Analysis of Proposed Programs to Mitigate Price Volatility in the U.S. Dairy Industry

Charles F. Nicholson and Mark W. Stephenson

September 2010

Executive Summary

Volatility of prices and incomes has been an issue of importance for the U.S. dairy industry since the early 1990s. Much of this volatility appears to arise in the dairy supply chain, particularly the production sector, consistent with observed patterns of behavior for other commodities (both agricultural and non-agricultural). Volatility in prices and incomes has been brought to the fore by recent events, especially a prolonged period of inadequate income for many dairy farmers during 2008 to 2009. There are likely high costs associated with price and income volatility throughout the U.S. dairy supply chain, but accurate estimates of these costs do not currently exist. Given the costs, a number of programs have been proposed in recent years with the objective of reducing variation in milk prices and farm income. Key questions related to these programs are: 1) can they be effective at reducing variation in prices and income? and 2) do they have other effects that industry organizations consider either positive or negative?

This report summarizes our analysis of the three main programs currently proposed as mechanisms to reduce price and income variability:

- Legislation introduced by Costa (H.R. 5288) and Sanders (S. 3531) (hereafter CS);
- The Marginal Milk Pricing (MMP) program proposed by Agri-Mark;
- Elements of the Foundation for the Future (FFTF) program proposed by the National Milk Producers Federation.

Our analyses employ a complex systems modeling approach previously used for many other commodities that represents the U.S. dairy supply chain in significant detail. Although the analysis is undertaken at a national level, the model incorporates many product categories (intermediate and final), all current national dairy policies, a trade sector that accounts for interactions with the rest of the world and detailed representation of the proposed programs.

We compare the outcomes of each of the programs to a Baseline scenario (which assumes continuation of current policies and no new programs) for the period 2010 to 2018. We undertake this comparison assuming no shocks, a single large shock to feed costs and export demand, and a set of stochastic shocks for which the timing and magnitude of changes in feed cost and export demand are randomly chosen for 200 simulations. These shocks are not forecasts of the future, but represent the types and magnitude of shocks that may occur during the next 9 years. We also explore the impact of selected alternative program implementations and behavioral assumptions.

Our assessment focuses on the level and variation in the all milk price, the level of milk income less feed costs for dairy herds of a constant size, milk marketed, government expenditures, net exports of three key dairy products (American cheese, NDM and dry whey) and total sales of fluid milk and American cheese. These indicators provide a spectrum of outcomes of interest to dairy producers, processors, consumers and government policy makers.

Key Results

- All three programs would reduce milk price volatility significantly compared to the Baseline, both with and without shocks. Under the assumption of large shocks, the programs would reduce the average absolute deviation from $1.75/cwt to $1.26/cwt, $1.25/cwt and $1.13/cwt, respectively;

- Cumulative milk production from 2010-18 would be reduced by 0.4% to 0.7% under the MMP and FFTF (range with and without shocks). Milk production would be increased 0.6% to 0.8% under CS with assumed program parameters;

- All three programs would reduce government expenditures for dairy programs significantly. Under the assumption of large shocks, government expenditures would be reduced from about $3.2 billion over 2010-18 to $1.6 billion for MMP and FFTF and $1.1 billion for CS;

- The Marginal Milk Pricing (MMP) and the Foundation for the Future (FFTF) programs would increase the average All-Milk price by $0.23 and $0.17/cwt, respectively without shocks, and by $0.12/cwt and $0.06/cwt, respectively, with shocks. These price enhancement effects occur because MMP and FFTF spend collected monies on demand enhancing activities (modeled as food donations through non-commercial channels);

- The programs would have different effects on net exports of American cheese, NDM and dry whey. Under the scenarios assuming the large shock, the MMP and FFTF would reduce average monthly net exports of American cheese by 17% and 22% respectively, compared to the Baseline. Net exports would continue to grow under the programs, just a slower rate than under the Baseline. Moreover, the lower exports under MMP and FFTF would be offset to some degree by additional purchases for domestic markets. Average monthly dry whey exports would be reduced by 3.1% and 2.8% under MMP and FFTF, respectively. Because CS produces somewhat more milk than the Baseline, American cheese exports and dry whey exports would increase by 2.6% and 8.1% respectively, compared to the Baseline.

- The impact of the programs on cumulative fluid sales during 2010-18 would be less than 0.4% (the reduction under FFTF). The impact on cumulative domestic and export sales of American and other varies with the program. MMP and FFTF would reduce cumulative American cheese sales by 1.7% and 0.7% respectively. Reductions in cumulative other cheese sales would be 0.2% and 0.3% for MMP and FFTF, respectively. CS would increase cumulative sales of fluid milk by 0.2%, but decreases American cheese and other cheese by 0.5%, 1.0%, respectively.

- The programs would have different effects on Class III and IV prices. Due to purchases of American cheese, the MMP and FFTF programs tend to enhance Class III prices compared to the Baseline (an average over 2010-18 of $0.45/cwt and $0.57/cwt, respectively) for the scenario assuming large shocks. Average Class IV prices are higher under MMP ($0.09/cwt for 2010-18) and lower under FFTF ($0.04/cwt) compared to the Baseline for the scenario assuming large shocks, which implies a larger average price spread between Class III and IV. The CS tends to lower both Class III and IV prices ($0.14/cwt and $0.20/cwt) for 2010-18 assuming large shocks, but maintains a smaller price spread.

Acknowledgments

This study was carried out in part under a contract between a consortium of national and regional dairy industry organizations and Cal Poly. The organizations the provided partial financial support include:

Associated Milk Producers Inc.
Agri-Mark
Dairy Farmers of America
Dairy Farmers Working Together
Dairy Policy Action Coalition
Darigold
Family Dairies U.S.A.
Holstein Association U.S.A.
Milk Producers Council
National Farmers Organization
St. Albans Cooperative Creamery
Northeast Dairy Leadership Team, including:
  H.P. Hood
  Dairylea Cooperative
  Jefferson County Agricultural Development Corporation (NY)
  Pennyslvania Center for Dairy Excellence
  New York Center for Dairy Excellence
  Northeast Organic Dairy Producers Alliance
Upper South Milk Producers
Upstate Niagara Cooperative Inc.
Western United Dairymen

In addition to financial support, this research benefited from the comments, criticisms information and suggestions from a large number of individuals, only a few of which will be acknowledged here (in alphabetical order):

Scott Brown
Jaime Castaneda
Jim Grueble
Tiffany LaMendola
Andy Novakovic
Bill Schiek
Bill Van Dam
Rob Vandenheuvel
Peter Vitaliano
Bob Wellington
John Wilson

Other constructive comments and criticisms were offered by workshop participants on July 20-21, 2010 in Chicago, and during webinars for the funding organizations and the Dairy Policy Reform Task Force of the International Dairy Foods Association. As is always the case with a study such as this, any errors or omissions remain the responsibility of the authors.

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Introduction

Volatility predominates in supply chains for many commodities—from aircraft to zinc—and agricultural commodities are no exception (Sterman, 2000). Historically, one of the principal motivating factors for government intervention in agriculture has been the high degree of variability of farm incomes, in part because variations in revenues for businesses with large fixed costs results in large changes in net incomes (Knutson and Outlaw, 2010). A standard explanation for this variability in agriculture—usually measured by the degree of variation in farm-level prices—is that both supply and demand are inelastic, that is, changes in the amount produced or consumed are relatively insensitive to prices, at least over a short time horizon. Variation in prices and profitability also can be viewed more specifically from a supply chain perspective. Supply chains typically involve substantial time delays, so they are prone to oscillation. Sterman (2000) notes that "production in inventories chronically overshoot and undershoot the appropriate levels" in many industries, and it is common to observe what is called "amplification." The size (amplitude) of price oscillations tends to increase as one moves along the supply chain (that is, from consumer to farmer, in the case of agriculture) so that price and income variation is larger for primary suppliers (farmers) than for consumers.

Prices and other key indicators in the dairy industry have strong cyclical components (Nicholson, Stephenson and Novakovic, 2009). Why is such cyclical variation so prevalent for dairy and other commodities? Sterman (2000) argues that one source of the problem is a lack of information about the aggregated effects of individual businesses' (farms') impact. The individual company tends to view itself as small relative to the market and thus treats the market as beyond its control. Thus, firms (farms) tend to continue to invest and expand when profits are high, without regard for the production (expansion) decisions of others. When most businesses respond in this way to current profitability, "the result is overshoot and instability." Sterman also notes that a common explanation for commodity cycles is that demand is cyclical. He argues, however, that the evidence for this explanation is limited: commodity markets fluctuate far more than the economy as a whole (and therefore more than demand changes) and the cycles in commodities are not "entrained" (in line with the timing) to business cycle movements. This suggests that many commodity cycles are endogenous, that is, generated by the aggregated decisions of the companies in the supply chain. Nor are exogenous shocks typically a good explanation for observed variability in prices, in part because the cyclical patterns are often quite regular—in a way that (random) shocks would not be. Moreover, it is essential to ask why the current supply chain organization cannot mitigate random shocks (Nicholson and Fiddaman, 2003).

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Although farmer incomes have historically been the focal point for policy efforts, other companies in the supply chain often are affected by volatility. A recent and costly example is the U.S. housing market. In the U.S. dairy industry, concerns have been expressed about the loss of equity at the farm level and reductions in demand growth—both domestic and export—or modification of product formulations to use more non-dairy ingredients due to price variability. Sterman notes that "there is no doubt that instability and oscillation are costly," and adds that these costs are likely to occur in all levels and functions in the supply chain (including operations, reliability of suppliers, labor force, financial transactions, management, marketing, and pricing). Although in principle many of these costs are measurable (at least at the level of an individual firm), little or no information is available about the magnitude of these costs in the U.S. dairy supply chain. This restricts, to no small extent, the ability to assess the costs and benefits of alternative approaches to address volatility in the dairy industry.

The existence of persistent and pervasive costs of instability in commodity supply chains does not in and of itself suggest that government intervention to address the problem is appropriate. (In fact, such intervention is limited in most supply chains outside of agriculture.) There are a number of issues to be assessed to determine the desirability of government intervention. One such issue is whether private (individual firm) solutions could be developed and implemented at lower cost or greater effectiveness than government interventions. Examples of such interventions might be additional information about key (aggregated) supply chain decisions, forward contracts or risk management tools such as hedging with futures or options contracts. Information about supply chain developments is relatively well-developed in the dairy industry and risk management tools (also including the recent Livestock Gross Margin Insurance) have seen limited use by dairy producers. Perhaps new forms of information or additional incentives for private risk management could reduce volatility, particularly if some participation threshold is reached[2].

Another important issue is whether government interventions can be effective. The history of U.S. agricultural policy provides numerous examples of programs that were less effective than expected (payment limits and production controls are notable examples) or that had other undesirable (and sometimes unanticipated) negative consequences. The Dairy Price Support Program was implemented through the Agricultural Act of 1949. It provided a mechanism to moderate milk price swings by purchasing storable dairy products from the market during times of low milk prices and selling those products back into the market when prices were higher. The program was effective in moderating price volatility. However, it became clear that although a Dairy Price Support Program with a support price greater than $13/cwt provided price stability, that stability came at what was considered a large cost to the government in the 1980s.

Other dairy programs have been implemented to moderate milk production. Prior to the 1990s, much of price volatility was attributed to seasonal differences in the milk supply and demand for dairy products. A surge of calvings and a greater reliance on pastured-based feeding meant that the spring flush of milk was much greater than the fall production. This pattern of production was out of phase with consumption, which was lower during the

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[2] Bill Schiek of the Dairy Institute of California has suggested that this might be the case for hedging in the U.S. dairy industry.

summer and higher during the fall-winter holiday season. Attempts to modify producer supply patterns using financial incentives and disincentives through the Federal Milk Marketing Orders were common in the 1950s through the 1970s. Base-excess, takeout-payback and Louisville plans transferred a portion of income to producers who altered their production patterns from those who did not.

In the early 1980s the Milk Diversion Program made direct payments of $10 per hundredweight to producers who agreed to reduce their marketings 5 to 30% below their established base for a fifteen-month period of time. Later in the 1990s, Congress collected two separate 50-cent assessments from dairy producers. The first assessment was used to partially offset the large taxpayer expenditures on the Dairy Price Support Program but the second assessment was to be refunded to producers who reduced their marketings at least 8.4% below their base. This was later modified in the 1990 Omnibus Budget Reconciliation Act to an 11.25-cent assessment that was refunded to producers who held their milk marketings constant relative to the previous year.

A related question for the volatility of the supply chain is the nature of the problem to be addressed. As noted previously (Nicholson and Stephenson, 2009), the objective of limiting *variation* in prices (or incomes) is often blurred with the *adequacy* of the average price level, the *depth and length of low-price or low-income periods* and the *predictability* of price changes. Programs may be effective at addressing some but not all of these dimensions. Producers who simply wish to "take the bottom" out of milk price volatility are fundamentally requesting a higher average milk price—a price adequacy problem. If the problem is truly price volatility, then being willing to give up some of the price peaks to fill in some of the troughs should be an acceptable practice.

Finally, any government intervention would involve costs as well as potential benefits. The most visible and direct cost for many programs is government expenditures funded by taxpayers, but government programs also affect the distribution of income and wealth for all supply chain actors. In general, few policy options exist that are "Pareto superior," that is, that improve the economic well-being for all groups.

With this background, the objective of this report is to analyze likely market and income impacts of selected[3] programs currently under consideration to address price volatility in the U.S. dairy industry. We examine the nature of recent price variability in the U.S. dairy industry, describe the methods used for the analysis, the different assumptions, scenarios and programs analyzed and the numerical results for key variables—with a focus on how the programs affect variability in the All-Milk price. In keeping with our view of our obligations as academic professionals, we have no intention to promote or recommend any program, or indeed, any form of government intervention to address the issue of supply chain instability. In particular, when analysis suggests that the program may have what are viewed as positive effects, this should not imply that we support the implementation of the program.

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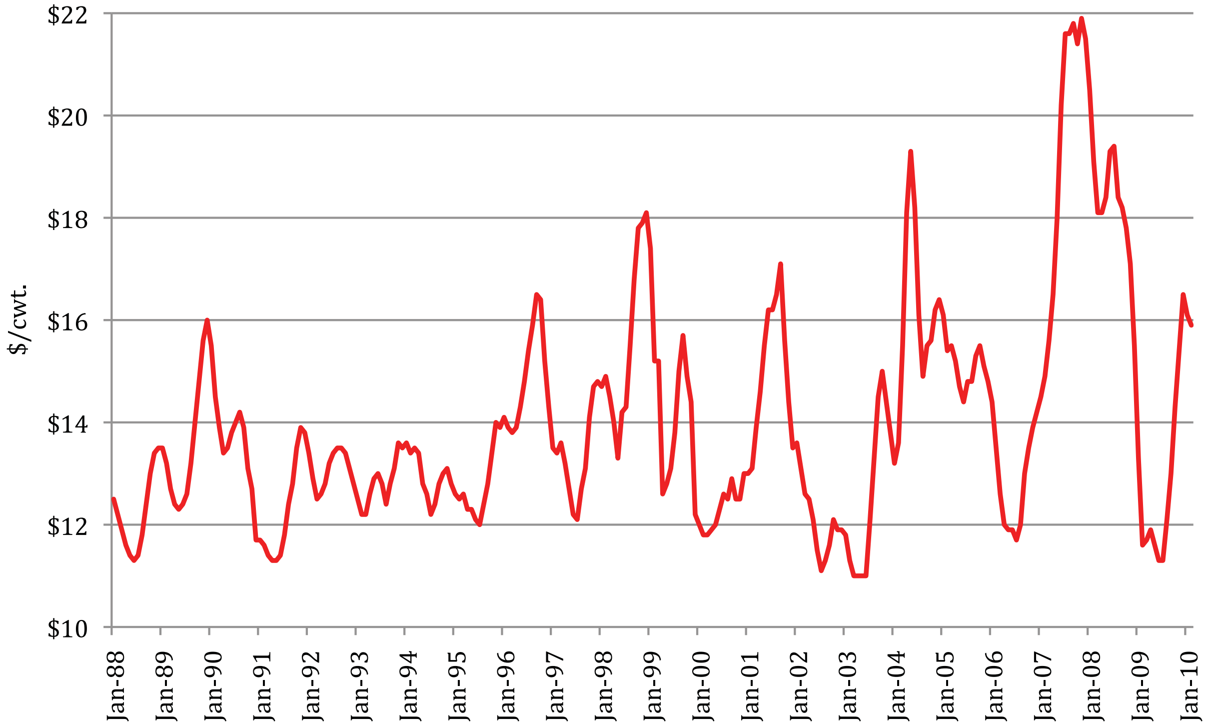
[3] The selection of programs in this case was primarily done by the study funders, with input from the authors. Other programs have been suggested but are beyond the scope of this study.

Volatility and Price Cycles in the U.S. Dairy Industry

It is often theorized that short-term milk price volatility is the result of highly inelastic supply of milk and demand for dairy products. Visual assessment of the U.S. All-Milk price from 1988 to 2009 shows an apparently random price with movements of $10 per hundredweight over a short period of months (Figure 1).

Figure 1. U.S. All-Milk Price, 1988-2010



Although the price movements appear to be random, a combination of cycles explains much of the variation. Using time series statistical techniques[4] to decompose the price series, 4 cycles explain most of the observed price movements (Figure 2). A short cycle, 9 months in length, is statistically significant. Although the underlying causes of these cycles require further research, a 9-month cycle in the dairy industry may be related to the gestation of a calf. A second cycle is seasonal, or 12 months in length. This cycle has been with the dairy industry for at least a century and has a very similar impact (about ±40 cents per cwt.) over a long period of decades. There also is an intermediate length cycle of about 26 months in length. The fourth cycle is of a longer period, 36 months. This 36-month cycle has become the largest component of cyclical variation in the All-Milk price.

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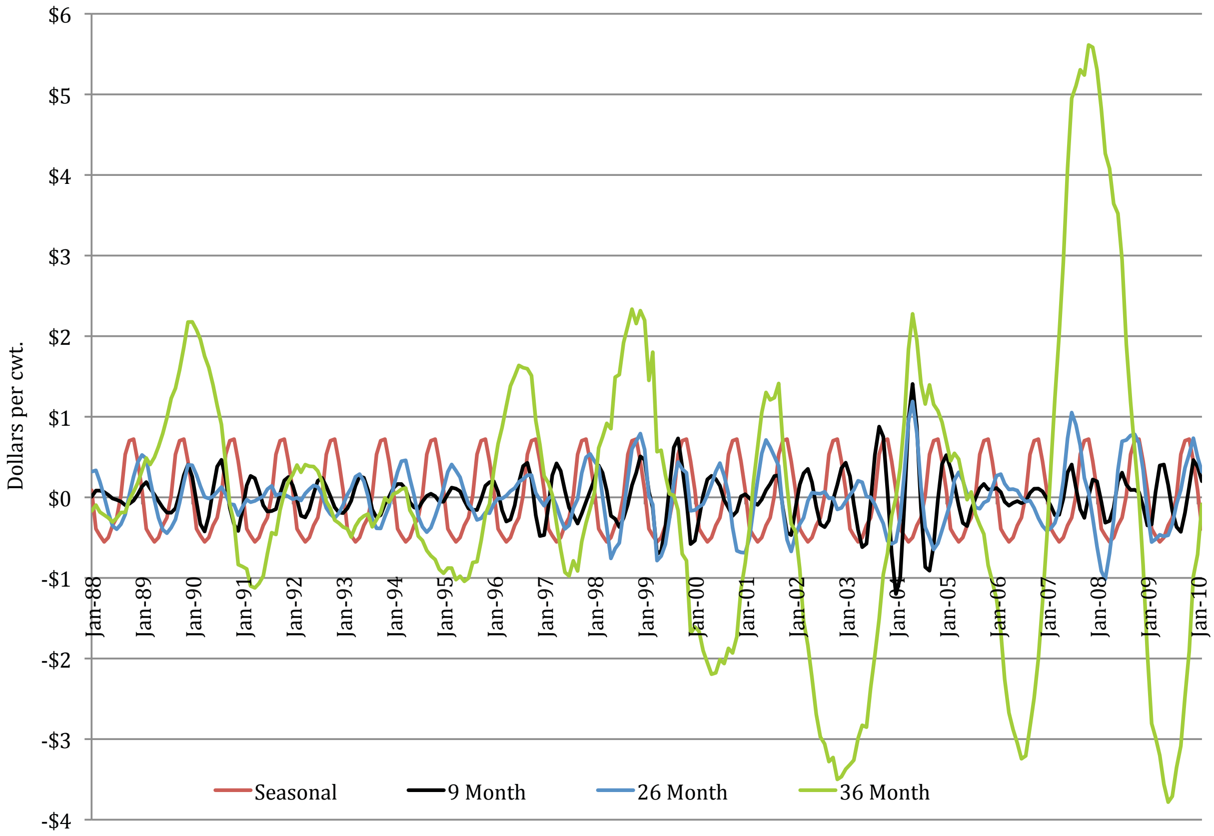
[4] State-space methods (Durbin and Koopmans, 2001) are used in this case.

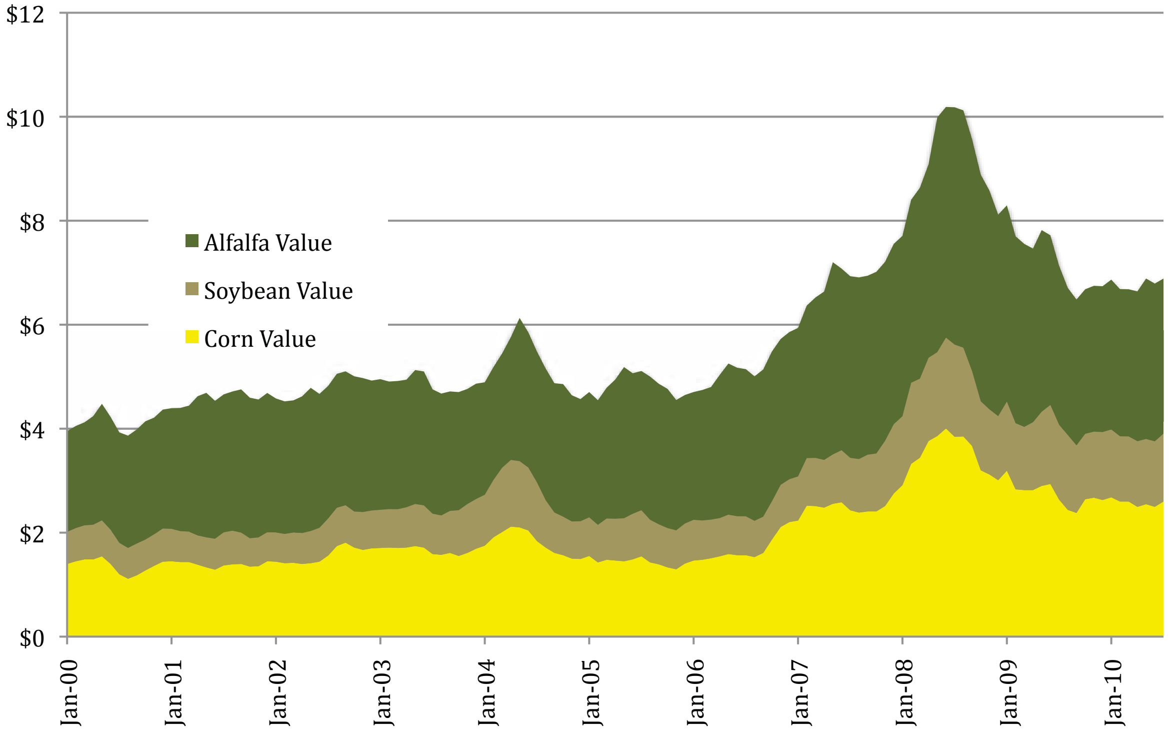
Figure 2. Decomposition of All-Milk Price Cycles, 1988-2010



The 36-month cycle appears consistent with the length of time required for a dairy producer to expand milk production by the decision to not cull a cow, raise her calf, breed the heifer and get that progeny into the milking herd. These cycles explain much of the variability that we observe in milk prices and suggest that much is "endemic" to the dairy industry. That is, this variability is complex but, to a certain extent, predictable.

