Plenary Paper presented at the 32nd International Conference of the System Dynamics Society, Delft, Netherlands July 20 – July 24, 2014

Modeling Government Intervention in Agricultural Commodity Markets: U.S. Dairy Policy Under the Agricultural Act of 2014

Charles F. Nicholson
Department of Supply Chain and Information Systems, The Pennsylvania State University, University Park, PA 16802 USA

Mark W. Stephenson
Center for Dairy Profitability, University of Wisconsin, Madison, WI 53706 USA

ABSTRACT

The U.S. Agricultural Act of 2014 creates a new "margin insurance" program under which dairy farmers can receive indemnity payments from the U.S. government if a margin (defined as the difference between milk prices paid to farmers and an index of feed costs) falls below the insured level. The design of this Margin Protection Program (MPP) suggests that it has the potential to substantially weaken feedback processes that would adjust milk production, prices and margins if margins fall below program threshold levels, especially if the proportion of milk covered by insurance is large. This paper describes potential impacts of the MPP using a CLD, then uses an empirical SD commodity model for the U.S. dairy industry based on the commodity model described in Sterman (2000) to assess the impacts quantitatively. We compare the results of a *Baseline* scenario representing *status quo* dairy policies to outcomes under implementation of the new MPP during 2015 to 2018. Our analyses indicate that if margins fall to levels that activate indemnity payments, weakened feedback processes are likely to result in persistent lower margins, lower farm incomes and larger government expenditures than the continuation of current policies. We also evaluate impacts under alternative assumptions about feed and dairy market conditions, the date of the annual deadline for participation decisions and the extent of farmer participation (proportion of milk covered by the MPP). Stochastic simulations indicate that lower margins, decreased farm incomes and higher government expenditures are highly probable during 2015 to 2018, but that the differences with *status quo* policies are smaller with lower feed prices or higher demand for dairy products, when participation decisions are required earlier, and when aggregate farmer participation (proportion of milk covered) is less. These results imply that assessments of producer decision strategies based on historical data that do not account for program impacts may be misleading, and that participation decisions by individual producers may need to consider the aggregated market effects of collective producer decision making.

INTRODUCTION

Commodity models based on System Dynamics have a long history beginning with Meadows (1970), but substantive treatment of government policies in commodity market models is less common. For many agricultural commodities, government intervention has been an important determinant of prices and returns since the 1930s, motivated by arguments that agriculture is inherently more risky than other business endeavors due to the size and structure of the agricultural production businesses, asset fixity and relatively few buyers. Concerns about equity were also offered as justification for government intervention to raise farm incomes. When the programs began, average farm household incomes were significantly lower in the U.S. than non-farm household incomes—although this is no longer the case (USDA Economic Research Service, 2014). More recently, there has been considerable debate regarding the appropriate role of government in commodity market stabilization, and this debate has been particularly contentious for the U.S. dairy industry.

Dairy prices have varied considerably during the past twenty-five years (Figure 1). Prior to the late 1980s, however, prices were relatively stable due to the Dairy Price Support Program (DPSP). This program offered to purchase selected dairy products at stated prices to help maintain a desired minimum milk price (the "Support Price," blue line in Figure 1) for dairy farmers. These product purchase prices (and therefore the support price) were increased during the 1970s in response to a campaign pledge by President Carter, but were decreased during the 1980s as purchases of dairy products and their disposal cost the U.S. government more than $2 billion in 1983. As the support price was lowered below a market-clearing level, farm milk and dairy product price variation increased. Industry professionals initially believed that dairy farmers and manufacturer inventory managers would take a few years to learn how to manage this variability, and then prices would stabilize. The history, however, indicates increasing price variability, with changes of nearly 50% occurring between peaks and troughs (e.g., decrease during 2008 from above $20 to below $10 per 100 lbs; Figure 1). In response to ongoing variation, the U.S. government introduced additional programs that made direct payments to farmers when prices fell below specified levels, and promoted the development and use of risk-management tools by dairy farmers, manufacturers and dairy product buyers. Although prices have become more variable, there is empirical evidence for price cycles with a period of about three years (Nicholson and Stephenson, 2014), consistent with the structure of SD commodity models (e.g., Sterman, 2000).

In 2009, farm milk prices and the margin between milk price and the costs of feed for dairy animals fell to historically low levels. Dairy farmers in many parts of the U.S. experienced substantial losses of business equity and many exited the industry. This event suggested to many observers that existing dairy policies no longer provided an adequate "safety net" for dairy farmers. Many policy options were discussed during the intervening years, but early in 2014, the U.S. Congress passed farm legislation (the so-called "Farm Bill") that markedly changed the nature of U.S. dairy policy. This legislation will eliminate the Dairy Product Price Support Program (DPPSP) that followed the DPSP and other support policies, replacing them with a new program that provides dairy farmers with the opportunity to purchase "margin insurance" through the Margin Protection Program (MPP). Under this program, farmers determine a level of margin (milk price less a specified feed cost value) they want to protect for a certain proportion of their historical milk production, and pay premiums to the government. If average margins for two consecutive months become lower than the level covered by the margin insurance, the government will pay farmers an indemnity based on the difference between the observed margin and their protected margin.

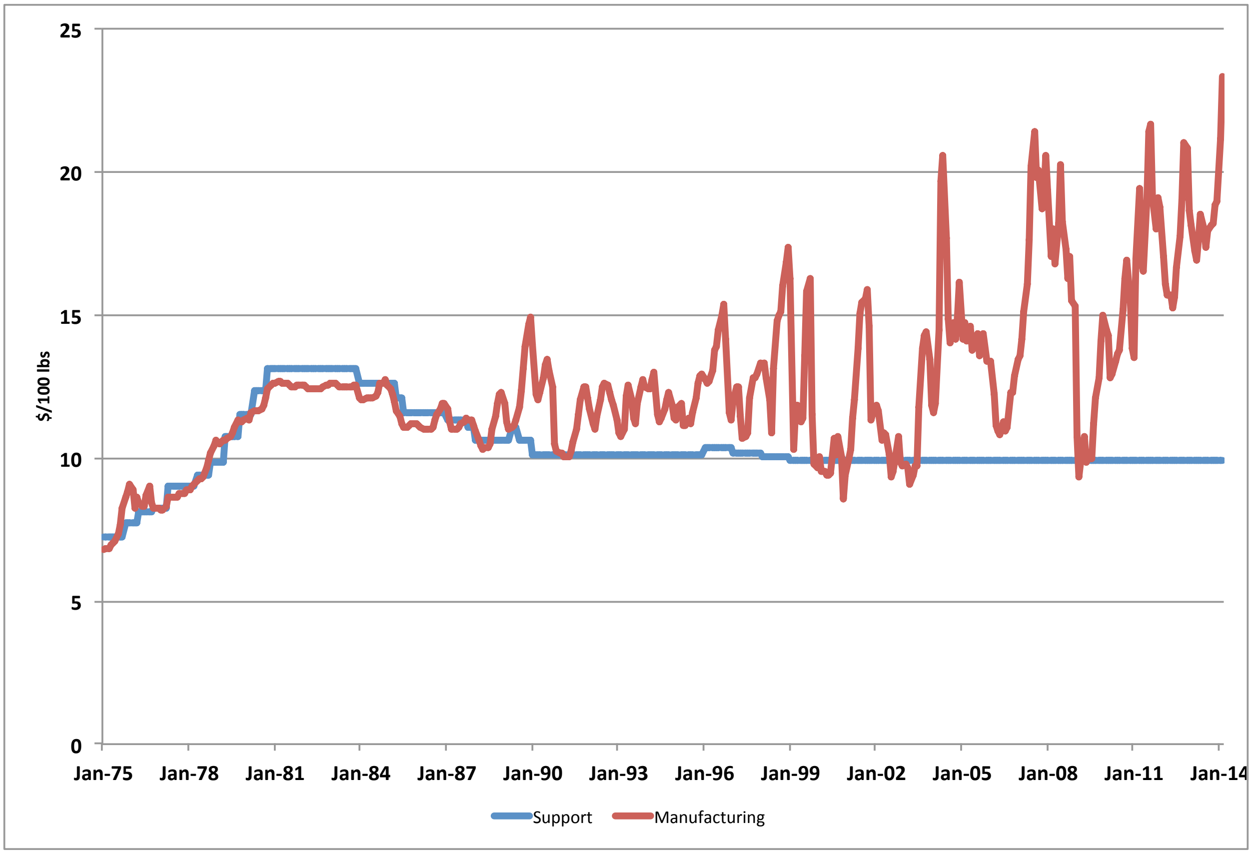


Figure 1. U.S. Manufacturing Milk Price and Manufacturing Milk "Support" Price, 1975 to 2014

Given the major change in the U.S. government's approach to providing support to dairy farmers, an *ex ante* analysis of program impacts is relevant. Thus, this paper has two principal objectives:

1) Describe a causal loop diagram that provides insights into possible behaviors of the U.S. dairy supply chain with the MPP;
2) Simulate outcomes of the MPP compared to status quo policies under different assumptions about market conditions, participation by dairy farmers, and selected elements program design (yet to be determined) using a detailed empirical model of the U.S. dairy sector.

CAUSAL LOOP DIAGRAM ANALYSIS

Although the approach used in the MPP makes U.S. dairy programs more consistent with other agricultural support programs such as crop insurance, it has several design features that could result in the program being less effective and more costly than expected. First, payment when margins are low will help sustain farm income, but this is likely to prolong the periods of low prices because milk production adjustments in response to market conditions will be muted. Second, there is evidence that the premium payments are highly subsidized (i.e., not 'actuarially fair') for most of the margin levels protected[1], which will encourage farmers to insure larger amounts and provide insufficient funding for indemnity payments. Third, farmers can decide for individual years whether to insure and how much, rather than making a decision to participate over the five-year life of the program. This could result in farmers purchasing insurance only when payments are likely to be made, further increasing government costs. Finally, the amount that farmers can insure could increase each year based on increases in total U.S. milk production.

These program features suggest that if low margins occur that result in indemnity payments, these could result in the unintended consequences of prolonged periods of low margins and large government expenditures. The feedback processes that could result in these outcomes include a number of key balancing and reinforcing loops, some with relevant delays (Figure 2). To illustrate this possibility, consider an increase in feed costs (which can comprise 50% of the variable costs of milk production). In the absence of the margin insurance program, an increase in feed costs would reduce farm profitability, which over time would reduce dairy farmers' expectations of profits and they would reduce their cow numbers (the key productive capital stock) and reduce milk per cow (intensity of utilization of that capital stock). This would result is less milk production, lower dairy product inventories, higher dairy product prices and higher farm milk prices. These balancing loops (*Profitability & Cows* and *Profitability & Productivity*) suggest effects that at least partly offset the initial increase in feed costs.

The margin insurance program alters this dynamic adjustment process by reducing the strength of the balancing feedback implied in the *Profitability & Cows* and *Profitability & Productivit*y feedback loops by adding the *Margin Profit Support* loop (Figure 2). An increase in feed costs would reduce profitability, but if it also reduces margins (i.e., milk price less feed costs)[2] below the level selected by the farmer, the government makes an indemnity payment that helps to support farm profitability, which weakens the balancing loop that would reduce milk production. Low margins affect farmer expectations of lower margins in the future and farmers would choose to cover larger amounts of production at higher production levels (*Margin Coverage Elected* loop). If the program is sufficiently subsidized, aggregate milk production could actually increase over time, which would allow larger amounts of milk to be covered under the margin program in the future, also

[1] *We evaluated indemnity payments less premium payments per farm for a wide variety of farm configurations during 2009 to 2013, finding that the expected value of net payments was positive. This is also the finding from our simulations results for future years, to be discussed subsequently.*

[2] *It is useful to distinguish between profitability and margin in this discussion. Farm profitability often is measured as Net Farm Operating Income (NFOI), which comprises revenues less variable costs (feed, labor, utilities, etc.). The 'margin' used in the program is milk price less a standardized measure of feed costs, which differs from profitability because it is a value per 100 lbs, because it does not consider an individual farm's actual feed costs and because it does not include other costs such as labor and utilities. We assume that farmer decisions depend on NFOI, but the program operates based on 'margin.'*

