that surplus onto the world market by developing domestic feeding programs for the poor, use in animal feed, or other programs. Care must be taken to ensure there is no slippage of SMP into the global market. In summary, the EU is allowed to spend within the disciplines of their AMS calculation, but must not adversely impact other exporters and distort global markets and trade.

APPENDIX: GLOBAL ECONOMETRIC MODEL

For an individual exporting country, excess supply (or exports) is defined via an identity as production plus imports minus domestic use and change in stocks. Such an identity is used to link the estimated equations to exports. Conceptually, the excess supply functions for major exporters is specified below with the first equation describing the supply function and the second linking the farm-gate milk price to global SMP and butter prices.

$$ES_{j,t}^{SMP} = a + b \times P_{j,t}^{RMK} + c \times \beta_{j,t}$$

$$P_{j,t}^{RMK} = d + e \times P_{G,t}^{SMP} + f \times P_{G,t}^{B} + g \times EXR_{j,t}$$

where,

ES = excess supply
P = price
β = all other supply inducing variables
RMK = raw milk
SMP = skim milk powder
B = butter
EXR = exchange rate, local currency per US dollar
j = exporting country or region
t = time, year
G = global

For an individual importing country, excess demand (imports) is defined as domestic use plus exports and change in inventory, minus production. Conceptually, the country/regional import demand functions are specified as follows:

$$ED_{i,t}^{SMP} = a - b \times \frac{P_{i,t}^{SMP}}{CPI_{i,t}} + c \times \left\{ \left(\frac{GDP_{i,t}}{POP_{i,t}} \right) / CPI_{i,t} \right\}$$

$$P_{i,t}^{SMP} = d + e \times P_{G,t}^{SMP} \times EXR_{i}, t$$

where:

ED = excess demand
P = price
SMP = skim milk powder
CPI = inflation index
GDP = gross domestic product
POP = population
EXR = exchange rate, local currency per US dollar
i = importing country or region
t = time, year
G = global

The specification above estimates the excess demand function in terms of local prices, inflation, and income, then uses a price transmission equation to measure the impact of global prices on local prices. But in many cases finding a country-level SMP price will be difficult. In that case, the following reduced-form excess demand equation is used:

$$ED_{i,t}^{SMP} = A - B \times \frac{P_{G,t}^{SMP} \times EXR_{i,t}}{CPI_{i,t}} + C \times \left\{ \left(\frac{GDP_{i,t}}{POP_{i,t}} \right) / CPI_{i,t} \right\}$$

In the above specification, the price transmission equation was substituted into the ED equation. The global price of SMP is used along with the local exchange rates. Parameter B basically captures some of the information in the price transmission equation.

With the definitions of excess supply and demand in place, the following describes the global dynamic market clearing conditions:

$$P_{G,t}^{SMP} \; s.t.$$

$$\sum_j ES_{j,t}^{SMP}\left(P_{G,t}^{SMP}\right) - \sum_i ED_{i,t}^{SMP}\left(P_{G,t}^{SMP}\right) - ED_{ROW,t}^{SMP}\left(P_{G,t}^{SMP}\right) = 0$$

The dynamic partial equilibrium model will solve for P in each time period until the above condition is met. This specification fundamentally solves for the condition global excess demand equal to global excess supply.

A unique feature of this model is that whenever possible, one should estimate the supply of milk components (fat and protein), and then allocate these components to dairy product production. The residual use of this allocation process is excess fat and protein, which in turn is converted into butter and SMP production. This replicates the commercial process of milk component allocation in most dairy exporting countries and explains why SMP production growth exceeds milk production growth in years when milk production is growing, and vice versa.

The econometric model was estimated with annual data over the period 2001-18 using EViews. The estimation method was Ordinary Least Squares. The model was simulated within MS Excel using a proprietary solver. The individual submodels are presented below including model specification, estimated parameters, and a listing of endogenous and exogenous variables.

European Union Submodel

The EU Commission provides a wealth of data on farm milk production, component levels in milk, dairy product production, and various internal prices (SMP and the EU average farm-gate milk price). Global Trade Atlas provides EU exports and imports (excluding intra-EU trade). The EU dairy model is designed to specify an excess supply function for SMP. Start by estimating EU milk production as a function of the internal price of milk. Next, estimate internal dairy product demand for fresh products, and production for manufactured products. From there estimate the milk components needed to make those products (as well as other residual products) and allow the excess to flow into SMP production. Next, model the excess supply function for SMP by subtracting the internal demand for SMP and stocks (including Intervention stocks) from the SMP production equation. Price linkage equations are estimated for the internal SMP price and for the farm-gate milk price. Thus all internal prices are linked to the global price of SMP (USDA SMP price for Oceania). The estimated elasticities, model specifications, and parameter estimates for the EU can be found in Appendix Tables 1 and 2.

Appendix Table 1. European Union Dairy Model Elasticities with Respect to SMP Prices

	Supply	------- Demand -------		Price
	own price	own price	income	Linkage
Milk	0.237			
Fluid milk, per capita consumption		n.a.	-0.057	
Cream, per capita consumption		n.a.	0.333	
Yogurt, per capita consumption		n.a.	0.727	
Cheese production		n.a.	n.a.	
Skim Milk Powder Domestic Consumption		-0.562	-1.64	
Farm gate milk price				0.32
Derived Skim Milk Powder Excess Supply [a]	1.907			

[a] Average derived elasticity simulated over the period 2012-18 with respect to the global SMP price.

Appendix Table 2. European Union Dairy Model Parameter Estimates

Variables	Parameter Estimates	Standard Error	t-statistic	Sample Period	Adjusted R-square	Durbin-Watson
Dependent Variable:						
LN(EU_RMK_A_TMT_DEL)				2001-2018	0.544	0.427
Independent Variables:						
INTERCEPT	10.976	0.529	20.739			
LN(EU_MK_A_E100KG)	0.237	0.153	1.550			
DUM_2015_2018	0.149	0.034	4.389			
Dependent Variable:						
LN(EU_FLDRK_A_TMT * 1000 * 1000 / EU_POP)				2004-2018	0.852	1.085
Independent Variables:						
INTERCEPT	4.796	1.480	3.240			
TREND_A	-0.006	0.004	-1.612			
LN(EU_PCAP_GDP)	-0.057	0.146	-0.393			
Dependent Variable:						
LN(EU_CHZ_PRD_A_TMT)				2006-2018	0.959	1.668
Independent Variables:						
INTERCEPT	-0.167	0.560	-0.298			
LN(EU_RMK_A_TMT_DEL)	0.758	0.050	15.259			
LN(EU_CDR_A_E100KG)	0.042	0.025	1.643			

Appendix Table 2. - continued

Variables	Parameter Estimates	Standard Error	t-statistic	Sample Period	Adjusted R-square	Durbin-Watson
Dependent Variable:						
LN(EU_CRM_PRD_A_TMT*1000*1000 / EU_POP)				2005 - 2018	0.855	0.986
Independent Variables:						
INTERCEPT	-1.869	0.911	-2.052			
LN(EU_PCAP_GDP)	0.333	0.087	3.813			
DUM_2015_2018	0.030	0.020	1.520			
Dependent Variable:						
LN(EU_YGT_PRD_A_TMT *1000*1000 / EU_POP)				2005 - 2018	0.849	2.018
Independent Variables:						
INTERCEPT	-4.545	3.866	-1.176			
LN(EU_PCAP_GDP)	0.727	0.380	1.912			
TREND_A	-0.024	0.010	-2.459			
DUM_2012	-0.255	0.034	-7.393			
Dependent Variable:						
LN(EU_SMP_DUS_MT * 1000 / EU_POP)				2002 - 2018	0.932	2.251
Independent Variables:						
INTERCEPT	-4.518	7.547	-0.599			
LN(EU_SMP_A_E100KG)	-0.562	0.227	-2.474			
LN(EU_WHP_A_E100KG)	0.214	0.123	1.737			
LN(EU_PCAP_GDP)	0.742	0.786	0.944			
TREND_A	-0.082	0.026	-3.179			
DUM_2009	-0.407	0.084	-4.844			
DUM_2016	-0.441	0.088	-5.011			
DUM_2013_14	0.364	0.100	3.636			
Dependent Variable:						
LN(EU_MK_A_E100KG)				2009 - 2018	0.832	2.060
Independent Variables:						
INTERCEPT	-0.354	0.565	-0.627			
LN(EU_SMP_A_E100KG)	0.320	0.069	4.666			
LN(EU_BT_A_E100KG)	0.362	0.065	5.600			
Dependent Variable:						
LN(EU_SMP_A_E100KG)				2005 - 2018	0.959	2.150
Independent Variables:						
Intercept	-0.967	0.435	-2.225			
LN(OC_SMP_M_DMT)	0.865	0.061	14.131			
LN(DEXUSEU_M)	-1.193	0.244	-4.879			
TREND_A	-0.019	0.004	-4.924			