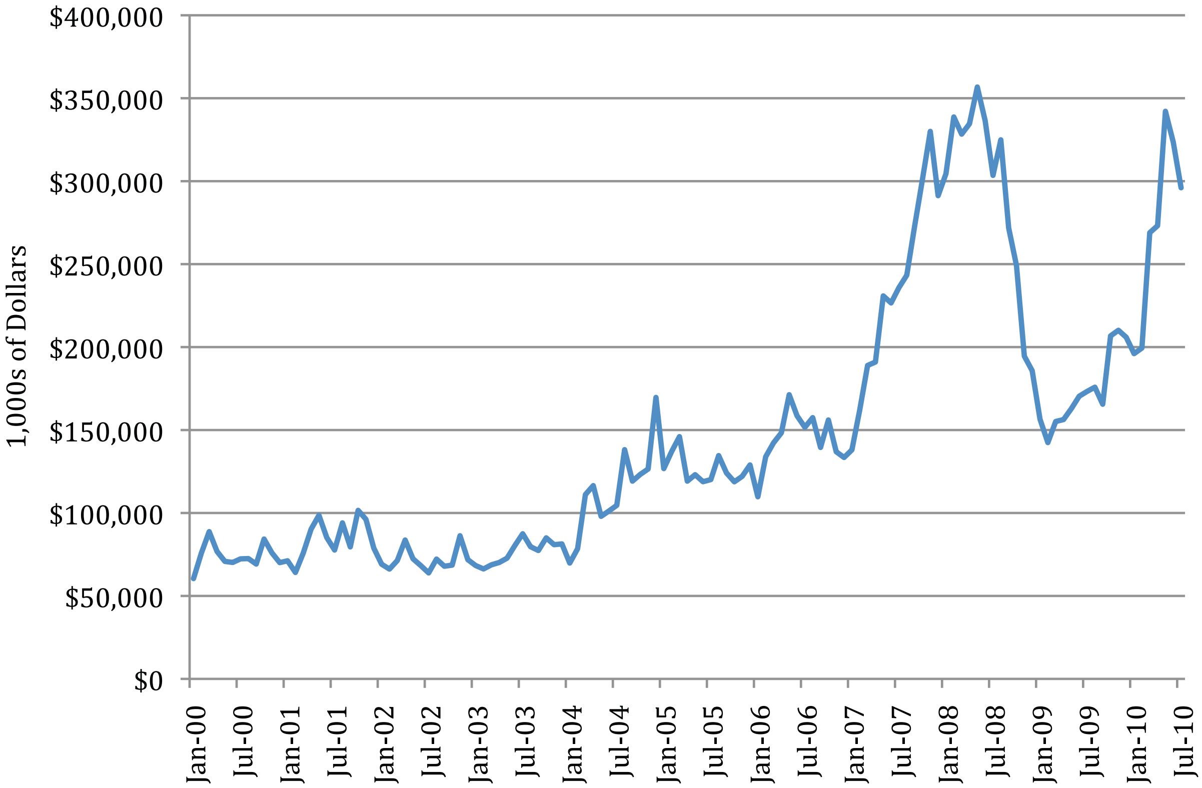
However, there are also contributors to variability that are not predictable, which an economist would call "shocks". An economic shock is an unanticipated event that temporarily increases or decreases the supply or demand for goods or services. The dairy industry has seen a few substantial shocks in recent years. In response to high fuel prices, incentives created to produce more renewable fuels—ethanol from corn and biodiesel from soybeans. This new demand for corn and soybeans is one cause of higher prices for the grains and other crops, such as alfalfa, because demand increased for land to grow biofuel crops. This resulted in an increase in the cost of feed (Figure 3). This shows the National Agricultural Statistics Service value of 100 pounds of dairy ration. This value had been fairly stable around $5 for many years but doubled over a short period of time before settling to a new plateau around $7. This was a significant supply shock for the dairy industry.

Figure 3. NASS Dairy Ration Value, 2000-2010



In 2007 several global events combined to dramatically increased exports of dairy products from the U.S. Common Agricultural Policy reforms in the European Union reduced their dairy export subsidies, making less product available for world trade. A simultaneous drought in Oceania reduced production of dairy products from two principal world suppliers. China was experiencing dramatic growth in GDP and increased demand for animal products. Finally, the U.S. dollar weakened relative to other major currencies, which increased incentives for U.S. exports. During this period, the U.S. exported between 10 and 12% of milk solids, compared to a historical average of 3 to 4% (Figure 4). The combined effect of these events was a global demand shock that overlapped with the U.S. supply shock. These demand and supply shocks resulted in historically high U.S. milk prices in 2008. However, global demand fell later in 2008 as the world entered into economic recession. The value of exports fell markedly, as did U.S. milk prices. (Figure 4).

Figure 4. Value of Dairy Exports, 2000-2010

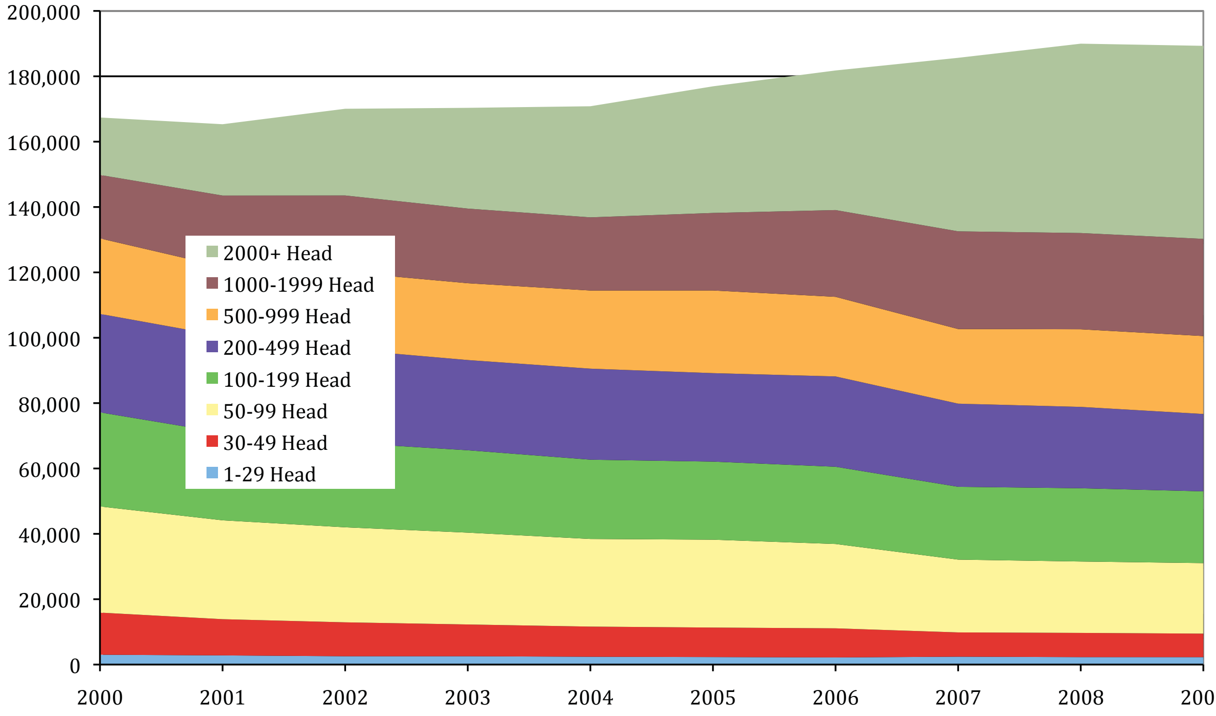


Methods and Data

Given the nature of the volatility in supply chains and its hypothesized causes, an analytical approach is required that is capable of replicating the types of behaviors observed in the industry under normal conditions and under large shocks. In particular, the model must be capable of producing variation in prices and other variables on a relevant time scale (in this case monthly) with an amplitude similar to that observed in the past. We have chosen to build a mathematical model for our analyses based on the commodity supply chain model described in Sterman (2000), which has been applied previously to numerous commodities that demonstrate cyclical production and profitability. (An early application to agriculture is a model of hog cycles by Meadows (1970)). Moreover, our approach is consistent with recent recommendations that the analysis of food systems and agricultural policies is best done using dynamic systems methods (Pinstrup-Andersen and Watson, 2010). This commodity model represents the essential elements of the stock, flow and feedback structure that is common to the supply chain for many commodities. It contains many features common to economic models, such as demand and supply responses, but represents them in a way that explicitly recognizes the inherent delays and limited information available to industry decision makers.

This commodity model has been developed and adapted to the U.S. dairy industry over a number of years, and many model details are provided in Nicholson and Fiddaman (2003), Pagel (2005), Nicholson and Stephenson (2007), Stephenson and Nicholson (2007), Nicholson and Kaiser (2008) and Nicholson and Stephenson (2009). The model employed under this project was adapted from previous modeling work, and relevant model elements were combined mathematically to allow analysis of major proposed programs. In addition, programmatic elements not analyzed in our previous work were incorporated as required to achieve the research objectives, and data were updated to represent the most recent calendar year available (2009). The model calculates monthly outcomes from 2010 to the end of 2018 to simulate the likely time horizon of the next Farm Bill. The *Milk Supply* components of the model are based on four farm size categories (1-99, 100-499, 500-1999 and >2000 cows). For each farm size category, the total number of farms is modeled, as is the average financial situation (both elements of the income statement and the balance sheet) for each farm category. Milk per cow is assumed to grow at a potential rate of 2% per year, but can be adjusted in the short run in response to the milk-feed price ratio. The number of cows for each farm size category is treated as a productive asset, and modeled using an "anchoring and adjustment" approach based on Sterman (2000). This anchoring and adjustment mechanism assumes that desired cow numbers for each farm size category respond to the profitability (measured in terms of Net Farm Operating Income, NFOI) relative to a benchmark but are based on current cow numbers. When the desired number of cows changes, the voluntary culling rate is adjusted. Changes in the culling rate in response to profitability changes are asymmetric: producers are assumed to respond more fully when lower culling rates (to increase cow numbers) than to increase culling rates (to decrease cow numbers). The model includes a representation of increased use of sexed semen in the U.S. dairy herd during the period modeled.

Figure 5. Milk Production by Herd Size, 2000-2009



As noted above, herd size categories have been modified for this revision of the model. The National Agricultural Statistics Service reports milk production by the herd size categories employed (Figure 5). It is apparent that the major segment of growth in U.S. milk supply is coming from dairy herds who are moving into a larger herd size category and the 740 herds in the largest herd size category (2000+ Head in year 2009) now account for more than 31 percent of the total milk supply. The cost structure of farms in the different herd size categories is quite different as is the responsiveness to price signals. We reduced the eight herd size categories into four representing roughly equal amounts of milk production.

The *All-Milk Price* is calculated using the federal milk marketing order blend price and over-order premiums paid for Class I, II and III milk. Over-order premiums change as market conditions change. The All-milk price is a main input into both the milk-feed price ratio used to adjust milk per cow and NFOI, which influences cow numbers. It therefore has a large role in determining model outcomes.

Table 1. Products Represented in the Model

Product	Product
Fluid Milk	Dry Whey
Yogurt	Whey Protein Concentrate 34
Frozen Desserts	Whey Protein Concentrate 80
Cottage Cheese	Lactose
American Cheese	Butter
Other Cheese	Nonfat Dry Milk
Fluid Whey	Condensed Skim Milk
Separated Whey	Other Evap, Condensed & Dry products
Whey Cream	Casein & Milk Protein Concentrates

The *Dairy Processing* component of the model incorporates 21 products, 18 of which are “final” products (have explicit demand curves) and 13 of which are “intermediate” products that can be used in the manufacture of other dairy products (Table 1). Non-storable products (fluid, yogurt, ice cream and cottage cheese) are assumed manufactured in the month in which they are consumed. Storable products have inventories, and inventories relative to sales (inventory coverage) is used in setting prices for these products. Milk is allocated preferentially to fluid, soft and cheese manufacturing, with the remaining milk allocated to NDM and butter manufacture. The model explicitly tracks skim milk and cream quantities to ensure component balance. To represent potential substitutability among intermediate products as relative prices change, the lowest cost of three potential ingredient combinations (for example, NDM versus MPC used in cheese manufacturing) is calculated and adjustments in intermediate product use occur over the course of a month following a change in the lowest-cost combination. The proportional utilization of existing manufacturing capacity for storable products depends on current profit margins, calculated on an aggregated enterprise basis (for example, the profitability of American cheese manufacturing in the U.S. as a whole). The manufacturing capacity for storable products also changes over time in response to long-term changes in profitability (although this is represented as a continuous rather than “lumpy” process).

Dairy Product Demand for the final products is represented using constant elasticity demand equations, which also are assumed to shift over time in response to population and income growth. Cross-price effects are included for NDM, MPC products, casein products and whey products but not for others. The quantity demanded adjusts over time in response to price changes, rather than instantaneously. Retail prices for fluid milk products, yogurt, cottage cheese and ice cream are modeled using constant proportional mark-ups. Wholesale prices for storable products, as noted earlier, depend on inventory coverage.

The model includes a detailed *Trade* component. Imports and exports are represented for 12 "tradable" U.S. dairy products. Imports and exports are modeled separately and "net exports" (exports minus imports) can be calculated. For U.S. imports, products are subject to Tariff Rate Quota (TRQ) and "over-quota" restrictions. The TRQ specify a total annual amount of allowable imports at a relatively low tariff rate. We have ignored the country-specific restrictions associated with some imported products. "Over-quota" imports are not limited in quantity but face higher tariff rates. Both *ad valorem* (percentage based on value) and specific (per unit) tariffs are represented for both categories of imports. U.S. exports of dairy products are modeled using a simplified "Rest of World" (ROW) that has production and inventories of tradable products but also demands U.S. dairy products. The model uses 2009 U.S. trade data as base, and imports and exports in future years are determined based on the growth in demand in the ROW, relative prices in the U.S. and the world market (using Oceania pricing as a base) and import restrictions. Prices in the world and U.S. markets can be compared for consistency.

Current Policies in addition to trade policy are represented in the model, including the Dairy Product Price Support Program, Milk Income Loss Contracts, and Federal Milk Marketing Orders. Because ours is a national model, individual FMMOs are not modeled, nor are state-level milk pricing or pooling provisions. We assume that pricing for cheese milk not pooled under orders has an average long-run price equal to the Class III price. The Dairy Export Incentive Program (DEIP) is assumed to operate under current limits when U.S. prices are higher than world prices.

The model obviously must incorporate the elements of the proposed programs to address price volatility, and much of the new model structure represents these. The original scope of work called for an analysis of five programs, including the Costa (H. R. 5288) and Sanders (S. 3531) legislation, the Marginal Milk Pricing (MMP) program proposed by Agri-Mark, the Foundation for the Future (FFTF) program proposed by the National Milk Producers Federation, the mandatory CWT-type program proposed by Dairy Farmers Working Together, the Dairy Growth Management Initiative described by DFA. Although the model has been developed to allow the analysis of all of these programs, the funders suggested that this report focus on just three programs: Costa/Sanders, MMP and FFTF.

The principal elements of Costa/Sanders (CS) are identical and include an allowable percentage growth in milk production per year, and a market access fee per hundredweight to be paid on either all milk or marginal milk at the producer's choice. Our model incorporates the schedule for allowable growth based on the milk-feed price ratio from the legislation, but also explores a proposed alternative based on the margin over feed costs used by the Foundation for the Future (FFTF) program. We also include the schedule of market access fees from the legislation, but allow this to be scaled to determine a varianceminimizing schedule for market access fees. For the purposes of analyzing this proposed program, we separate the decision-making of farms that will limit production to stay within the allowable growth in a given year from those that will increase production by more than the allowable growth. The proportion of farms in each group is determined based on a distribution of farms centered on the average annual amount of growth in milk per farm for each size category (1.1, 1.4, 1.7 and 2.4% per year, respectively), adjusted based on the difference in NFOI between farms limiting production and those not limiting production. That is, larger market access fees would encourage a greater number of farms to limit production, because their NFOI would be reduced by the market access fee payments.

Because in a given year many farms will not be expanding milk production by a significant amount, many farms will "limit" production to be within the allowable growth. Farms limiting production are assumed to adjust culling rates to stay within the allowable amounts, but continue to increase milk production per cow consistent with annual milk per cow growth rates. Farms increasing production above the allowable growth are assumed to pay the market access fee on all milk, which is the lower-cost alternative for milk production increases above about 25% given the 5:1 ratio for market access fees on marginal and all milk in the legislation. The model accounts for the process of observing the milk-feed price ratio in a given quarter, the 30 days notice provided by the Secretary of Agriculture and the subsequent quarterly periods for measuring milk production and making or receiving payments.

For the Marginal Milk Pricing (MMP) program, the model includes a Class III-based trigger at $14/cwt. The program is activated when the Class III price is below the trigger for 2 consecutive months and de-activated when the Class III price is above the trigger for 2 consecutive months. Marginal milk is milk produced above the required reductions based on the Class III price, which generally require a 1% reduction for each $1/cwt the Class III price is below the trigger. Farms receive payment for marginal milk equal to the national average All-Milk price less Class III. Buyers would be required to pay the current classified prices for any marginal milk, which would create a pool of dollars that can be spent on purchase of dairy products for distribution outside of commercial channels (such as school or other feeding programs). We assume that 80% of funds collected would be spend on American Cheese purchases and 20% on NDM purchases, the latter either for direct donation or for exchanges to allow donation of other products such as yogurt. Funds are assumed spent at a rate proportional to the funds available (the accumulated difference between funds received and funds expended on product purchases). The rate is set so that if no further funds were collected, all money would be spent within approximately 12 months.[5]

Uncertainty exists about how dairy farmers would respond in aggregate to required milk marketing reductions under MMP, in part because dairy producers face a relatively complicated set of incentives under this program and the FFTF. We have modeled three possible behavioral options: 1) dairy farmers continue to respond to long-term profitability to determine the desired level of cow assets (numbers) which is affected by the program but not fully in the short term, 2) dairy farmers respond to long-term profitability with regard to milk production, but find alternative uses for marginal milk (such as calf

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[5] As a product, cheese is readily used in food donations. In practice, NDM may be bartered or swapped for other dairy containing products such as yogurt, soups, etc.

feeding, or disposal) so as to reduce marketings by an amount sufficient to avoid receiving the marginal milk price, and 3) dairy farmers respond immediately and fully to reduce production to a level that avoids receiving the marginal milk price on a significant proportion of their milk. Which option is the most appropriate is unclear, because the costs of alternative disposal of milk produced but not marketed may be larger than the net receipts (difference between the All-Milk and Class III prices less hauling costs) for some farm, because current milk marketings determine the production base for future marketing reductions under FFTF, and because increases in culling rates may be limited by slaughter capacity and concerns about lower cull cow prices. Under options 2) and 3), marketings can be reduced sufficiently so that few funds are available for purchasing products.

The FFTF program consists of a marginal milk pricing component (albeit with somewhat different structure than the MMP) and a margin protection component (safety net). Although the FFTF may also include proposed changes to federal milk marketing orders (FMMO) in the future, we have not attempted to model any changes to FMMOs in our analysis of the FFTF program because the specifics of any proposed changes are not yet available. Under the Dairy Market Stabilization Program (DMSP), a margin over feed cost is calculated based on the difference between the All-Milk price and the value of a ration based on alfalfa hay prices, soybean meal prices and corn prices (adjusted to the Chicago Mercantile Exchange values). When the value of this margin is below \$6/cwt for 2 consecutive months, the program is activated until the margin exceeds \$6/cwt for two consecutive months. The DMSP differs from the MMP in that the value for marginal milk under the DMSP is \$0/cwt, the schedule for required reductions is somewhat more aggressive (the initial reduction is 2% rather than 1% for example), includes a cap on the amount of milk that will be paid the marginal milk value, and stipulates that if U.S. prices for NDM or cheddar cheese become 25% higher than world market prices, the program will be de-activated. We considered the same set of three possible behavioral responses to dairy farmers for the DMSP as we did for the MMP.

The margin protection component of the FFTF program (Dairy Producer Income Protection Plan, DPIPP) includes a base level of coverage (provided without cost to producers) and a supplemental level (provided at a subsidized rate). The margin used for this component is the same as that for DMSP. Although the actual level of the margin is to be determined by Congressional Budget Office under the current proposals, we assumed a \$4/cwt margin for the base plan and a \$6/cwt margin for the supplemental plan. We assumed that all farmers would receive protection under the base plan for 90% of their base marketings, and that 60% of farmers would purchase supplemental coverage on 45% of their milk. We assumed a \$0.14/cwt premium on milk for which the margin was protected under the DPIPP. These values were chosen to be consistent with previous analyses (FAPRI, 2010a).

The data used to develop the parameter values for the model are from diverse sources, including NASS publications, U.S. Census Bureau (for trade statistics) previous modeling studies (e.g., Bishop, 2004; Pagel, 2005), other industry documents, and in some cases, judgment of dairy industry analysts. This use of a broad range of sources is common for dynamic simulation models, and is consistent with the three types of data needed according to Forrester (1980): numerical, written and mental data. To make assumptions as consistent as possible between our model and the annual FAPRI model, we used annual feed cost projections from FAPRI (2010b), and annual growth rates for domestic dairy product demand from FAPRI. Growth in world demand for dairy products was specified as percentage growth rates based on information in FAPRI (2010).

Model Evaluation

According to Sterman (2000), models cannot be "validated" (shown to be true representations of the world they model) because all models are a simplification of reality. However, all models should be thoroughly evaluated to determine whether they are consistent with their stated purpose. The simulation model used for this study was evaluated using the process proposed by Sterman, which includes test of *boundary adequacy* (does the model include sufficient endogenous representation of the system modeled?), *structure assessment* (is the model consistent with the relevant descriptive knowledge of the system, physical laws, and observed decision making behaviors?), *dimensional consistency* (are the units of equations consistent without arbitrary parameters?), *parameter assessment* (are the parameters consistent with the relevant descriptive and numerical knowledge of the system?) , *extreme conditions tests* (do equations make sense when inputs take on extreme values?), *integration error* (are the results sensitive to the choice of calculation interval?) and *behavior reproduction* (does the model reproduce the behavior of interest, both qualitatively and quantitatively?). The model was judged to be adequate for its stated purpose of evaluating the dynamic impacts of programs designed to reduce variation in the U.S. All-Milk price on the basis of these tests.

The model was also subjected to various sensitivity tests to examine the sensitivity of its results to assumptions. Sterman (2000) identifies three types of sensitivity: numerical, behavioral, and policy. *Numerical sensitivity* arises when changes in assumed parameter values modify the values generated by the model and nearly always occurs. *Behavioral sensitivity* exists when changes in assumptions about parameter values cause changes in the behavioral mode (for example, from equilibrium to oscillation). Of most importance for this study, *policy sensitivity* occurs when changes in assumptions significantly change the policy implications due to changes in model results. It is often the case in dynamic systems models that results are largely insensitive to the majority of parameters (this occurs because of the effects of balancing feedback loops specified in the model structure), and this was true for our model. Some results were numerically sensitive, but we did not identify any behavioral or policy sensitivity that would undermine the model's usefulness for its stated purpose.

Scenarios, Analyses and Outcome Indicators

Outcomes for each of the proposed programs are examined relative to *Baseline* scenarios that assume the continuation of current programs (and their scheduled modifications, such as under MILC)—and no new programs to address price volatility. The Baseline represents what would have happened without the program given certain assumptions about the timing and magnitude of possible shocks to the industry. The ability of proposed programs to reduce price variability relative to the Baseline scenarios is a key indicator of program effectiveness. The *deterministic* (non-random) Baseline consists of two alternative simulations, one without any major shocks that would influence price variability, and the other with permanent increases in the cost of feed in 2015 (which affects the ration value and therefore the margin used for the FFTF) and a rapid increase in U.S. exports of dairy products in 2016 for one year, followed by a decrease from the overall trend of increased U.S. exports for one year. The purpose of the first of these deterministic simulations is to examine the effectiveness of the programs under more normal industry conditions, whereas the second simulation is designed to emulate the impacts of shocks observed in the U.S. dairy industry from 2007 to 2010. It is important to note that these are not forecasts of the future, but are experiments using the model that allow us to examine the outcomes conditional on assumptions about the timing and nature of shocks to the industry.