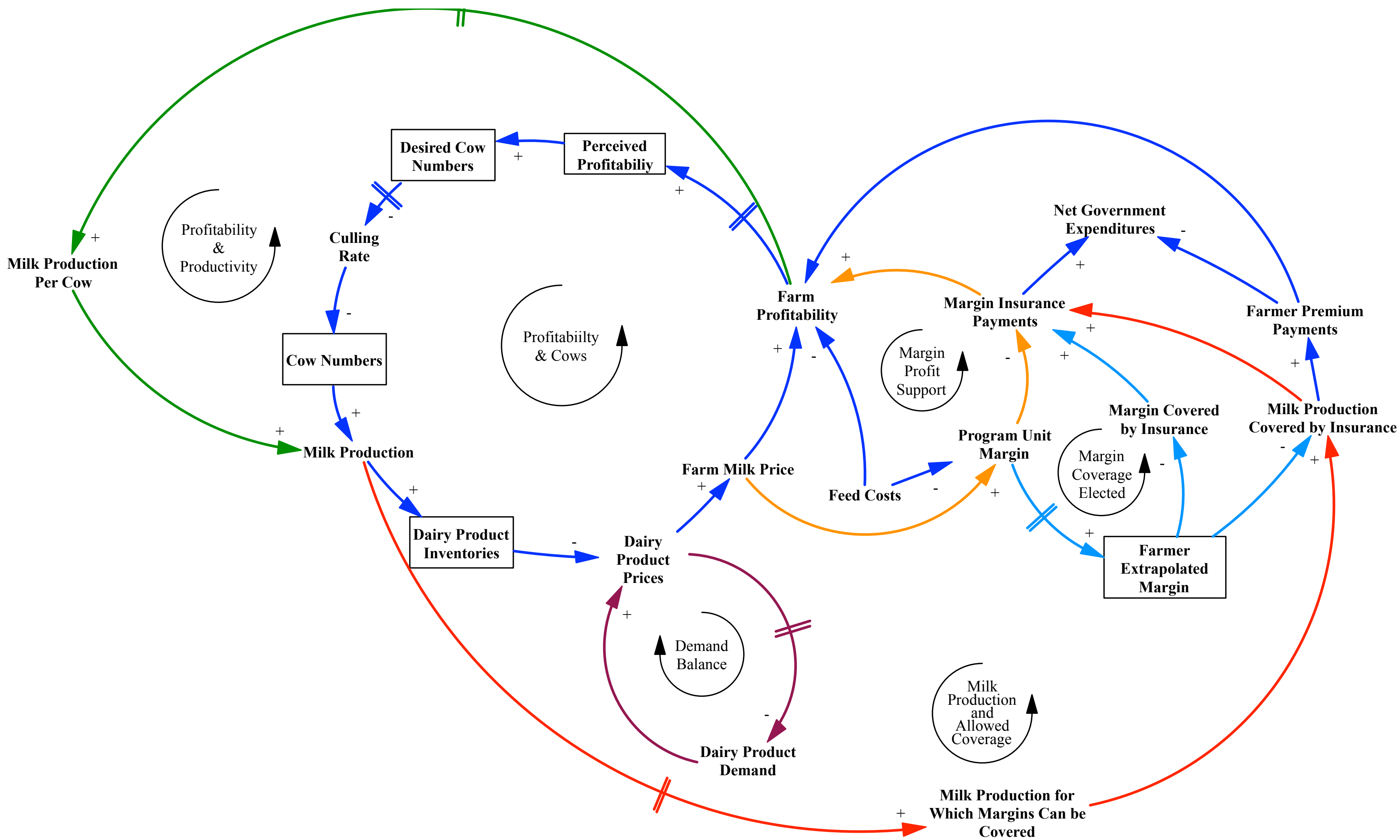


Figure 2. Feedback Structure Related to Dairy Production, Demand and the Margin Protection Program of the Agricultural Act of 2014

increasing the milk production covered by insurance (*Milk Production and Allowed Coverage* loop). Although farmer premium payments will also increase as higher levels of insurance are selected, the subsidization of the program implies that net government expenditures would increase. Under certain conditions, it is possible that the feedback structure implied by farmer decisions and margin program insurance design could "lock-in" low margins, low milk prices and high government expenditures. (Although this is undesirable for government and farmers, consumers in the U.S. and countries to which we export dairy products would be beneficiaries of the program.)

As noted by Sterman (2000), conceptual models such as the one described above are useful but are complemented by the development of empirical simulation models. The extent to which the MPP would result in extended periods of low prices, low margins, low farm incomes and large government expenditures will depend on a variety of factors that are best assessed with an empirical model.

EMPIRICAL U.S. DAIRY SUPPLY CHAIN MODEL METHODS AND DATA

Our assessment of the impacts of the MPP uses a detailed empirical SD model of the U.S. dairy supply chain adapted from the commodity supply chain model described in Sterman (2000), which builds on an initial formulation by Meadows (1970). This model has been developed and adapted to the U.S. dairy industry during the past 10 years, and the feedback structure relevant for this analysis was discussed above (Figure 2). Additional model details are provided in Nicholson and Fiddaman (2003), Nicholson and Kaiser (2008) and Nicholson and Stephenson (2010). The base data used for the model are for 2011. The model is more detailed than many SD models in part because detail was required to capture factors considered important by industry decision makers and to adequately represent current and future dairy policies.

The model calculates monthly outcomes from 2012 to the end of 2019 (when the current farm legislation will be revisited). The model comprises modules that represent farm milk supply, farm milk pricing, dairy product processing, inventory management and trade, and dairy policies (both those existing prior to implementation of the Agricultural Act of 2014 and the margin insurance to be implemented going forward). Each of these is discussed in detail below.

Farm Milk Supply

The milk supply components of the model are based on four farm-size categories based on numbers of cows owned for two U.S. regions, California and the rest of the U.S[3]. 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. The cost structure of farms in the different herd size categories is different as is the responsiveness to price signals. Based on genetic improvement rates over the past 20 years, milk per cow is assumed to grow at a potential rate of 2% per year, but is

[3] *California is modeled separately because it is the largest milk producing state and maintains a state-level system of milk price regulation different from the rest of the U.S.*

adjusted in the short run based on the margin between farm milk prices and feed prices. 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, which equals total revenues less variable costs for feed, labor, and other expenses) 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).

Farm Milk Pricing

The U.S. government and many states maintain regulations that set minimum allowable farm milk prices based on market prices of dairy product prices and the product for which the farm milk is used. The details are provided in Nicholson and Stephenson (2010) and are not discussed here because these programs will not be modified under the Agricultural Act of 2014. Milk prices affect both milk per cow and NFOI and therefore influence cow numbers. A standard measure of the farm milk price is the "All-milk" price reported for the entire U.S. (including California) by the National Agricultural Statistics Service, and this is included in the model as a benchmark price.

Dairy Processing

The dairy processing component of the dynamic model incorporates 21 products, 18 of which are "final" products (have explicit demand curves) and 13 of which are "intermediate" products that are 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 nonfat dry milk (NDM) and butter manufacture. The model explicitly tracks skim milk and cream quantities to ensure component (mass) balance. To represent potential substitutability among intermediate products as relative prices change, the lowest cost of three potential ingredient combinations (for example, NDM versus milk protein concentrates (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. The manufacturing capacity for each region was assigned based on production shares in California and the U.S. in 2011. Capacity for cheese and whey products changes over time in response to long-term changes in profitability.

Table 1. Dairy Product Categories Included in the Dynamic Model

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

Dairy Product Demand

Dairy product demand for final products is represented separately for California and the rest of the U.S. Fluid milk consumption is based on fluid utilization from California and sales from the Federal regulatory bodies that determine minimum regulated farm milk prices using data for 2011. Consumption of other products was calculated as national U.S. commercial disappearance (production + imports – exports – dairy industry use) and allocated on the basis of regional population. The impacts of product prices on demand are modeled using constant elasticity demand functions[4], which also are assumed to shift over time in response to population and income growth. Intermediate product demand isdetermined by the use of dairy components in the production of other dairy products, based on relative costs. Cross-price effects for intermediate products 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.

---

[4] *These constant elasticity demand functions have the basic form* $QD_p = QD_p^{REF} \cdot \left(\frac{P_p}{P_p^{REF}} \right)^{\eta}$, *where*

QD_p is the quantity demanded of product p, P is the relevant price per unit for product p ($/100 lbs), REF indicates a reference value used to initialize the model for QD and P, and η is the demand elasticity (η<0). For some p, the demand also includes cross-product effects. Growth that shifts the demand over time is included in the model formulation but not shown above for simplicity.

Dairy Product Trade

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 2011 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. Total exports for each product are calculated based on interactions between an aggregated U.S. market and the ROW, and sales for California and the rest of the U.S. are assigned proportional to production in each region.

Dairy Policies

All current national dairy policies in addition to trade policy are represented in the model, including the Dairy Product Price Support Program, Milk Income Loss Contracts (MILC, a direct payments program based on milk and feed prices), and minimum farm milk price regulation under what are called milk marketing orders. The Dairy Export Incentive Program (DEIP, an export subsidy program) is assumed to operate under current limits when U.S. prices are higher than world prices. Although many of these policies will be eliminated when the Agricultural Act of 2014 is fully implemented, they are included to represent periods before implementation and as part of a Baseline scenario that simulates the policy status quo.

The Margin Protection Program

We modify the policy structure of the model to account for the major impacts of the MPP. The program includes a premium schedule (Table 2) based on the margin level protected, from $4 to $8 per 100 lbs of milk[5] produced. Premiums are lower for the first tier (for coverage on up to 4 million lbs milk produced per year, or the production from about 180 cows) than for the second tier, so larger farms that want to protect more than 4 million lbs of milk will pay higher average rates. The premium payments schedules are represented as LOOKUP functions. Although the formal administrative procedures are still being drafted by the U.S. Department of Agriculture (USDA), it is likely that the program will allow dairy farmers to select a participation level prior to the beginning of each calendar year. The extent to which farmers will participate in a new program such as margin insurance is challenging to model, but we initially assume a simplistic decision rule

[5] *In the U.S. milk is priced in dollars per 100 lbs ("hundredweight", abbreviated "cwt"), approximately equivalent to 45.4 kg.*

consistent with earlier assessments of the degree to which premiums are subsidized by the government. We assume that producers use extrapolative expectations (Sterman, 2000) to assess likely margins during the year for which the decision is to be made, and make a decision about their degree of participation based on their expectations of margin just prior to the beginning of the calendar year, and then explore the impact of this assumption with additional analysis[6] (Table 3). The initial decision rules assume that farmers will sign up to insure either 75% or 90% of their milk (the maximum under the program is 90% of an historical base, which is updated each year), but the margin level protected will vary from $4 (when expected margin is above $8) to $8 (when expected margin is below $4). As an example that corresponds to the second row of Table 3, we assume that if farmers expect the margin to be $6.00/cwt during the covered year, they will choose to cover 75% of their production history with a margin protection of $6.50/cwt. Overall, this schedule is consistent with farmers attempting to maximize benefits from a subsidized program, in contrast with more typical risk-management decisions[7]. The legislation for the MPP also includes a demand enhancement component, authorizing the U.S. government to purchase product when margins are below $4.00/100 lbs of milk. We assume that under this condition the government would purchase cheddar cheese (a product that can be purchased under current price support programs) sufficient to increase the margin to $4.00 over a two-month period.

Table 2. Premium Schedule for Margin Insurance Levels, $/100 lbs Milk

Margin Level Insured, $/100 lbs Milk	Tier 1 (up to 4 million lbs milk per year)	Tier 2 (for above 4 million lbs milk per year)
4.00	0.000	0.000
4.50	0.010	0.020
5.00	0.025	0.040
5.50	0.040	0.100
6.00	0.055	0.155
6.50	0.090	0.290
7.00	0.217	0.830
7.50	0.300	1.060
8.00	0.475	1.360

[6] *A key issue for program design is how far in advance farmers must make this decision. Previous studies (Newton et al., 2013) have argued that costs will be reduced by requiring farmers to choose six months or more in advance of the year in which they will protect their margin.*

[7] *We explore the impact of more limited participation as an additional scenario below.*

Table 3. Assumptions Regarding Farmer Participation in the Margin Protection Program

Expected Margin Based on Extrapolative Expectations, $/100 lbs Milk	Proportion of Milk Insured	Margin Level Insured, $/100 lbs Milk
Less than $4.00	90%	$8.00
$4.00 to $8.00	75%	$6.50
Greater than $8	90%	$4.00

Data Sources

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 (professional knowledge) data.

Model Evaluation

The model was evaluated using the multiple-step process proposed by Sterman (2000), and was judged to be adequate for its stated purpose of evaluating the impacts of the margin insurance program. 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. Many results were numerically sensitive, but we did not identify any behavioral or policy sensitivity that would undermine the model's usefulness for this analysis.

Scenarios Analyzed and Key Variables

We simulate and compare a number of scenarios to assess the MPP and the impact of our underlying assumptions. To illustrate empirically the basic impacts of the program, we compare two scenarios, a *Baseline* that assumes continuation the current suite of U.S. dairy programs and an *MPP* scenario that assumes implementation of the dairy provisions of the Agricultural Act of 2014 in January 2015 (conditional on the other assumptions indicated above). The principal variables of interest include the margin, farm milk prices and government expenditures, but we also examine impacts on dairy farm incomes, selected dairy product prices and U.S. dairy net exports.

However, the impacts of the program are likely to depend to a large extent on market conditions. To assess how market conditions affect program impacts, we compare outcomes with status quo dairy policies and MPP implementation for two sets of market conditions, *Limited Impacts* conditions and *Major Impacts* conditions. The *Limited Impacts* conditions assume 25% lower feed prices (and therefore a larger margin—at least initially) beginning in May 2015 and lasting through 2018 and a 10% increase in global demand for all dairy products that persists for 12 months beginning in May 2015. The *Major Impacts* conditions assume 25% higher feed prices (and therefore a smaller margin—at least initially) beginning in May 2015 and lasting for through 2018 and a 10% decrease in global demand for all dairy products that persists for 12 months beginning in May 2015. These assumptions about market conditions will have a direct impact on margins and milk prices and therefore on the MPP impacts compared to current dairy programs. We further explore the ranges of possible impacts with a stochastic analysis that uses Latin hypercube sampling of a range of possible feed costs increases (-25% to +25% through 2018 beginning in May 2015) and global demand changes (-10% to +10% for 0 to 24 months beginning in May 2015) for N=200 simulations. Using the same random seed for each N=200 simulations, we can develop the empirical probability distribution of differences in outcomes between *Baseline* and *MPP* scenarios.

Producer participation will undoubtedly influence outcomes of the MPP; at a logical extreme, if there is very limited participation, the impacts of MPP should also be limited. We have assumed a high level of participation for our initial scenarios based on the extent to which the premium schedule is subsidized, but many U.S. dairy farmers are not familiar with risk management tools more generally, and the level of effort to participate is higher than with current programs such as MILC. It is not uncommon to hear U.S. dairy producers indicate that they will not participate in the program—although the previous analysis suggests that there may be some significant negative financial impacts of not doing so (such as periods of lower margins and NFOI exacerbated by the lack of indemnity payments).