Component Allocation and Residual Product Production:

$Fat\ Supply_t = Milk\ Deliveries_t \times MFat_t$

$Fat\ Use_t^{BUT} = Fat\ Supply_t - Fat\ Use_t^{FL} - Fat\ Use_t^{CRM} - Fat\ Use_t^{YGT} - Fat\ Use_t^{CHZ} - Fat\ Use_t^{OT}$

$Butter\ Production_t = Fat\ Use_t^{BUT}/0.82$

$Prt\ Supply_t = Milk\ Deliveries_t \times MPrt_t$

$Prt\ Use_t^{SMP} = Prt\ Supply_t - Prt\ Use_t^{FL} - Prt\ Use_t^{CRM} - Prt\ Use_t^{YGT} - Prt\ Use_t^{CHZ} - Prt\ Use_t^{OT}$

$SMP\ Production_t = Prt\ Use_t^{SMP}/0.359$

where,

t = year
MFat = fat level in milk, percent
MPrt = protein level in milk, percent
Fat = milk fat
Prt = protein
BUT = butter
SMP = skim milk powder
FL = fluid milk
CRM = cream
YGT = yogurt
CHZ = cheese
OT = other uses

Appendix Table 3. European Union Component Levels, Percent

	Fat	Protein
Cream	25.0%	3.0%
Yogurt	1.55%	5.25%
Cheese	26.13%	26.72%
Butter	82.0%	0%
Skim Milk Powder	0%	35.9%

Endogenous Variables:

EU_RMK_A_TMT_DEL = EU raw milk deliveries, annual, thou mt.

EU_FLDRK_A_TMT = EU fluid drinking milk, annual, thou mt.

EU_CHZ_PRD_A_TMT = EU cheese production, annual, thou mt.

EU_CRM_PRD_A_TMT = EU cream for direct consumption, annual, thou mt.

EU_YGT_PRD_A_TMT = EU acidified milk and yogurt, annual, thou mt.

EU_SMP_DUS_MT = EU SMP implied domestic use, mt.

EU_MK_A_E100KG = EU farm-gate milk price, annual, euros/100 kg.

EU_SMP_A_E100KG = EU internal SMP price, annual, euros/100 kg.

EU_SMP_PRD_MT = EU SMP production, annual, mt.

EU_BUT_PRD_MT = EU butter production, annual, mt.

Exogenous Variables:

EU_BT_A_E100KG = EU internal butter price, annual, euros/100 kg.

WU_WHP_A_E100KG = EU dry whey internal price, annual, euros/100 kg.

EU_CDR_A_E100KG = EU Cheddar internal price, annual, euros/100kg.

EU_SMP_PUB_MT = EU SMP public stocks (Intervention), mt.

EU_SMP_PRI_ MT = EU SMP private stocks, mt.

EU_SMP_TRADER_MT = EU SMP estimated trader inventory, mt.

EU_SMP_IMP_MT = EU SMP imports, mt.

EU_FFM_EXP_MT = EU exports of fat-filled milk, mt.

DEXUSEU_A = US-EU exchange rate, US$/euro.

EU_PCAP_GDP = EU purchasing power parity, international dollars/person, IMF.

EU_POP = EU annual population, number of persons.

TREND_A = annual trend, 2012 = 13, 2013 = 14, etc.

DUM_20XX_20YY = dummy variable, equals 1 in year 20XX-YY (eg. XX = 15, YY = 18 → 2015-18)

DUM1213 = dummy variable, equals 1 in year 2012-13.

DUM_20XX = dummy variable, equals 1 in year 20XX (eg. XX = 09 → 2009).

New Zealand Submodel

The objective with the New Zealand submodel is to simulate SMP exports on a calendar year basis from milk production and component allocation on a marketing year basis (June-May). New Zealand exports roughly 95% of their farm milk production. Of the farm produced butterfat, roughly 86% is allocated to the production of WMP, butter and anhydrous milkfat, and cheese for export purposes. Of the farm produced protein, roughly 66% is allocated to WMP, SMP, butter and anhydrous milk, and cheese for export purposes. For protein that leaves a significant portion that is unexplained. Of the remaining milk components, 5% is used for domestic consumption and the balance is manufactured into specialized protein products and other value-added products.

New Zealand does not report data on dairy product production. They do report monthly data on milk production and milk solids production. They also report monthly exports. Therefore, one can approximate the production of key dairy products destined for exports by making a few assumptions. First, the time between production and exports is roughly 2 months. Second, assume there is a 1% shrink factor between production and exports. Using the monthly export data, assumptions discussed already, and component content of these dairy product, one can re-engineer dairy product production. The process was simplified by estimating relationships on a New Zealand marketing year basis (June-May) and then converting SMP exports from a marketing year to a calendar year basis. While production is modeled to occur on a June/May period, the annual estimate of exports is assumed to occur two months later on a August/July basis (based on an earlier assumption). Thus the final step is to convert SMP production (June/May) to SMP exports (August/July), and then to a calendar year basis (January-December).

With regard to price linkages, a linkage between the Fonterra announced payout for milk solids on a marketing year basis and the USDA Oceania prices for SMP and butter on an annual basis was estimated. These represent the value for the key components in New Zealand milk pricing: fat and protein.

The estimated elasticities along with the dynamic simulated elasticities with respect to the global price of SMP are provided in Appendix Table 3.

Appendix Table 4. New Zealand Dairy Model Elasticities with Respect to SMP Prices

	Supply Own price	Price Linkage
Milk Supply	0.087	
NZ Farm Payout		0.555
Derived Skim Milk Powder Excess Supply [a]	0.083	

[a] Average derived elasticity simulated over the period 2013-18 with respect to the Oceania SMP price.

Appendix Table 5. New Zealand Dairy Model Parameter Estimates

Variables	Parameter Estimates	Standard Error	t-statistic	Sample Period	Adjusted R-square	Durbin-Watson
Dependent Variable:						
LN(NZ_RMK_MY_TMT)				2008 - 2017	0.9170	2.371
Independent Variables:						
INTERCEPT	3.366	1.419	2.373			
LN($NZ\_RMK\_MY\_TMT_{t-1}$)	0.643	0.144	4.473			
LN($RM\_PRI\_NZD\_KGMS_{t-1}$)	0.087	0.048	1.839			
DUM_2013_18	0.053	0.035	1.525			
Dependent Variable:						
LN(RM_PRI_NZD_KGMS)				2007 - 2017	0.6969	1.277
Independent Variables:						
INTERCEPT	-6.535	1.882	-3.473			
LN($OC\_SMP\_M\_DMT_{t+1}$)	0.555	0.169	3.281			
LN($OC\_BT\_M\_DMT_{t+1}$)	0.485	0.165	2.935			
DUM_2012	-0.329	0.156	-2.113			
DUM_2013	0.130	0.139	0.929			

Production Identities:

NZ_MS_MY_TKG = NZ_MS_MY_PCT*NZ_RMK_MY_TMT

NZ_BF_MY_TKG = (1-0.445)*NZ_MS_MY_TKG

NZ_PR_MY_TKG = 0.445*NZ_MS_MY_TKG

Production of Key Dairy Products Destined to the Export Market (thou MT of product):

$$WMP\ for\ Exports_{MY} = NZ\_BF\_MY\_TKG \times \%Fat\ Allocation_{MY}^{WMP} / 0.263$$

$$Butter\ for\ Exports_{MY} = NZ\_BF\_MY\_TKG \times \%Fat\ Allocation_{MY}^{BUT} / 0.829$$

$$AMF\ for\ Exports_{MY} = NZ\_BF\_MY\_TKG \times \%Fat\ Alloction_{MY}^{AMF} / 0.999$$

$$Cheese\ for\ Exports_{MY} = NZ\_BF\_MY\_TKG \times \%Fat\ Alloation_{MY}^{CHZ} / \%\ Fat\ Comp_{MY}^{CHZ}$$

where,

MY = June/May marketing year.

%Fat Allocation = the percent of farm produced fat in New Zealand allocated to the production of dairy product i that is exported two months later. The allocation is computed on a marketing year basis using monthly data.

%Fat Comp^{CHZ} = estimate of the average fat level in a basket of cheese products that are produced for export in a given marketing year.