Consistent with the analyses undertaken by FAPRI and others, we also employ the idea of a *stochastic* (random) Baseline, which examines the impacts of a one-time feed cost increase (from 0 to +20%) a one-time rapid increase in U.S. exports resulting from a reduction of the supply of dairy products from the rest of the world (from 0 to -10%) lasting one year and followed by a one-time decrease in U.S. exports resulting from an increase in the supply of dairy products from the rest of the world (from 0 to +5%) compared to levels prior to the shock. For the stochastic Baseline, 200 simulations were run with values for the timing and magnitude of the shocks selected at random from a uniform distribution. The 200 simulations provide a range of estimates for outcomes that can be displayed as a probability distribution. Comparison of the probability distributions is a better approach for evaluation of the programs because the nature, timing and magnitude of any future shocks are not known. If the programs reduce price variability under a wider range of shocks, this provides additional evidence of the programs' potential effectiveness[6]

The proposed programs are analyzed using a approach similar to the Baseline, with two deterministic simulations and a stochastic simulation of 200 model runs. In each case, we assumed that the programs would be implemented in January 2012 to be roughly consistent with the expected timing for the Farm Bill. For CS, we used optimization techniques to determine the value of the Market Access Fee scheduled that would result in minimum price variation from 2013 (that is one year after implementation, to allow for adjustments) as measured by the average absolute deviation from the average All-Milk price[7]. For the MMP and DMSP programs, we also determined the rate of spending of any funds collected (the difference between the All-Milk price and the marginal milk price times the amount of marginal milk marketed) that would minimize variability in the average absolute deviation from the average All-Milk price. For these latter two programs, we also ran deterministic scenarios with and without the major shocks to test the impact of our assumptions about producer milk marketing behavior in response to marginal milk pricing.

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[6] Note that in our stochastic simulations for the Baseline and the programs, we sample from the same uniform distribution of parameter values to generate the shocks, but do not generate exactly the same shocks for the Baseline and each of the programs. Thus, it is not possible to compare whether a program would always result in reduced variation compared to the Baseline, given the shocks although this would complement our analyses.

[7] This measure is used in the optimization exercise because it can be calculated during the model simulations. We report also the coefficient of variation and the Black-Scholes indicator of variability based on calculations using model output data.

Because we believe that the scenario in which some milk would be produced and not marketed is most likely, our stochastic simulations assume this to be the case and that only 35% of marginal milk would be marketed.

The model consists of a large number of variables and equations (several thousand), which means that an overwhelming number of outcomes could be reported. This is compounded by the fact that 200 simulation runs are undertaken for each of the stochastic analyses. Although we have reviewed in detail the results for many of the variables as one component of our model evaluation, we will focus on a more limited set of outcomes for reporting purposes (Table 2). These measures describe key outcomes important to a broad spectrum of the industry. It is important to note that although we include the All-Milk price (and its average value from 2013 to 2018) and milk income less feed costs (for different farm size categories), the objective of this analysis is whether the programs reduce price variability, as measured by the average absolute deviation and the Black-Scholes volatility measure for the All-milk price. We also report the average level and variability indicators for the Class III and IV prices because the programs have different impacts on these prices.

Table 2. Indicators Reported

Indicator	Definition or Comment
All-Milk price, \$/cwt	Graphical representation for deterministic and stochastic scenarios over model simulation period, 2010-2018
Average All-milk price, \$/cwt	Average All-milk price after program implementation and one-year adjustment period (2013-2108). Graphical representation for deterministic and stochastic scenarios post-implementation simulation period, 2013-2018.
Average absolute deviation from average All-milk price, \$/cwt	Variable calculates the sum of absolute deviations from the current calculated average price. Value reported for end 2018 is a measure of variability from 2013 (one year after program implementation). Graphical representation for deterministic and stochastic scenarios post-implementation simulation period, 2013-2018.
Coefficient of variation of the All-milk price, %	Standard deviation divided by the average. Reported for the deterministic scenarios post-implementation period, 2013-2018
Black-Scholes volatility indicator for the All-Milk price	The standard deviation of the values of $ln(\text{All-Milk price}_t)/ln(\text{All-milk price}_{t-1})$ from Reported for the deterministic scenarios post-implementation period, 2013-2018.
Milk income less feed costs, \$/farm/year	Revenues from milk sales for each of four farm size categories assumed to maintain the same number of cows throughout the time horizon of the model, less feed costs. Graphical representation for deterministic and stochastic scenarios over model simulation period, 2010-2018, and cumulative value
Total milk marketings, cwt/month	Milk marketed by all farms in the four farm size categories. Graphical representation for deterministic and stochastic scenarios over model simulation period, 2010-2018, and summary measures
Net exports of U.S. dairy products, cwt/month	Exports of U.S. dairy products less imports of U.S. dairy products are reported for four products: American cheese, NDM, butter and dry whey. Graphical representation for deterministic and stochastic scenarios over model simulation period, 2010-2018, and summary measures.
Cumulative government program expenditures, \$	Sum of total government program expenditures from 2012 to 2018. Graphical representation for deterministic and stochastic scenarios over post-implementation simulation period, 2010-2018.
Total product sales, cwt/month	Total product sales are reported for three products: fluid milk, American cheese and other cheese. For fluid milk, these are domestic sales. For cheese, sales include domestic sales, export sales and any purchases under MMP or FFTF

Results

We report many outcome indicators because the programs analyzed are not inherently "effective" or "ineffective" or "good" or "bad". As is often the case in economic analyses, the programs perform differently when different outcomes are considered. The overall judgment about the combined effects of a program is most appropriately made by those individuals and organizations directly affected by its implementation. Some programs perform better in one measure—for example, in reducing variability—but less well in others, perhaps government expenditures. Further, although we have represented in our analyses the basic mechanisms of the programs, modifications to program parameters (that is, the manner in which the programs are operated) can have a numerical (although not behavioral) impact on simulated outcomes.

Reporting Framework: The model uses values observed in the 2009 production year as a starting point. From there, monthly values are generated for the time period of 2010 through 2018. A Baseline indicates projections assumed to maintain the current dairy policies. That is, the Baseline includes Federal Milk Marketing Orders with current product price formulas, the Dairy Product Price Support Program with the current values for purchase prices (the program as modeled does include the triggers which modify purchase prices if threshold quantities of product are purchased), Milk Income Loss Contracts with the feed cost adjustor and payment caps at 2.985 million pounds of production (payout rate at 45% until September, 2012 then dropping to 34% thereafter), tariff rate quotas on specific imported dairy products and the DEIP program.

Three policy options are modeled: the Costa-Sanders bills[8], the Foundation for the Future[9], and the Marginal Milk Pricing[10] proposal. For all scenarios, it was assumed that new policies would be implemented on January 1, 2012—a timeline consistent with the next anticipated Farm Bill legislation. For some outcome indicators, like the Average Variation After the Program, we report values beginning January 1, 2013, which allows the programs a year to be implemented and time for markets to react.

Although the language of the Costa-Sanders provides the relevant details necessary for analysis, for the MMP and FFTF programs there were details about program implementation that were not specified in available documentation. In those cases, we made judgments about what would be done for the purposes of modeling the programs. One example is how any monies collected would be used "to effectively stimulate the consumption of dairy products". As noted above, we made the assumption that 80 percent of the funds would be spent on cheese and 20 percent on nonfat dry milk. The MMP and the FFTF also do not specify, how rapidly any collected money would be spent on the dairy

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[8] These bills are H.R.5288 and S.3531 in the House and Senate respectively. Draft language of the Costa and Sanders bills can be found at http://www.opencongress.org/bill/111-h5288/text and http://www.opencongress.org/bill/111-s3531/text

[9] Foundation for the Future represents a suite of changes in dairy policy that has been crafted by the National Milk Producers Federation. Documentation about the program can be found at http://nmpf.org/washington_watch/ordersandpolicies/foundation_for_the_future

[10] The Marginal Milk Pricing plan has been formulated by Bob Wellington, an economist with Agri-Mark dairy cooperative in New England. Documentation about the program can be found at http://www.agrimark.net/

product purchases for food assistance programs. We used the model and optimization procedures to specify a spending rate to minimize the average absolute deviation in the All-Milk price. This occurred when funds were completely spent over 12 months. The CS bill language includes a table of Market Access Fees (MAF) to be charged for exceeding the allowable growth at various Milk-Feed Price Ratios. We used optimization techniques to determine the schedule of MAF that minimized variation in the All-Milk price (Table 3).

Table 3. Costa/Sanders Market Access Fees

Milk / Feed Price Ratio	Bill Language MAF	Optimized MAF
Greater than/equal to 3.0	$0.03	$0.11
2.50-2.99	$0.13	$0.46
2.00-2.49	$0.25	$0.88
Less than/equal to 1.99	$0.50	$1.75

Results with No Shocks

The first set of program indicators are run with no shocks imposed over the 2010 through 2018 period. This set of “No Shocks” scenarios gives an indication as to how well the programs handle the endemic volatility in the dairy industry.

All-Milk Price. Given the model structure and the assumptions used, the Baseline is projecting continued milk price volatility with major peaks and troughs occurring about every three years (Figure 6). The high to low range in prices is about $4/cwt over that time period.

Figure 6. All Milk Price, No Shocks

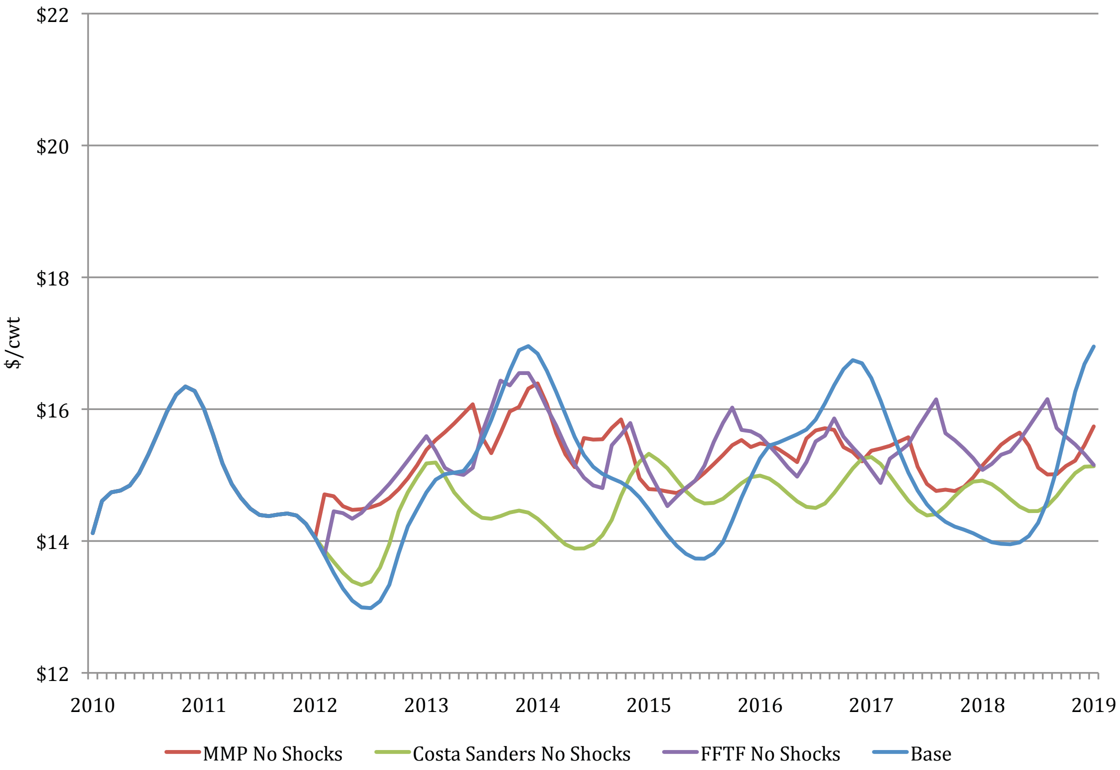
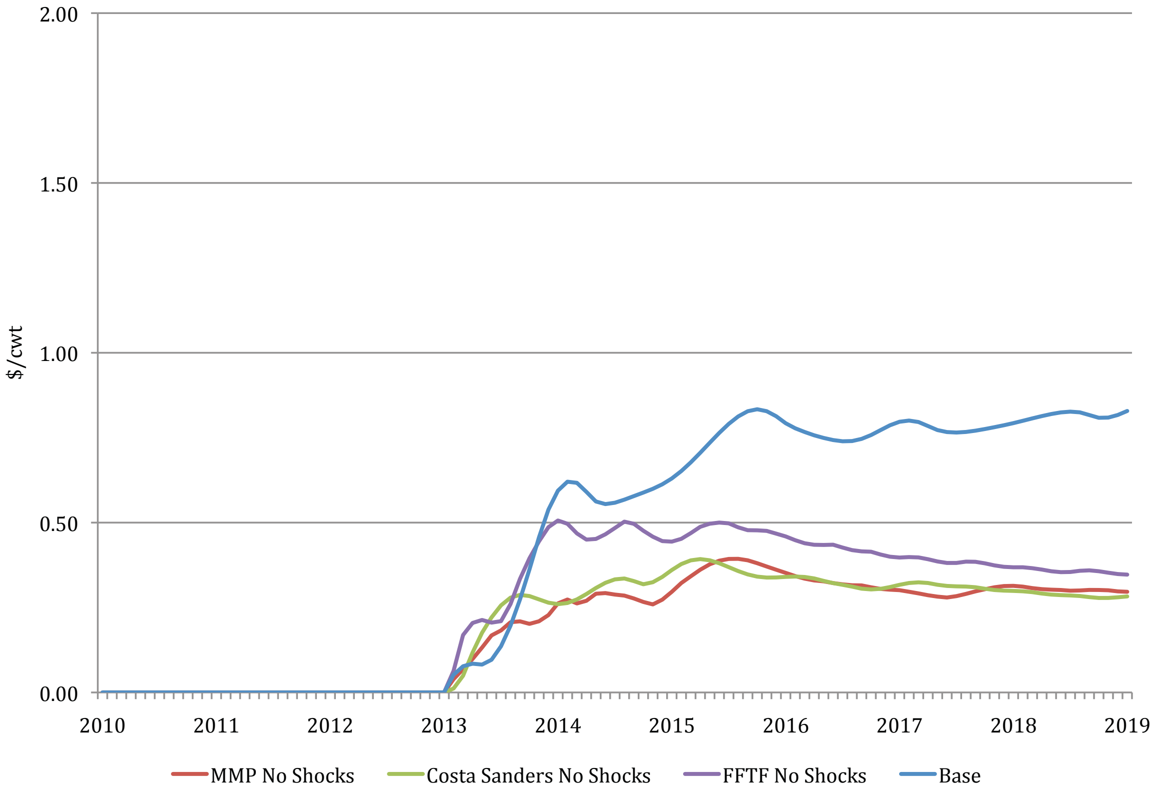


Figure 7. Average Absolute Deviation from Average All Milk Price, No Shocks



The effects of the three programs are visible shortly after implementation. Both the MMP and the FFTF have nearly immediate impact as the $6 milk feed margin is triggered in January 2012 when the programs take effect. There is a reduction in the payments to producers for milk marketed beyond their base production. There are also some monies collected that are used to begin purchases of dairy products under food giveaway programs. The CS program has a bit more of a muted effect as it begins collecting market access fees for those producers who have exceeded their allowable growth levels. The average level of the All-Milk price is lower under CS under our assumptions. This is due to the setting of combined allowable annual growth percentage and the MAF that minimizes variation. Additional model simulations not reported here indicate that more restrictive annual growth and (or) higher access fees would result in All-Milk prices more comparable to those under MMP and FFTF. For the period 2013-2018, the average All-Milk price would be increased by $0.23/cwt under MMP, increased by $0.17/cwt under FFTF and decreased by $0.69/cwt under CS. (Appendix Table A1)

Variation in All-Milk Price. The Average Absolute Deviation measure (Figure 7) indicates differences among the programs in about the second year after implementation. This measure calculates the average deviation from 2013 to each point along the progressing timeline. In the later years of the model runs, all three programs show a marked impact on reducing milk price volatility over the Baseline. Each of the programs reduces the average absolute deviation from the average All-Milk price during 2013 to 2018 from about $0.80/cwt to about $0.30/cwt in the absence of major shocks.

Another measure of volatility is the Black-Scholes calculation. Black-Scholes is the standard deviation of the series of values generated as the natural logarithm of the ratio of the price in a current month divided by the price in the previous month. The Black-Scholes measure better captures the frequency of price changes. By this measure (reported in the appendix tables), the CS program results in the lowest volatility. The FFTF program has a Black-Scholes value equal to that of the Baseline, so by this indicator does not reduce variability. The reason for the difference in volatility indicators can be seen (Figure 6) because the MMP and FFTF have many more ups and downs.

Farm-Level Financial Performance. In order to simplify reporting of farm-level financial performance under the different programs, we use milk income less feed costs for a farm in each of the four farm size categories that maintains a stable herd size over the life of the simulation. The milk income measure includes reductions due to marketing limitations under MMP and FFTF[11] and don't include other sources of income such as program payments or cull cows nor the other costs of operation. We report these as annualized values (the monthly value times 12) to account for the effect of seasonal production and other factors. This makes it easier to determine the impact of milk and feed prices. We provide graphical results for a farm of 183 cows (our "medium" size category) during the period 2010 to 2018 (Figure 8). There is a modest upward trend in milk prices over the time period (Figure 6), but the somewhat stronger trend (Figure 8) is due to increasing milk per cow over time and the dilution of maintenance feed costs. Similar patterns, but very different levels, are observed for farms in all size categories. These are not reported graphically but are reported in Appendix Table A1. The programs analyzed reduce the

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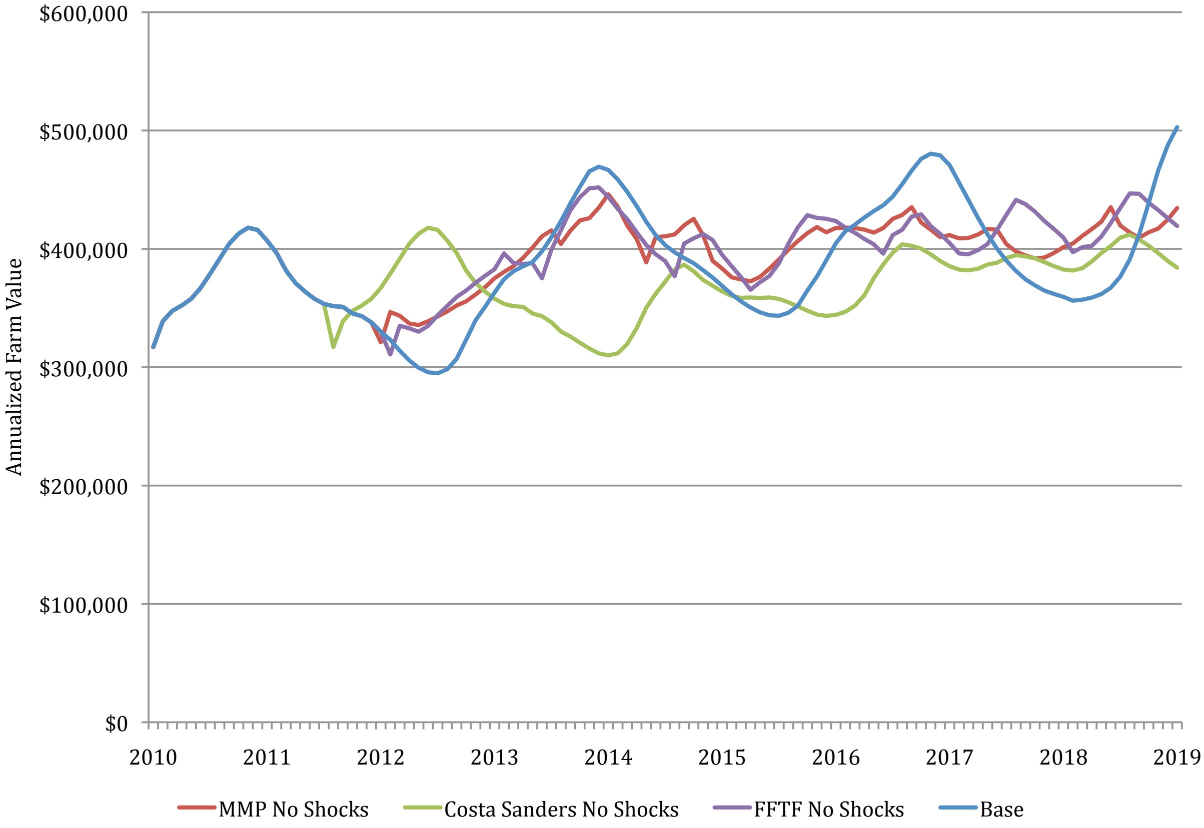
[11] It does not include payments of Market Access Fees under CS, for which the net payment will be zero across all farms.

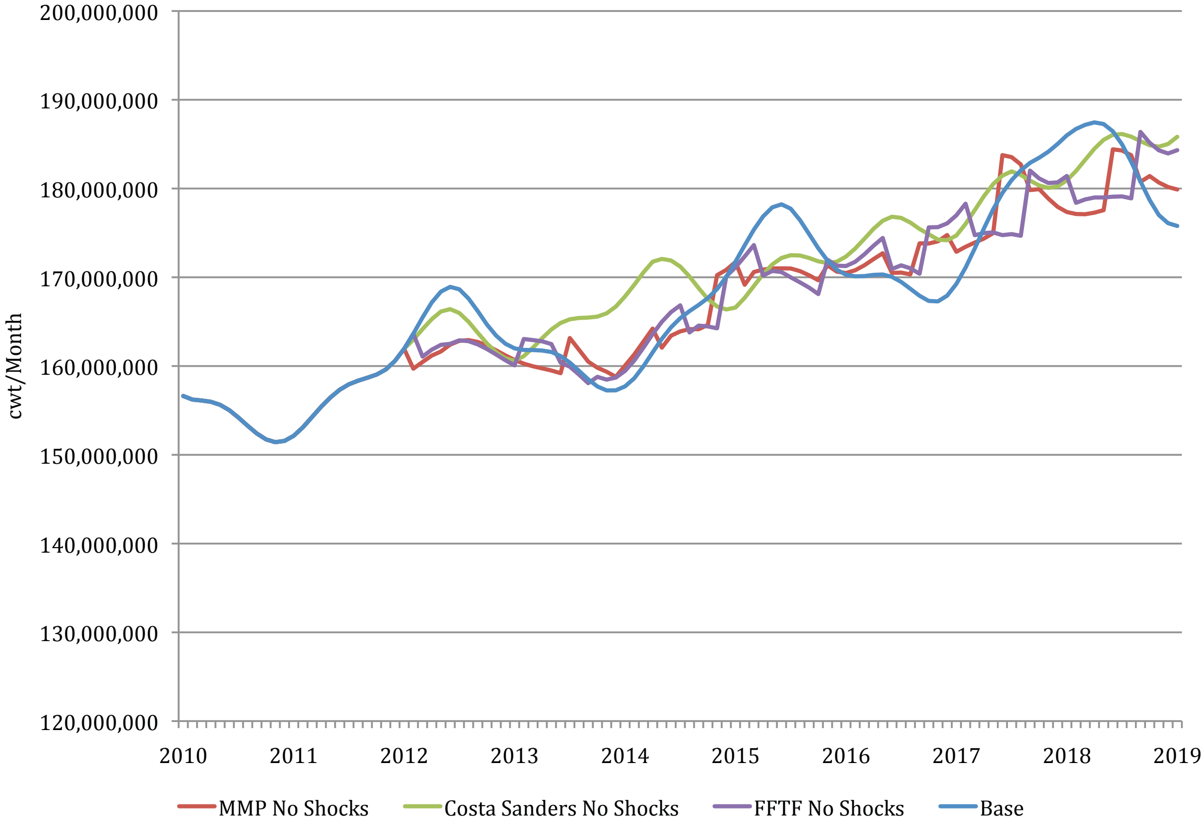
variation in milk income less feed costs in a manner that mirrors reductions in milk price variability, without a significant change in the average value compared to the Baseline during the simulated period. The MMP and FFTF programs would increase milk income less feed costs for the medium-sized farm by $2,958 and $5,490, respectively (Appendix Table A1). Milk income less feed costs would be $37,632 lower under CS than under the Baseline.