We assess the impacts of the timing of participation decisions by dairy farmers and the extent of participation, measured by the percentage of their production history (i.e., milk volume) protected by the MPP. We develop two additional MPP scenarios to assess the impacts of these assumptions. An *MPP 3 Months Advance* scenario assumes that producers must make decisions regarding the margin level to be protected and the percentage of their production history 3 months prior to the beginning of coverage (e.g., by 30 September 2014 for coverage that begins on 1 January 2015), but maintains the level of producer participation assumed previously. An *MPP 3 Months Advance 25% Participation* scenario assumes that when the margin is below $8.00/cwt but above $4.00/cwt, producers will choose to cover only 25% of their production history, rather than 75% as initially assumed. (For margins > $8.00/cwt and < $4.00/cwt, the previous assumptions about the margin level and percentage of production history are the same as previously.) The expected impacts of a change in the timing will depend on how margin expectations will change during the three months between 30 September and 31 December, and how this affect margin levels and percentage of production history that producers will choose to protect. Assuming a much lower proportion of production history protected when margins are between $4/cwt and $8/cwt is likely to lessen the impacts of the MPP because it weakens the *Margin Coverage Elected* feedback loop if margins fall in that range, and therefore the effects of the MPP on farm profitability, productivity and assets (cows).

RESULTS

Empirical Results of *Baseline* and *MPP* Scenarios

The simulated outcomes (Table 4, first two results columns) are largely consistent with our hypothesis that implementation of the margin insurance program based on our assumptions about participation has the potential to sustain low margins, low milk prices and large government expenditures. Compared to the *Baseline*, the margin used to make indemnity payments is lower under the *MPP* once margins become low due to a reduction in milk prices in 2016 that is consistent with a three-year price cycle. Once the program becomes active as a result of low margins, the program margin value only occasionally rises above a value of $8 (Figure 3) due to increased milk production arising from the effects of the program that weaken feedback loops that would otherwise bring about adjustments in response to lower profitability. The average value of the program margin is $0.91/100 lbs milk lower from 2015 through 2018 with the MPP. The U.S. All-milk price is also markedly lower, with an average value after program implementation of $16.07 compared to $16.98 in the *Baseline* (Figure 4). (To the extent that variation in milk prices per se is considered a management challenge, the MPP has a positive effect because it reduces the coefficient of variation by about 30%.)

Table 4. Simulated Outcomes of the Margin Protection Program During 2015-2018, Three Baseline Scenarios and Differences Due to the Margin Protection Program

Outcome	Baseline	Difference with MPP	Baseline Limited Impacts Case	Difference with Limited Impacts MPP	Baseline Major Impacts Case	Difference with Major Impacts MPP
All-milk price, $/cwt	16.98	-0.91	14.94	-0.12	20.78	-3.37
MPP margin, $/cwt	7.40	-0.91	7.56	-0.12	8.99	-3.37
Cumulative government payments, $ billion	0.2	3.5	1.4	0.2	0.1	8.4
NFOI, Medium US Farm, $/farm/year	76,706	-20,292	76,255	-3,251	150,575	-101,412
Indemnity payments, Medium US farm, $/farm/ year	0	34,022	0	13,056	0	52,595
Cumulative NFOI, $ billion	19.6	-5.0	18.4	-0.4	34.0	-19.9
Cheese price, $/lb	1.57	-0.07	1.38	-0.01	1.85	-0.23
US net exports, cheese, mil lbs/year	512	+96	857	+13	77	+230

Once the program becomes active, the persistent low margins result in government payments through the end of 2016 (Figure 5), and in some cases these payments reach more than $400 million per month. The cumulative government expenditure under the margin program (and for purchases of cheese under the demand component of the program) total more than $3.7 billion from 2015 to 2018 (Figure 6), compared to about $200 million simulated under current programs. Compared to historical expenditures on dairy programs and agricultural programs more generally, $3.7 billion is large. The Congressional Budget Office (CBO, 2014) estimated that all "commodity" provisions of the Agricultural Act of 2014 would cost $21.4 billion during 2015 to 2019, with crop insurance programs costing an additional $44 billion. This level of expenditures is also large compared to the historical cost of any previous dairy program, and could indicate that Congress would modify the program—by raising premiums and(or) lowering coverage levels—prior to 2018.

The MPP is simulated to make decrease farm incomes, but to make them more stable, with fewer months in which NFOI is negative. Despite average annual payments (most occurring during the low-price period of 2016) of more than $34,000 per year for a medium-sized U.S. dairy farm (230 cows), simulated income during 2015 to 2018 is decreased by about $20,000 per year compared to current dairy policies (Figure 7). However, the program provides payments during low margins (Figure 7, green dashed line) that decrease the number of months of negative NFOI. Lower average—but more stable—returns may be welcomed by some U.S. dairy farmers, reflecting risk-return trade-off preferences.

Simulated cumulative NFOI for all U.S. dairy farms is nearly $5 billion lower under the MPP scenario than the Baseline (Figure 8). Cumulative NFOI is also less variable with the MPP compared to the Baseline, as indicated by the more or less continuous increase in cumulative income. In contrast, the Baseline scenario indicates periods of decreasing cumulative NFOI, which implies that at times NFOI is negative for U.S. dairy farms as a whole. To the extent that the reduction in variability of NFOI and the risk of negative profitability is decreased, many dairy farmers would consider the program successful (despite its costs).

Another outcome that would be considered positive by many in the U.S. dairy industry is the effect of the MPP on dairy product exports. The share of U.S. dairy product exports has grown rapidly in recent years, and most policy proposals have been examined for their impacts on dairy trade. Because the MPP reduces the cost of the major input (milk) for dairy product manufacturers, it lowers product prices. For example, average American (cheddar-type) cheese prices would be reduced by $0.07/lb (about 5%) and would be more stable (Figure 9). This would increase average annual exports of U.S. cheese by more than 18% during 2015-2018 (96 million lbs per year, Figure 10).

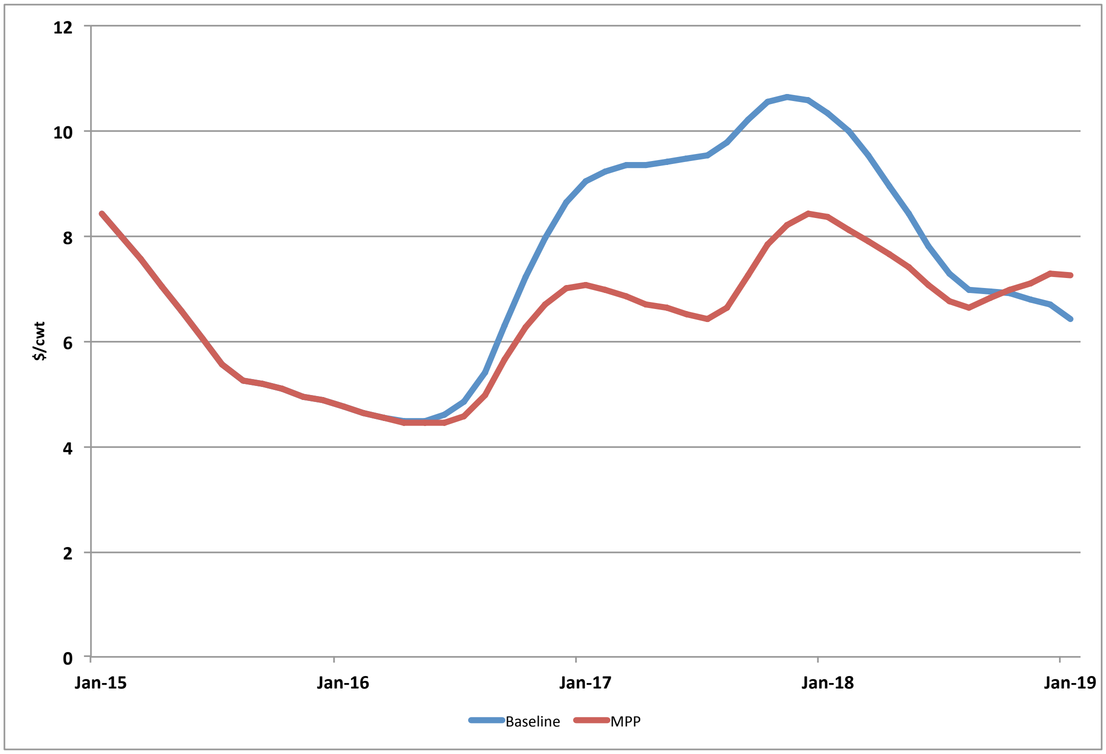


Figure 3. Simulated Value of the Margin Used to Pay Indemnities, Baseline and Margin Protection Program Scenarios, 2015 to 2018

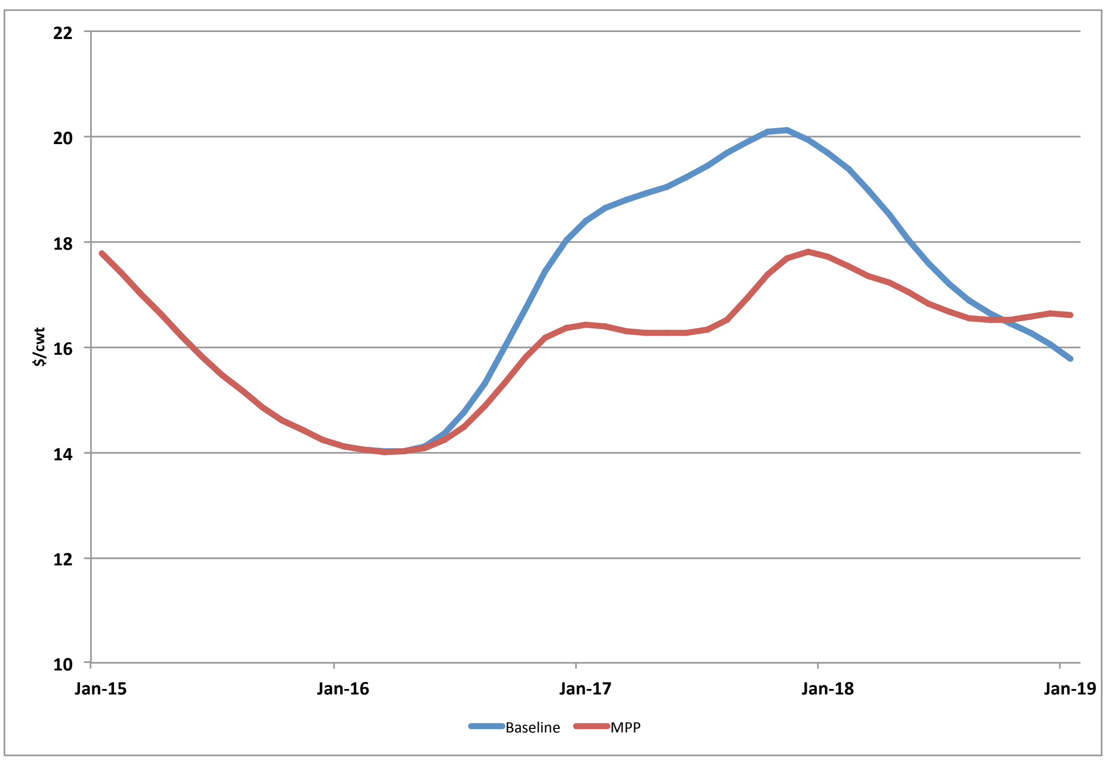


Figure 4. Simulated Value of U.S. All-milk Price, Baseline and Margin Protection Program Scenarios, 2015 to 2018

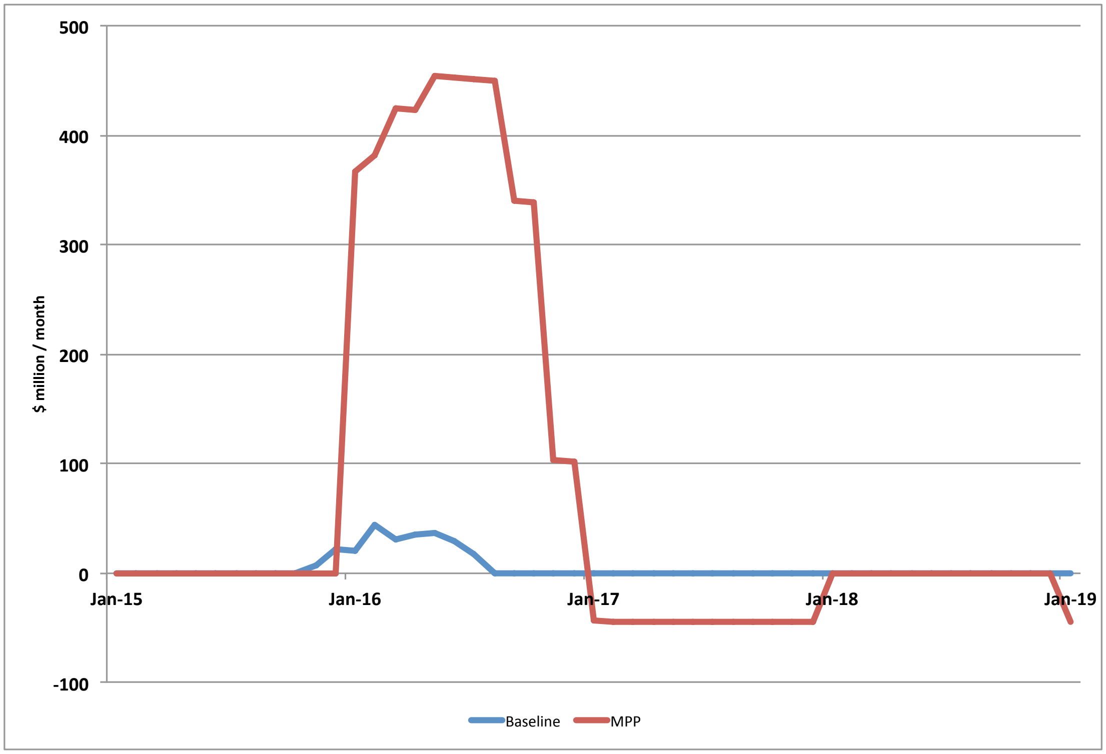


Figure 5. Simulated Value of Monthly Government Indemnity Payments, Baseline and Margin Protection Program Scenarios, 2015 to 2018