Residual Supply of Protein on a June/May Marketing Year:

$$Protein_{MY}^{SMP} = NZ\_PR\_MY\_TKG - WMP\ for\ Exports_{MY} \times 0.245 - Butter\ for\ Exports_{MY} \times 0.0083 - Cheese\ for\ Exports_{MY} \times Protein\ Comp_{MY}^{CHZ} - Residual\ Protein$$

$$SMP\ for\ Exports_{MY} = Protein_{MY}^{SMP} / 0.329$$

Estimate of SMP Exports on a Calendar Year Basis:

$$SMP\ Exports_{CY} = \left\{SMP\ for\ Exports_{MY,t-1} \times \left(\frac{7}{12}\right) + SMP\ for\ Exports_{MT,t} \times \left(\frac{5}{12}\right)\right\} \times 0.99$$

where,

Protein^{SMP} = the residual supply of protein available for the production of exportable SMP.

%Protein Comp^{CHZ} = estimate of the average protein level in a basket of cheese products that are produced for export in a given marketing year.

Appendix Table 6. New Zealand Assumptions for Milk Components

TS/MS ratio	59.9%
TS [a]	8.5%
Protein/TS ratio	44.5%
Milk Solids [a]	14.2%
Butterfat [a]	4.7%
Protein [a]	3.8%
Other Dairy Solids [a]	5.7%
Protein/butterfat ratio	80.3%
Butterfat-TS ratio	55.5%

Note: TS = total solids (butterfat + protein), and Milk solids incorporates all dairy solids (butterfat, protein, other dairy solids).
[a] Calculated as a percent of a unit of raw milk.

Appendix Table 7. Component Content of Key Dairy Exports

	SMP	WMP	Butter	Butter Substitutes	AMF	Cheese
Total Solids	33.8%	50.8%	83.8%	82.8%	99.9%	55.7%
Butterfat	0.9%	26.3%	82.9%	82.0%	99.9%	31.5%
Protein	32.9%	24.5%	0.9%	0.8%	0.0%	24.2%

Note: Total solids = butterfat + protein.

Appendix Table 8. Allocation of New Zealand Butterfat to Key Dairy Products Manufactured for Exports, Jun/May Marketing Year

	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18
Whole Milk Powder	34.5%	37.4%	34.8%	34.5%	35.2%	35.0%
Butter	22.3%	25.2%	22.0%	23.6%	22.2%	23.0%
Butter Substitutes	0.2%	0.1%	0.2%	0.1%	0.2%	0.2%
Anyhdrous Milk Fat	23.2%	19.0%	19.5%	21.9%	20.2%	17.8%
Cheese	10.8%	8.3%	9.5%	10.8%	11.0%	10.4%
Other	8.9%	10.0%	14.0%	9.1%	11.1%	13.7%

Endogenous Variables:

NZ_RMK_MY_TMT = New Zealand raw milk production, Jun/May marketing year, thou MT

NZ_MS_MY_TKG = New Zealand milk solids production (fat+protein), Jun/May marketing year, thou KG

RM_PRI_NZD_KGMS = Fonterra milk solids final payout, Jun/May marketing year, NZ$/kgMS

OC_SMP_A_DMT = Global price of SMP, Oceania, annual, US$/mt (solved simultaneously)

Exogenous Variables:

NZ_MS_MY_PCT = New Zealand milk solids (fat+protein) as a percent of milk production, Jun/May marketing year, percent

OC_BT_M_DMT = Annual Oceania butter price, USDA, calendar year, US$/MT

DUM_2013_18 = dummy variable, equals 1 in years 2013-18.

DUM_2012 = dummy variable, equals 1 in 2012.

DUM_2013 = dummy variable, equals 1 in 2013.

Australian Submodel

The Australian submodel has similarities to both the EU and NZ submodels. In both cases milk production is simulated, components are allocated, and production of SMP is derived as a residual allocation of protein. The Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) reports a great deal of data on dairy product production. It's similar to the NZ model, however, in that production and exports are computed on a marketing year basis (July-June for Australia) which must then be converted to a calendar year basis.

ABARES reports the milk component levels in farm milk, so one can compete the volume of fat and protein produced each year. After completing a component analysis, the main uses of milk components are fluid milk, cheese, and whole milk powder. After accounting for other uses for milk components (AMF, buttermilk powder, etc), the balance of components are allocated to butter and skim milk powder production. Thus SMP production (on a marketing year basis) is derived first by computing the residual protein available after allocation protein to major dairy processing products, and then converting to an SMP equivalent.

A price linkage equation was estimated to explain the year-to-year variation in the Australian farm gate milk price. Fundamentally the farm price of milk was estimated as a function of the global prices of butter and SMP, as well as an exchange rate.

Finally, after deriving an annual estimate for domestic consumption plus imports plus the change in stocks, one can derive an excess supply function for Australia:

Australian SMP Exports (MY basis) = SMP Production – (Domestic Use-Imports+ΔStocks)

Note that the model explains (endogenizes) SMP Production, allowing us to derive an estimate for exports. The last endogenous equation simply converts exports from an Australian marketing year to a calendar year basis.

Appendix Table 9. Australian Dairy Model Elasticities with Respect to SMP

	Supply	------- Demand -------		Price
	own price	own price	income	Linkage
Milk	0.119			
Fluid milk, per capita consumption		-0.136	0.043	
Cheese	0.163			
Whole Milk Powder	1.04			
Farm gate milk price				0.276
Derived Skim Milk Powder Excess Supply [a]	0.134			

[a] Average derived elasticity simulated over the period 2013-18 with respect to the Oceania SMP price.

Appendix Table 10. Australian Dairy Model Parameter Estimates

Variables	Parameter Estimates	Standard Error	t-statistic	Sample Period	Adjusted R-square	Durbin-Watson
Dependent Variable:						
LN(AU_RMK_MY_MLT)				2007 - 2017	0.102	1.934
Independent Variables:						
INTERCEPT	8.695	0.307	28.296			
LN(AU_MK_MY_ACL)	0.119	0.081	1.462			
Dependent Variable:						
LN(AU_FLDRK_MY_MLT / AU_POP)				2007 - 2017	0.724	2.842
Independent Variables:						
INTERCEPT	-9.561	0.440	-21.752			
LN(AU_FL_MY_AUD)	-0.136	0.107	-1.269			
LN(A U_PCAP_GDP*100 / AU_DEFL_MY)	0.043	0.036	1.184			
DUM_2015_2017	-0.012	0.008	-1.519			
Dependent Variable:						
LN(AU_CHZ_PRD_MY_MT)				2005 - 2017	0.280	1.266
Independent Variables:						
INTERCEPT	8.525	3.601	2.367			
LN(OC_CDR_A_DMT / OC_WMP_A_DMT)	0.163	0.128	1.272			
LN(AU_RMK_MY_MLT)	0.459	0.394	1.167			
DUM_2017	0.098	0.045	2.169			
Dependent Variable:						
LN(AU_WMP_PRD_MY_MT)				2005 - 2017	0.756	1.143
Independent Variables:						
INTERCEPT	12.671	0.175	72.591			
LN(OC_WMP_A_DMT / OC_CDR_A_DMT)	1.040	0.471	2.206			
TREND_A	-0.075	0.013	-5.619			
DUM_2017	0.147	0.187	0.787			
Dependent Variable:						
AU_SMP_EXP_A_MT				2006 - 2017	0.581	2.988
Independent Variables:						
$AU\_SMP\_EXP\_MY\_MT_{t-1}$	0.636	0.172	3.691			
$AU\_SMP\_EXP\_MY\_MT_{t}$	0.364	0.175	2.081			
Dependent Variable:						
LN(AU_MK_MY_ACL)				2005 - 2018	0.710	2.315
Independent Variables:						
INTERCEPT	-0.950	0.859	-1.105			
LN(OC_BT_A_DMT)	0.301	0.066	4.542			
LN(OC_SMP_A_DMT)	0.276	0.091	3.019			
LN(AU_US_MY_EXR)	-0.392	0.204	-1.922			

Production Identities:

AU_SMP_PRD_MY_MT = (see component allocation below)

AU_SMP_EXP_MY_MT = AU_SMP_PRD_MY_MT – (SMP Domestic Use – Imports + change in Inventory)

