Regional variation in margin response, participation, and potential federal expenditures under Dairy Margin Protection Program

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Abstract

Dairy policy under the 2014 farm bill is an insurance program based on national milk and feed prices, despite considerable regional variation in feed costs and milk prices. Milk production response to low margin periods between 2000 and 2012 is compared by region. Consistent with prior research, the response is much greater in the West. There is no evidence that eastern and mid-western dairies reduce production in response to low margins. Implications for potential total and regional government expenditures for the Dairy Margin Protection Program are evaluated in the context of historical supply response and 2015 participation rates. [1]

Key Words: Dairy, Agricultural Policy

JEL Classifications: R38, Q13, Q18

[1] In the interest of disclosure, together with my family, I own a small grazing dairy in Texas. I believe this is a fair and unbiased evaluation of the current policy, but the reader should be aware that I will be financially affected by this policy.

Introduction

In 2009 the U.S. dairy industry experienced a period of falling output prices, a continuation of rapid increases in input costs, and the resultant loss of equity and loss of farms. Despite infusions of over $1.35 billion of government support during the calendar year 2009, the number of dairy farms fell by three percent (Shields, 2010).

The erosion of equity and accelerated loss of dairy farms caused acute frustration with the slow speed of adjustment of milk production to market conditions. A voluntary, non-governmental supply management program, the Cooperatives Working Together (CWT), was utilized three times in 2009, removing almost four billion pounds of milk production from the market. Government programs injected over $1.35 billion into the industry, but this arguably served to further dampen the supply response. Farmers tried desperately to produce enough milk to pay their own bills and hoped the market correction would be brought by somebody else folding and not them personally. The situation created at least partial consensus to change existing dairy policy.

The farm bill signed into law by President Obama on February 7, 2014, did not include any supply management provision. It replaced and ended the Milk Income Loss Contract (MILC) and the Dairy Product Price Support Program (DPPSP). The MILC was a counter-cyclical direct payment program. MILC was the first to use a volume-based cap on benefits rather than income-based limits. This method of production cap was the source of most of the controversy about this program. Large farms met the production limit in less than a month. This left large percentages of US milk production without assistance, and disproportionately benefited small farms. USDA estimates that 63 percent of US milk production comes from 5 percent of U.S. farms. These very large farms benefited much less from MILC than did the 88 percent of small farms that collectively produce only 24 percent of US milk (Newton and Kuethe, 2014).

Under the new farm bill, the government is providing an insurance program under which farmers can insure an Income Over Feed Cost (IOFC) margin on a percentage of their milk production. Farmers will choose the percentage of their annual milk production they want to insure. This percentage is referred to as the coverage level. Margins are defined as the difference between the price of a hundred pounds of milk and the price of a specified dairy feed ration. When this margin falls below the insured level, direct indemnity payments will be made to farmers to make up the difference on covered milk production. Margin insurance of $4.00 is provided for free (in addition to an administrative fee of $100) to enrolled dairy farmers, this is referred to as a catastrophic insurance level. The margin level can be increased by $0.50 increments up to $8.00, but requires the dairy farmer to pay additional premium money. If a farmer selected a coverage level of 90 percent and a margin level of $5.00 then margin levels fell to $4.75, the farmer would receive 90 percent of $0.25 for the portion of their base production level from that time period.[2] The program has been described as a way to move away from the straight subsidies of the past, and towards a concept that requires a more active risk management role by the farmer.

The complications and difficulties associated with dairy policy are often blamed on the highly perishable nature of fluid milk. But a significant portion of the difficulty of regulating milk markets is geographical in nature. The Federal Milk Marketing Order (FMMO) that

[2]Base production must be specified as historic production from either 2011, 2012, or 2013. Each individual farmers base production level is adjusted annually by the U.S. average increase in milk production.

provides the basis for most milk pricing in the US is intended to create "orderly marketing of milk" through a series of geographically-based programs. The MILC program repealed by this legislation grew out of a compromise to appease differing regional needs in order to pass the 2002 farm bill. Much of the dissatisfaction with the MILC had the sharp regional discrepancies in benefits at the heart of the issue. This research focuses on regional imbalances that may occur as part of the new policy. Specifically, the focus here is to compare and contrast the response to low IOFC margin periods from region to region. A time series model is used to compare the response of milk production within each region to the low margin periods on which the new farm bill is focused. This is used to investigate the regional aggregate milk production response to the IOFC national margin, as it is specified in the farm bill.