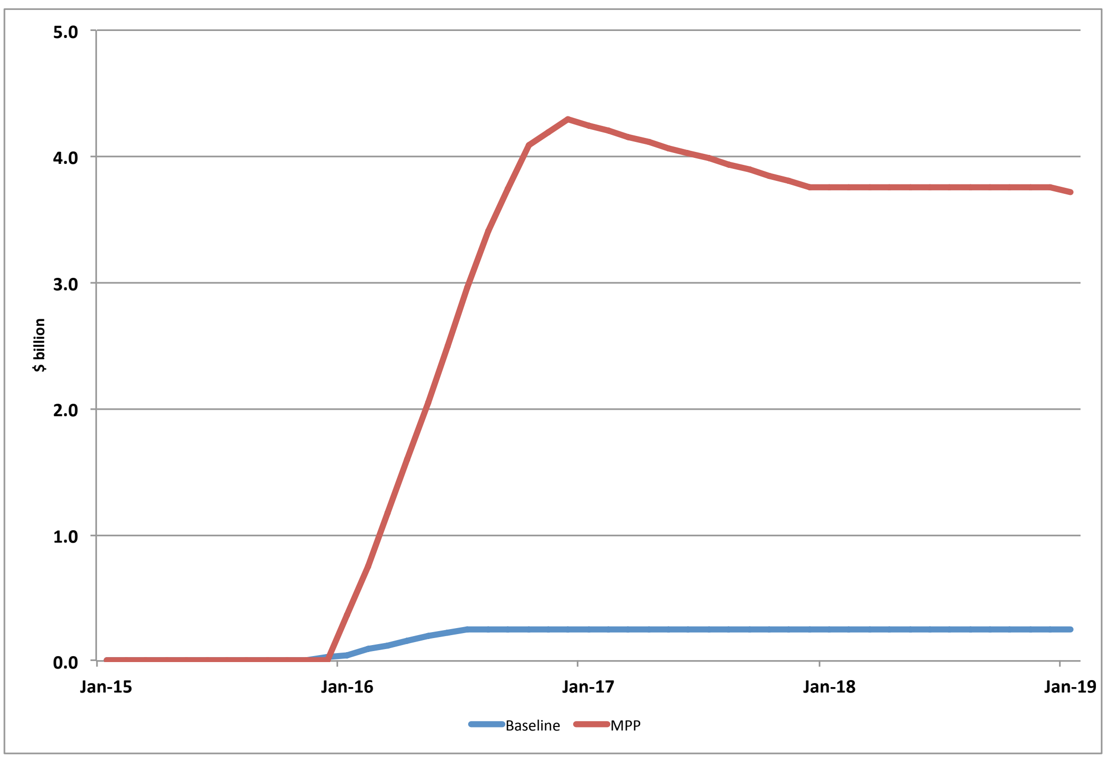


Figure 6. Simulated Value of Cumulative Government Indemnity Programs, Baseline and Margin Protection Program, 2015-2018

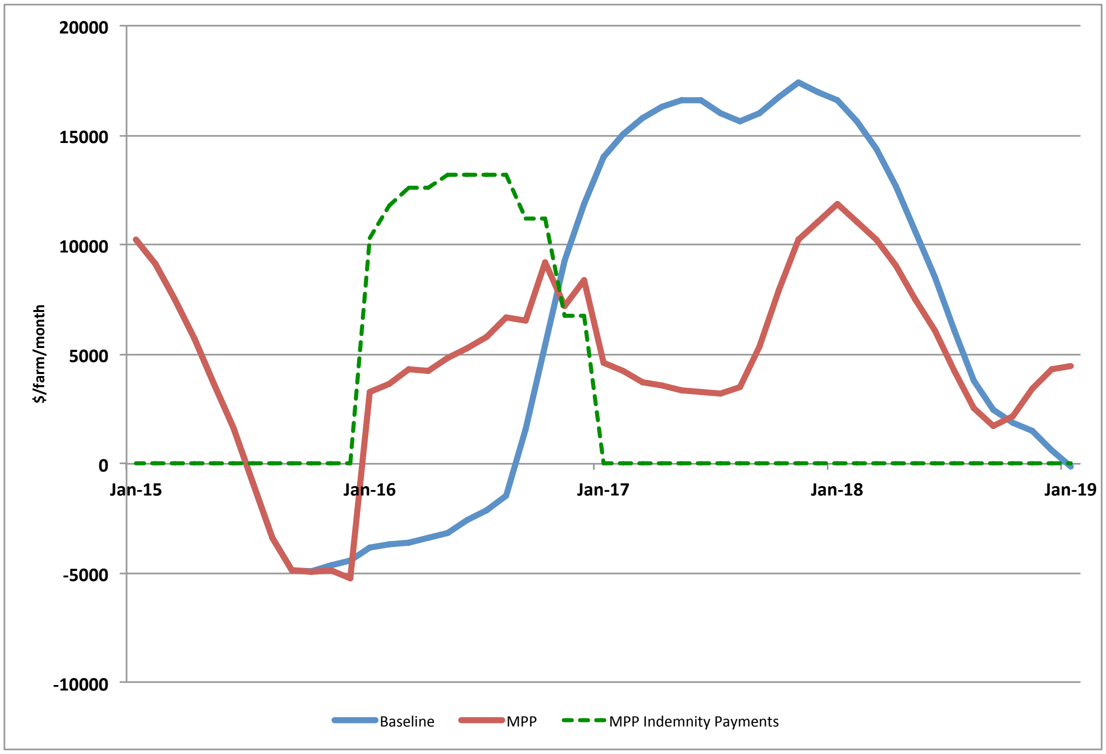


Figure 7. Simulated Value of Monthly Net Farm Operating Income and Indemnity Payments for a Medium-size (230 cows) U.S. Dairy Farm, Baseline and Margin Protection Program Scenarios, 2015 to 2018

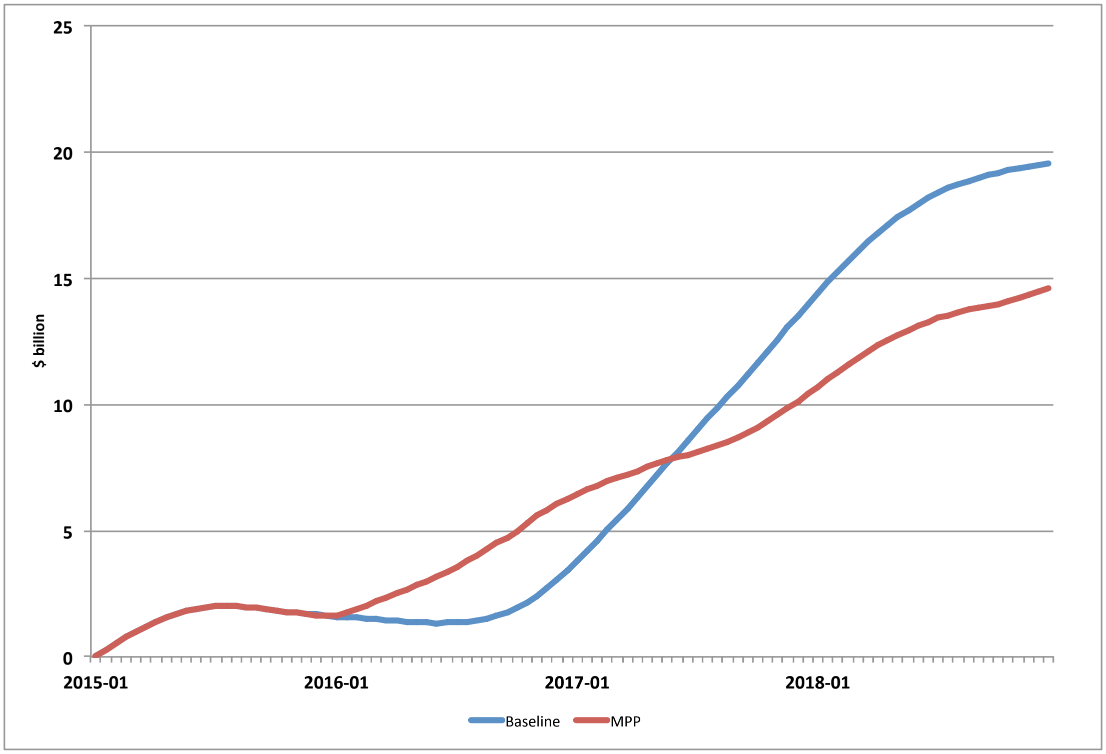


Figure 8. Simulated Value of Cumulative Net Farm Operating Income for All U.S. Dairy Farms, Baseline and Margin Protection Program Scenarios, 2015 to 2018

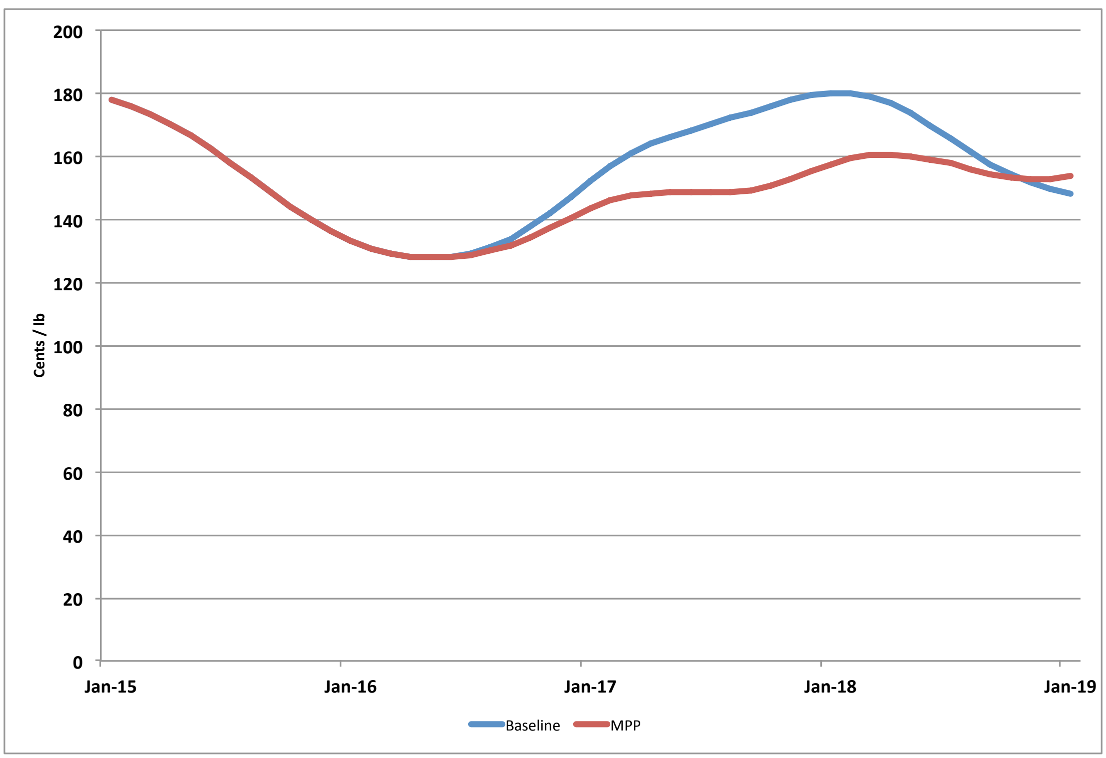


Figure 9. Simulated Value of U.S. American Cheese Price, Baseline and Margin Protection Program Scenarios, 2015 to 2018

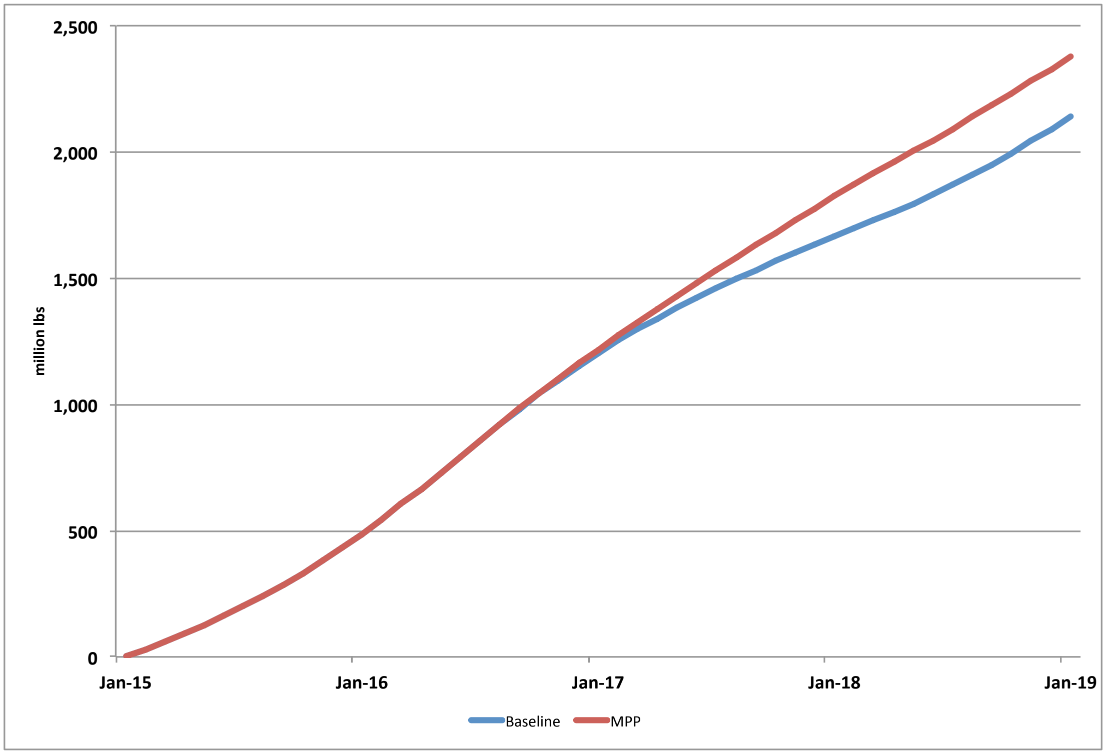


Figure 10. Simulated Value of Cumulative American Cheese Exports, *Baseline* and *Margin Protection Program* Scenarios, 2015 to 2018

Impacts of the MPP With Alternative Market Conditions

Market conditions substantially affect the impacts of the MPP compared to current dairy policies. As expected, when market conditions are much more favorable (lower feed prices and stronger global demand) under the *Limited Impacts* assumptions, the effects of the MPP on the All-milk price and margin are much smaller, with a decrease of $0.12/cwt rather than $0.91/cwt during 2015 to 2018 (Table 4, columns 4 and 5; Figure 11a). The impacts of MPP on government expenditures compared to the baseline are much smaller ($200 million compared to $5 billion), as are the reductions in NFOI for a medium-sized farm and for all US dairy farms (Table 4, Figure 12a). The decrease in U.S. cheese prices and the increase in exports due to MPP are also much smaller under more favorable market conditions.