Component Allocation and Residual Product Production:

$$Fat\ Supply_t = Milk\ Production_t \times MFat_t$$

$$Fat\ Use_t^{BUT} = Fat\ Supply_t - Fat\ Use_t^{FL} - Fat\ Use_t^{AMF} - Fat\ Use_t^{WMP} - Fat\ Use_t^{CHZ} - Fat\ Use_t^{OT}$$

$$Butter\ Production_t = Fat\ Use_t^{BUT}/0.829$$

$$Prt\ Supply_t = Milk\ Production_t \times MPrt_t$$

$$Prt\ Use_t^{SMP} = Prt\ Supply_t - Prt\ Use_t^{FL} - Prt\ Use_t^{WMP} - Prt\ Use_t^{CHZ} - Prt\ Use_t^{OT}$$

$$SMP\ Production_t = Prt\ Use_t^{SMP}/0.329$$

where,

t = year
MFat = fat level in milk, percent
MPrt = protein level in milk, percent
Fat = milk fat
Prt = protein
BUT = butter
AMF = anhydrous milkfat
SMP = skim milk powder
FL = fluid milk
WMP = whole milk powder
CHZ = cheese
OT = other uses

Appendix Table 11. Assumptions for the Australian Component Content of Key Dairy Products

	Fat	Protein	Other Dairy Solids	Moisture
Skim Milk Powder	0.9%	32.9%	62.4%	3.8%
Whole Milk Powder	26.3%	24.5%	46.1%	3.1%
Butter	82.9%	0.8%	0.6%	15.7%
Anhydrous Milk Fat	99.9%	0.0%	0.0%	0.1%
Young Cheese	34.7%	24.0%	4.8%	36.5%
Buttermilk Powder	7.8%	31.0%	57.4%	3.8%
Drinking milk, regular	3.5%	3.3%	5.2%	88.0%
Drinking milk, reduced fat	1.5%	3.4%	7.1%	88.0%
Drinking milk, no fat	0.2%	3.5%	8.4%	88.0%
Drinking milk, flavored	1.5%	3.4%	7.1%	88.0%
Drinking milk, UHT	1.5%	3.4%	7.1%	88.0%

Endogenous Variables:

AU_RMK_MY_MLT = Australian raw milk production, marketing year, mil liters

AU_MK_MY_ACL = Australian farm-gate milk price, marketing year, AU cents/liter

AU_FLDRK_MY_MLT = Australian fluid milk production, marketing year, mil liters

AU_CHZ_PRD_MY_MT = Australian total cheese production, marketing year, MT

AU_WMP_PRD_MY_MT = Australian whole milk production, marketing year, MT

AU_SMP_PRD_MY_MT = Australian SMP production, marketing year, MT

AU_SMP_EXP_MY_MT = Australian SMP exports, marketing year, MT

AU_SMP_EXP_A_MT = Australian SMP exports, calendar year, MT

OC_SMP_A_DMT = Global price of SMP, Oceania, annual, US$/mt (solved simultaneously)

Exogenous Variables:

AU_POP = Australian population, number of people

AU_FL_MY_AUD = Australian fluid milk price, supermarket avg sales price per MY, AU$/liter

AU_PCAP_GDP = Australian IMF estimate for per capita GDP in US$

AU_DEFL_MY = Australian IMF estimate for GDP deflator, index

OC_CDR_A_DMT = USDA Oceania cheddar cheese price, US$/mt

OC_WMP_A_DMT = USDA Oceania whole milk price, US$/mt

TREND_A = trend, 1=2000

DUM_2015_2017 = dummy variable, equals 1 in 2015-17

DUM_2017 = dummy variable, equals 1 in 2017

United States Submodel

The US dairy market can be characterized as steady annual production growth, strong demand for cheese, and declining demand for fluid milk. The balance of milk components are allocated to Class II needs (fresh dairy products like cottage cheese, ice cream, yogurt), and other miscellaneous products like WMP, whey products, etc. The balance of surplus fat and protein is then allocated to NFDM/SMP and butter production. Those are the last products that are manufactured from surplus cream and skim milk.

US milk production is highly correlated to the farm price of milk and trend. Those two variables explain 99% of the variability of the dependent variable. Trend is a proxy for two factors: technology and management skills. Farms continue to consolidate, and cow productivity continues to grow. A milk supply elasticity of just 0.014 was estimated, implying a very inelastic supply curve. Agraph of the dependent variable over time will show that. The annual component levels in the milk for fat and protein were also endogenized. Both were estimated as a function of wholesale commodity prices and trend. Only True Protein showed a positive correlation to price (in this case, the nonfat dry milk). Milk production and the component variables then determine the supply of fat and protein.

Next, component demand is estimated by forecasting the demand for fluid milk and cheese. The annual decline in per capita fluid milk consumption and the annual production of total cheese has been surprisingly linear over time (2012-18). Per capita fluid milk demand was not correlated with the retail price of fluid milk, but was significantly correlated with real per capita GDP. A trend variable to separate out annual changes in tastes and preferences from income was also included. Total cheese production was estimated as a function of the wholesale price of cheese and milk production. Only the latter variable was significant. Again, the allocation of milk components (fat and protein) to cheese production is also highly linear over time.

SMP production was separated from NFDM production namely because SMP is produced to meet the specific needs of international customers and has been growing over time. SMP production as a percent of total dry protein production has been growing over time.

Two price linkage equations were estimated. First, the Federal Order nonfat dry milk price was estimated as a function of the global price of SMP (USDA's price for Oceania). Second, the US farm-gate price of milk was estimated as a function of the wholesale commodity prices for butter and nonfat dry milk. While it's true that the farm-gate price of milk is fundamentally driven by the pool value of four classes of milk, the fundamental determinate are the two basic component values of fat and skim. One can observe that lower butter and SMP prices are correlated with lower cheese prices and vice versa. SMP acts as the minimal floor value for milk in the US.

The production of butter and nonfat dry milk is then simulated by subtracting the component demand for fluid milk, total cheese, SMP and residual uses from the supply of milk components. The residual component uses reflects the processing of other dairy products such as WMP, Class II products, etc. The analysis shows that this residual demand is fairly stead year over year when computed as a percent of supply (e.g. 28.8% for fat in 2012 and 30.1% in 2018, 20.5% for True Protein in 2012 and 22.1% in 2018). Once the surplus balance of fat and True protein is computed for a given year, it is allocated to butter and nonfat dry milk production processing. Butter and nonfat dry milk production is then estimated by diving the components used in processing by the component content of each.

A summary of the US elasticities including a derived elasticity for NFDM/SMP excess supply (exports) with respect to the global price of SMP is as follows:

Appendix Table 12. US Dairy Model Elasticities with Respect to the NFDM/SMP Price

	Supply	------- Demand -------		Price
	own price	own price	income	Linkage
Milk	0.014			
Fluid milk, per capita consumption		na	-0.482	
Cheese	na			
Skim Milk Powder	0.32			
NFDM, per capita consumption		na	-1.51	
NFDM, ending stocks		-0.794		
US NFDM linkage equation				0.927
Farm gate milk price				0.501
Derived Skim Milk Powder Excess Supply [a]	0.159			

[a] Average derived elasticity simulated over the period 2012-18.

Appendix Table 13. US Dairy Model Parameter Estimates

Variables	Parameter Estimates	Standard Error	t-statistic	Sample Period	Adjusted R-square	Durbin-Watson
Dependent Variable:						
LN(US_RMK_A_MLBS_PROD)				2007 - 2018	0.990	2.308
Independent Variables:						
INTERCEPT	11.972	0.031	390.160			
LN(US_RMK_A_DCWT_PRI)	0.014	0.011	1.309			
TREND_A	0.015	0.000	32.982			
Dependent Variable:						
US_TPRT_A_PCT				2007 - 2018	0.900	1.794
Independent Variables:						
INTERCEPT	0.02958	0.00019	154.491			
US_NFM_A_DLB_PRI	0.00026	0.00008	3.100			
TREND_A	0.00009	0.00001	9.907			

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Appendix Table 13 - continued