Figure 8. Annualized Milk Income Less Feed Costs for Medium-Sized Farm, No Shocks



Milk Marketed. As expected, the MMP and the FFTF yield abrupt changes in milk marketings. These changes would require more significant adjustments for some manufacturing plants when the program triggers in (or out). The CS program results in a less variable supply of milk over the 9-year time horizon. MMP and FFTF supply less total milk to the market place than the Baseline, 0.5 and 0.4%, respectively. CS results in 0.8% more total milk produced over the model time period than the Baseline, This results in a lower average milk price over that time. However, altering the CS program implementation parameters would alter this outcome. If the schedule of allowable growth was somewhat more restrictive, then less milk would be marketed and the average All-Milk price would be somewhat higher. Another difference between the programs and the Baseline is the timing of the peaks and troughs in the All-Milk price (Figure 6).

Figure 9. U.S. Monthly Milk Marketings, No Shocks[12]



U.S. Dairy Product Trade. Another outcome of importance is the impact of the program on U.S. dairy product trade. We highlight the impacts on American cheese, NDM and dry whey here (Figures 10, 11 and 12). These figures indicate "net" exports (exports minus imports) for each of these product categories. As can be seen, there are numerical differences in exports among the programs but no behavioral differences. That is, our results suggest that U.S. dairy product exports will increase in the future under all of the programs, although there are differences in magnitudes. Because CS yields more milk production and lower average prices, more cheese is produced and average net exports increase 9.0% compared to the Baseline (Appendix Table A1). More cheese in CS also means 3.8% more dry whey powder exported. More NDM (0.9%) is exported on average under CS. Average net exports of cheese are 15.3% and 21.0% lower than the Baseline under MMP and FFTF respectively. Average dry whey net exports would be reduced 3.4% and 4.1% under MMP and FFTF, respectively. Average NDM net exports would decrease 7.7% under MMP but increase 5.6% under FFTF.

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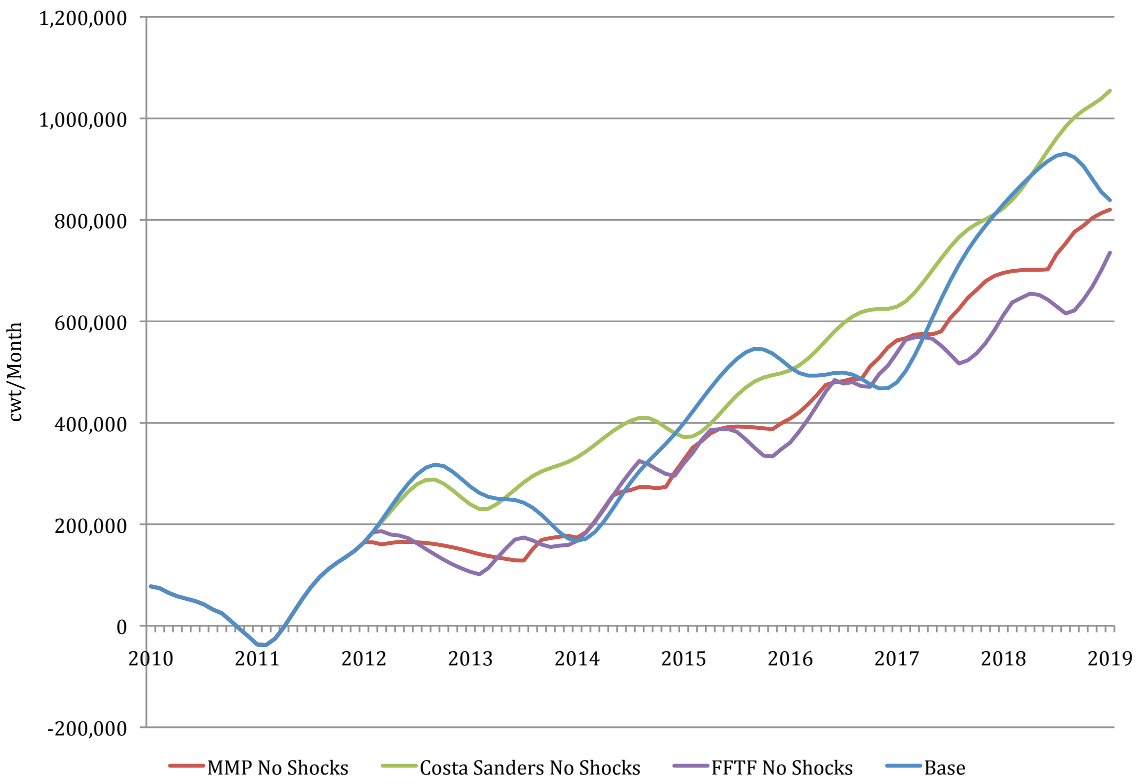
[12] Please note that the vertical scale of the graph does not begin at 0. This makes the differences easier to see but may be visually misleading as to the actual impact of changes in milk marketings.

Figure 10. Net Cheese Exports, No Shocks



In the CS program, milk is relatively less expensive and the quantity demanded of cheese for domestic and export sales is greater. This leaves relatively less milk available for Class IV products and results in somewhat higher price and thus lower exports than under FFTF.

Figure 11. Net Dry Whey Exports, No Shocks

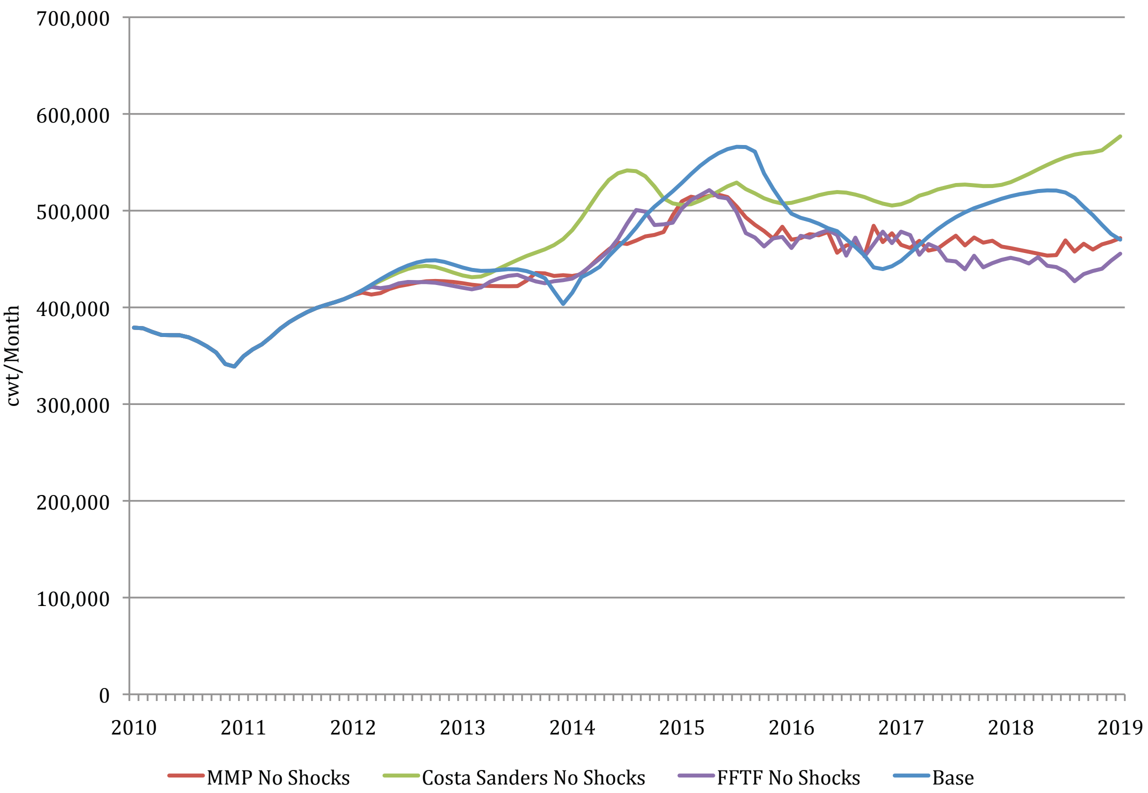
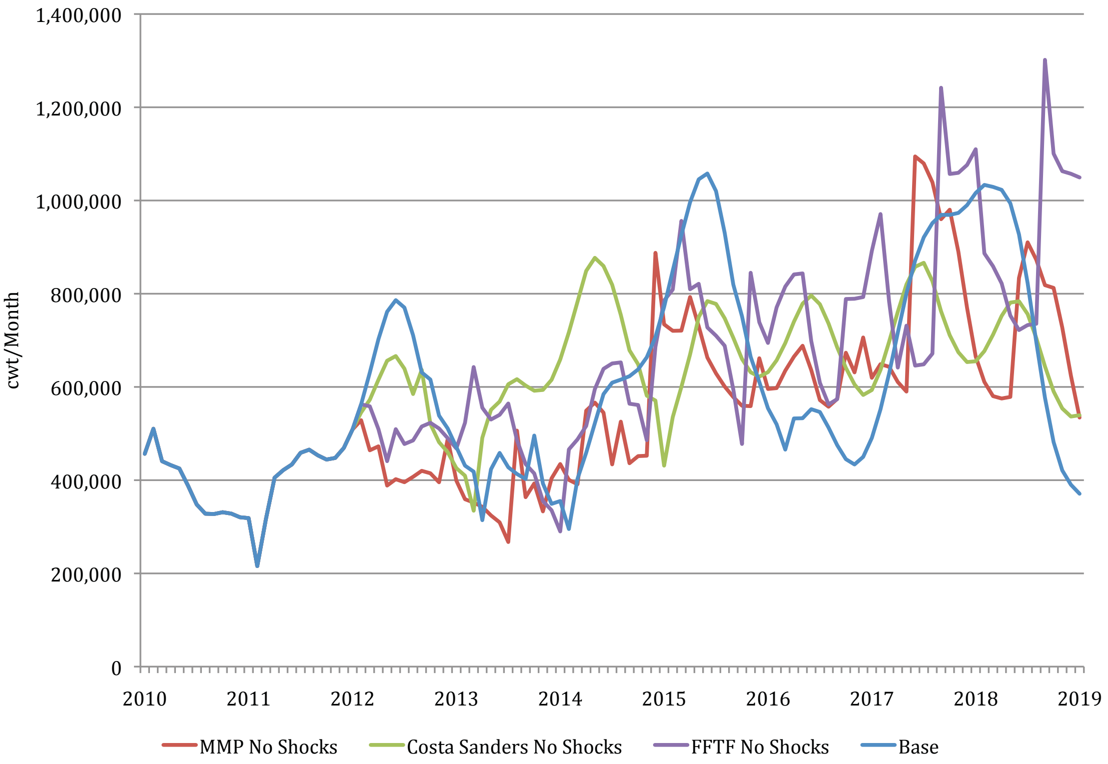


Figure 12. Net Milk Powder Exports, No Shocks



Class III and Class IV Prices. As noted above, the programs have the potential to affect Class III and IV prices differently, particularly given the assumption that Class IV is a residual claimant on the milk supply. The programs result in different average Class III prices and patterns of prices over time (Figure 13). From one year after program implementation (2013) through the end of the model run (2018), the Class III price averages $12.99 for CS, whereas the Class III price averages $13.91/cwt and $14.14/cwt under MMP and FFTF, respectively. The Class IV price averages $13.18 during the model simulation period, whereas the MMP and FFTF average $13.26 and $13.00, respectively. These different average Class prices and behavior over time imply different impacts for different regions of the country. Visual assessment of the Class IV price patterns are confirmed by the Black-Scholes measure of volatility, that the residual product manufacturing is most affected by the reduced marketings under MMP and the FFTF. MMP and FFTF increase the variability of Class IV, as measured by Black-Scholes, and FFTF Increase the variability of Class III by this measure. The CS program would reduce the variability of Class III and IV based on Black-Scholes.

Figure 13. Federal Order Class III Milk Price, No Shocks

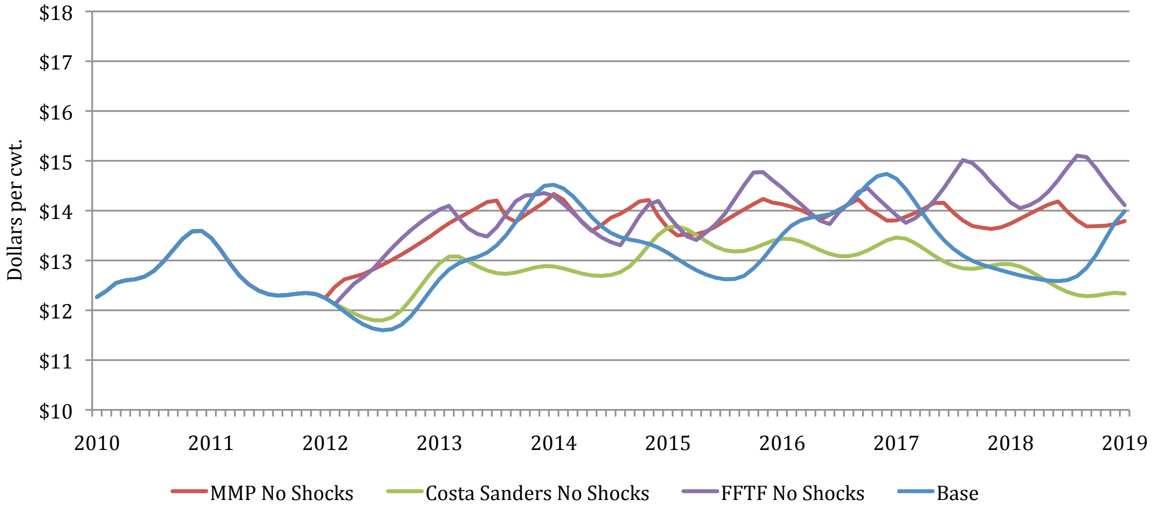
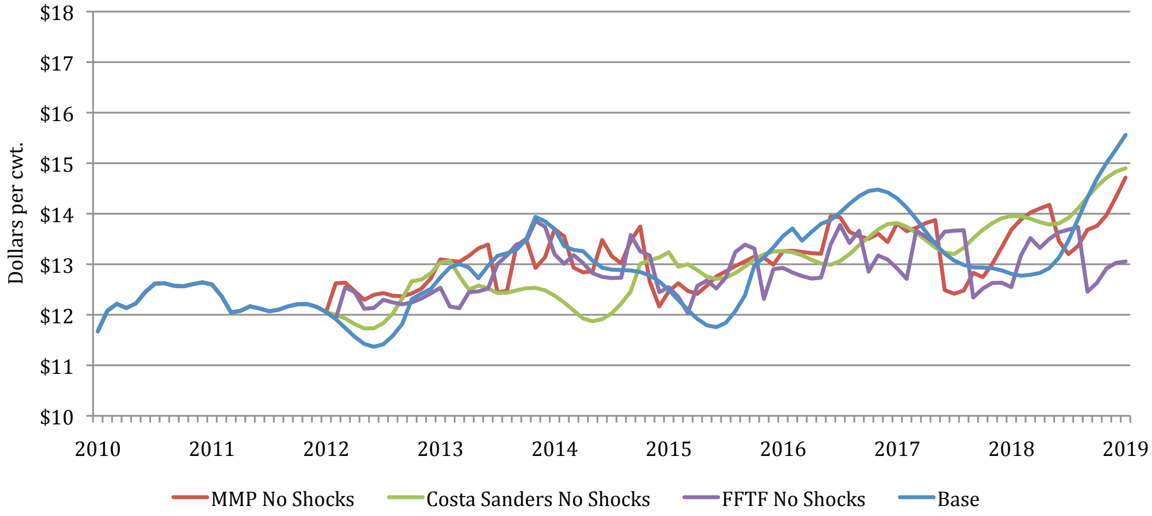


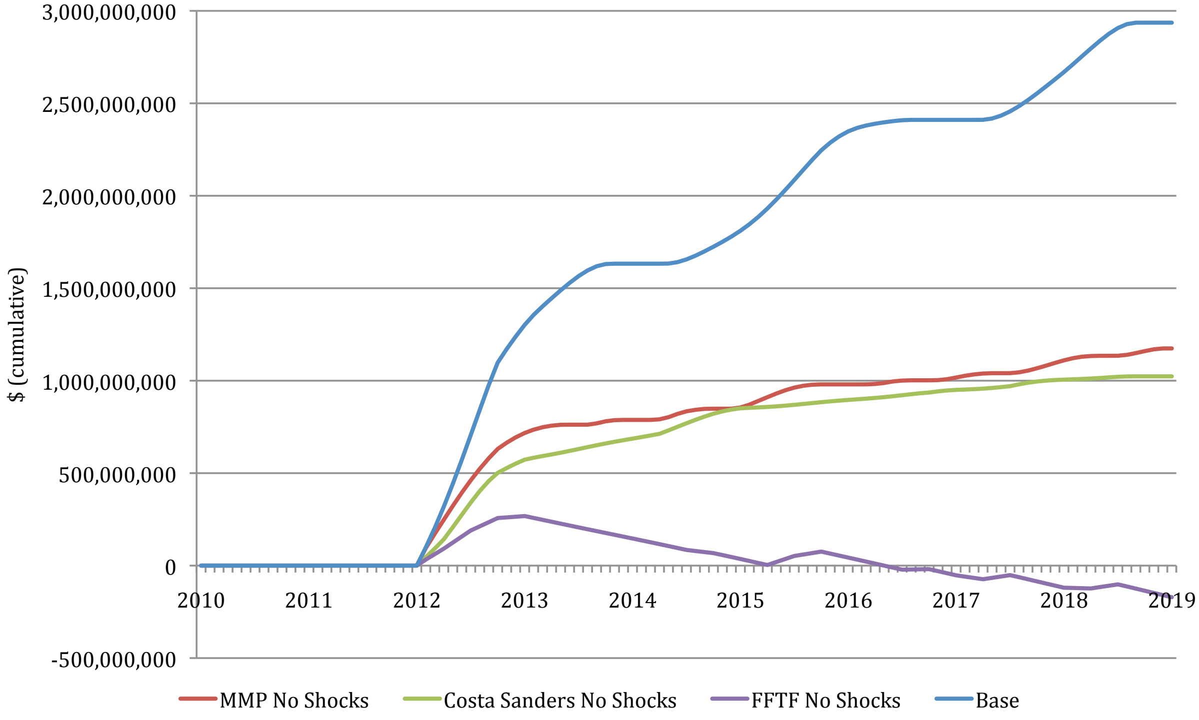
Figure 14. Federal Order Class IV Milk Price, No Shocks



Product Sales. Fluid milk, American cheese and other cheese sales would be modified by the programs (Appendix Table A1). Cumulative fluid milk sales, under the no shocks scenarios, change by at most a drop of 0.4% under the FFTF program but increase by 0.2% under CS. This latter outcome is a response to Class I price decreases compared to the Baseline. Cumulative American cheese sales would decrease 1.3% under FFTF and 1.2% under MMP, but would rise 1.5% under CS. Sales of other cheese would be less affected than sales of fluid milk: they would increase by less than 0.1% under all programs.

Government Expenditures. Another important criterion for the evaluation of the programs is the effect on government expenditures. The Baseline keeps the current Federal Order, MILC, Dairy Product Price Support Program, TRQs and DEIP in place. The same is true of the CS and the MMP. The FFTF would eliminate the Dairy Product Price Support Program and replace the MILC program with the Dairy Producer Income Protection Program (DPIPP). Cumulative government expenditures for the Baseline and the new programs differ markedly (Figure 15, Appendix Table A1). However, each of the programs reduces government expenditures substantially compared to the Baseline. Both the MMP and the CS moderate milk prices to the point that almost no expenditures under the Dairy Product Price Support Program are made and much more modest expenditures are made under the MILC program. The government cost is about one-third of what would be expected under the Baseline for CS and MMP. The FFTF proposes to eliminate these programs so the only expenditures would be associated with DPIPP. Under our assumptions about producer buy-up and premium payments there are negative government expenditures over the life of the program[13]

Figure 15. Cumulative Government Expenditures from 2012 through 2018, No Shocks



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[13] We assume that 60% of farmers would purchase supplemental coverage on 45% of their milk. We also assumed a $0.14/cwt premium on milk for which the margin was protected under the DPIPP. These values were chosen to be consistent with previous analyses (FAPRI, 2010).

Results with Shocks

Shocks occur continuously in most markets. Many shocks are relatively small and the market adapts quickly. Occasionally, larger shocks occur, like the feed and demand shocks experienced by the dairy industry in 2007-2009. The previous discussion looked at program projections without shocks to see fundamental differences in the way they handled volatility. It is also relevant to impose shocks that represent price patterns observed in 2007-2009 to examine how the programs handle these more significant price movements. The shocks analyzed here include increased feed costs in 2015, export demand increases in 2016 and export demand decreases in 2017. These shocks are designed to be similar to those that were experienced in 2007-2009.

All Milk Price. Shocks of the nature and magnitude described above have a significant impact on price levels in the Baseline (Figure 16; compare to the Baseline scenario in Figure 6). The All-Milk price reaches a peak above $20/cwt in 2016, but declines to below $14/cwt in 2017. This pattern of behavior is consistent with that observed in the U.S. dairy industry during 2007-2010. The average All-Milk price during 2013-18 for the Baseline with the shocks is $0.55/cwt higher than for the Baseline without shocks, and the average All-Milk price is also higher for each of the programs with the shocks (Appendix Table A2). The MMP and FFTF programs would increase the average All-Milk price during 2013-18 by $0.12/cwt and $0.06/cwt, respectively. CS would decrease the average All-Milk price during 2013-18 by $0.88/cwt compared to the Baseline.