When market conditions are less favorable (higher feed prices and weaker global demand in the Major Impacts assumptions) than for the initial Baseline and MPP scenarios, the impacts of the MPP are much larger (Table 4, columns 6 and 7). The decrease in the All-milk price and margin is more than three times larger than for our original market condition assumptions ($3.37/cwt compared to $0.91/cwt, Figure 11b). Government expenditures are simulated to increase by more than $8.4 billion during 2015-2018 with MPP compared to the Baseline under these market conditions. Despite

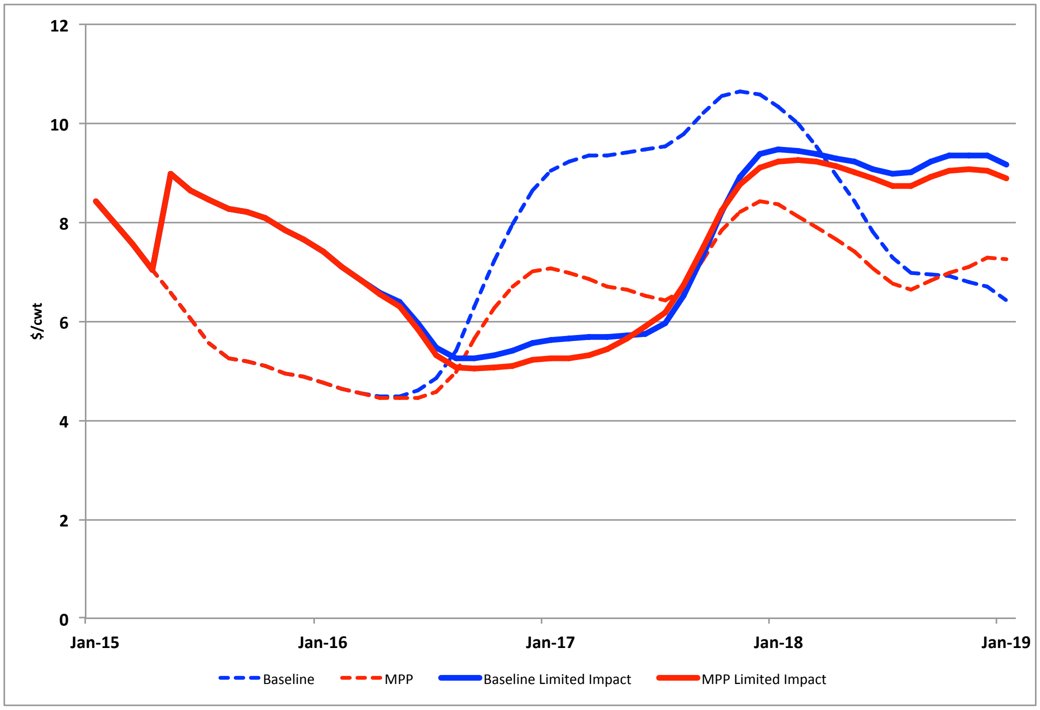


Figure 11a. Simulated Value of the Margin Used to Pay Indemnities, *Limited Impact Baseline* and *Margin Protection Program* Scenarios Compared to Original *Baseline* and *MPP* Scenarios, 2015 to 2018

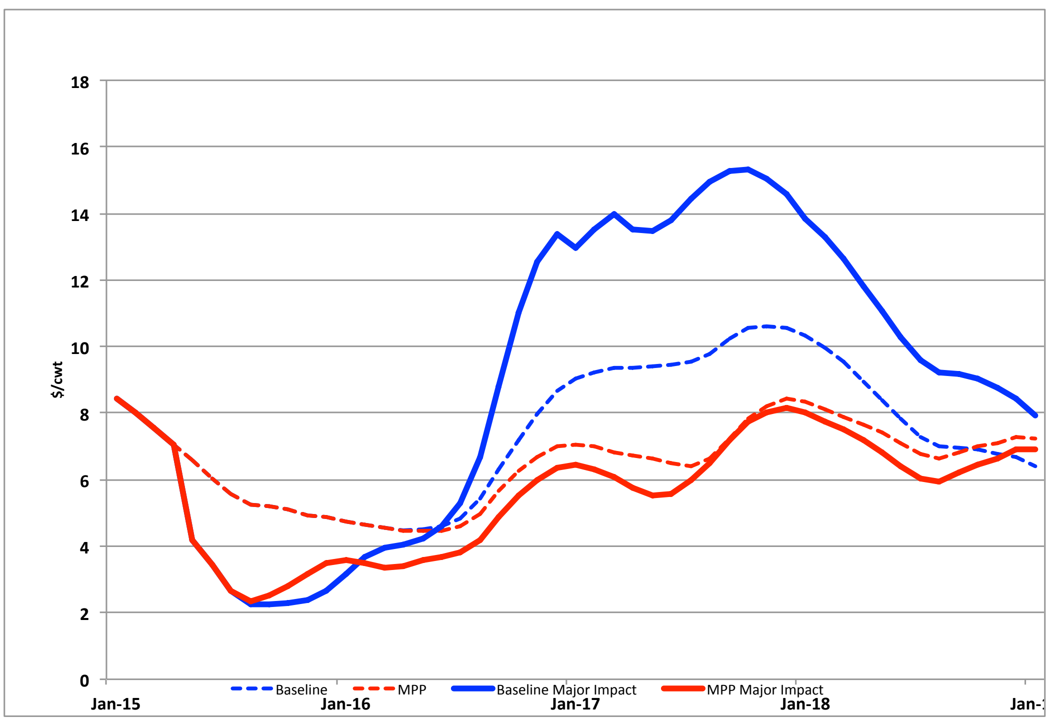


Figure 11b. Simulated Value of the Margin Used to Pay Indemnities, *Major Impact* Baseline and *Margin Protection Program* Scenarios Compared to Original *Baseline* and *MPP* Scenarios, 2015 to 2018

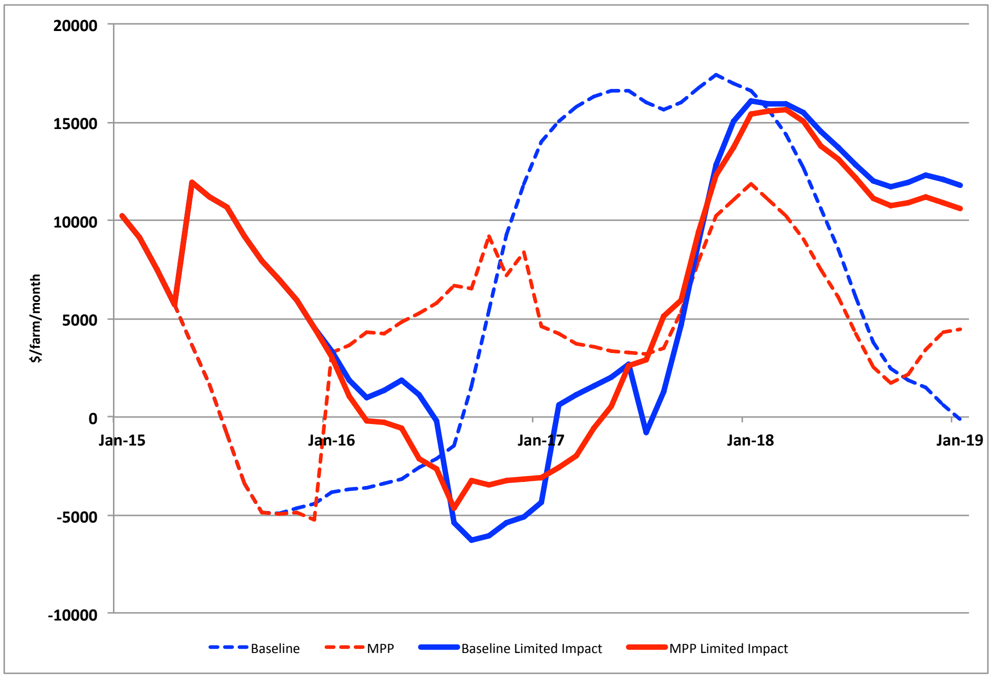


Figure 12a. Simulated Value of Monthly Net Farm Operating Income and Indemnity Payments for a Medium-size (230 cows) U.S. Dairy Farm, *Limited Impact* Baseline and *Margin Protection Program* Scenarios Compared to Original *Baseline* and *MPP* Scenarios, 2015 to 2018

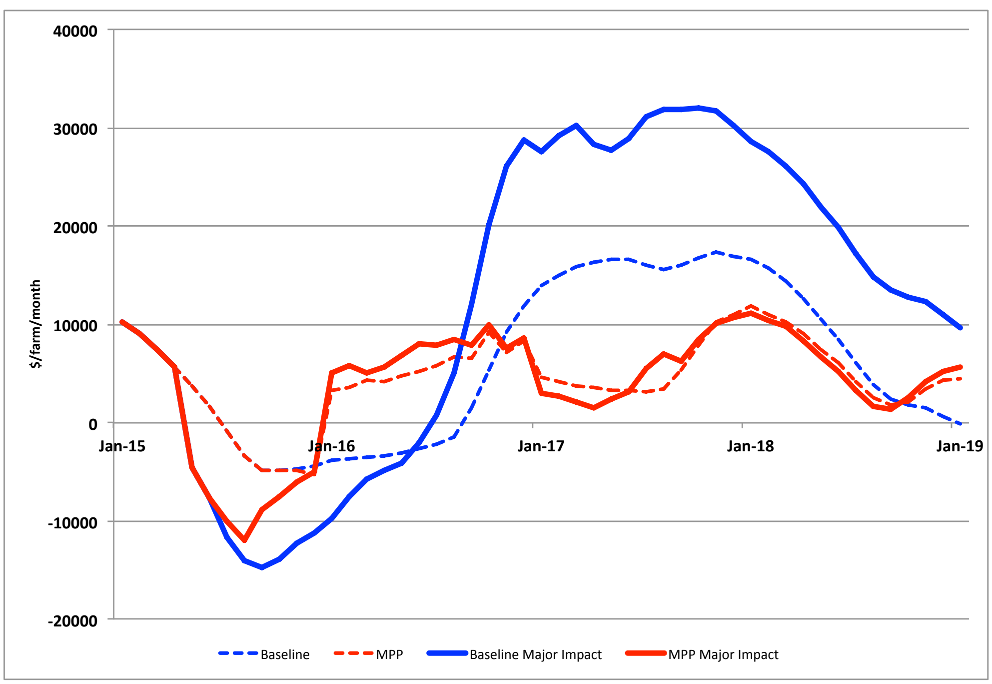


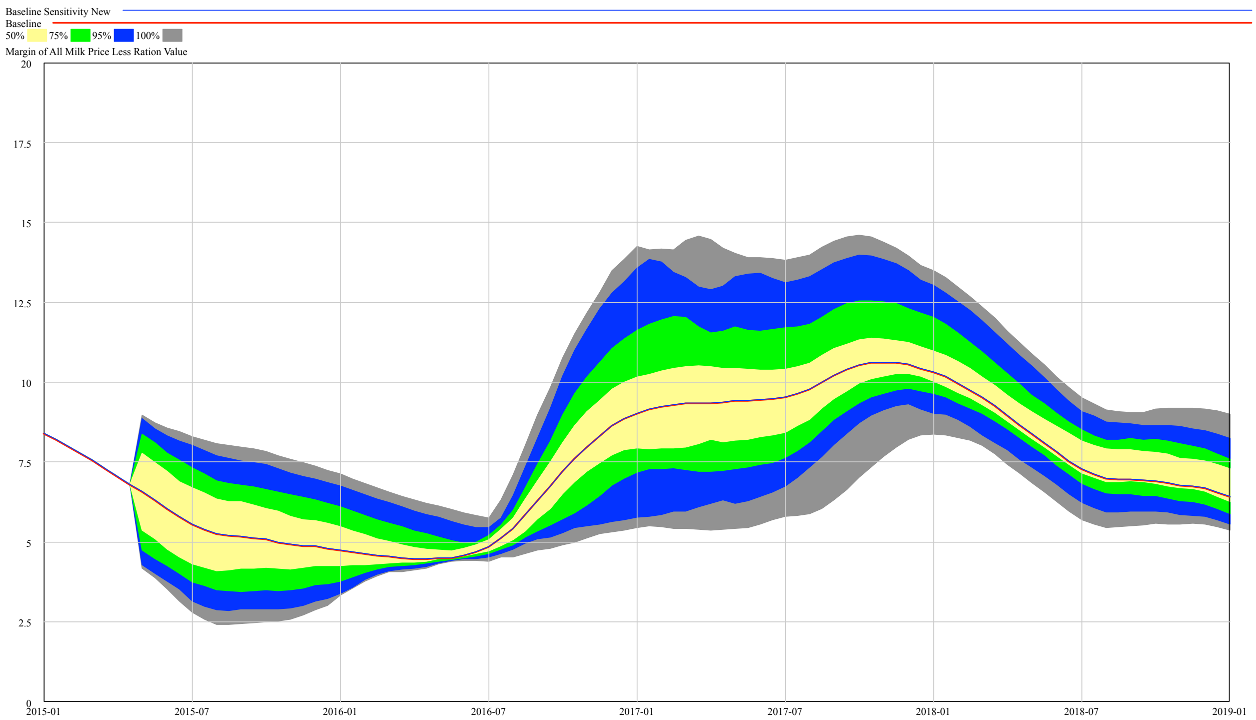
Figure 12b. Simulated Value of Monthly Net Farm Operating Income and Indemnity Payments for a Medium-size (230 cows) U.S. Dairy Farm, *Major Impact* Baseline and Margin Protection Program Scenarios Compared to Original *Baseline* and *MPP* Scenarios, 2015 to 2018

indemnity payments averaging more than $50,000 per farm per year for a medium-sized U.S. farm, average NFOI is reduced by more than $100,000 per year during 2015 to 2018 (Table 4, Figure 12b), and cumulative NFOI for all U.S. dairy farms is reduced by nearly $20 billion (60% of the cumulative NFOI in the *Baseline* for these market conditions). There is a major impact on U.S. cheese markets (a 13% decrease in average cheese prices) and U.S. net exports are tripled.