Variables	Parameter Estimates	Standard Error	t-statistic	Sample Period	Adjusted R-square	Durbin-Watson
Dependent Variable:						
US_FAT_A_PCT				2007 - 2018	0.811	1.831
Independent Variables:						
INTERCEPT	0.035	0.000	80.660			
US_BT_A_DLB_PRI	0.001	0.000	4.485			
DUM_2013	0.001	0.000	2.992			
DUM_2018	0.001	0.000	3.213			
Dependent Variable:						
LN(US_FLDRK_A_MLBS_SVOL *1000*1000 / US_POP_A)				2000 - 2018	0.952	0.278
Independent Variables:						
INTERCEPT	7.878	1.071	7.354			
LN(US_GDP_PCAP_A / US_CPI_A)	-0.482	0.201	-2.403			
TREND_A	-0.012	0.002	-6.719			
Dependent Variable:						
LN(US_CHZ_A_MLBS_PRD)				2000 - 2018	0.989	1.122
Independent Variables:						
INTERCEPT	-10.077	0.470	-21.426			
LN(US_RMK_A_MLBS_PRD)	1.588	0.039	41.047			
Dependent Variable:						
LN(US_SMP_A_MLBS_PRD)				2006 - 2018	0.684	2.964
Independent Variables:						
INTERCEPT	-67.639	13.933	-4.854			
LN(US_NFM_A_DLB_PRI)	0.320	0.222	1.443			
LN(US_RMK_A_MLBS_PRD)	6.028	1.141	5.283			
Dependent Variable:						
LN(US_NFM_A_MLBS_DUS *1000*1000 / US_POP_A)				2007 - 2018	0.795	1.619
Independent Variables:						
INTERCEPT	1.291	4.946	0.261			
LN(US_GDP_PCAP_A / US_CPI_A)	-1.510	0.731	-2.067			
LN(US_NFM_A_MLBS_PRD)	1.140	0.289	3.940			
TREND_A	-0.027	0.014	-1.966			
DUM_2008	-0.154	0.066	-2.345			
DUM_2009	0.096	0.060	1.583			

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Appendix Table 13 - continued

Variables	Parameter Estimates	Standard Error	t-statistic	Sample Period	Adjusted R-square	Durbin-Watson
Dependent Variable:						
LN(US_NFM_A_MLBS_END)				2008 - 2018	0.917	1.765
Independent Variables:						
INTERCEPT	-5.093	3.271	-1.557			
LN(US_NFM_A_DLB_PRI)	-0.794	0.185	-4.296			
LN(US_CHZ_A_DLB_PRI)	1.755	0.363	4.838			
LN(US_NFM_A_MLBS_PRD)	1.290	0.454	2.842			
DUM_2015	-0.228	0.099	-2.303			
DUM_2017	0.191	0.101	1.898			
Dependent Variable:						
LN(US_NFM_A_DLB_PRI)				2006 - 2018	0.983	1.974
Independent Variables:						
INTERCEPT	-7.243	0.305	-23.750			
LN(OC_SMP_M_DMT)	0.927	0.038	24.107			
DUM_2014	0.195	0.042	4.656			
Dependent Variable:						
LN(US_RMK_A_DCWT_PRI)				2006 - 2018	0.931	1.749
Independent Variables:						
INTERCEPT	2.539	0.035	72.846			
LN(US_BT_A_DLB_PRI)	0.459	0.057	8.056			
LN(US_NFM_A_DLB_PRI)	0.501	0.044	11.356			

Component Allocation and Residual Product Production:

$$Fat\ Supply_t = Milk\ Production_t \times MFat_t$$

$$Fat\ Use_t^{BUT} = Fat\ Supply_t - Fat\ Use_t^{FL} - Fat\ Use_t^{SMP} - Fat\ Use_t^{CHZ} - Fat\ Use_t^{OT}$$

$$Butter\ Production_t = Fat\ Use_t^{BUT}/0.802$$

$$Prt\ Supply_t = Milk\ Production_t \times MPrt_t$$

$$Prt\ Use_t^{NFDM} = Prt\ Supply_t - Prt\ Use_t^{FL} - Prt\ Use_t^{SMP} - Prt\ Use_t^{CHZ} - Prt\ Use_t^{OT}$$

$$NFMD\ Production_t = Prt\ Use_t^{NFDM}/0.3357$$

where,

t = year

MFat = fat level in milk, percent

MPrt = protein level in milk, percent
Fat = milk fat
Prt = protein
BUT = butter
SMP = skim milk powder
NFDM = nonfat dry milk
FL = fluid milk
CHZ = cheese
OT = other uses

Appendix Table 14. Assumptions for US Component Content of Key Dairy Products

	------------- Dairy Component Content (%) -------------			
	Fat	True Protein	Other Dairy Solids	Moisture
Fluid Milk:				
Whole milk	3.3%	3.0%	5.4%	88.3%
Reduced fat 2%	2.0%	3.1%	5.6%	89.3%
Low fat 1%	1.0%	3.2%	5.9%	89.9%
Skim	0.2%	3.2%	5.8%	90.8%
Butter	80.2%	0.4%	2.4%	17.0%
Cheese:				
Cheddar	32.9%	24.5%	4.9%	37.7%
Mozzarella	15.9%	24.3%	6.0%	53.8%
Other cheese	27.5%	22.2%	6.2%	44.0%
Nonfat dry milk	0.7%	33.6%	61.9%	3.8%
Skim Milk Powder CODEX	0.6%	30.9%	64.7%	3.7%

Endogenous Variables:

US_RMK_A_MLBS_PRD = US estimated milk production, mil lbs.

US_FT_A_PCT = average USDA test for fat in milk in federal milk marketing orders, %.

US_TPRT_A_PCT = average USDA test for True Protein in milk in federal milk marketing orders, %.

US_FLDRK_A_MLBS_SVOL = estimated total US fluid milk products, sales volume, mil lbs.

US_CHZ_A_MLBS_PRD = total US cheese production, mil lbs.

US_SMP_A_MLBS_PRD = US production of skim milk powder, mil lbs.

US_NFM_A_MLBS_DUS = US domestic use of nonfat dry milk, mil lbs.

US_NFM_A_MLBS_END = US ending stocks of nonfat dry milk, mil lbs.

Exogenous Variables:

US_CHZ_A_DLB_PRI = federal order cheese price, US dollars/lb.

US_BT_A_DLB_PRI = federal order butter price, US dollars/lb.

US_ODS_A_PCT = average USDA test for Other Dairy Solids in federal milk marketing orders, %.

US_FLM_BF_PCT = average annual fat level in total US fluid milk production, %.

US_FLM_PR_A_PCT = average annual True Protein in total US fluid milk production, %.

US_CHZ_BF_A_PCT = average annual fat level in total US cheese production, %.

US_CHZ_PR_A_PCT = average annual True Protein in total US cheese production, %.

US_POP_A = US population.

US_GDP_PCAP_A = US GDP per capita, current US dollars

US_CPI_A = US consumer price index, all items, US city average, no seasonally adjusted, 1982-84=100.

US_NFM_A_MLBS_IMP = US imports of nonfat dry milk, mil lbs.

TREND_A = trend, 2000 = 1.

DUM_2013 = dummy variable, 2013=1.

DUM_2014 = dummy variable, 2014=1.

DUM_2015 = dummy variable, 2015=1.

DUM_2017 = dummy variable, 2017=1.

Belarus Submodel

In 2018 the country of Belarus exported 121,428 mt of SMP. They were the 5th largest exporter following the EU, US, New Zealand, and Australia. The Republic of Belarus is a small country in Northeast Europe that borders Russia. They have a small population of 9.5 million, a relatively low GDP (US$6,304/capita according to the World Bank), and they have their own currency, the Belarusian ruble (BYN).

Milk production in Belarus has grown at a compounded annual rate of 1.4% since 2012, whereas their internal population has been stable. Much of the excess milk has been exported overseas, particularly to Russia and other former CIS countries. Dairy exports are an excellent source of foreign exchange earnings which has no doubt helped offset their internally high rates of inflation.

The data source used in this submodel is from the National Statistical Committee of the Republic of Belarus, as well as macro data from the IMF. Milk production was estimated as a function of the nominal price of raw milk in Belarus divided by a CPI index, and the BYN/USD exchange rate. Over the period of estimation, the value of the Belarus ruble has declined relative to the US dollar. In addition, the domestic population remained relatively flat. It was hypothesized that as the value of the US dollar increased, dairy farmers produced more milk for the export market. Thus, milk production is negatively correlated to the BYN/USD exchange rate.

The farm price of milk in Belarus was estimated as a function of the global prices of SMP, butter, and cheese, which are major exports for Belarus. The dependent variable was first corrected for inflation and then converted to USD. Only the global price of SMP was positively correlated.

The final step in the model was to estimate the relationship between milk production and SMP exports. Normally this would be done by first estimating internal production and consumption of dairy products. However, given the limited availability of data, SMP exports were directly estimated as a function of domestic milk production. The fact that there was a positive coefficient and a high R-square indicates that SMP exports have grown proportionally with production.

The estimated model has a supply elasticity of 0.15 for milk production with respect to the real farm gate milk price. Under simulation, the elasticity of excess supply for SMP with respect to the global price of SMP averaged 0.70 over the period 2012-18.

Appendix Table 15. Belarus Dairy Model Elasticities.

	Supply own price	Price Linkage
Milk	0.15	
Farm gate milk price [a]		1.277
Derived Skim Milk Powder Excess Supply [a]	0.7	

[a] Average derived elasticity simulated over the period 2012-18.