Figure 16. All Milk Price with Shocks

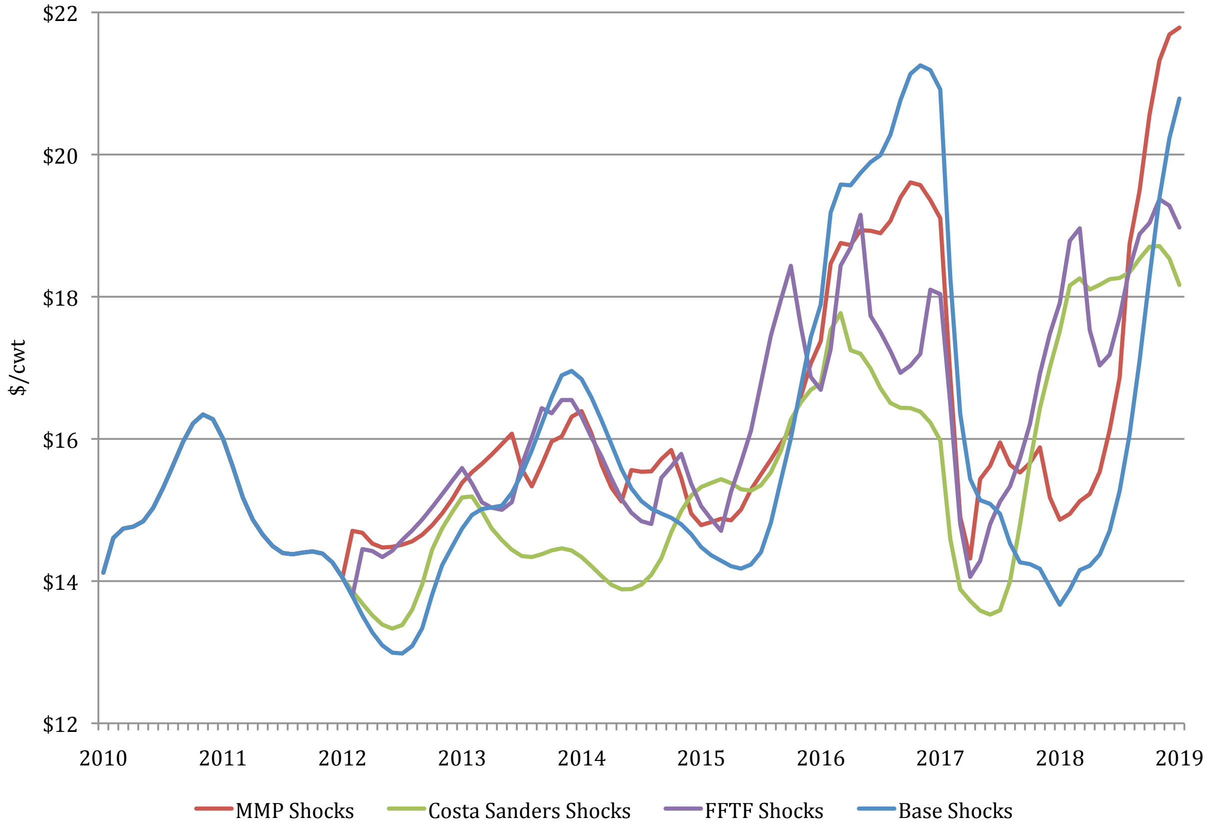
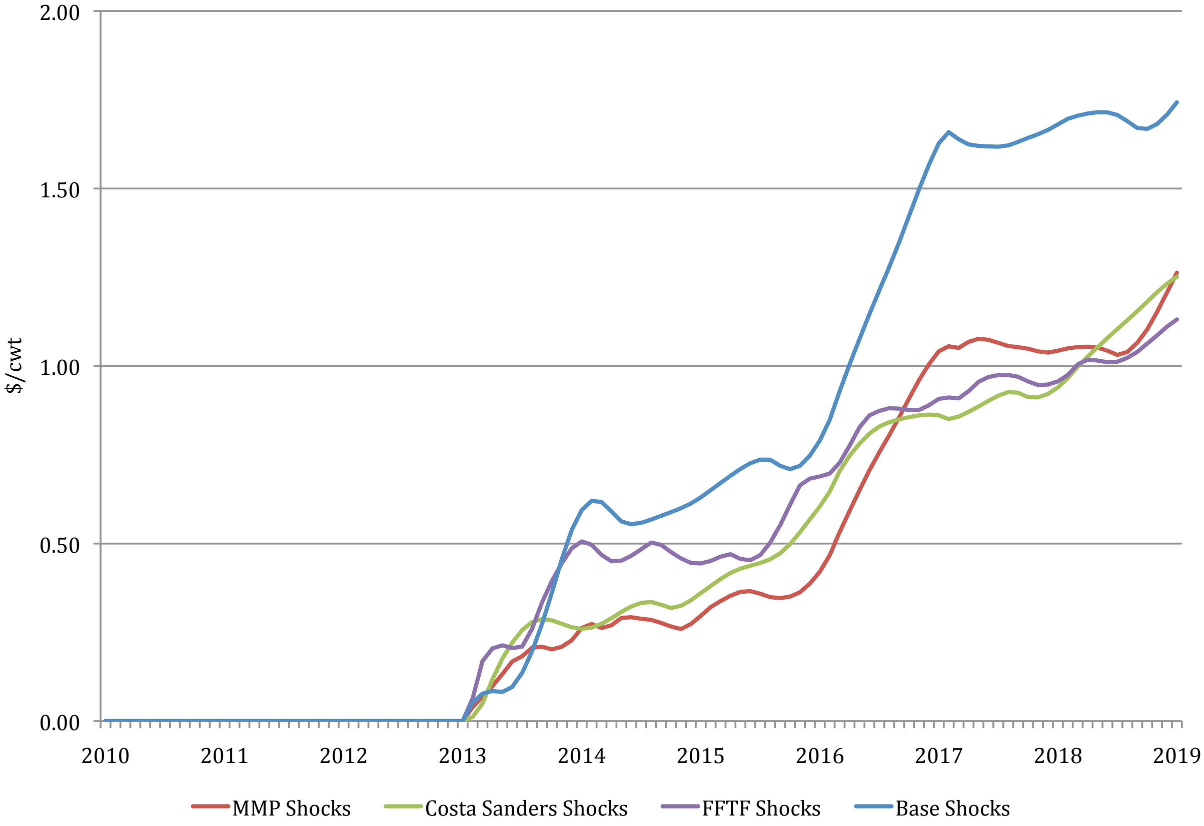


Figure 17. Average Absolute Deviation from Average All Milk Price with Shocks



Variation in All-Milk price. Each of the three programs reduces variation in prices given the shocks using the measure of absolute deviation from the average All-Milk price. The effects of the three programs are quite similar using this measure, reducing variation from an average of $1.74/cwt for the Baseline to about $1.26/cwt, $1.25/cwt and $1.13/cwt for MMP, CS and FFTF, respectively. The Black-Scholes measure of volatility indicates that MP and FFTF would increase variation somewhat, but CS would reduce volatility (Appendix Table A2).

Farm-Level Financial Performance. Similar to the analyses in the absence of shocks, the programs also reduce variation in milk income less feed costs (Figure 18). The CS program has the largest moderating impact on farm income over feed costs given the shocks. The annual average milk income less feed costs for the medium sized farm was $398,143 in the Baseline, $368,017 for CS, $405,370 for MMP and $400,767 for FFTF from 2010 through 2018 (Appendix Table A2).

Milk Marketed. The milk marketed under the programs with shocks differs from that of the Baseline (Figure 19). The cumulative milk marketed would be reduced 0.7 and 0.5% under the MMP and FFTF programs, respectively, but would increase 0.3% under CS (Appendix Table A2). Note that for some periods of time (e.g., 2016), milk marketed is larger under the programs than the Baseline, and this is one reason for the reduction in price increases during that time period. Effectively, greater stabilization of milk production and prices prior to the shock enhances the ability of the system to mitigate even these large shocks.

Figure 18. Annualized Milk Income Less Feed Costs for Medium-Sized Farm, with Shocks

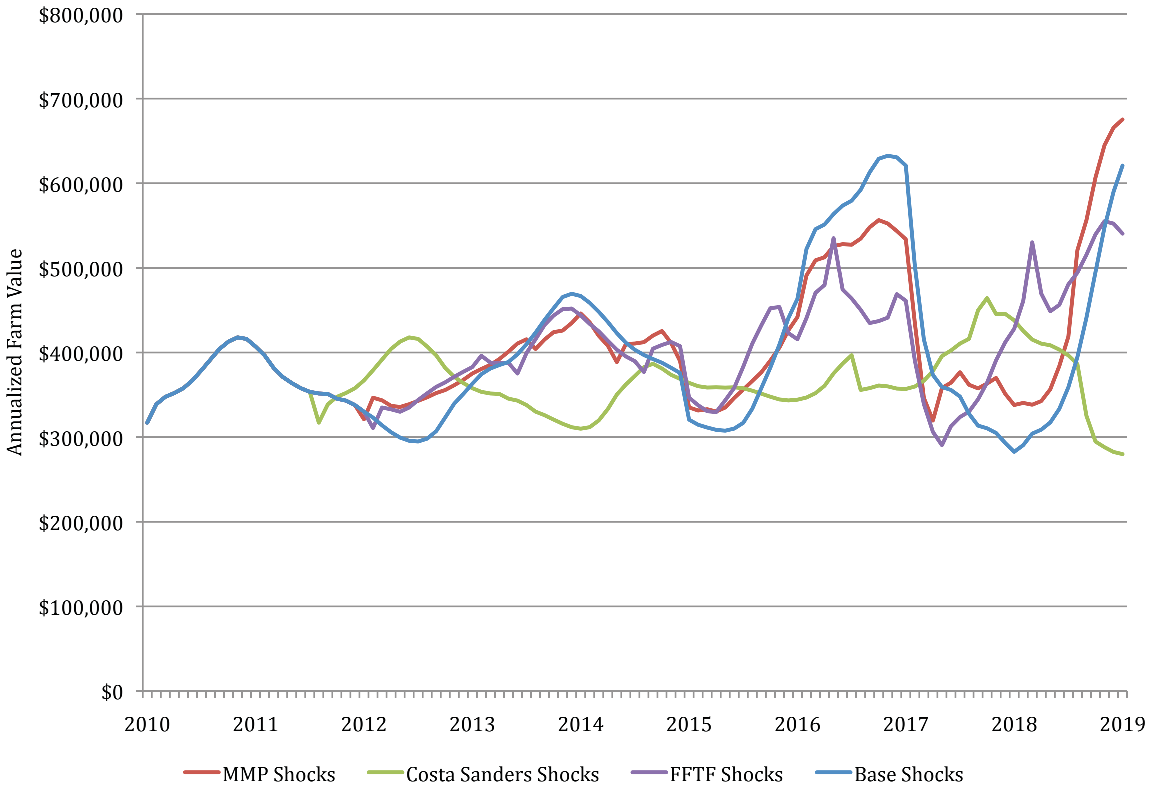


Figure 19. U.S. Monthly Milk Marketings, with Shocks

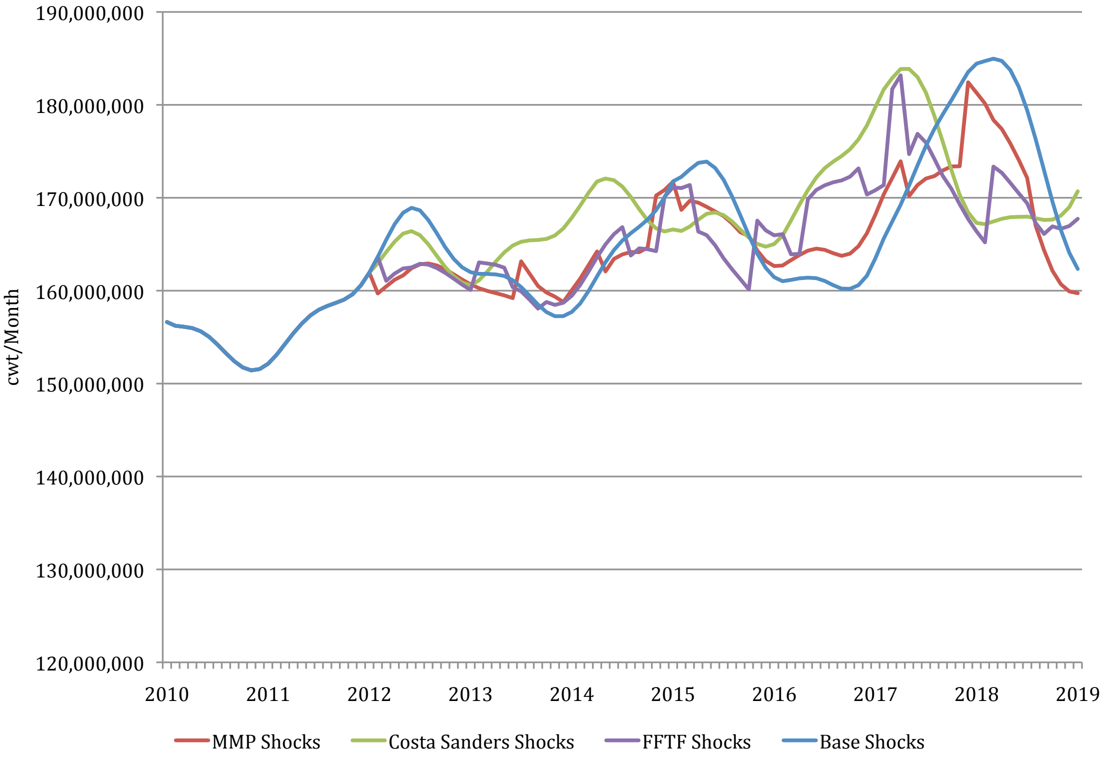


Figure 20. Net Cheese Exports, with Shocks

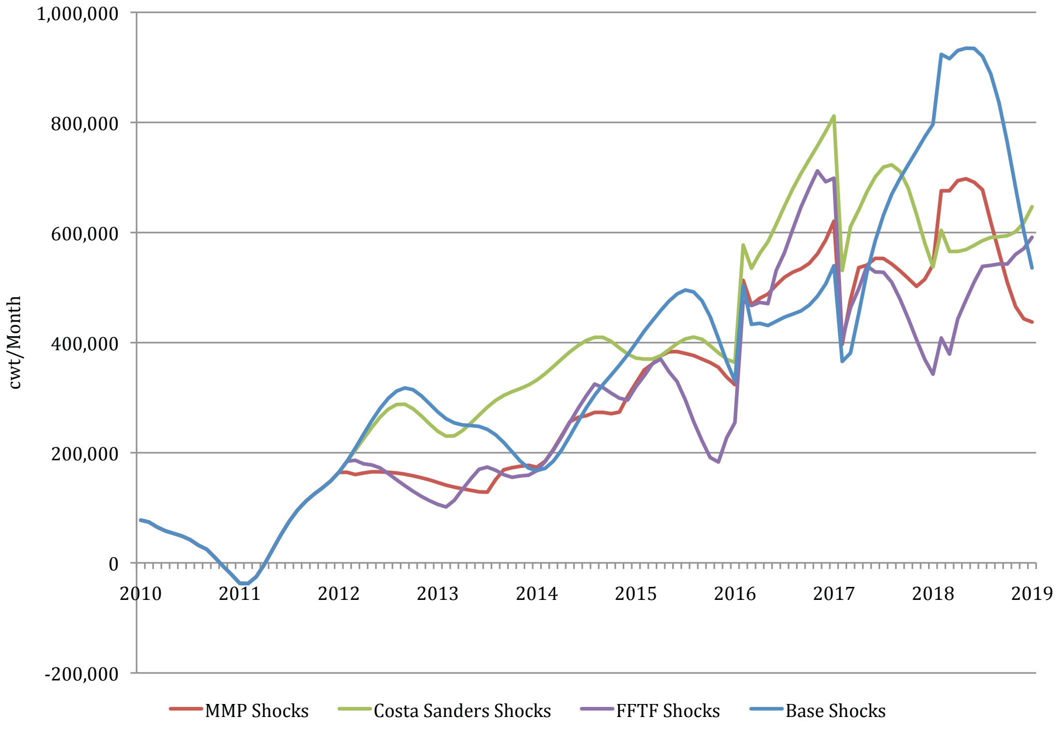


Figure 21. Net Dry Whey Exports, with Shocks.

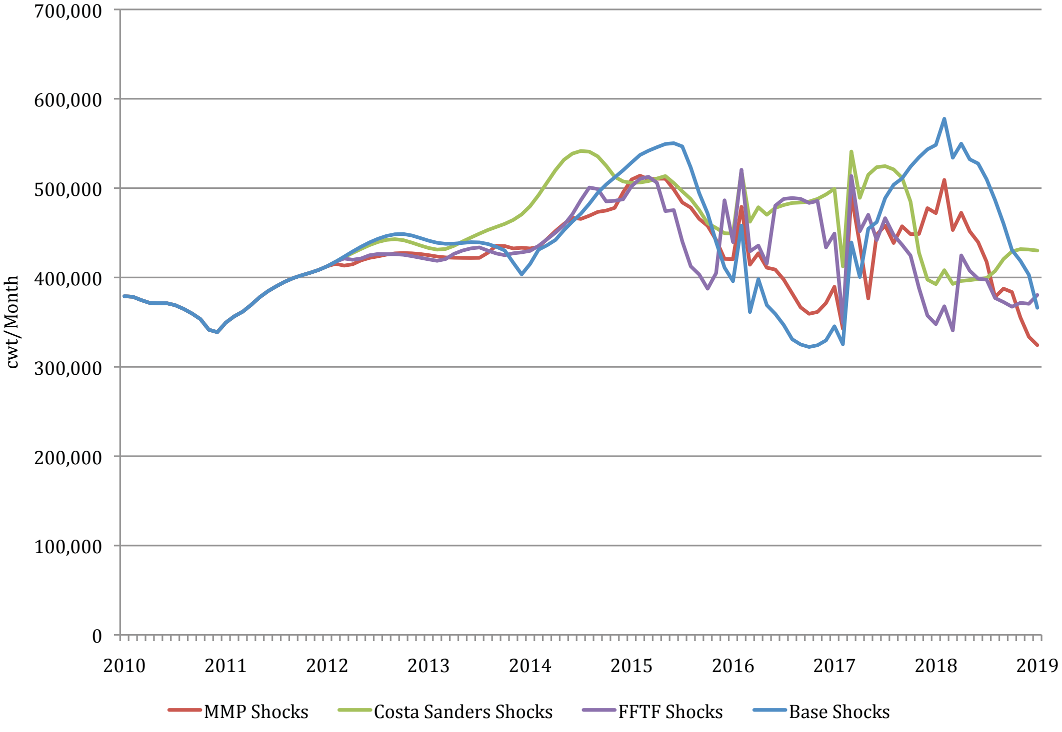
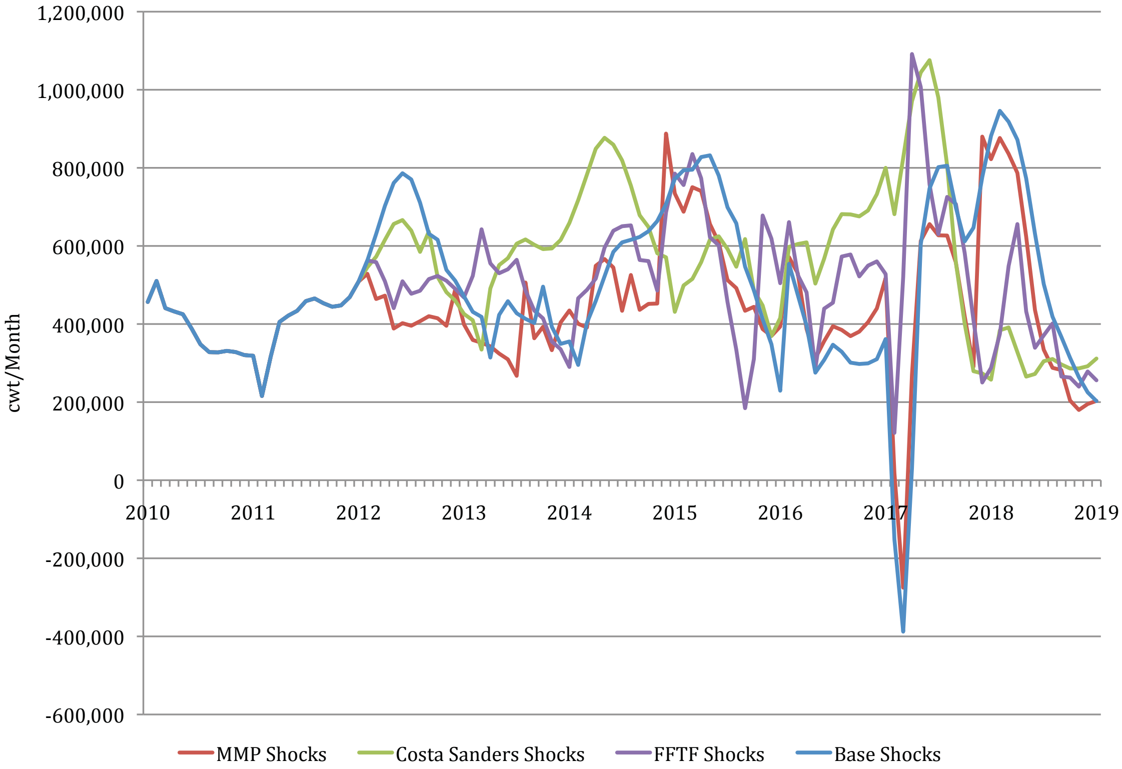


Figure 22. Net Milk Powder Exports, with Shocks



U.S. Dairy Product Trade. The shocks, as expected, have a significant effect on the numerical values for U.S. net exports (Figures 20, 21 and 22). As for the analyses without shocks, net exports for products grow under the Baseline and the programs. Average net exports of cheese and dry whey are higher than the Baseline under CS, and lower under MMP and FFTF than the Baseline. The average net exports of American cheese would be reduced 17.0% and 22.0% compared to the Baseline under the MMP and FFTF programs, respectively (Appendix Table A2). Under CS, average net exports of American cheese would increase 2.5%. Average net exports of dry whey would decrease 3.1% and 2.8% under MMP and FFTF, respectively, but would increase 2.6% under CS. Average net exports of NDM would increase 8.1% under CS, but would decrease 10.0% and 8.9% under MMP and FFTF, respectively.

Class III and Class IV Prices. The shocks also have a significant impact on Class III and IV prices (Figures 23 and 24). As for the scenarios without shocks, each of the programs has the effect of reducing the variation in Class III and IV prices given the shocks. The MMP and FFTF would increase the average Class III price during 2010-18 by $0.52/cwt and $0.67/cwt. The MMP would increase the average Class IV price during that period by $$0.03/cwt, but FFTF would reduce it by $0.12/cwt. The CS program would reduce both the average Class III and Class IV prices, by $0.24/cwt and $0.34/cwt, respectively. With the large shocks, the MMP and FFTF program would increase variability in the Class IV price, as measured by Black-Scholes. MMP would also increase variation in Class III by this measure. The CS program would reduce variation in both Class III and Class IV by the Black-Scholes measure.