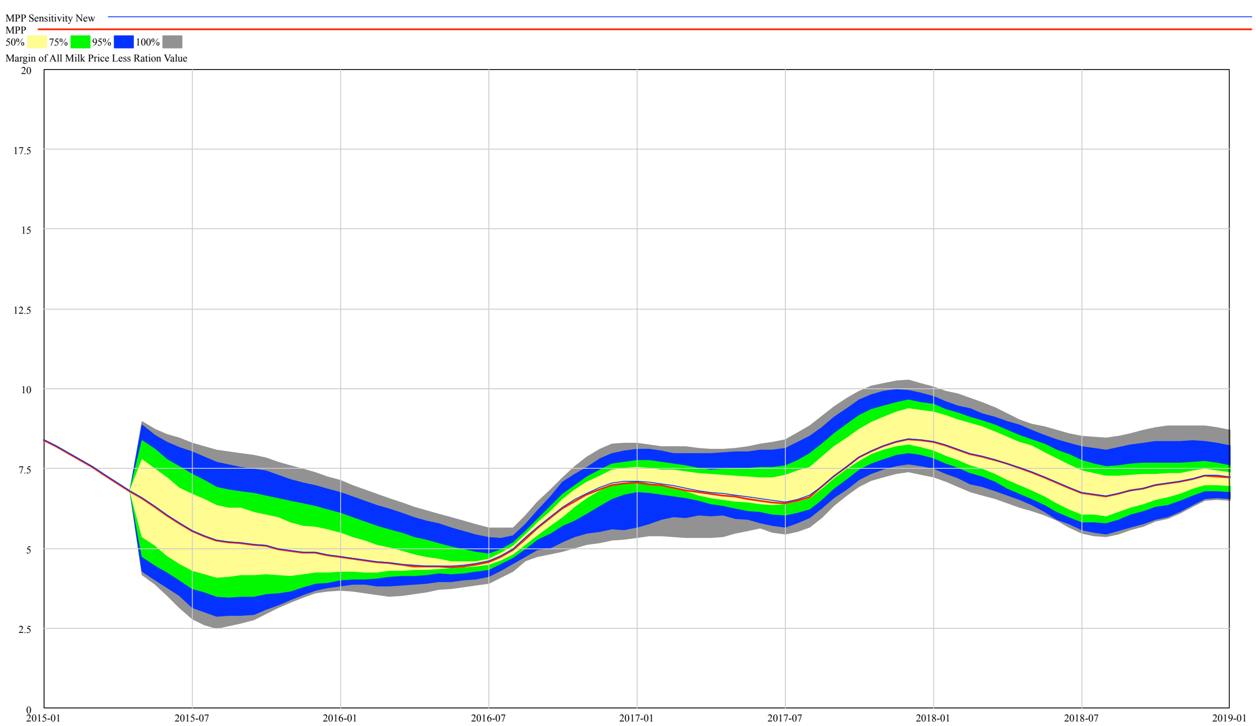
Thus, market conditions can have a substantial influence of the impacts of the MPP. However, the two market conditions simulated above assume rather extreme values for feed costs and global demand shocks. To provide further insights about the ranges and probabilities of possible outcomes under the *MPP* compared to the *Baseline*, we assess the distributions generated by N=200 stochastic simulations. Unsurprisingly, the range of possible margin values during 2015 to 2018 is large for both the *Baseline* and the *MPP* as market condition parameters are modified (Figure 13). However, it is clear that the distribution of margin values over time has a smaller range and a lower average value for the *MPP* simulations (Figure 13b) than for the *Baseline* simulations (Figure 13a). This is further quantified by comparison of the average difference in the margin (and all-milk price) values during 2015 to 2018 for each of the N=200 stochastic simulations (Figure 14). Only 1 of 200 simulations resulted in an increase in the average margin and all-milk price during 2015 to 2018, and the average reduction in margin or milk price was $0.96/cwt. Well more than half of the simulations in the range of -$0.25/cwt to -$1.25/cwt. The distribution of cumulative NFOI outcomes suggests a high probability of reductions in that value, with more than three-quarters of the simulation values in the range from -$1 billion to -$8 billion (Figure 15). The average reduction in cumulative NFOI for N=200 simulations was -$5.5 billion. There also appears to be a high probability that the MPP will increase government expenditures compared to current programs—only 1 simulation reported a reduction in expenditures with MPP compared to the Baseline. The average increase for N=200 simulations was $2.8 billion, based on a bi-modal distribution with more than half of the simulations in the range of $4 billion to $7 billion (Figure 16). Thus, although the exact empirical magnitude of impacts of the MPP program are uncertain, there appears to be a high probability of the types of impacts predicted by the conceptual model and reported in our comparisons of the initial Baseline and MPP scenarios.

Impacts of Program Design and Producer Participation Decisions

As noted earlier, program design decisions such as how far in advance producers must select margins levels and percentage of their production history to cover can influence MPP impacts. Our simulations indicate that the impacts of the MPP would be less during 2015 to 2018 with a 3-month advance decision rule rather than one that allowed participation decisions up to the end of the calendar year (Table 5). The impact is less in this case because producers' extrapolative expectations three months ahead do not fully anticipate margins lower than $4/cwt during 2016 (despite an overall downward trend in prices and margins). As a result, the participation decision three months out based on our decision rules is to cover 75% of production history at a $6.50/cwt margin, rather than the decision to cover 90% of production history at an $8/cwt margin, which is



a) Stochastic Simulation Results with *Baseline* Assumptions



b) Stochastic Simulation Results with *MPP* Assumptions

Figure 13. Range of Margin Values during 2015 to 1018 for N=200 Simulations for a) *Baseline* and b) *Margin Protection Program* Scenarios

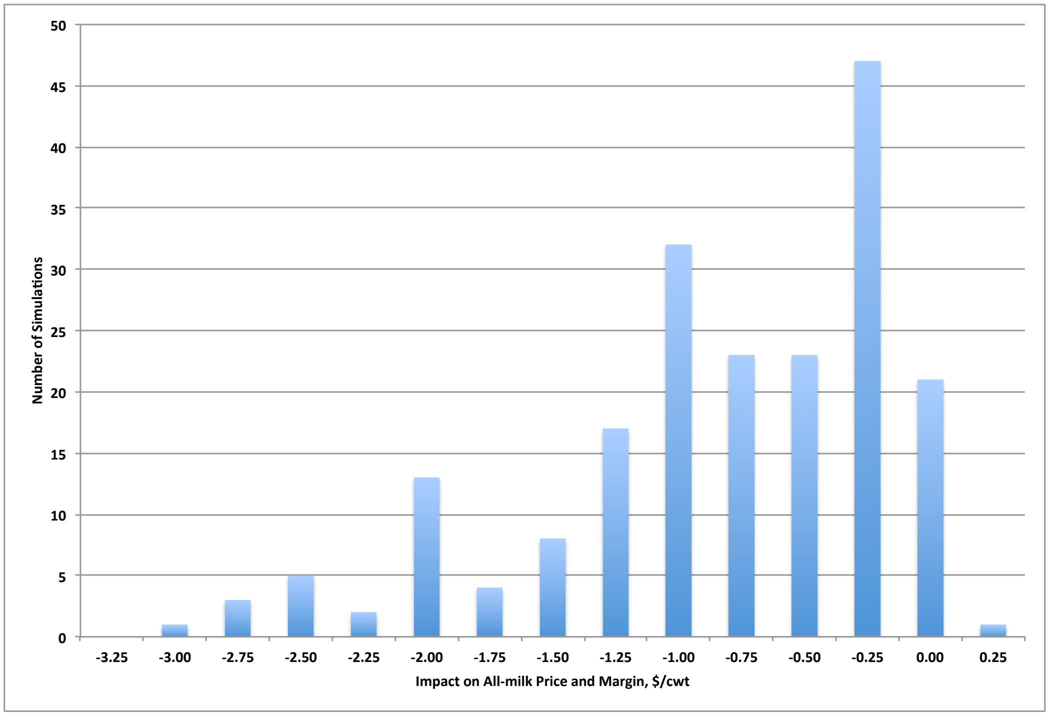


Figure 14. Distribution of Differences in the Average All-milk Price and MPP Margin During 2015 to 2018 Between *Baseline* and *MPP* Scenarios for N=200 Simulations with Variable Feed Prices and ROW Demand Pulse Values

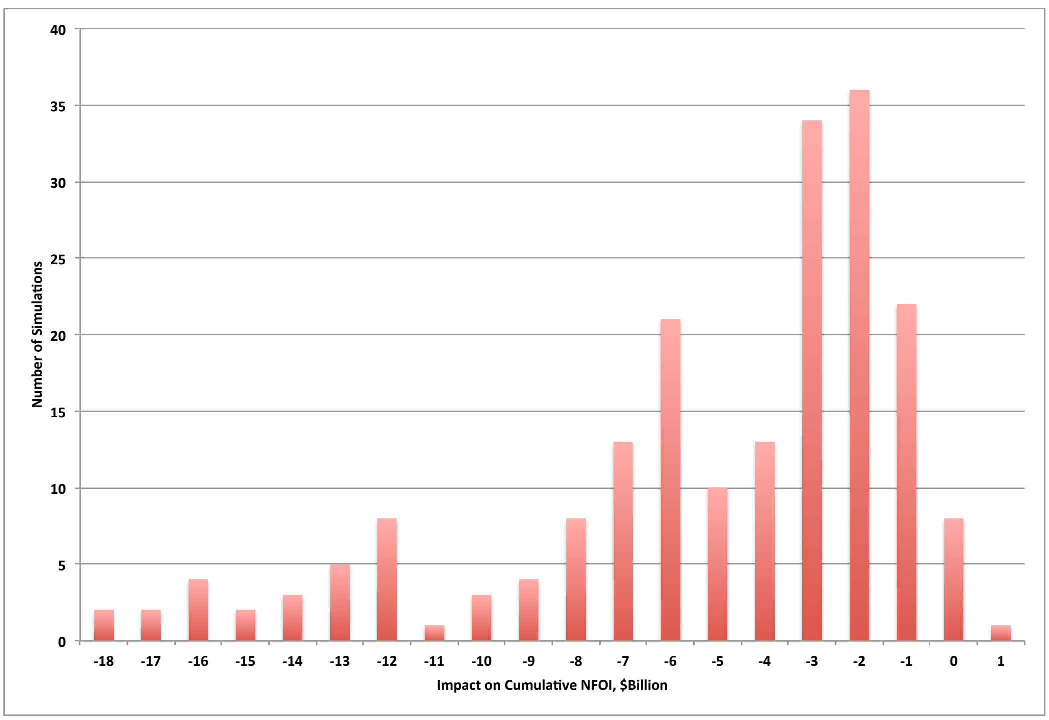


Figure 15. Distribution of Differences in the Cumulative Net Farm Operating Income During 2015 to 2018 Between *Baseline* and *MPP* Scenarios for N=200 Simulations with Variable Feed Prices and ROW Demand Pulse Values

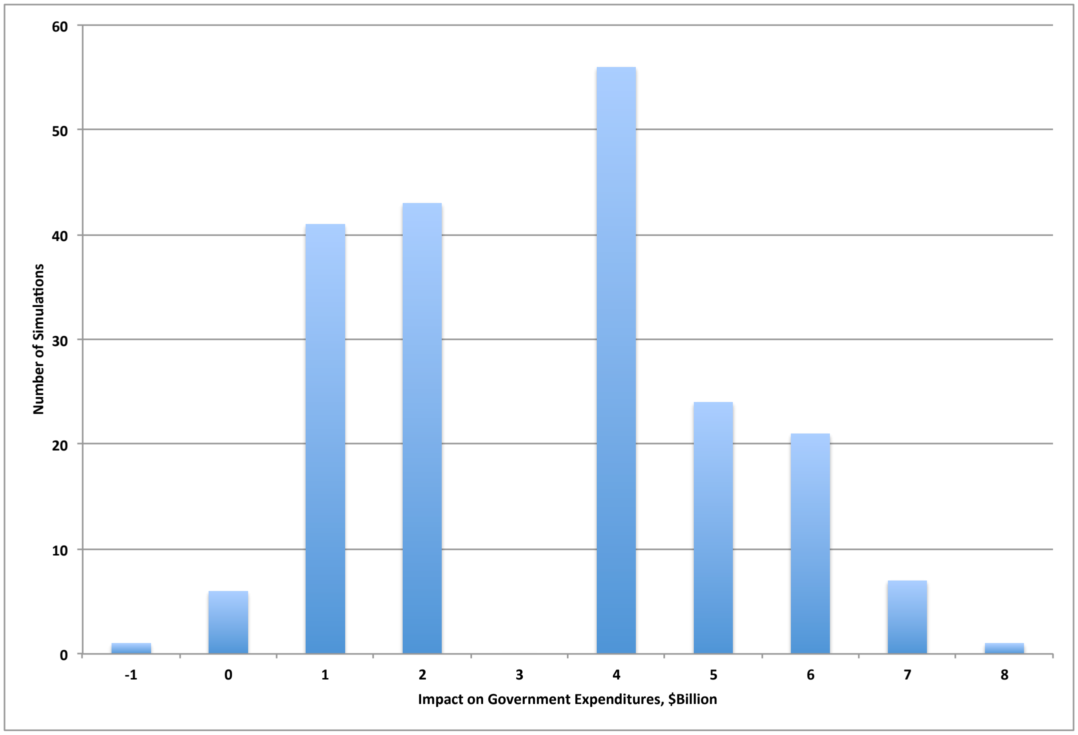


Figure 16. Distribution of Differences in the Cumulative Government Expenditures During 2015 to 2018 Between *Baseline* and *MPP* Scenarios for N=200 Simulations with Variable Feed Prices and ROW Demand Pulse Values

the decision taken if producers could decide very close to the end of 2015. The impacts are qualitatively and quantitatively similar to those discussed earlier (Table 5), with reductions in the average margin value, all-milk price, NFOI and cheese prices, and increases in government expenditures and U.S. net exports of cheese. However, the lower participation based on decisions three months out reduces government expenditures by more than $2 billion ($1.6 billion compared to $3.7 billion). Although the specific impacts of the timing of producer decisions will vary depending on the evolution of margins over time between the decision and the beginning of coverage, our analysis suggests that this implementation decision could likely influence the outcomes of the MPP—particularly government expenditures.