Appendix Table 16. Belarus Dairy Model Parameter Estimates

Variables	Parameter Estimates	Standard Error	t-statistic	Sample Period	Adjusted R-square	Durbin-Watson
Dependent Variable:						
LN(BLR_RMK_CY_TMT_PRD)				2011 - 2018	0.944	1.528
Independent Variables:						
INTERCEPT	8.196	0.293	27.938			
LN(BLR_RMK_CY_BYN_MT_PRI / BLR_CPI_CY_IND)	0.150	0.070	2.157			
LN(BLR_US_CY_EXR)	0.073	0.010	7.315			
DUM_2014	-0.038	0.015	-2.638			
Dependent Variable:						
LN(BLR_SMP_CY_MT_EXP)				2008 - 2018	0.869	1.998
Independent Variables:						
INTERCEPT	-21.694	5.797	-3.743			
LN(BLR_RMK_CY_TMT_PRD)	3.753	0.656	5.719			
DUM_2010_11	-0.324	0.086	-3.765			
Dependent Variable:						
LN[(BLR_RMK_CY_BYN_MT_PRI / BLR_CPI_CY_IND) /BLR_US_CY_EXR]				2011 - 2018	0.729	1.321
Independent Variables:						
INTERCEPT	-5.941	2.244	-2.648			
LN(OC_SMP_A_DMT)	1.261	0.283	4.454			

Endogenous variables:

BLR_RMK_CY_TMT_PRD = Belarus milk production, thou MT

BLR_SMP_CY_MT_EXP = Belarus SMP exports, MT

BLR_RMK_CY_BYN_MT_PRI = Belarus raw milk farm prices, denominated in BYN/MT

Exogenous variables:

BLR_CPI_CY_IND = Belarus CPI index derived from consumer inflation (IMF), index 2005=1

BLR_US_CY_EXR = Belarus ruble to USD exchange rate, BYN/USD

DUM_2010_11 = dummy variable, equals 1 in 2010-11

DUM_2014 = dummy variable, equals 1 in 2014

Mexican Submodel

Mexico is a unique dairy production and consuming nation. Despite being located on the Tropic of Cancer and realizing a fair bit of sunshine and heat, the country is a major milk producer. They are also a major dairy consumer with a population over 130 million and per capita dairy consumption of roughly 117 liters of Milk Equivalent per person (for comparison, over 260 liters of ME per person in the US). Mexico consumes more dairy products than they produce, thus they are a net importer. In the last few years Mexico actually exported some product to Venezuela, mainly SMP, and therefore imported more than they normally do. Another unique aspect of the country is that while their consumers pay in Mexican pesos for dairy products, the country must import product in US dollars. Mexico has also experienced a moderate level of inflation which ranged from 2.7-6% over the period of study from 2012 to 2018.

Mexico has a solid statistical reporting system for agriculture, and in particular dairy. Most of the data used in this report was from a Mexican government quarterly publication called the "Milk Bulletin" which is produced by SIAP-SAGARPA. While it does not report average milk components, it does detail milk production and dairy product production. Thus, one came make assumptions on milk component content and approximate a mass balance.

Mexican milk production was estimated as a function of the farm-gate price of milk. The farm-gate milk price was in turn estimated as a linkage equation in relation to global prices for SMP and butter, as well as a measure of Mexican inflation. The hypothesis was that as inflation rose, the local farm price denominated in pesos would increase. Milk is than allocated to domestic processing needs. Fresh dairy products, including fluid drinking milk and cream, were estimated on a per capita basis as a function of price and income. Retail fluid milk prices were available, but none on cream. Yogurt production, which declined over the period of study, was not statistically related to income. Manufactured dairy products such as cheese and whole milk powder were estimated next. Cheese production was estimated as a function of milk production and real per capita income. Cheese production continued to grow in relation to the milk supply over the period of study, from 14.7% of available protein from farm milk in 2012 to 19% by 2018. Rising GDP was hypothesized to be an important factor that contributed to the allocate of milk components to cheese production. Whole milk powder production steadily rose from 2012 to 2016 and peaked at 143,575 mt, then declined thereafter. The development of a statistically relevant WMP model was not successful. Infant formula production was also difficult to estimate. Year to year production of infant formula was relatively stable, growing from 75,000 mt in 2013 to 77,700 mt by 2018. Thus yogurt, WMP and infant formula production were considered exogenous variables in this model.

Butter and SMP production were derived as a residual component after satisfying both fresh and manufacturing needs. Both production levels are relatively small when compared to cheese, yogurt and WMP production.

The key variable to estimate for Mexico is domestic use of SMP. In fact the goal of the model was to create an excess demand submodel that is a function of the global price of SMP. To do that, SMP production was derived from component allocations for milk protein (residual use), estimated per capita domestic use of SMP as a function of the global price of SMP and real GDP in pesos, and assumed exports were a residual. Exports of SMP were almost nonexistent until 2016 when Mexico began to ramp up exports to Venezuela. Thus excess demand was defined as follows:

Mexican Excess Demand for SMP = SMP Production – SMP Exports – SMP Domestic Use

In theory, as internal farm milk prices rose, SMP production would rise all else the same. Thus excess demand would decline. Likewise, as global SMP prices rose, internal SMP prices would rise, reducing demand for domestic consumption. Thus excess demand would decline.

Appendix Table 17. Mexican Dairy Model Elasticities with Respect to SMP

	Supply	------- Demand -------		Price
	own price	own price	income	Linkage
Milk	0.312			
Fluid milk, per capita consumption		-1.245	-0.44	
Cheese allocation			0.445	
Cream allocation			0.484	
Infant formula production			0.118	
Skim Milk Powder Domestic use per capita		-0.302	3.497	
Farm milk price wrt Oceania SMP price				0.091
Derived Skim Milk Powder Excess Supply [a]		-0.29		

[a] Average derived elasticity simulated over the period 2012-18 with respect to the Oceania SMP price.

Appendix Table 18. Mexican Dairy Model Parameter Estimates

Variables	Parameter Estimates	Standard Error	t-statistic	Sample Period	Adjusted R-square	Durbin-Watson
Dependent Variable:						
LN(MEX_RMK_A_MLT_PRD)				2007 - 2018	0.824	0.630
Independent Variables:						
INTERCEPT	8.793	0.071	123.146			
LN(MEX_MK_A_PPL)	0.312	0.043	7.253			
Dependent Variable:						
LN(MEX_FLDRK_A_MLT*1000*1000 / MEX_POP)				2007 - 2018	0.886	1.871
Independent Variables:						
INTERCEPT	8.747	1.207	7.249			
LN(MEX_FL_A_PPL)	-1.245	0.179	-6.953			
LN(MEX_PCAP_GDP / MEX_DEFL_A)	-0.440	0.173	-2.551			
Dependent Variable:						
LN(MEX_CHZ_PRD_A_MT)				2007 - 2018	0.946	1.161
Independent Variables:						
INTERCEPT	-43.104	7.067	-6.099			
LN(MEX_RMK_A_MLT_PRD)	5.768	0.674	8.558			
LN(MEX_PCAP_GDP / MEX_DEFL_A)	0.445	0.194	2.299			

-- *continued*

Appendix Table 18. - continued

Variables	Parameter Estimates	Standard Error	t-statistic	Sample Period	Adjusted R-square	Durbin-Watson
Dependent Variable:						
LN(MEX_CRM_PRD_A_MT*1000 / MEX_POP)				2010 - 2018	0.819	1.729
Independent Variables:						
INTERCEPT	-3.982	0.397	-10.030			
LN(MEX_PCAP_GDP / MEX_DEFL_A)	0.484	0.087	5.541			
DUM_2015	0.129	0.039	3.273			
Dependent Variable:						
LN(MEX_SMP_DUS_A_MT*1000/ MEX_POP)				2007 - 2018	0.694	1.225
Independent Variables:						
INTERCEPT	-22.178	7.741	-2.865			
LN (OC_SMP_A_DMT)	-0.302	0.154	-1.960			
LN(MEX_PCAP_GDP*MEX_US_A_EXR/MEX_DEFL_A)	3.497	0.998	3.504			
DUM_2012	0.278	0.141	1.969			
DUM_2018	-0.201	0.162	-1.239			
Dependent Variable:						
LN(MEX_MK_A_PPL)				2007 - 2018	0.944	1.426
Independent Variables:						
INTERCEPT	-3.043	0.658	-4.628			
LN(OC_SMP_A_DMT)	0.091	0.048	1.884			
LN(OC_BT_A_DMT)	-0.143	0.062	-2.311			
LN(MEX_DEFL_A)	1.120	0.118	9.461			