Figure 23. Federal Order Class III Milk Price, with Shocks

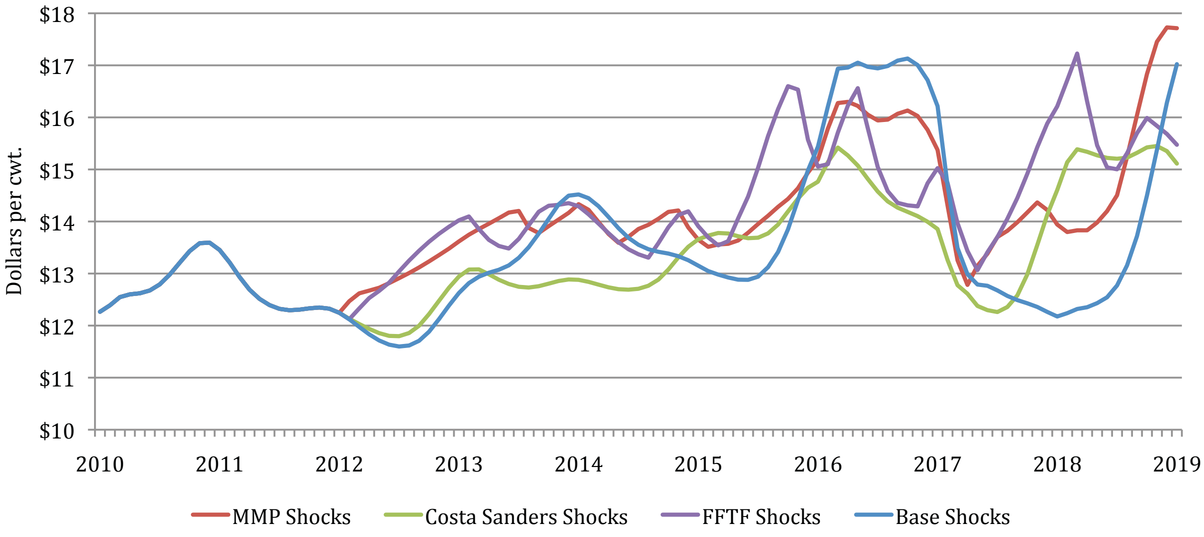
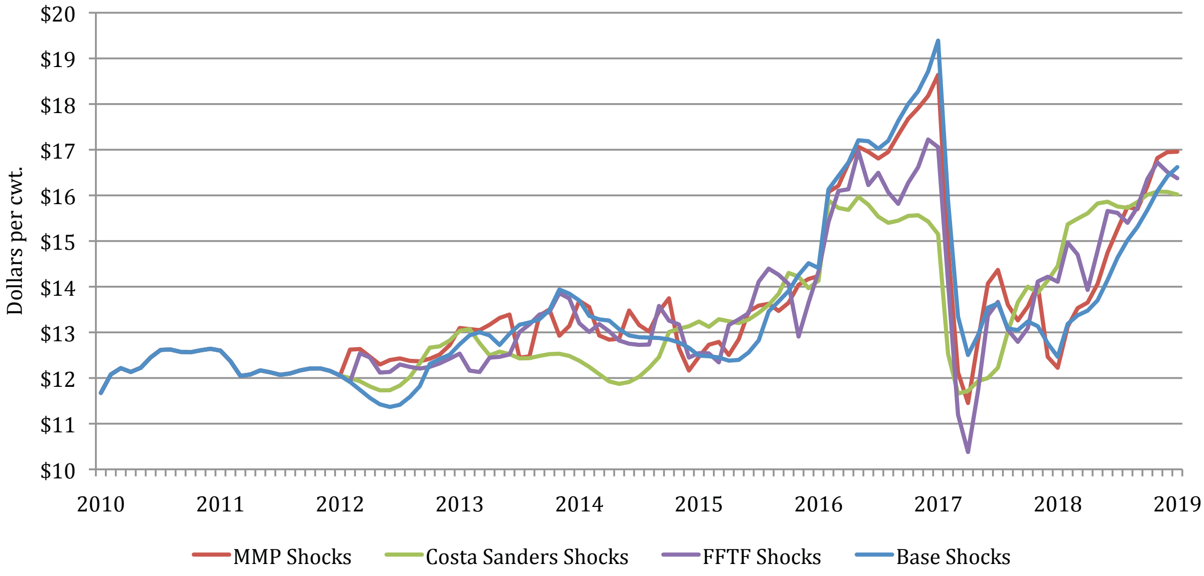
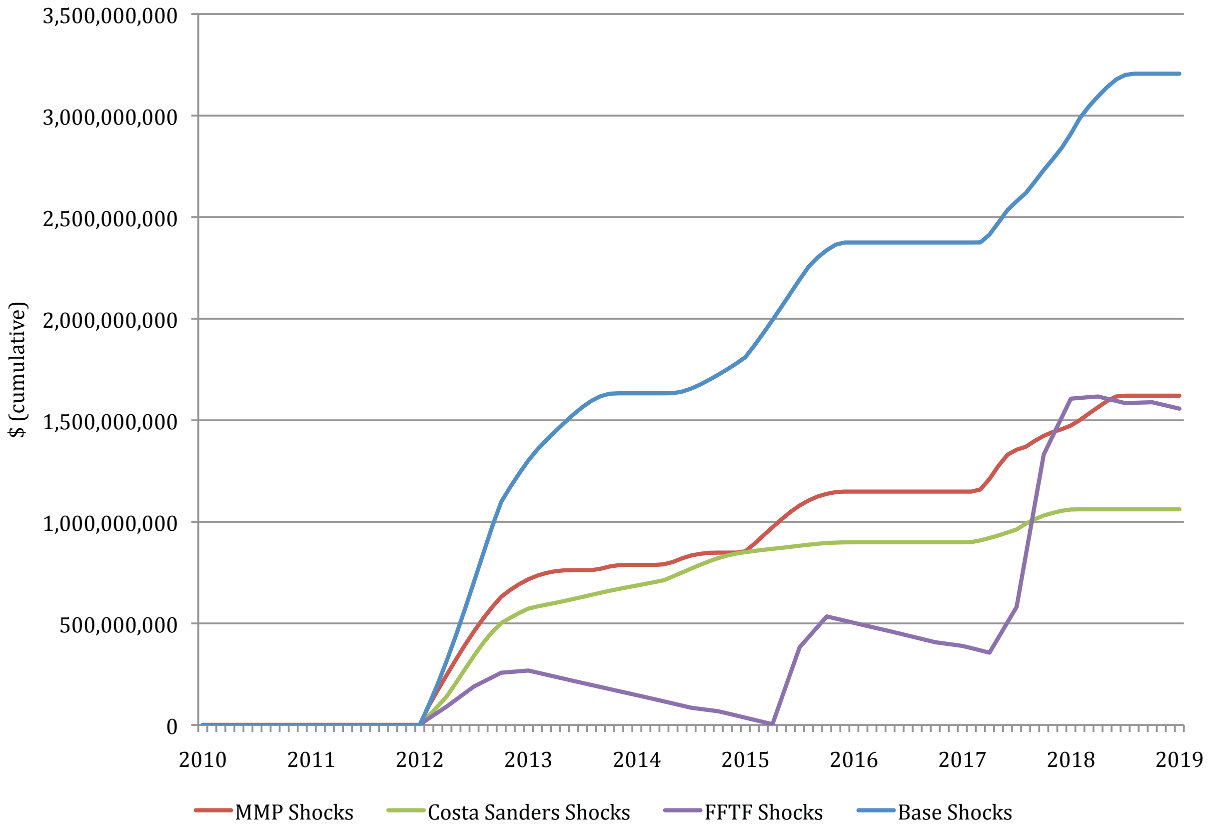


Figure 24. Federal Order Class IV Milk Price, with Shocks



Government Expenditures. Cumulative government expenditures are somewhat higher than for the scenarios without shocks for the Baseline. With the shocks, the relative magnitude of government expenditures is altered compared to the situation without shocks. The CS program is the least costly (has expenditures similar to the scenario without the shocks), whereas the MMP and FFTF are projected to cost about $1.5 billion over the simulated time horizon. The rapid increase in government expenditures under FFTF is due to DPIPP payments resulting from low prices coupled with higher feed costs in 2017 (Figure 25).

Figure 25. Cumulative Government Expenditures from 2012 through 2018, with Shocks



Results with Stochastic Shocks

The previous section imposed specific shocks to illustrate the effectiveness of programs to reduce price volatility under relatively extreme conditions. These shocks were similar to shocks seen during 2007-2010, but, by definition, the magnitude and timing of future shocks is unknown. To assess the ability of the programs to mitigate volatility under a broader range of shocks, we analyzed a large number of stochastic, or random, shocks. As noted above, this randomness was in both the size of the shock and the timing of the shock. For the Baseline and each of the programs, the stochastic shocks were run 200 times.

One way to report these results is with bands of distributions (essentially, probability distributions) for the outcomes that were observed in the 200 model runs. For the Baseline, the results for the All-Milk price and average absolute deviation in All-milk price illustrate this (Figures 26 and 27). The green lines show the same values observed in the Baselines of Figures 6 and 7 respectively, and the red lines show the values in the Baselines of Figures 16 and 17 (the scale is much different). The yellow band shows the range of values in the 200 stochastic runs where the middle 50 percent of the observations were seen. The lighter green bands shows the range of the middle 75 percent of observations, the blue bands are 95 percent and the dark grey bands incorporate the full range of observations. Clearly, there can be very different outcomes to even the Baseline depending on when shocks occur and how large they may be.

Figure 26. All Milk Price Baseline with 200 Stochastic Shocks on Feed Prices and Export Demand

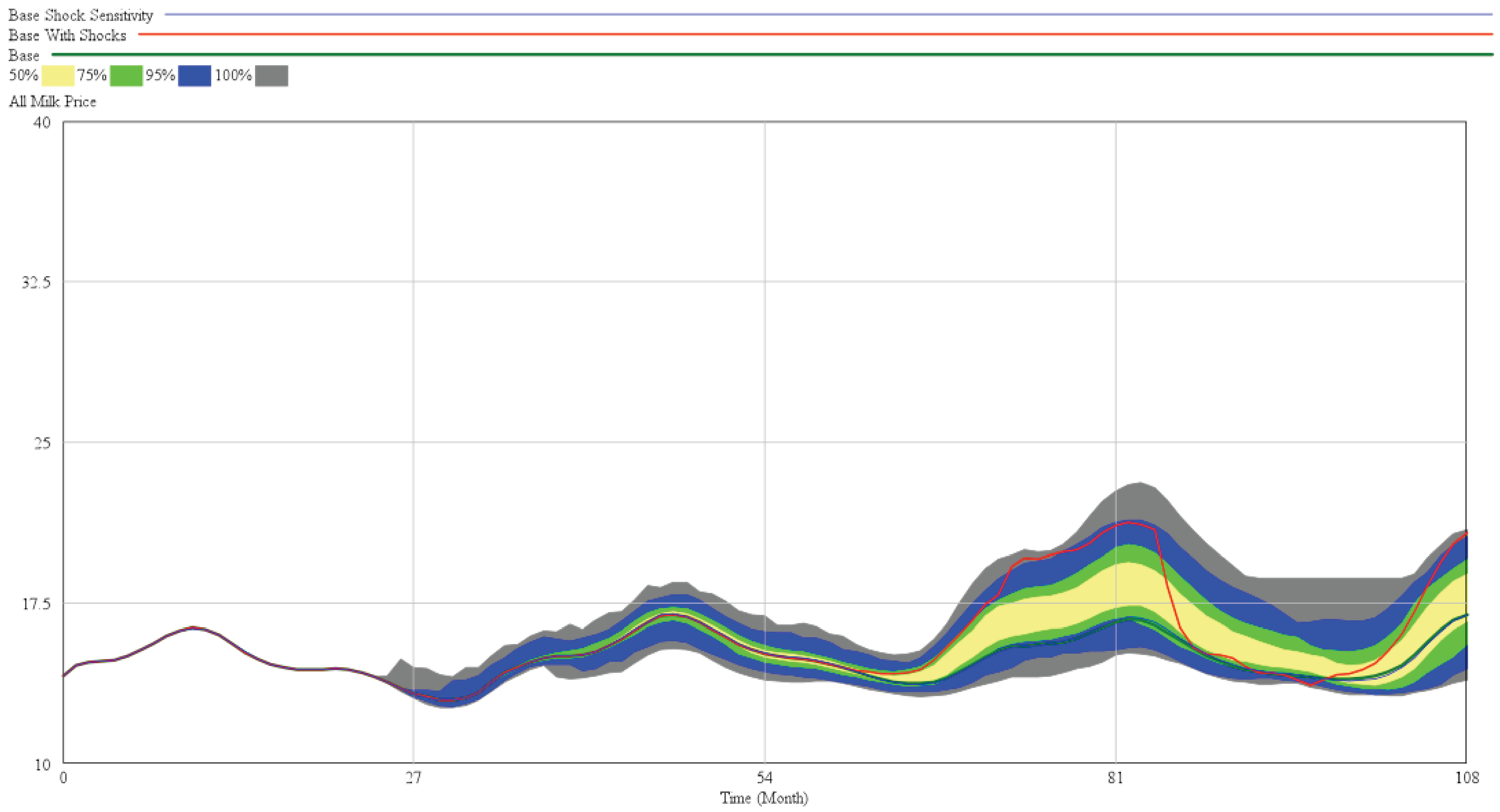
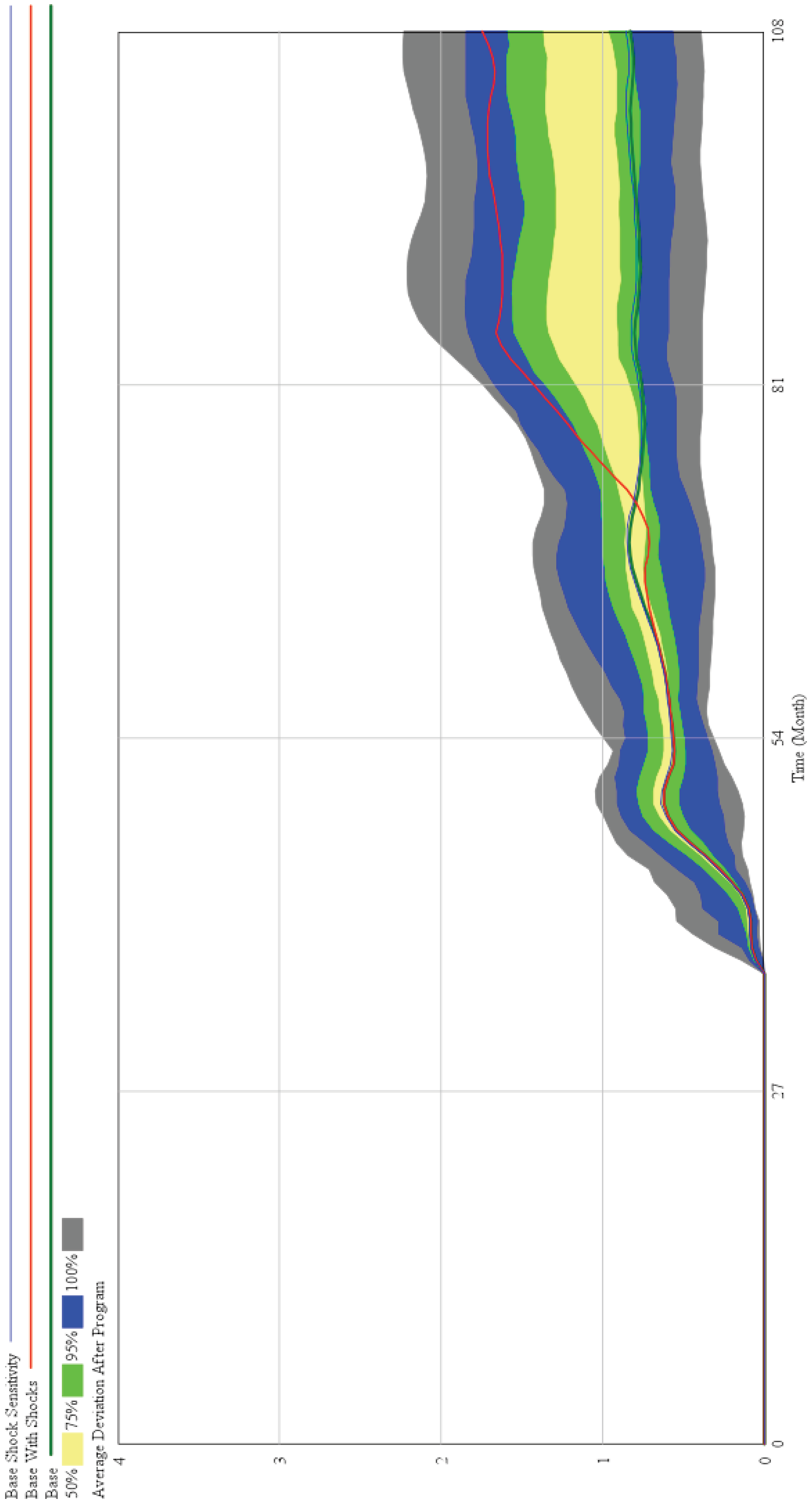
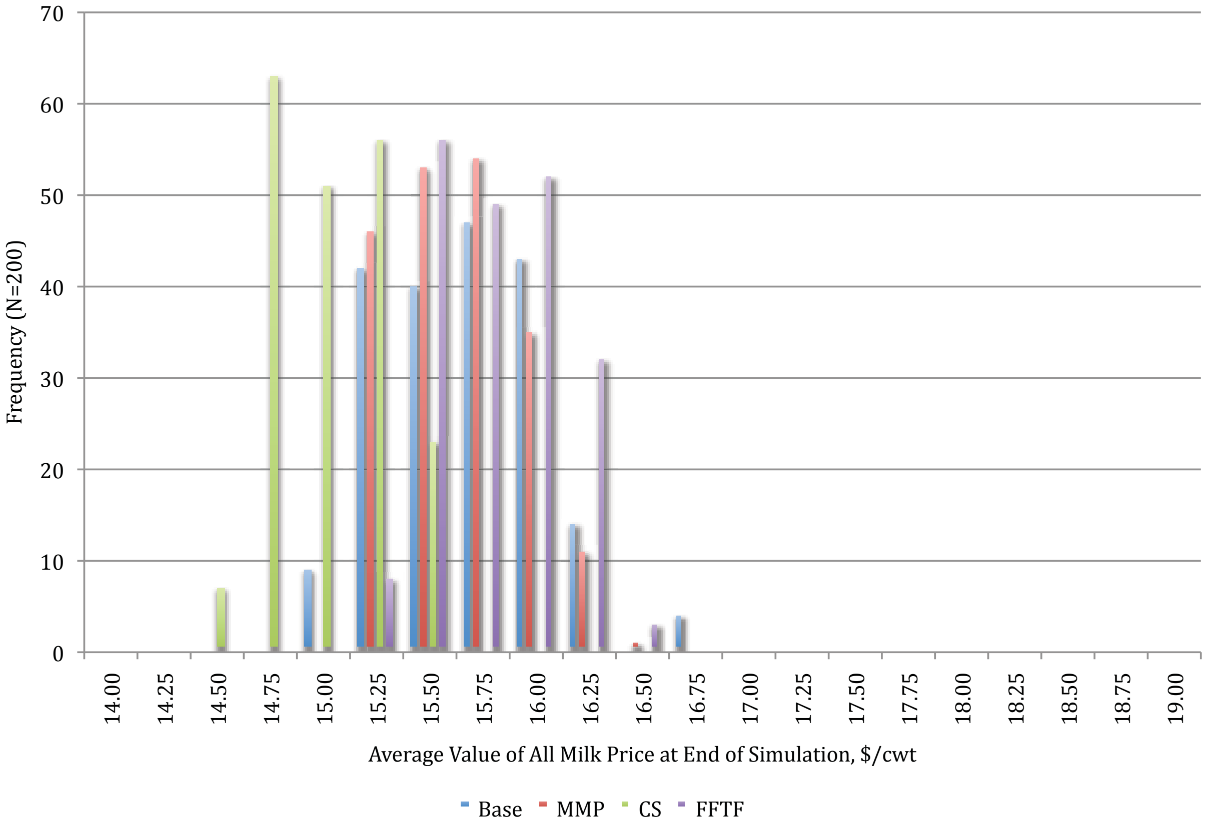


Figure 27. Average Absolute Deviation with 200 Stochastic Shocks on Feed Prices and Export Demand



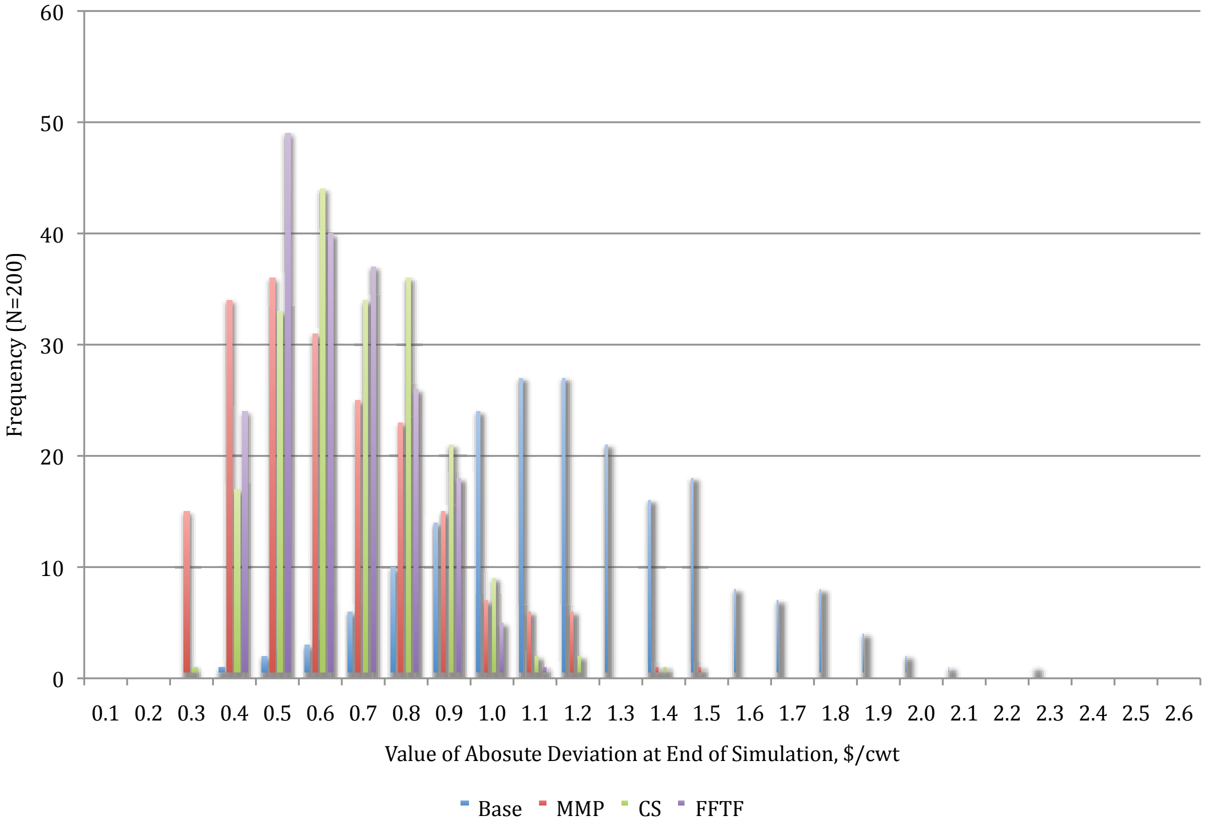
All Milk Price. Graphs such as Figures 26 and 27 provide a good representation of the range of outcomes over a random set of variables for any one program or Baseline. However, these graphs per se do not allow a direct comparison of possible outcomes across the Baseline and the programs. Thus, we calculated an average all milk price for each of the 200 stochastic runs and each of the programs and Baseline and generated frequency distributions (histograms) of the values. This provides an indicator of each of the programs in their ability to deal with a range of shocks. In this analysis, comparison of the distribution (spread) of values (rather than individual points) is most relevant.

Figure 28. Average All Milk Price, $/cwt, 200 Stochastic Runs



The Baseline scenario has a normal distribution of average All-Milk price in response to stochastic shocks (Figure 28). "Normal" in this sense means that there is a bell-shape to the curve with most observations (the mode) in the middle ($15.75) and fewer in either direction above and below the mode. The CS program has a distribution that is more uniform, meaning that it is almost as common to see a value of $14.75 as it is to see $15.00 or $15.25. Values above and below that range are much less common. The FFTF also has a very uniform distribution across the range of $15.50 to $16.00 with fewer observations above and below those values. The MMP appears to have a distribution that is skewed to the right but somewhere between CS and FFTF. Thus, the CS distribution is shifted to the left compared to the Baseline, whereas the FFTF distribution is shifted to the right. The MMP distribution is similar to Baseline, although with fewer low values. Taken together, these results are consistent with the results of individual scenarios, which indicated somewhat higher average All-Milk prices under MMP and FFTF, and somewhat lower average All-Milk prices under CS.

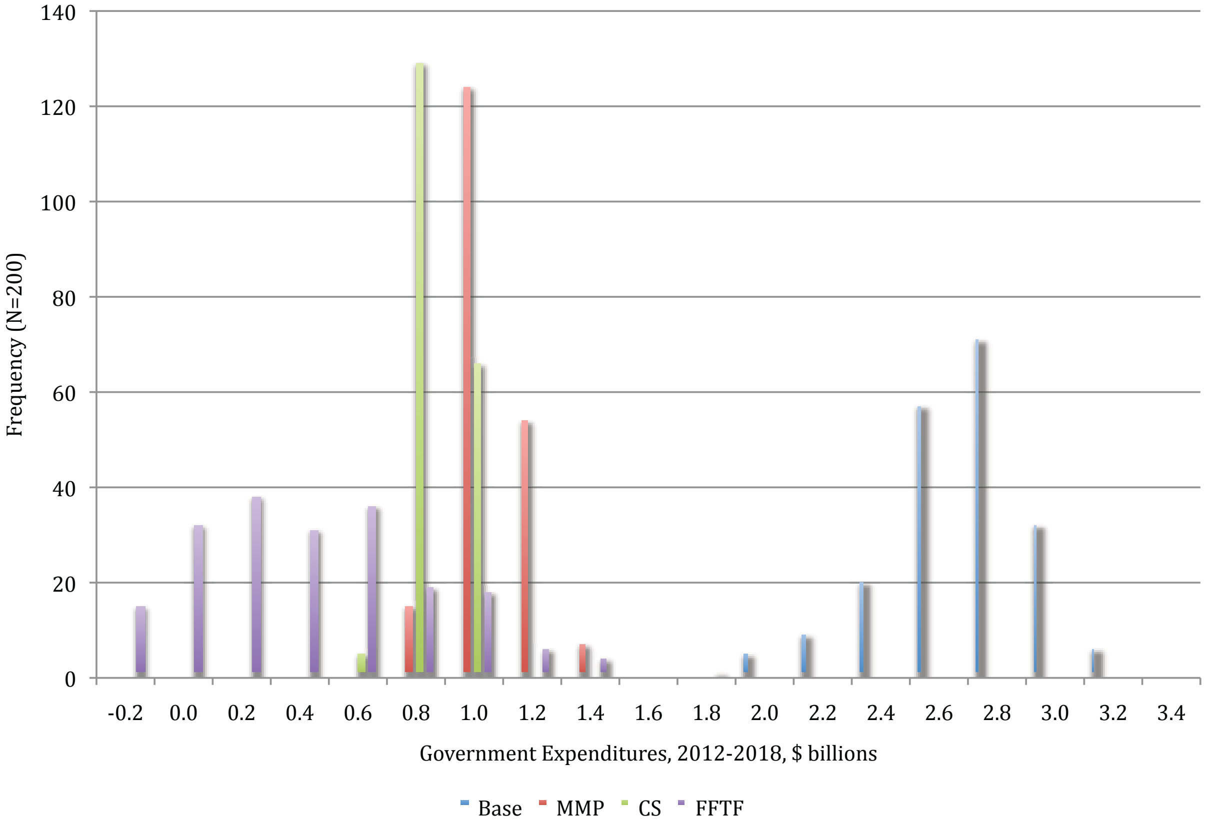
Figure 29. Average Absolute Deviation in All-Milk Price, $/cwt, 200 Stochastic Runs



Variation in All-Milk Price. The distribution of average absolute deviation in the All-Milk price under the Baseline is roughly normal (Figure 29). In this figure, less volatility is represented by outcomes to the left and more volatility to the right. Based on the distribution of outcomes, each of the programs reduces the variation in the All-milk price compared to the Baseline. The FFTF has the tightest distribution, meaning that the range of outcomes is smaller than the Baseline and all other programs. FFTF and MMP have the lowest mode, or most common observation across all of the programs. Although the MMP has the same modal value as the FFTF, it is more dispersed. Like the FFTF, the CS program also has a tight distribution but its modal value is somewhat higher. These results again suggest that in response to a variety of shocks, each of the programs would reduce variability in the All-Milk price, at least by the measure of absolute average deviation.