Table 5. Simulated Outcomes of the Margin Protection Program During 2015-2018, Baseline and Three MPP Scenarios with Different Assumptions about Decision Timing and Participation

Outcome	Baseline	Difference with MPP	Difference with MPP, 3 Month Advance Decision	Difference with MPP, 3 Month Advance Decision and 25% Production Coverage
All-milk price, $/cwt	16.98	-0.91	-0.61	-0.05
MPP margin, $/cwt	7.40	-0.91	-0.61	-0.05
Cumulative government payments, $ billion	0.2	3.5	1.4	-0.9
NFOI, Medium US Farm, $/farm/year	76,706	-20,292	-16,933	-782
Indemnity payments, Medium US farm, $/farm/year	0	34,022	20,722	8,248
Cumulative NFOI, $ billion	19.6	-5.0	-4.1	-0.9
Cheese price, $/lb	1.57	-0.07	-0.05	0.00
US net exports, cheese, mil lbs/year	512	96	60	5

We explore the market impacts of the producer participation decision when combined with an implementation rule that assumes a participation decision three months in advance. Although we maintain our decision rules for expected margins > $8/cwt and < $4/cwt, a reduction in the percentage of production history covered from 75% to 25% at a $6.50/cwt margin when margins are between $4/cwt and $8/cwt greatly modifies the impacts of the MPP program (Table 5). The decrease in the All-milk price and margin is much smaller (-0.05/cwt rather than -$0.61/cwt with the three-month advance decision, Figures 17 and 18). Government expenditures are negative during 2015 to 2018, that is, the government is collecting more in premiums than it is paying in indemnities (Table 5 and Figures 19 and 20), and the negative impacts on NFOI are also much smaller (Table 5 and Figures 21 and 22). This suggests that program participation decisions have a significant impact on the outcomes resulting from the MPP. Importantly, this also suggests that an individual producer's decision to participate could depend on the collective decisions of other producers. If overall participation in the program is limited, then the negative impacts of non-participation will be less—which if perceived and used for decision-making could lead to more limited participation (and smaller MPP impacts). Conversely, if participation is high, the costs of non-participation are also likely to be high, and if perceived by producers and used for decision-making, this could lead to high participation (and larger MPP impacts).

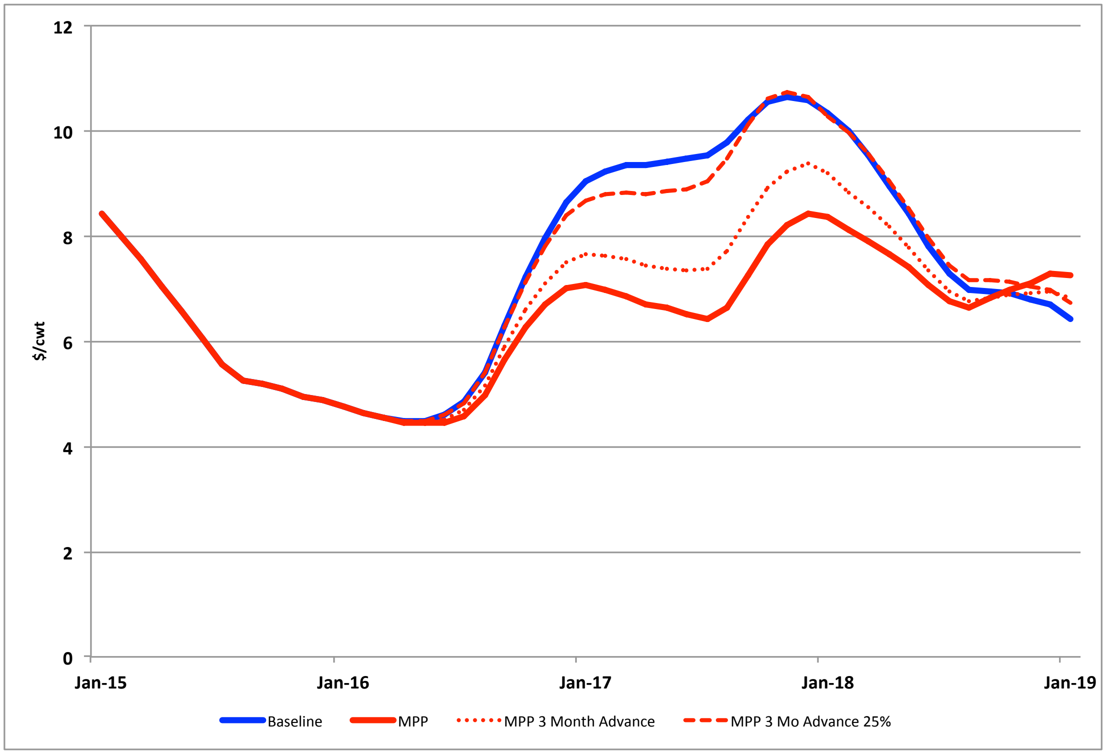


Figure 17. Simulated Value of the Margin Used to Pay Indemnities During 2015 to 2018, *Baseline* and Three *Margin Protection Program* Scenarios With Alternative Assumptions about Decision Timing and Participation

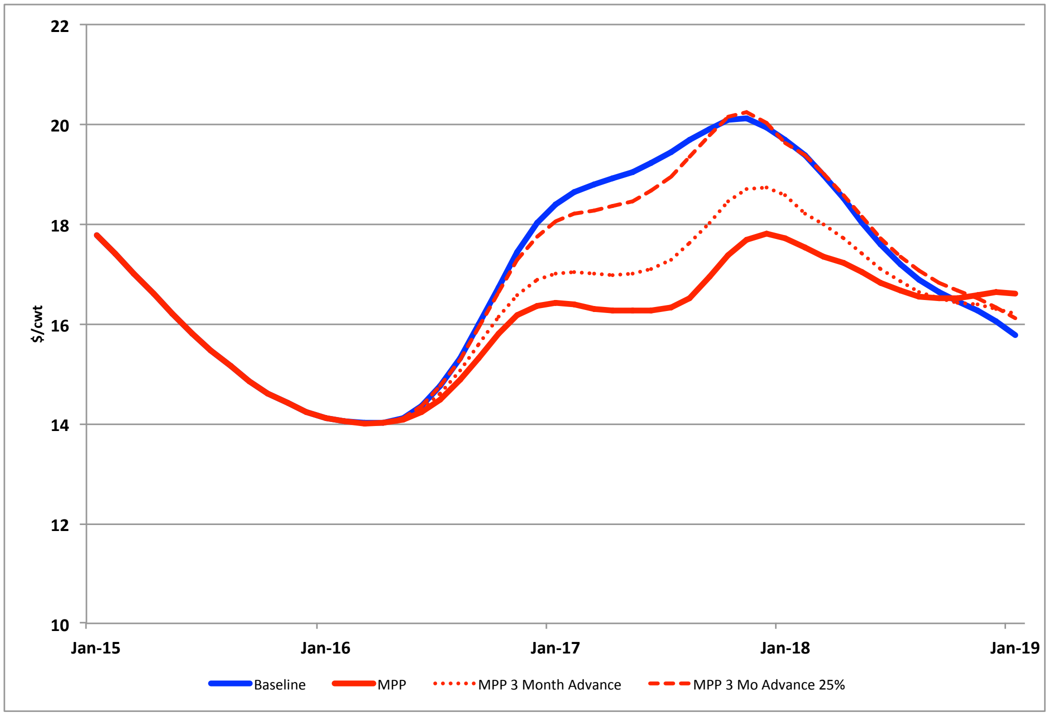


Figure 18. Simulated Value of the All Milk Price During 2015 to 2018, *Baseline* and Three *Margin Protection Program* Scenarios With Alternative Assumptions about Decision Timing and Participation

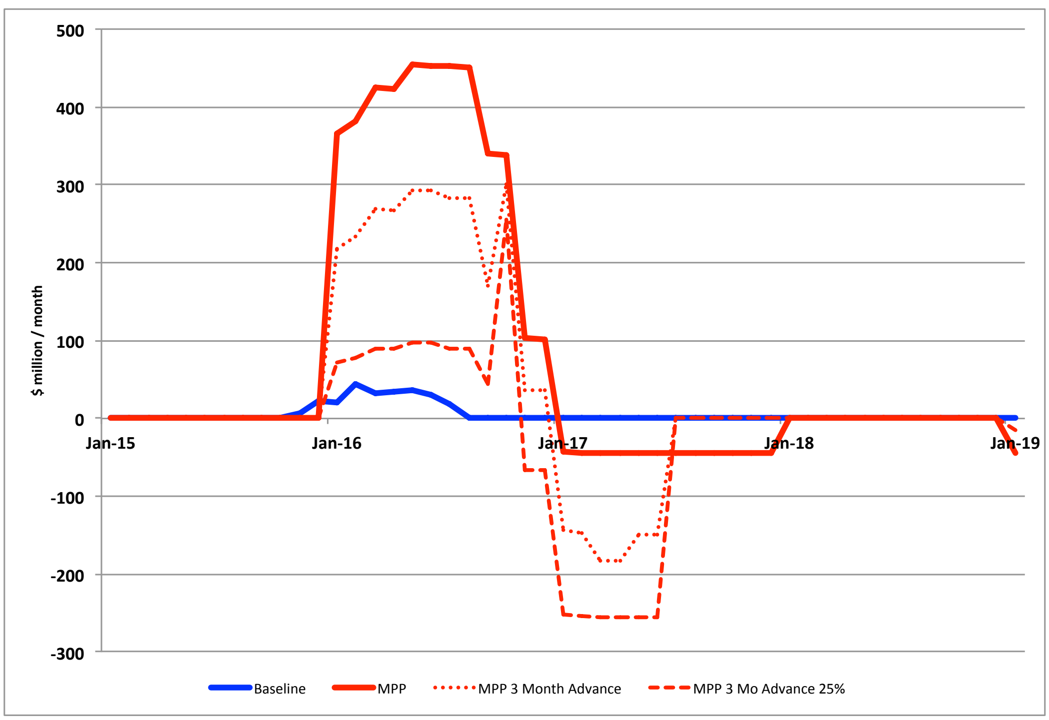


Figure 19. Simulated Value of Government Expenditures During 2015 to 2018, Baseline and Three Margin Protection Program Scenarios With Alternative Assumptions about Decision Timing and Participation

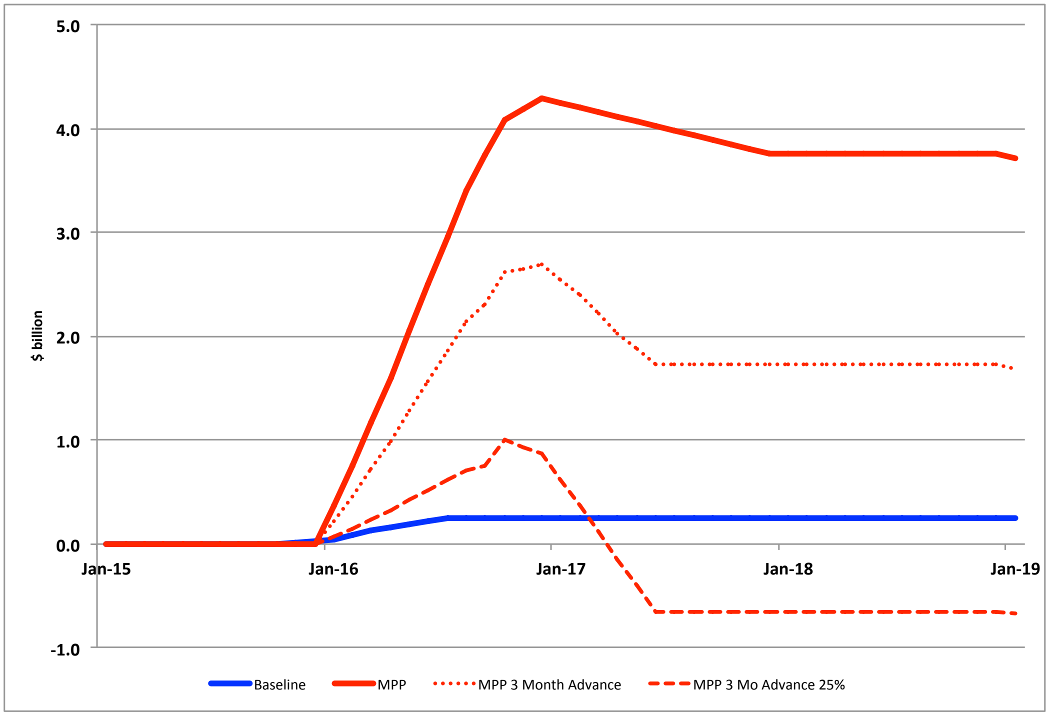


Figure 20. Simulated Value of Cumulative Government Expenditures During 2015 to 2018, *Baseline* and Three *Margin Protection Program* Scenarios With Alternative Assumptions about Decision Timing and Participation