Production Identities:

MEX_RMK_A_TMT_PRD = 1.033*MEX_RMK_A_MLT_PRD

MEX_FLDRK_A_TMT_DUS = 1.033*MEX_FLDRK_A_MLT_US

Component Allocation and Residual Product Production:

$$Fat\ Supply_t = Milk\ Production_t \times MFat_t$$

$$Fat\ Use_t^{BUT} = Fat\ Supply_t - Fat\ Use_t^{FL} - Fat\ Use_t^{CHZ} - Fat\ Use_t^{CRM} - Fat\ Use_t^{YGT} - Fat\ Use_t^{WMP} - Fat\ Use_t^{OT}$$

$$Butter\ Production_t = Fat\ Use_t^{BUT}/0.8299$$

$$Prt\ Supply_t = Milk\ Production_t \times MPrt_t$$

$$Prt\ Use_t^{SMP} = Prt\ Supply_t - Prt\ Use_t^{FL} - Prt\ Use_t^{CHZ} - Prt\ Use_t^{YGT} - Prt\ Use_t^{WMP} - Prt\ Use_t^{INF} - Prt\ Use_t^{OT}$$

$$SMP\ Production_t = Prt\ Use_t^{SMP}/0.329$$

where,

t = year
MFat = fat level in milk, percent
MPrt = protein level in milk, percent
BUT = butter
SMP = skim milk powder
NFDM = nonfat dry milk
FL = fluid milk
CHZ = cheese
CRM = fluid cream, heavy
YGT = yogurt, plain
WMP = whole milk powder
INF = infant formula, retail, dry
OT = other uses

Endogenous Variables:

MEX_RMK_A_MLT_PRD = Mexican milk production, mil liters

MEX_RMK_A_TMT_PRD = Mexican milk production, thou mt

MEX_FLDRK_A_MLT_DUS = Mexican drinking milk, mil liters

MEX_FLDRK_A_TMT_DUS = Mexican drinking milk, thou mt

MEX_CHZ_A_MT_PRD = Mexican total cheese production, mt

MEX_CRM_A_MT_PRD = Mexican fresh cream, Crema de leche natural, mt

MEX_SMP_A_MT_DUS = Mexican skim milk production, mt

MEX_MK_A_PPL = Mexican farm-gate milk price, pesos/liter

MEX_BUT_A_MT_PRD = Mexican butter production, mt

MEX_SMP_A_MT_PRD = Mexican SMP production, mt

Exogenous Variables:

MEX_POP = Mexican annual population

MEX_PCAP_GDP = Mexican nominal per capita GDP, US$/person

MEX_DEFL_A = Mexican GDP deflator

MEX_US_A_EXR = annual exchange rate, Mexican pesos per US dollar

MEX_FL_A_PPL = price of Parmalat ultra-pasteurized milk, whole, retail, Mexican pesos/liter

MEX_YGT_A_MT_PRD = Mexican yogurt production, mt

MEX_INF_A_MT_PRD = Mexican infant formula, Para lactantes, mt

MEX_WMP_A_MT_PRD = Mexican whole milk production, mt

OC_BT_A_DMT = USDA Oceania butter price, US$/mt

DUM_2012 = dummy variable, 2012 = 1

DUM_2015 = dummy variable, 2015 = 1

DUM_2018 = dummy variable, 2018 = 1

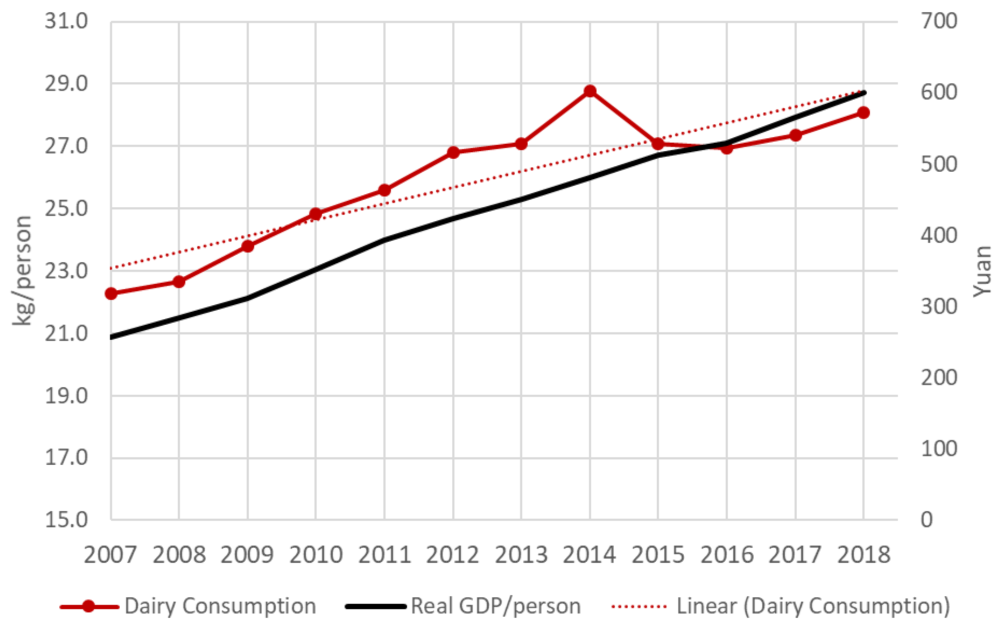
China Submodel

China is the largest dairy importer in the world. In 2014 China imported 670,043 mt of WMP and 252,840 mt of SMP. Two factors contributed to this high level of imports. First, the Chinese government has focused on improving the diets of their citizens. And rising per capita incomes helped to finance this growing demand. The second factor is the melamine crisis of 2008 which created a lack of confidence in the local milk supply. Imports of retail infant formula have grown steadily from 42,179 mt in 2008 to 333,117 mt by 2018. Chinese milk production has not kept pace with demand as the Government imposed new standards in order to improve milk quality. Despite one of the highest farm-gate milk prices in the word, the production of milk actually fell from 31.749 million metric tons in 2012 to 30,746 million metric tons in 2018.

In terms of data, there were three sources available. The official source for milk production and the farm-gate milk price is the National Bureau of Statistics of China. For fluid milk consumption and dairy product production the PS&D database estimated by USDA's FAS was used. For imports and exports, Global Trade Atlas was used.

The allocation of milk components was approximated by comparing milk production to component use in fluid drinking milk, and WMP and SMP production. There were two obvious conclusions. First, very little SMP is actually produced in China. FAS estimates that SMP production declined from 60 thousand MT in 2005 to 20 thousand MT in 2018. Second, roughly 40% of the fat and 26% of the protein was unaccounted for in the component allocation. The conclusion is that all of this missing or unallocated components likely is used in fresh dairy product processing or beverage use that was not accounted for with the limited dataset. Another important factor is that imports of lower priced milk components are blended with higher priced domestic milk in order to lower the overall cost of dairy processing.

Domestic consumption of dairy ingredients computed on a milk equivalent basis is generally correlated with rising inflation adjusted GDP per person (see figure below). The exception was the stock building years of 2012-14 and the stock depleting years of 2015-16. In terms of a global SMP model, there was no need to endogenize the local milk supply since very little of the milk components ended up in SMP production, and the latter has dramatically trended lower over time. Second, in terms of consumption, efforts were placed on endogenizing the domestic demand for SMP which is defined as production plus imports less exports. An econometric model was estimated to endogenize domestic SMP consumption.



Appendix Figure 1. Estimated Chinese Dairy Consumption: Liquid Milk Equivalents

Appendix Table 19. China Dairy Model Elasticities with Respect to SMP

	Supply	------- Demand -------		Price
	own price	own price	income	Linkage
Milk	0.097			
Skim Milk Powder Domestic use per capita		-0.853		
Farm milk price wrt Oceania SMP price				0.304
Derived Skim Milk Powder Excess Supply [a]		-0.93		

[a] Average derived elasticity simulated over the period 2012-18 with respect to the Oceania SMP price.

Appendix Table 20. China Dairy Model Parameter Estimates

Variables	Parameter Estimates	Standard Error	t-statistic	Sample Period	Adjusted R-square	Durbin-Watson
Dependent Variable:						
LN(CHN_SMP_A_MT_DUS * 1000 / CHN_POP)				2009 - 2018	0.756	2.260
Independent Variables:						
Constant	6.522	2.648	2.463			
LN(OC_SMP_A_DMT * CHN_US_A_EXR)	-0.853	0.270	-3.156			
DUM_2009	-0.651	0.165	-3.946			
DUM_2013_14	0.587	0.153	3.837			
DUM_2015_16	-0.181	0.145	-1.250			

Identities:

CHN_SMP_A_MT_IMP = CHN_SMP_A_MT_DUS – CHN_SMP_A_TMT_PRD*1000 + CHN_SMP_A_MT_EXP

Endogenous variables:

CHN_SMP_A_MT_DUS = Chinese domestic consumption of SMP, mt.