H_0 : Dairies throughout the U.S. react consistently and uniformly to low margin periods

H_a : There is a regional difference in the milk production response to low margin periods

Previous Literature

In 1990, Chavas et. al. investigated the elasticity of the US milk supply by region. The authors found that milk supply elasticity with respect to milk price was 0.059 in the short-run. It became elastic in year seven (1.056), reached 1.527 at ten years and 3.088 at twenty years. The investigation of regional elasticities at that time was motivated by dramatic westward shifts in the geography of milk production. California had gone from producing 5.1 percent of the nation's milk in 1950 to 12 percent in 1987. This trend has continued. In 2012, California production had grown to 20.9 percent of national milk production. Calculating elasticities from the model they created, they found considerable regional variation. For own-price supply elasticity in the very short-run, this ranged from a low of 0.015 in the New England region to a high of 0.110 in the East South Central region. At twenty years, the variation was phenomenal, the Pacific region had an elasticity of 9.843, while the South Atlantic remained inelastic at 0.527 even in this time horizon. The authors noted that with a price drop, the Middle Atlantic, East South Central, and West South Central would gain market share relative to other regions, but it would take 20 years to do so. The Pacific region appeared to have more flexibility and responsiveness to feed cost, slaughter price, and slightly more than other regions for risk, as well. (Chavas et al., 1990). In prior work, Chavas and Klemme used a model that incorporated cow biology to measure national milk supply elasticity. They showed that 99.7 percent of output adjustments are made through changes in herd size (Chavas and Klemme, 1986).

Weersink and Howard (1990) evaluated the regional response to a change in US dairy policy that lowered milk support prices using the 10 USDA farm production regions. They used dynamic optimization models of firm input demand and output decisions using annual data for the period between 1950 to 1986. Three inputs were included: feed, cows and labor. They found that the rate of adjustment to lower prices via milk cow numbers was the highest in the Corn Belt region and slowest in the Appalachian region. Their conclusion was that reductions in milk supply are borne largely by regions with a relatively elastic supply function. Importantly, they did find considerable regional discrepancy in how fast cow numbers were expected to adjust to a lower price environment (Weersink and Tauer, 1990).

Bryant, Outlaw and Anderson (2007) investigated the supply response to the MILC program. They avoided the complexities of a dynamic programming approach in favor of a partial adjustment model of the long-run equilibrium. They analyzed the supply response using both dairy cattle numbers and yield as the dependent variable. Using their model, they estimated the speed of adjustment to equilibrium levels in response to a sustained change in supply determinant as 10.5 years. With the slow responses to changes in price, they were unable to discover a significant effect from the MILC program on cow numbers or yield. This could be the result of short-term import restrictions against Canadian-raised heifers or possibly due to the sunset provisions of the MILC program itself (Bryant et al., 2007). The partial adjustment model they used is modified in this paper and used to evaluate the the response of regional milk production to low margin periods.

Bozic et. al. (2011) used a mixed frequency model to estimate national supply responsiveness. This utilized the herd dynamics developed by Chavas and Klemme (1986) and Schmitz (1997), but used quarterly yield data combined with herd and heifer numbers that are only collected annually. The use of mixed frequency data allowed the authors to incorporate herd dynamics that accounted for the probability of cows in any age group being culled, and the resulting effects of the heifer population in subsequent years. The authors included MILC payments into the All Milk Price for the Milk Price explanatory variable. In the period from 1975 to 2005, the authors found a declining trend in long-run supply responsiveness. However, while milk was becoming less own-price elastic, it was becoming more responsive to feed costs (Bozic et al., 2011).

A fair amount of literature was written in the four years between the difficult prices of 2009 and the passage of the farm bill. Even though much of the literature reviewed in this section deals with bills that did not pass, the comparison of what was proposed with what is law provides information on how this policy will affect farmers.

Newton, Thraen, and Bozic (2013) focused on two main questions: whether the policy change would disproportionately favor the wealthiest dairy farmers, and if the margin insurance program would be fiscally responsible. They preface their work with the acknowledgment that the shift away from any type of means testing or benefit limitations is a dramatic shift in both policy and philosophy. The authors used futures prices as a short-term predictor of prices. To evaluate potential outlays under the DSA and DFA, they use Monte Carlo experiments to evaluate how 5,000 representative farms would be affected under the new program alternatives and measured the effect of the policy using changes in certainty equivalency. Under DFA, gains were 30.6 percent for a catastrophic scenario and 8.4 percent for a year like 2013 (Newton et al., 2013, 11). They also pointed out that because farmers have the ability to opt out of the insurance program under DFA, farmers would likely opt out of the program and the premium expense when margins appeared favorable, creating an adverse selection problem with high participation only in years when expected payouts exceeded premiums.