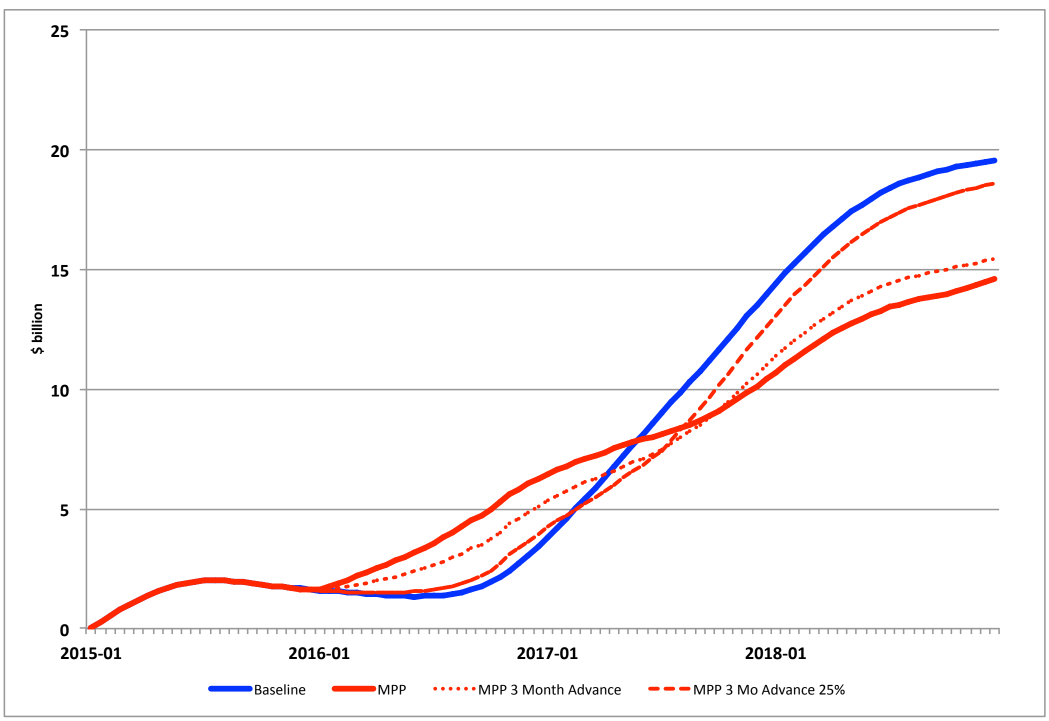


Figure 21. Simulated Value of Cumulative Net Farm Operating Income During 2015 to 2018, *Baseline* and Three *Margin Protection Program* Scenarios With Alternative Assumptions about Decision Timing and Participation

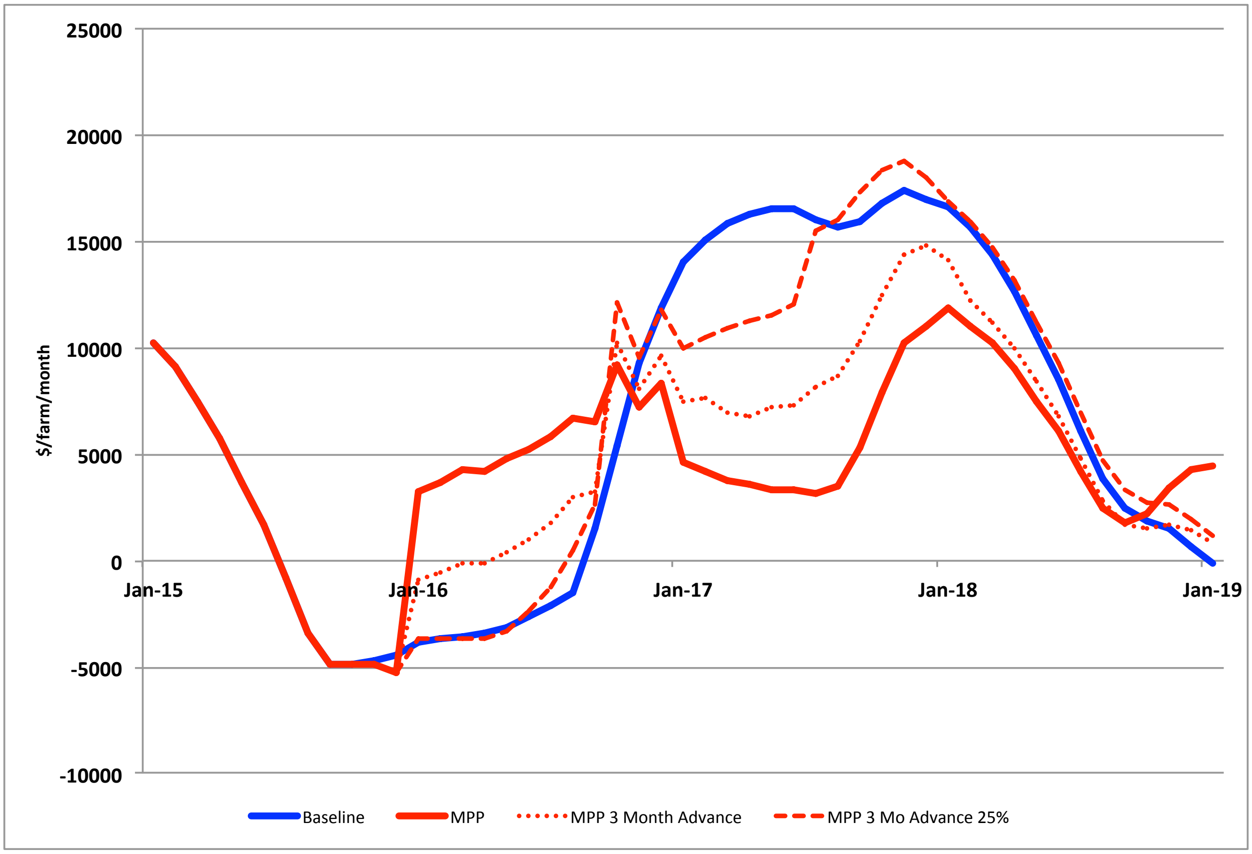


Figure 22. Simulated Value of Net Farm Operating Income During 2015 to 2018, Medium-size (230 cows) U.S. Dairy Farm, *Baseline* and Three *Margin Protection Program* Scenarios With Alternative Assumptions about Decision Timing and Participation

IMPLICATIONS

The foregoing conceptual and empirical analyses are largely consistent in their assessment of MPP impacts compared to current policies, albeit with considerable uncertainty based on a range of future market conditions under which the MPP would operate. Despite the uncertainty inherent in the stochastic analysis, there are a number of implications of our conceptual and empirical findings:

- *Use of historical margin data to make participation decisions for the future could be of very limited usefulness and may be misleading*. It is common for analysts to illustrate the potential impacts of the MPP at the farm level using historical data (for the past 5 to 10 years) for a hypothetical farm, but this may be misleading, for at least two reasons. First, our analyses suggest that under conditions observed during the previous decade or so, the program would have been active on many occasions (assuming at least moderate levels of producer participation), and the MPP probably would have markedly altered the trajectory of future margins, prices and program participation decisions. That is, the past with the program probably would have been very different from the actual past observed without the program and therefore should not be used to assess the impacts of alternative farm-level decision strategies. Second, future costs and benefits of the program for producers will depend on current market conditions and the degree of participation by other producers, not on the potential benefits observed under previous years. These are not easily assessed with historical data.

- *Program design for implementation will likely influence MPP outcomes*. We assessed one important design decision, the timing of producer participation decisions, and found that this can affect the impacts of the MPP and government expenditures in particular. We did not assess the impacts of other program design issues that must be decided by the implementing Farm Service Agency (FSA), isuch as which price series (advanced reporting values or final values) will be used for the margin calculation, when premiums must be paid (we assumed continuous payment of premiums in the foregoing analyses) and whether that will influence participation decisions and how the premium structure will be applied based on milk production thresholds[8]. Although the timing of decisions is likely to have the largest impact on outcomes, these other design decisions could affect MPP outcomes, particularly if they affect participation decisions.

- *Participation decisions have the potential to markedly affect MPP outcomes*. As noted in our analysis, lower participation implies much more limited impacts of the MPP, but these impacts are also likely to affect participation. This suggests that it may be useful for the implementing agency (FSA) to report aggregate participation levels during the sign-up period (e.g., the amounts of milk protected at what margin levels), which will be useful to producers making decisions and to futures markets for dairy products in assessing the likely impacts of MPP.

- *The dairy producer participation decision is different for MPP than for other risk-management decisions, but may not be independent of them*. We assumed high levels of participation in our initial analyses based on the implied subsidies in the premium schedule. Although it was marketed as a risk management tool and will perform that function to a certain extent (paying when NFOI is low), the program differs from other insurance programs that pay indemnities in the case of catastrophic losses. Our analyses suggest that the MPP may be frequently active during 2015 to 2016, with substantive impacts on margins. This will affect both the future probability of indemnity payments and the participation decision, neither of which is typical for a product such as fire insurance (or crop insurance). Moreover, for most risk management products, producers would make decisions based on a careful assessment of their costs and benefits. For a highly subsidized program such as MPP, this decision

[8] *For example, it is uncertain the interpretation of the premium schedule for the 4 million pounds of milk production. For example, if a producer has a 6 million pound production history and wants to insure 50%—3 million pounds, does that mean 50% of the first 4 million at the lower premium—2 million pounds—and 50% of the above 4 million pounds—1 million pounds—at the higher premium; or does that mean 3 million pounds at the lower level.*

could focus more on how to maximize benefits from the program, given its relatively low costs. Finally, for farmers currently using other risk-management tools, the option for coverage under MPP could modify the best use of these tools—with aggregate effects on the markets for risk if a sufficient number of producers substitute MPP coverage for other risk management coverage.

CONCLUSIONS

Our analyses suggest that many of the negative effects of a margin insurance program that weakens corrective feedback processes in milk production could occur, including persistent periods of lower prices, lower margins and large government expenditures. However, these results are conditioned on two key factors. The first is that cyclical behavior in U.S. milk prices results in sufficiently low margins in 2016, thereby activating indemnity payments under the program and preventing the adjustment process. Although our simulated milk prices are consistent with previous price patterns, it is possible that structural changes in producer decision-making or different future feed prices could alter this pattern so that the margin insurance program is not frequently activated during 2015 to 2018. If this occurred, then the importance of weakening the relevant feedback loops could be minimal, because they would not be activated. However, our stochastic analyses suggest that these types of impacts have a high probability of occurring with the MPP under a wide variety of market conditions. Second, we assumed a significant degree of farmer participation in the margin based on a simple decision rule derived from estimates of the degree to which the program is subsidized. If participation is less than what we assumed, this could also lessen the degree to which the feedback processes are weakened by the margin insurance program, which could markedly alter the program's dynamics during 2015 to 2018. Finally, program design for implementation, such as the timing of the participation decision) is also likely to influence the magnitude (although not the direction) of the outcomes of MPP.

ACKNOWLEDGEMENTS

The authors thank four anonymous reviewers for the International System Dynamics Conference whose comments improved the clarity and scope of this paper.

REFERENCES

Bishop, P. M. 2004. Dairy market impacts of U.S. milk protein imports and trade policy alternatives. Ph.D. dissertation, Cornell University.

Congressional Budget Office. 2014. Letter to the Honorable Frank Lucas, Chair of the Committee on Agriculture Regarding Budgetary Effects of the Agricultural Act of 2014, January 28, 2014.

Forrester, J. W. 1980. Information Sources for Modeling the National Economy. Journal of the American Statistical Association, 75:555-574.

Meadows, D. 1970. Dynamics of Commodity Production Cycles. Wright-Allen Press.

Newton, John, Cameron S. Thraen, Marin Bozic, Mark W. Stephenson, Christopher Wolf and Brian W. Gould. 2013. Goodlatte-Scott vs. the Dairy Security Act: Shared Potential, Shared Concerns and Open Questions. Briefing Paper Number 13-01, Program on Dairy Markets and Policy, April. [http://dairy.wisc.edu/pubPod/Pubs/MP-DMAP%20Briefing%20Paper%2013-01.pdf]

Nicholson, C. F. and H. M. Kaiser. 2008. Dynamic Impacts of Generic Dairy Advertising. Journal of Business Research, 61:1125-1135.

Nicholson, C. F. and M. W. Stephenson. 2014. Milk Price Cycles in the U.S. Dairy Supply Chain and Their Management Implications. Program on Dairy Markets and Policy, Working Paper 14-02, May.

Nicholson, C. F. and M. W. Stephenson. 2010. Analysis of Proposed Programs to Mitigate Price Volatility in the U.S. Dairy Industry. September.

Nicholson, C. F. and T. Fiddaman. 2003. Dairy Policy and the Origins of Dairy Price Volatility. Paper presented at the 21st International Conference of the System Dynamics Society, July 20-24, 2003, New York, NY.

Pagel, Erica J. 2005. Dynamic Patterns of Change in Structure Under Different Support Policy Regimes: An Examination of the U.S. Dairy Industry. MS Thesis, Cornell University.

Sterman, J. D. 2000. Business Dynamics: Thinking and Modeling for a Complex World. Boston: Irwin/McGraw Hill

USDA Economic Research Service. 2014. Farm Household Well-being. <http://www.ers.usda.gov/topics/farm-economy/farm-household-well-being/farm-household-income-(historical).aspx#.U48fasbecdI> Accessed 4 June 2014.