CHN_SMP_A_MT_IMP = Chinese imports of SMP, mt.

Exogenous variables:

CHN_POP = Chinese population, persons.

CHN_US_A_EXR = exchange rate, Chinese yuan per US dollar.

CHN_SMP_A_TMT_PRD = Chinese SMP production, mt.

CHN_SMP_A_MT_EXP = Chinese SMP exports, mt.

DUM_2009 = dummy variable, 2009=1, reflects the drop in domestic production due to new Chinese regulations affecting small dairy farm.

DUM_2013_14 = dummy variable, 2013 to 2014 = 1, reflects period of SMP stock building.

DUM_2015_16 = dummy variable, 2015-16 = 1, reflects period of SMP stock depletion.

Rest of the World Submodel

In this portion of the model the focus is on key importing countries and regions. For the period 2007-18 the key importing countries regions outside of Mexico and China are SE Asia (Indonesia, Philippines, Malaysia, Thailand, and Singapore), North Africa (Algeria and Egypt), Russia, Japan and Pakistan. In 2018 these countries, along with Mexico and China, accounted for 84% of global SMP imports are reported by Global Trade Atlas.

The data sources for trade was Global Trade Atlas. For population it was the World Bank. For GDP and inflation it was the International Monetary Fund's World Economic Outlook database. For exchange rates, the USDA's Economic Research Service annual nominal exchange rate database was used.

SE Asia was aggregated into one region by summing net imports, population, and current GDP as measured in US dollars. For inflation, the average consumer prices (percent change) by country as reported by the International Monetary Fund was used, and then created an index (2005=100). From there a regional CPI index was constructed by weighting the individual country inflation indexes by population.

Appendix Table 21. Global Excess Demand Elasticities with Respect to SMP

	Own Price	Income
Southeast Asia	-0.245	0.592
Japan	-0.219	-0.967
Algeria	-0.265	1.175
Egypt	-0.349	2.037
Pakistan	-0.619	1.075
Russia	-1.484	7.9
Rest-of-the-world	-0.673	2.092

Appendix Table 22. Global Excess Demand Parameter Estimates

Variables	Parameter Estimates	Standard Error	t-statistic	Sample Period	Adjusted R-square	Durbin-Watson
Dependent Variable:						
LN(SEA_SMP_A_MT_NIM * 1000 / SEA_POP)				2005 - 2018	0.786	2.935
Independent Variables:						
INTERCEPT	10.987	2.328	4.719			
LN(OC_SMP_A_DMT / SEA_CPI_IND)	-0.245	0.043	-5.732			
LN((SEA_GDP_BUSD/SEA_POP)/SEA_CPI_IND)	0.592	0.133	4.445			
Dependent Variable:						
LN(DZA_SMP_A_MT_NIM * 1000 / DZA_POP)				2005 - 2017	0.429	2.268
Independent Variables:						
INTERCEPT	18.116	7.094	2.554			
LN(OC_SMP_A_DMT * DZA__US_A_EXR / DZA_CPI_IND)	-0.265	0.204	-1.298			
LN[(DZA_GDP_BUSD * DZA__US_A_EXR / DZA_POP)/ DZA_CPI_IND]	1.175	0.492	2.388			
DUM_2014	0.305	0.164	1.865			
Dependent Variable:						
LN(EGY_SMP_A_MT_NIM * 1000 / EGY_POP)				2007 - 2018	0.454	1.008
Independent Variables:						
INTERCEPT	33.858	16.144	2.097			
LN(OC_SMP_A_DMT * EGY__US_A_EXR / EGY_CPI_IND]	-0.349	0.345	-1.011			
LN[(EGY_GDP_BUSD * EGY__US_A_EXR / EGY_POP)/ EGY_CPI_IND]	2.037	1.054	1.933			
DUM_2011	0.667	0.335	1.988			

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Appendix Table 22. - continued

Variables	Parameter Estimates	Standard Error	t-statistic	Sample Period	Adjusted R-square	Durbin-Watson
Dependent Variable:						
LN(PAK_SMP_A_MT_NIM * 1000 / PAK_POP)				2010 - 2018	0.641	1.942
Independent Variables:						
INTERCEPT	20.110	22.654	0.888			
LN(OC_SMP_A_DMT / PAK_CPI_IND)	-0.619	0.172	-3.605			
LN[(PAK_GDP_BUSD / PAK_POP) / PAK_CPI_IND]	1.075	1.175	0.915			
Dependent Variable:						
LN(RUS_SMP_A_MT_NIM * 1000 / RUS_POP)				2006 - 2018	0.480	1.650
Independent Variables:						
INTERCEPT	110.760	31.107	3.561			
LN(OC_SMP_A_DMT * RUS__US_A_EXR / RUS_CPI_IND)	-1.484	1.225	-1.211			
LN[(RUS_GDP_BUSD * RUS__US_A_EXR / RUS_POP) / RUS_CPI_IND]	7.903	2.313	3.417			
Dependent Variable:						
LN(JPN_SMP_A_MT_NIM * 1000 / JPN_POP)				2005 - 2018	0.915	3.125
Independent Variables:						
INTERCEPT	-15.280	2.806	-5.445			
LN(OC_SMP_A_DMT / JPN_CPI_IND)	-0.219	0.074	-2.949			
LN[(JPN_GDP_BUSD / JPN_POP) / JPN_CPI_IND]	-0.967	0.183	-5.298			
DUM_2016	-0.405	0.079	-5.130			
TREND_A	0.041	0.005	8.202			
Dependent Variable:						
LN(ROW_SMP_A_MT_NIM * 1000 / ROW_POP)				2005 - 2018	0.913	2.317
Independent Variables:						
INTERCEPT	28.934	2.662	10.868			
LN(OC_SMP_A_DMT)	-0.673	0.112	-5.988			
LN(ROW_GDP_BUSD / ROW_POP)	2.092	0.183	11.429			

Endogenous variables:

SEA_SMP_A_MT_NIM = South East Asia SMP net imports (Indonesia, Philippines, Malaysia, Thailand, and Singapore), annual, metric tons

DZA_SMP_A_MT_NIM = Algeria SMP net imports, annual, metric tons

EGY_SMP_A_MT_NIM = Egypt SMP net imports, annual, metric tons

PAK_SMP_A_MT_NIM = Pakistan SMP net imports, annual, metric tons

RUS_SMP_A_MT_NIM = Russian SMP net imports, annual, metric tons

JPN_SMP_A_MT_NIM = Japan SMP net imports, annual, metric tons

ROW_SMP_SMP_A_MT_NIM = Rest of the world SMP net imports, annual, metric tons

OC_SMP_A_DMT = Global price of SMP, Oceania, annual, US$/mt (solved simultaneously)

Exogenous Variables:

SEA_POP = South East Asian population, head

SEA_CPI_IND = South East Asian consumer inflation, index 2005=100

SEA_GDP_BUSD = South East Asian gross domestic product, current, billion US dollars

DZA_POP = Algeria population, head

DZA_CPI_IND = Algeria consumer inflation, index 2005=100

DZA_GDP_BUSD = Algeria gross domestic product, current, billion US dollars

EGY_POP = Egypt population, head

EGY_CPI_IND = Egypt consumer inflation, index 2005=100

EGY_GDP_BUSD = Egypt gross domestic product, current, billion US dollars

ROW_POP = rest of the world population, head

ROW_GDP_BUSD = rest of the world gross domestic product, current, billion US dollars

PAK_POP = Pakistan population, head

PAK_CPI_IND = Pakistan consumer inflation, index 2005=100

PAK_GDP_BUSD = Pakistan gross domestic product, current, billion US dollars

RUS_POP = Russian population, head

RUS_CPI_IND = Russian consumer inflation, index 2005=100

RUS_GDP_BUSD = Russian gross domestic product, current, billion US dollars

JPN_POP = Japan population, head

JPN_CPI_IND = Japan consumer inflation, index 2005=100

JPN_GDP_BUSD = Japan gross domestic product, current, billion US dollars

ROW_POP = Rest-of-the-world population

ROW_GDP_BUSD = Rest-of-the-world gross domestic product, current, billion US dollars