Government Expenditures. A similar analysis can be conducted for government expenditures (Figure 30). This stochastic analysis suggests that the range of cumulative government expenditures from 2012-2018 is fairly narrow under CS and MMP, but is somewhat more variable for the FFTF. The overall distribution suggests that government expenditures would be reduced under the programs compared to the Baseline for a variety of shocks.

Figure 30. Cumulative Government Expenditures 2012-2018, 200 Stochastic Runs

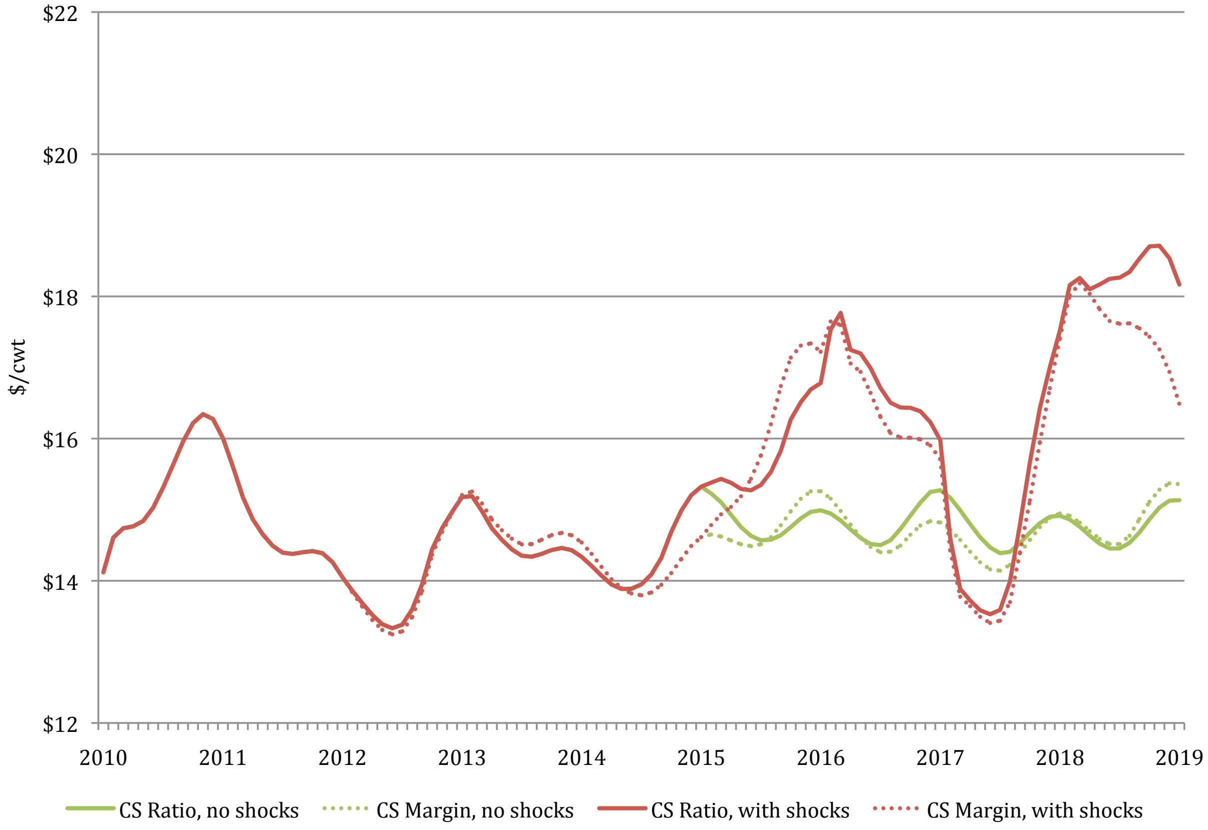


Results for Additional Analyses Under Alternative Assumptions

We also analyzed a version of the CS program that used a milk-feed margin trigger similar to that used by the FFTF. Using a ratio as a trigger mechanism could lead to problems if milk and feed prices shift substantially (note however, that is doesn't based on our previously-discussed analysis). For example, $12 milk and $5 feed is a milk feed ratio of 2.40 and a margin of $7. But if feed prices rise to $8 and milk prices to $15, the margin remains $7 but the ratio is now 1.67. Milk income over feed cost is unchanged but allowable growth would change from 3 percent to 0 percent and market access fees from $0.88 to $1.75. This suggests that the language of the bill should be flexible enough to accommodate a regime change in feed and (or) milk prices by changing the triggers, or the use of a margin calculation rather than a ratio.

The All-Milk price for CS with the milk-feed price ratio and the margin-based trigger have a similar patterns and levels with and without the shocks (Figure 31, Appendix Table A3). Although not analyzed, there are likely to be administrative benefits to using a margin rather than the milk feed price ratio to determine allowable growth and market access fees.

Figure 31. All Milk Price, Variations on the Costa Sanders Program



We also analyzed the importance of the assumption about milk marketings in the FFTF program. We assume that a proportion of milk that was receiving the no-payment penalty when the program was triggered would continue to be marketed under the program. We assumed that 35 percent of the penalty milk would continue to be marketed, but that adjustments to milk production and marketing would also be made over time in response to reduced profitability (Net Farm Operating Income). Given the uncertainty about aggregate production and marketing in response to a marginal milk value of $0/cwt, we also examined the impact of the program under the assumption that producers would make a full and immediate (permanent) adjustment in milk production to eliminate milk that would receive the marginal milk value. We note that we do not consider this the most likely assumption, but it provides additional information about the structure and functioning of the FFTF program.

Figure 32. All Milk Price, Assuming Immediate and Complete Supply Response Under FFTF

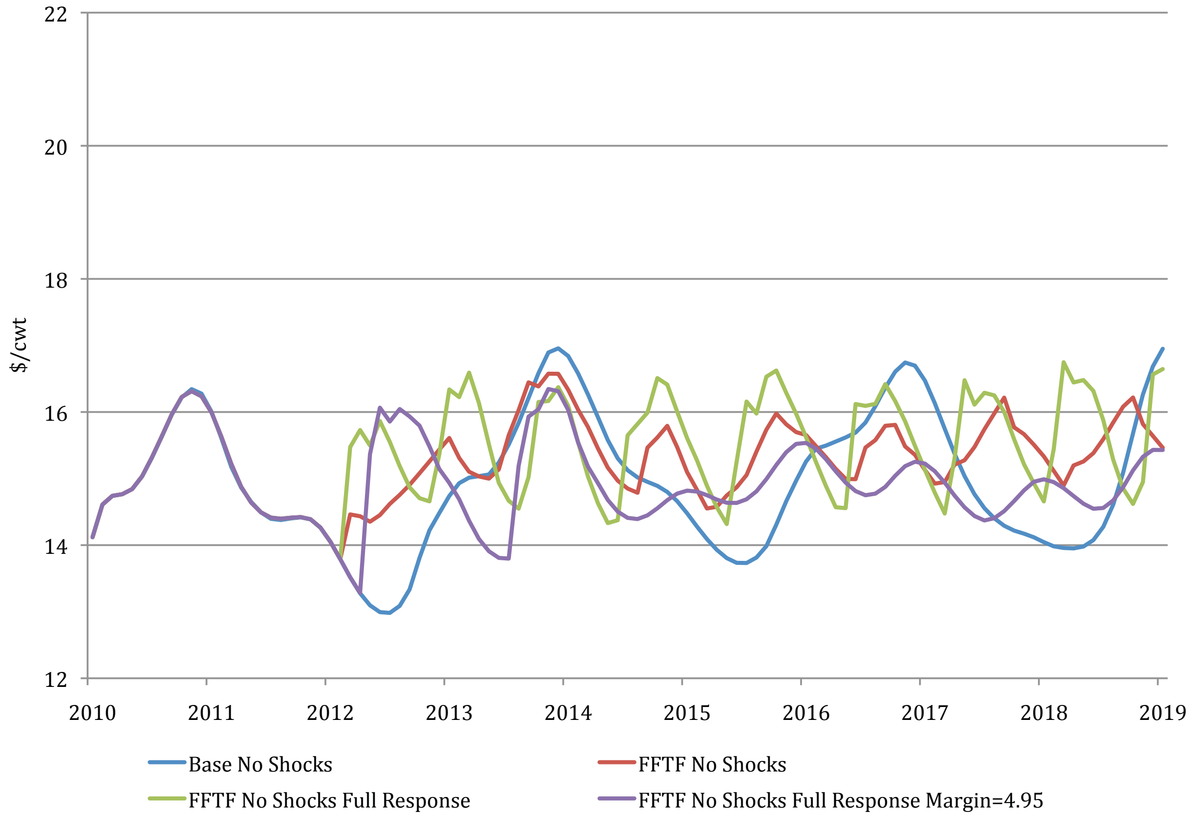
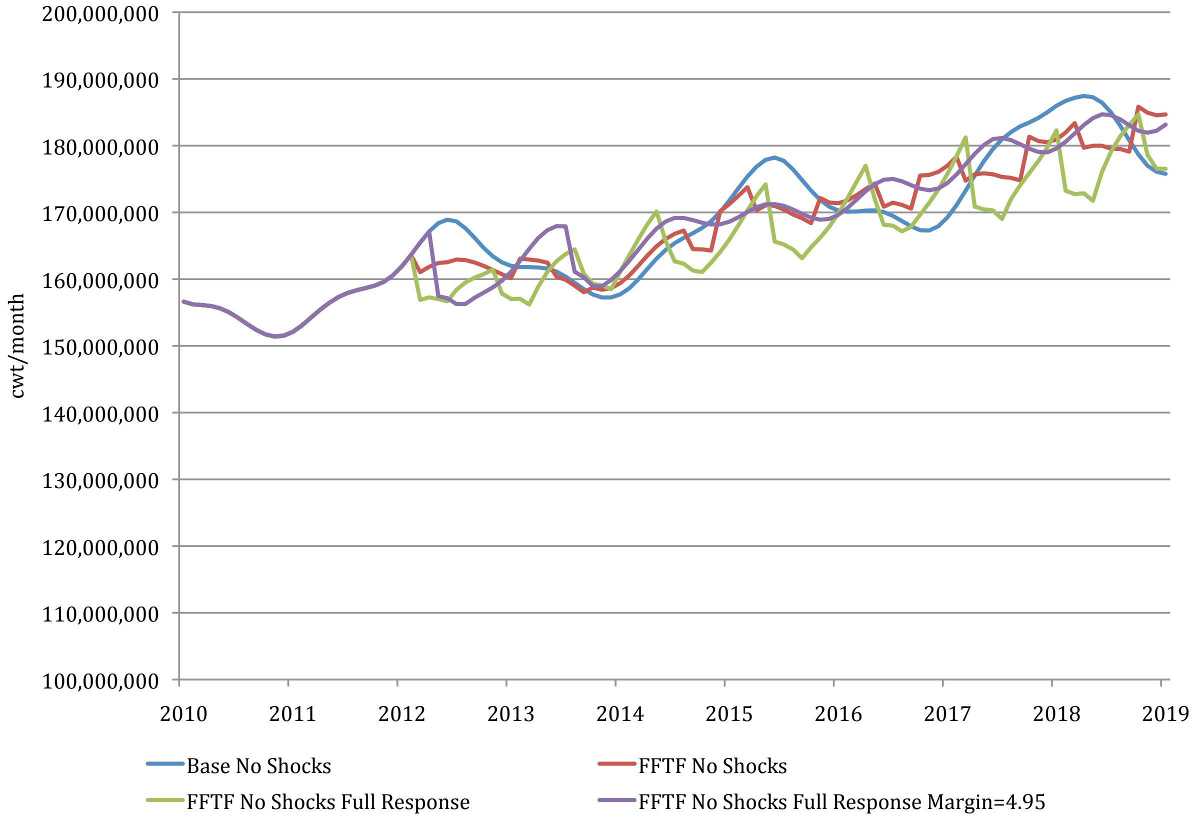
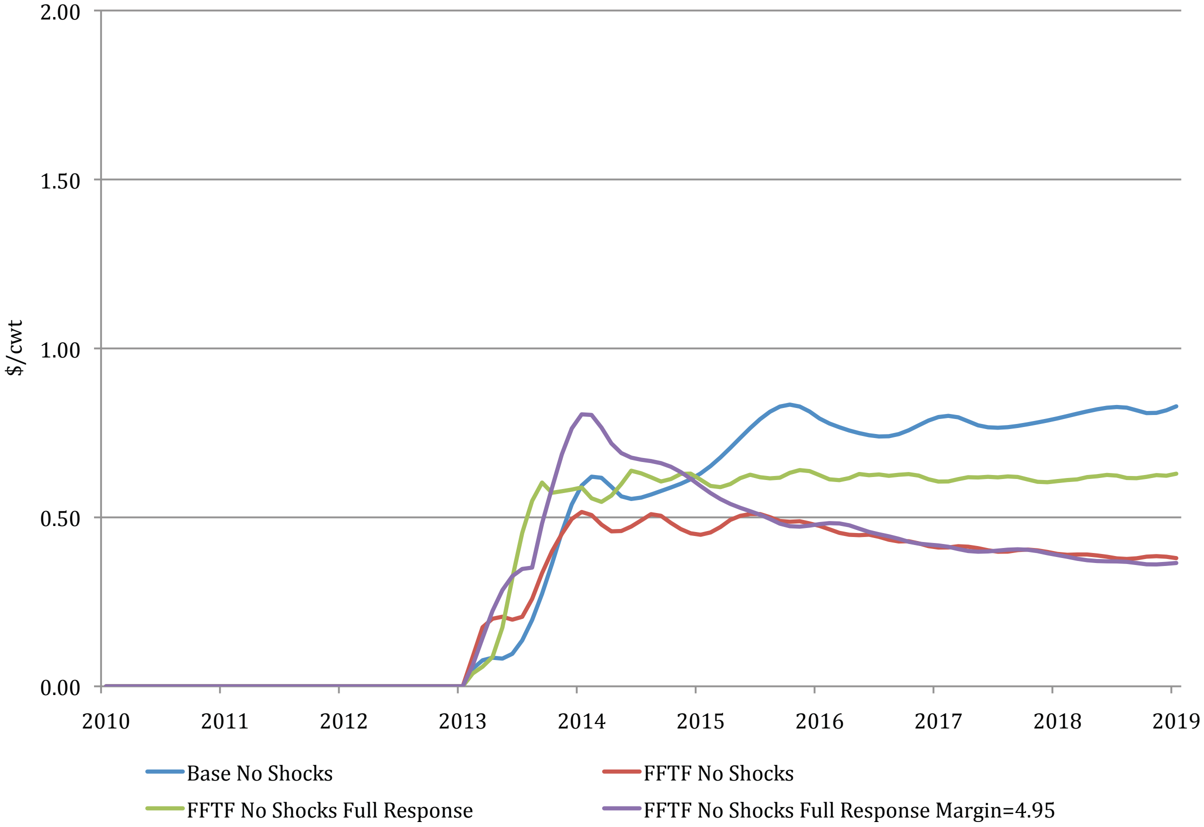


Figure 33. Milk Marketed Assuming Immediate and Complete Supply Response Under FFTF



This assumption has a relevant impact on the results of the FFTF program (Figures 32 and 33)—but only if other program implementation parameters are unchanged. The more immediate response of producers results in higher average and more variable milk prices than under our previous assumption about some milk being marketed. Under the program with the alternative assumption, reductions in milk marketings account for all of the market correction. Although this assumption is important numerically, it is important to note that the FFTF would still reduce variation compared to the Baseline by the absolute average deviation measure. Moreover, a programmatic change—making the margin that triggers reduced milk marketing $4.95/cwt rather than $6/cwt—would result in price patterns similar to those under the assumption of some milk continuing to be marketed when reductions are triggered under FFTF. Variation under this lower margin trigger would be comparable under our current assumption about milk marketings using the $6 margin. (Figure 34, Appendix Table A4).

Figure 34. Average Absolute Deviation of the FFTF Under Various Assumptions



Conclusions and Implications

Milk price volatility has clearly become a significant problem for the dairy industry since the 1990s, although the underlying causes of volatility continue to be debated. Some observers have hypothesized that without an active Dairy Product Price Support Program dairy manufacturers will simply not hold enough commercial stocks of product to buffer supply and demand imbalances. Others have suggested that it is our emergence into world trade in dairy products that has been a cause of the price swings. Still others have suggested that it is simply a faulty price discovery mechanism in the Federal Milk Marketing Order system. But some dairy producers have also suggested that volatility results from rational responses to profitability incentives in the absence of coordinated expansion decisions. Recent research has shown that there are complex cycles in milk prices. Over these last two decades, a 36-month cycle has emerged and is becoming larger, and these cycles are probably related to dairy producer decisions. This endogenous variability is consistent with the experience for other commodities, as noted in Sterman (2000). As a result, a number of dairy industry organizations have proposed programs with supply management components to reduce this volatility.

Our analyses of three proposed programs indicate that all three would significantly reduce milk price volatility and would reduce government expenditures on dairy programs in the absence of shocks, for a set of specific large shocks, and for a set of 200 randomly selected shocks. In general, the MMP and the FFTF programs would marginally enhance the average milk price over the Baseline, primarily because they are stimulating demand for dairy products through food purchases for domestic assistance programs. The CS program would somewhat diminish the average All-Milk price from the Baseline. This occurs because the allowable levels of growth are generous and without the deeper troughs in milk price, producers are willing and able to expand milk production.

The three programs have different impacts on exports. The CS program results in more cheese production (due to the additional milk marketed) and some of that additional cheese, dry whey and NDM are exported. The MMP and FFTF programs reduce exports of cheese and whey compared to the Baseline.

The ultimate objective of this research is to help the dairy industry better assess the tradeoffs associated with these policy options. This analysis attempts to account for a variety of potential unintended consequences, but we have not assessed every possibility. Moreover, we do not directly address implementation issues. We assume for the purposes of our analyses that the programs can be implemented by appropriate government agencies in a reasonably effective manner. Although we have no reason to believe this would not be the case, it is worth noting as an underlying assumption. The industry should now use this information to facilitate thoughtful discussion about the potential benefits and drawbacks of these programs.

Appendix

Table A1. Outcome Indicators for Scenarios with No Shocks

	Baseline	Marginal Milk Pricing	Costa Sanders	Foundation for the Future
Average All Milk Price After Program and Adjustment ($/cwt)	$15.32	$15.55	$14.63	$15.49
Average Deviation After Program Implementation ($/cwt)	0.83	0.30	0.28	0.35
Black Scholes volatility measure	0.0057	0.0048	0.0034	0.0057
Coefficient of Variation	0.0171	0.0092	0.0110	0.0079
Total Milk Marketed (Bil lbs)	1,826	1,816	1,841	1,818
Annual Average Milk Income Over Feed Cost Annual Rate, Small Farm (37 cows)	$82,125	$82,724	$74,517	$83,235
Annual Average Milk Income Over Feed Cost Annual Rate, Medium Farm (183 cows)	$406,187	$409,145	$368,555	$411,677
Annual Average Milk Income Over Feed Cost Annual Rate, Large Farm (910 cows)	$2,019,838	$2,034,548	$1,832,707	$2,047,138
Annual Average Milk Income Over Feed Cost Annual Rate, Extra Large Farm (3705 cows)	$8,223,628	$8,283,506	$7,461,737	$8,334,769
Total Government Expenditures 2012 to 2018 (Mil $)	$2,936	$1,174	$1,023	-$171
Cumulative Fluid Sales (Mil lbs)	544,008	542,464	544,886	541,809
Cumulative American Cheese Sales (Mil lbs)	41,900	41,394	42,514	41,362
Cumulative Other Cheese Sales (Mil lbs)	59,807	59,829	59,842	59,807
Average Monthly Net Exports American Cheese (1000s lbs)	38,034	32,228	41,457	30,036
Average Monthly Net Exports Dry Whey (1000s lbs)	45,528	43,967	47,289	43,647
Average Monthly Net Exports Milk Powders (1000s lbs)	59,423	54,819	59,968	62,731
Average Class III Price After Program Implement ($/cwt)	$13.43	$13.91	$12.99	$14.14
Average Class IV Price After Program Implement ($/cwt)	$13.30	$13.26	$13.18	$13.00

Table A2. Outcome Indicators for Scenarios with Imposed Shocks

	Baseline	Marginal Milk Pricing	Costa Sanders	Foundation for the Future
Average All Milk Price After Program and Adjustment ($/cwt)	$15.87	$15.99	$14.99	$15.93
Average Deviation After Program Implementation ($/cwt)	1.74	1.26	1.25	1.13
Black Scholes volatility measure	0.0112	0.0115	0.0078	0.0116
Coefficient of Variation	0.0335	0.0224	0.0266	0.0239
Total Milk Marketed (Bil lbs)	1,797	1,784	1,809	1,788
Annual Average Milk Income Over Feed Cost Annual Rate, Small Farm (37 cows)	$85,173	$86,338	$73,555	$84,969
Annual Average Milk Income Over Feed Cost Annual Rate, Medium Farm (183 cows)	$421,263	$427,024	$363,801	$420,252
Annual Average Milk Income Over Feed Cost Annual Rate, Large Farm (910 cows)	$2,094,803	$2,123,455	$1,809,067	$2,089,777
Annual Average Milk Income Over Feed Cost Annual Rate, Extra Large Farm (3705 cows)	$8,528,840	$8,645,488	$7,365,485	$8,508,371
Total Government Expenditures 2012 to 2018 (Mil $)	$3,206	$1,621	$1,062	$1,557
Cumulative Fluid Sales (Mil lbs)	540,734	539,383	542,112	538,883
Cumulative American Cheese Sales (Mil lbs)	41,725	40,998	41,513	41,448
Cumulative Other Cheese Sales (Mil lbs)	60,402	60,280	59,759	60,207
Average Monthly Net Exports American Cheese (1000s lbs)	35,590	29,563	36,502	27,762
Average Monthly Net Exports Dry Whey (1000s lbs)	43,457	42,103	44,585	42,221
Average Monthly Net Exports Milk Powders (1000s lbs)	49,194	44,231	53,178	48,768
Average Class III Price After Program Implement ($/cwt)	$14.01	$14.53	$13.77	$14.68
Average Class IV Price After Program Implement ($/cwt)	$14.16	$14.19	$13.82	$14.04