Important to the political backdrop of increased emphasis on federal cost savings, they found much higher total federal outlay under both DSA and DFA than under current policy. The 5,000 representative farms they constructed would have received $23 million in total from the current MILC program assuming 2013 conditions. Under the DFA version, this jumps to $123 million. As it was written, the DSA program would have paid out a forecast $186 million under the lower efficacy assumption for the stabilization program. In their model if they used optimistic assumptions about functionality of the stabilization program, the forecast payout under DSA dropped to around $78 million for these 5,000 farms (Newton et al., 2013, 12). Under any assumptions, they found that either proposal would be more expensive than the existing policy. However, the assumptions made then likely did not forsee the current drops in commodity prices that would have activated MILC, while maintaining IOFC margins above $8.00.

Woodard and Baker (2013) compared Dairy Freedom Act (DFA) and Dairy Security Act (DSA) and brought up interesting points about the differences in growth appetite being tied to regional differences in manufacturing growth. In the past six years, New York has tripled its production of yogurt. Under the new law, program benefits are tied to base production that is adjusted for each individual farm by the growth in the national production. If an area, like the Northeast, faces an increase in demand, producers within that area that expand to meet the demand will have the amount of growth beyond the national average ineligible under this program.[3] This is of limited importance in the short-term, but bears consideration in the long-term.

Woodard and Baker also bring up the issue of differences in regional feed costs. The differences in the percentage of feed purchased off-farm affects a farm's sensitivity to feed price changes. The discussion was in the context of evaluating how participation in the DSA would vary by regions. They predicted that western regions, with high external feed purchases and maximum benefit under the program, were more likely to have high participation (Woodard and Baker, 2013, 11). This prediction did not hold true, at least for 2015 participation.

Herbst et al. (2014) focused on the level of correlation between regional prices and the national margin specified in the legislation. Farm level income and costs were estimated from a policy simulation model. Farm level margins were comprised of farm level milk prices, the cost of purchased feed, and the costs for any farm-raised crops fed to cattle. Unsurprisingly,

[3]This could be positive if viewed as one force that may keep farmers utilizing private risk management markets.

the correlation between farm-level and national margins was greatest in regions that purchased most of their feed and lowest in areas where a significant portion was grown. Specifically, southern dairies that purchase a high percentage of their feed had correlations between farm level and national IOFC margins ranging from 0.89 to 0.92. It is worth noting that these simulator dairies are based in Texas and Florida and have larger herds than the average for most southern states. Midwestern dairies had correlations ranging from 0.63 to 0.80. The correlations between farm-level and national average margins for northeastern dairies in New York and Vermont ranged from 0.78 to 0.84. The West was similar to the Midwest and Northeastern regions but for different reasons. Dairies in the West generally purchase the majority of their feed, as they do in the South, but the lower milk prices in this region reduced the correlation between the national margin and the actual margin for western states (Outlaw et al., 2012).

Data

The data was obtained primarily from National Agricultural Statistics Service (NASS) through the Quikstats feature. NASS collects quarterly data for all states, but monthly data is only collected for the top 23 dairy producing states. To evaluate the changes in production, it is necessary to account for changes in the states that are not included in the top 23 dairy states. This requires use of the quarterly data on production, which includes every state. Yield data for the region is estimated by averaging the three months in each quarter for each of the top 23 dairy states for which monthly data are available. The average quarterly yield for these states is then used as the estimate for the entire region. Because yield is largely a function of geographic variables, like weather/climate and related influences on feed, yield in neighboring dairy states seemed to be a decent proxy. This is a better approximation for region 3, which contains many of the top 23 dairy states, and more problematic for region 2, which only contains two states for which monthly data is collected. Monthly data was not collected for March through June of 2013 due to the government shutdown, so the series ends in 2012.

Milk prices, corn prices, and alfalfa prices were obtained from NASS, while soybean meal prices were obtained from the Agricultural Marketing Service (AMS). The calculations on milk over feed margins were made in accordance with the formula specified in the Farm Bill.[4]

State data for milk production was grouped into five regions, using the regions defined by the Cooperatives Working Together (CWT) program. As the name implies, this organization is formed through the cooperation of thirty-five milk marketing cooperatives and individual producers and is managed by a non-profit organization, the National Milk Producers Federation (NMPF). Under the program, participating dairy cooperatives assessed a tax on producers per each hundredweight of milk sold. This money was used for two things, export assistance and periodic herd retirement programs. The herd retirement programs were a supply management program to remove milk production from the market. Farmers from a participating cooperative could, during the announced periods, submit competitive bids for the price they were willing to accept for their production history. Farmers whose bids were accepted were required to sell all milk cows for slaughter as beef. Their payment from the program was the bid they submitted times their historical milk production. They would also receive payment for the weight of their cattle times the price of beef when the cattle were slaughtered.