Table A3. Costa Sanders Ratio versus Margin Trigger

	No Shocks		Imposed Shocks	
	Costa Sanders Ratio	Costa Sanders Margin	Costa Sanders Ratio	Costa Sanders Margin
Average All Milk Price After Program and Adjustment ($/cwt)	$14.63	$14.61	$14.99	$15.00
Average Deviation After Program Implementation ($/cwt)	0.28	0.29	1.25	1.14
Black Scholes volatility measure	0.0034	0.0032	0.0078	0.0078
Coefficient of Variation	0.0110	0.0127	0.0266	0.0235
Total Milk Marketed (Bil lbs)	1,841	1,844	1,809	1,816
Annual Average Milk Income Over Feed Cost Annual Rate, Small Farm (37 cows)	$74,517	$73,788	$73,555	$73,467
Annual Average Milk Income Over Feed Cost Annual Rate, Medium Farm (183 cows)	$368,555	$364,951	$363,801	$363,365
Annual Average Milk Income Over Feed Cost Annual Rate, Large Farm (910 cows)	$1,832,707	$1,814,786	$1,809,067	$1,806,897
Annual Average Milk Income Over Feed Cost Annual Rate, Extra Large Farm (3705 cows)	$7,461,737	$7,388,770	$7,365,485	$7,356,651
Total Government Expenditures 2012 to 2018 (Mil $)	$1,023	$1,423	$1,062	$1,510
Cumulative Fluid Sales (Mil lbs)	544,886	545,114	542,112	542,479
Cumulative American Cheese Sales (Mil lbs)	42,514	42,583	41,513	41,682
Cumulative Other Cheese Sales (Mil lbs)	59,842	59,848	59,759	59,817
Average Monthly Net Exports American Cheese (1000s lbs)	41,457	41,775	36,502	37,480
Average Monthly Net Exports Dry Whey (1000s lbs)	47,289	47,435	44,585	44,896
Average Monthly Net Exports Milk Powders (1000s lbs)	59,968	61,240	53,178	55,143
Average Class III Price After Program Implement ($/cwt)	$12.99	$12.96	$13.77	$13.65
Average Class IV Price After Program Implement ($/cwt)	$13.18	$13.10	$13.82	$13.69

Table A4. Foundation for the Future With Behavioral Assumptions

	Baseline	No Shocks	Immediate Supply Response	Immediate Supply Response with $4.95 Margin
Average All Milk Price After Program and Adjustment ($/cwt)	$15.32	$15.49	$15.63	$14.87
Average Deviation After Program Implementation ($/cwt)	0.83	0.35	0.63	0.36
Black Scholes volatility measure	0.0057	0.0057	0.0131	0.0062
Coefficient of Variation	0.0171	0.0079	0.0123	0.0119
Total Milk Marketed (Bil lbs)	1,826	1,818	1,800	1,825
Annual Average Milk Income Over Feed Cost Annual Rate, Small Farm (37 cows)	$82,125	$83,235	$85,041	$79,479
Annual Average Milk Income Over Feed Cost Annual Rate, Medium Farm (183 cows)	$406,187	$411,677	$420,606	$393,099
Annual Average Milk Income Over Feed Cost Annual Rate, Large Farm (910 cows)	$2,019,838	$2,047,138	$2,091,537	$1,954,755
Annual Average Milk Income Over Feed Cost Annual Rate, Extra Large Farm (3705 cows)	$8,223,628	$8,334,769	$8,515,546	$7,958,646
Total Government Expenditures 2012 to 2018 (Mil $)	$2,936	-$171	-$226	$1,329
Cumulative Fluid Sales (Mil lbs)	544,008	541,809	541,744	543,810
Cumulative American Cheese Sales (Mil lbs)	41,900	41,362	41,025	41,895
Cumulative Other Cheese Sales (Mil lbs)	59,807	59,807	59,894	59,812
Average Monthly Net Exports American Cheese (1000s lbs)	38,034	30,036	33,670	38,319
Average Monthly Net Exports Dry Whey (1000s lbs)	45,528	43,647	43,588	45,664
Average Monthly Net Exports Milk Powders (1000s lbs)	59,423	62,731	53,564	58,491
Average Class III Price After Program Implement ($/cwt)	$13.43	$14.14	$13.78	$13.24
Average Class IV Price After Program Implement ($/cwt)	$13.30	$13.00	$13.57	$13.23

Figure A1. Class III and ClassIV Prices, Baseline, No Shocks

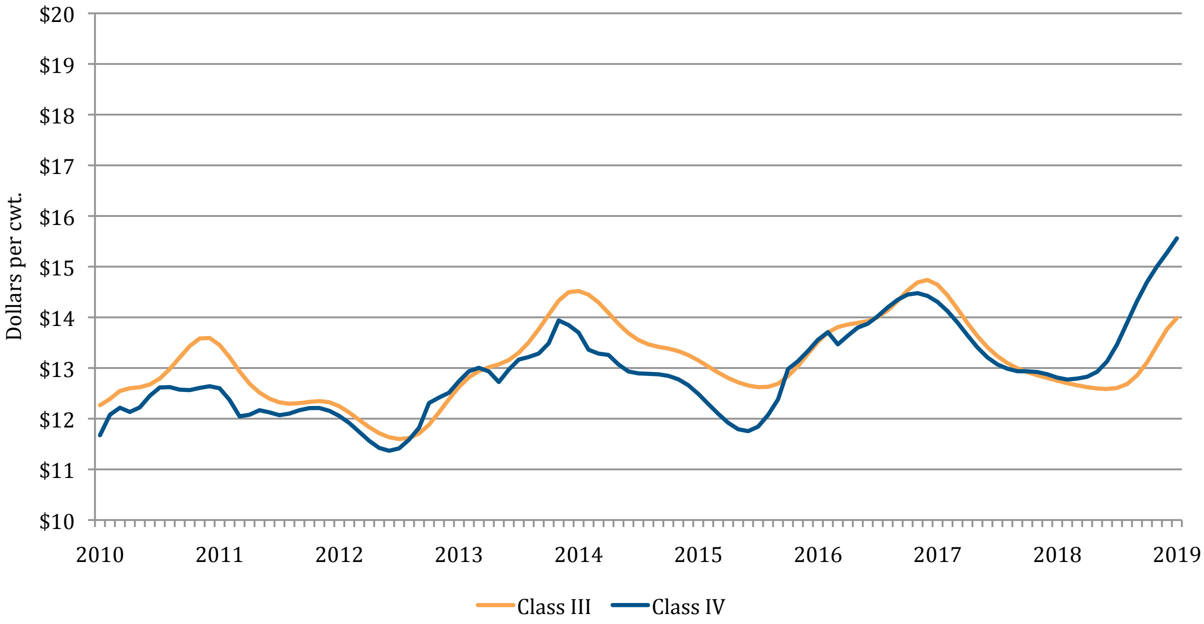


Figure A2. Class III and ClassIV Prices, Baseline, With Shocks

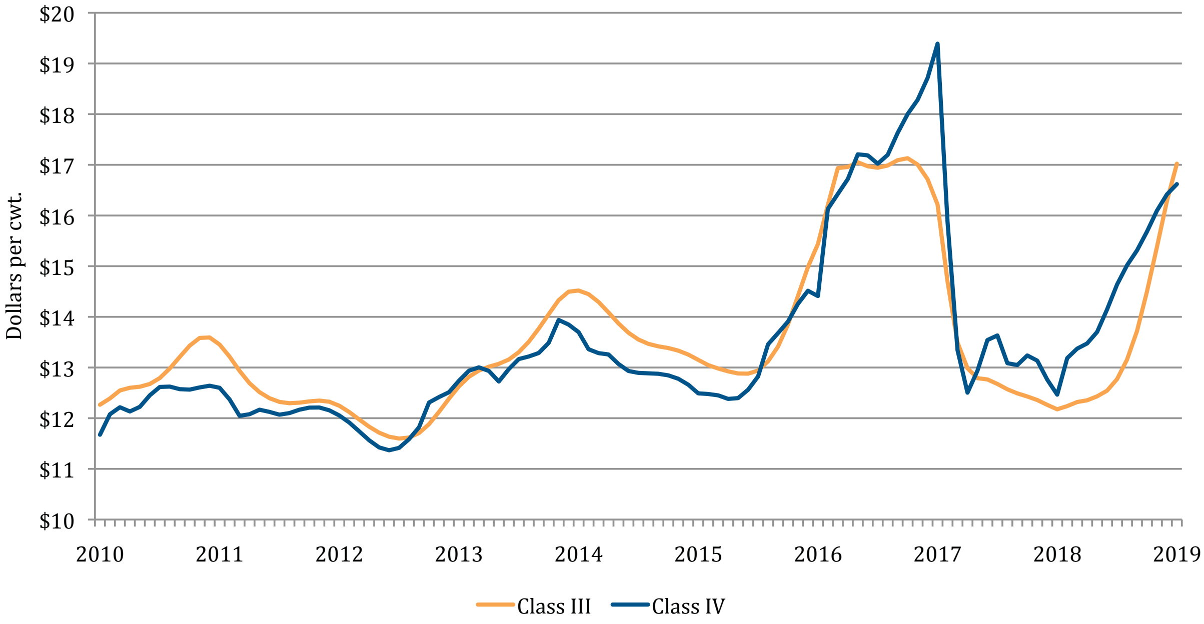


Figure A3. Class III and ClassIV Prices, Marginal Milk Pricing, No Shocks

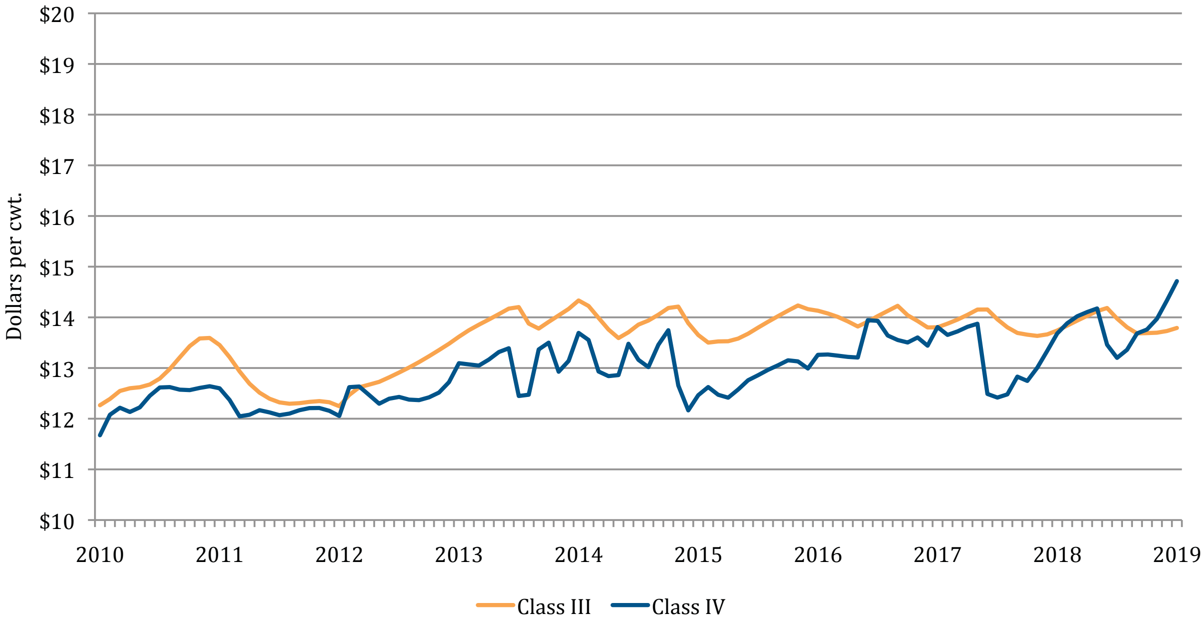


Figure A4. Class III and ClassIV Prices, Marginal Milk Pricing, With Shocks

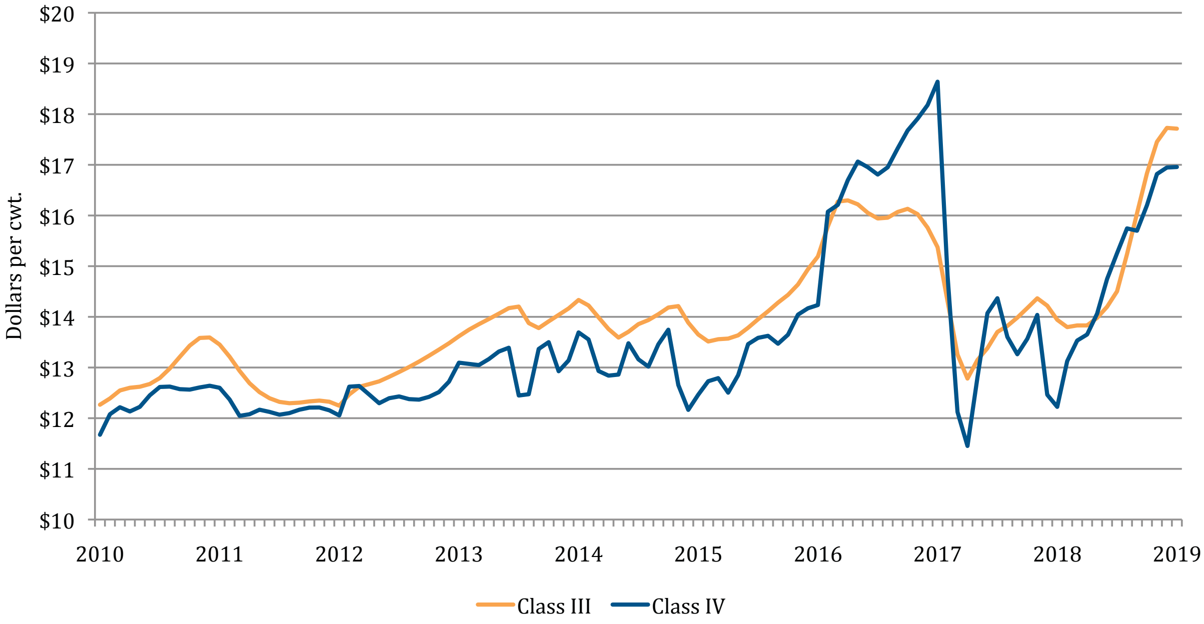


Figure A5. Class III and ClassIV Prices, Costa Sanders, No Shocks

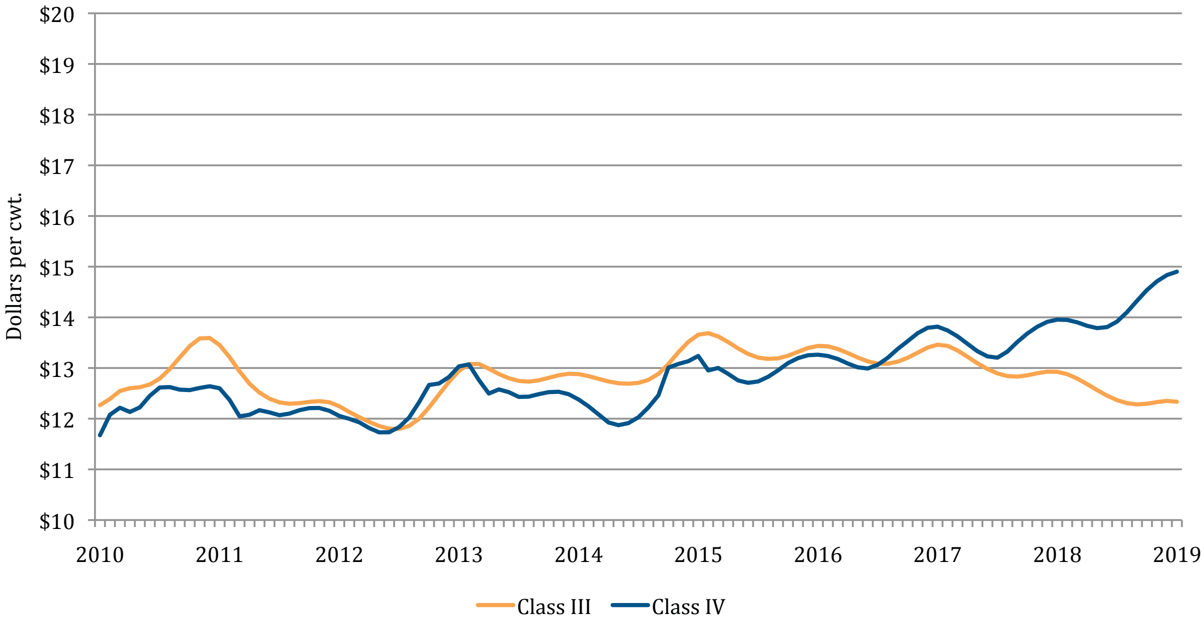


Figure A6. Class III and ClassIV Prices, Costa Sanders, With Shocks

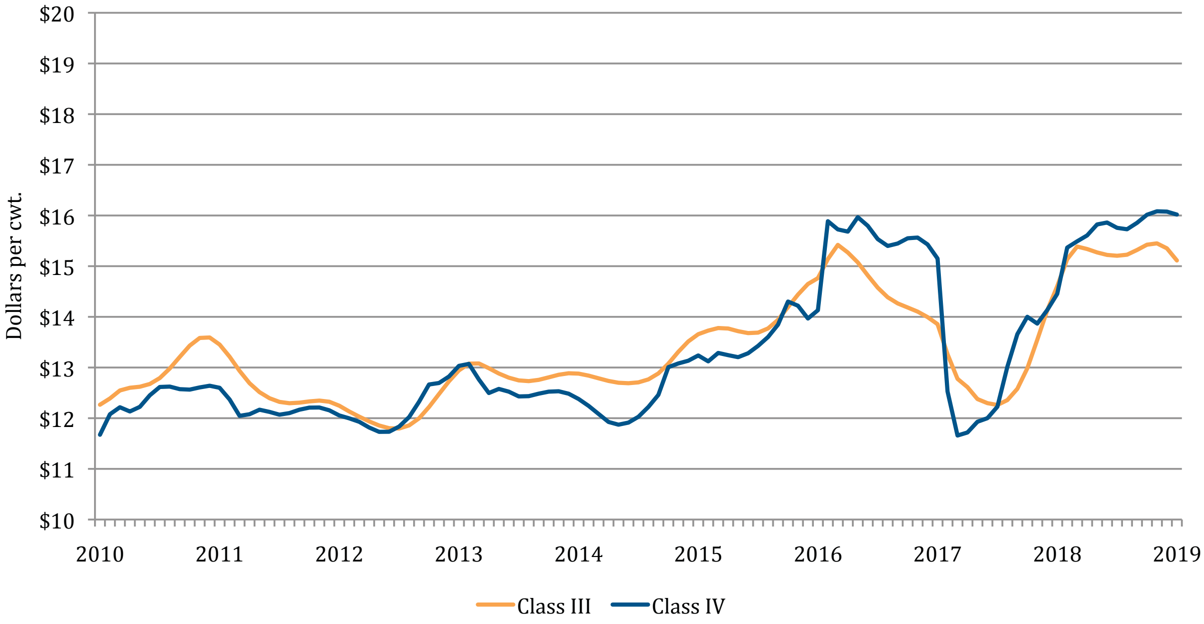


Figure A7. Class III and ClassIV Prices, Foundation for the Future, No Shocks

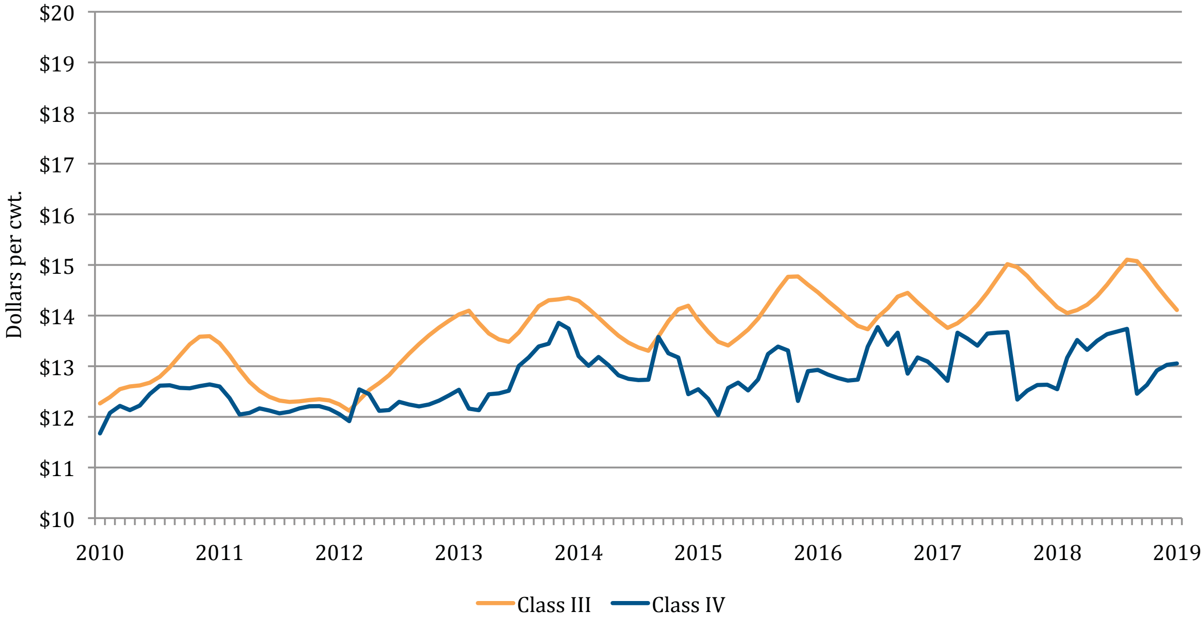
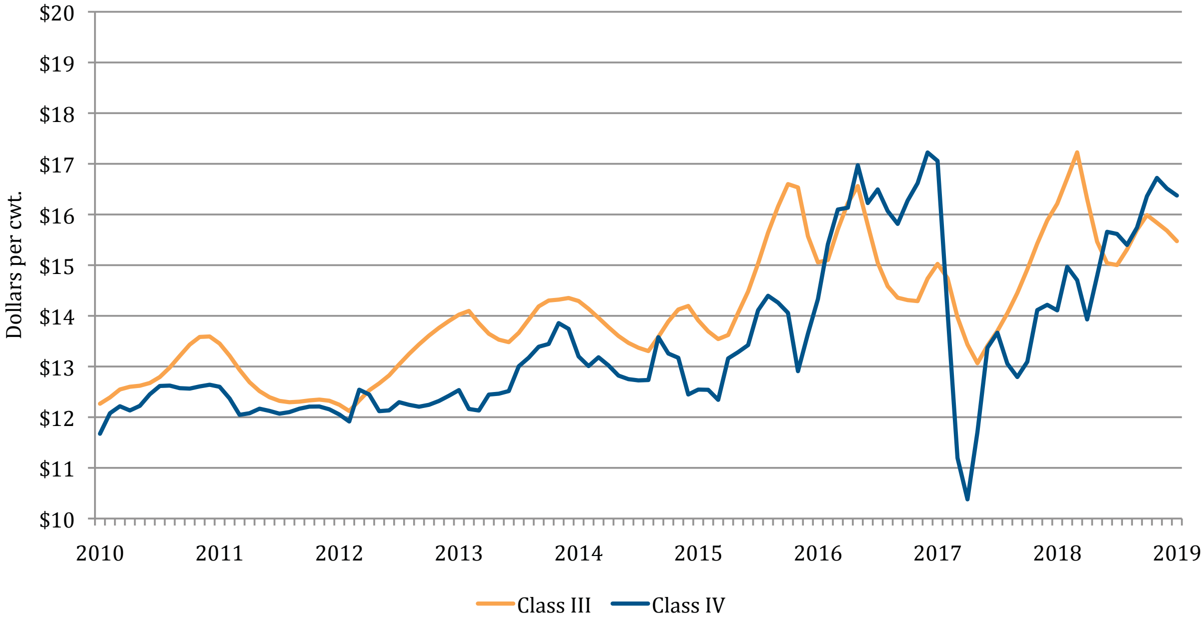


Figure A8. Class III and ClassIV Prices, Foundation for the Future, With Shocks



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