[4]The estimated feed cost is: $\$\text{Feed} = 1.0728 \times \$\text{Corn} + 0.00735 \times \$\text{SoybeanMeal} + 0.0137 \times \$\text{AlfalfaHay}$ The weighting adjusts for feed usage in the standardized dairy ration and is intended to capture the feed cost of producing 100 pounds of milk, including the feed to support dry cows and heifers. This ration cost subtracted from the All-Milk Price is the IOFC margin.

Herd retirements provided a way for farmers to retire, even if other dairies were not expanding and looking to purchase cattle, although there was no requirement that farmers exit the industry.[5]

Between 2003 and 2010 there were ten herd retirements. NMPF is no longer releasing the numbers of cattle removed or the amount of milk removed from each region. Those numbers were not available for the three herd retirements in 2009 or the last retirement in 2010, which removed a total of 4.5 billion pounds of milk from production.[6] However, cattle removals by region were published from the 2003, 2004, and the second 2008 retirement. These are shown in Table . For those retirements, the ratio of milk removed to total production was much greater in region 4 than for any other region. The CWT programs had a budgeted amount of funds to purchase milk production history. Retirements that happened during periods of higher beef prices pushed the realized value of a successful CWT bid higher, and may have lowered the bid farmers were willing to accept. If this happened, it would stretch the CWT dollar further, allowing the program to increase the number of cows accepted. If this holds, it would increase the apparent responsiveness of milk production to beef prices. Unfortunately, a lawsuit against the CWT program has made obtaining data to test this theory impossible at this time.

[5]There was some variation in different iterations of the program, including a heifer option and a varied pay for farmers who did not begin milking again within a year. However, the program focused primarily on achieving immediate gains from what was effectively a spike in culling and then longer term benefits to price from the removal of heifer births.

[6]IOFC Margins dropped below $6.00 for 23 months between 2000 to 2013 in nominal dollars, nine of these low margin months were during 2009-2010, or 39 percent during this two year period. This also explains why four of the ten retirements were conducted during this two-year window.

Variations in regional milk production

Table 2 shows how farms are distributed across the CWT regions, and the reduction in the number of farms for the ten-year period between 2003 and 2012. Contrast this with the changes in production directly below, and the changing farm size and productivity is apparent. Another noteworthy point, region 2, the only region to have a drop in production during the ten-year span, is also the only region that has a milk shortage.

The regions defined by the CWT program grouped fairly homogeneous states with regards to milk production, so these regions are used here. This ensures that of the top twenty-three dairy producing states for which USDA collects the majority of dairy data, at least three of these are in each region except the Southeastern region, only two states are consistently in the top 23 for which monthly data are collected.

Since the program will be conducted using the national price for both feed and milk, the response in output to these national prices will drive program expenditures and efficacy. The variation in regional prices means that a farm's individual margin is not what is insured. The farm is insured only for deterioration of the *national margin.* This creates something analogous to a basis risk for traditional risk management approaches. Instead of measuring a region's response to the actual prices received and paid within the region, which is not what the program covers, here the regional output response to national average prices is measured, which *is* what the program covers. Previous work on supply elasticity has either measured national response to national prices or regional response to regional prices. The change in approach here is in keeping with the format of the new dairy policy being evaluated. Although the legislation allows for indemnity payments to be made when margins drop for two consecutive months, quarterly data is used here. It's important to note that this is a slight variation from the specifics of the enacted legislation.

The margin calculation specified in the legislation was applied retroactively to price records from January 2000 through December 2012. The number of periods when a margin payment would have been made are shown in table 3. A dummy variable was created to indicate quarters for which the average margin was below a \$7.00 margin. The initial industry supported legislation tied the proposed stabilization program to a \$6.00 margin. However, only 8 quarters have an average margin below \$6.00. By increasing to a \$7.00 margin level, the number of low margin periods is increased to 11, and this level is still low enough to cause considerable financial pain on US dairies. The number of low margin periods for each trigger value is shown in Table 3. The periods included for a \$7.00 trigger are:

- Third quarter of 2002, lasting one year through the second quarter of 2003, average margin was \$6.24;
- Second quarter of 2006, lasting one quarter, average margin was \$6.82;
- Second quarter of 2009, lasting three quarters through third quarter of 2009, average margin was \$3.57;
- First quarter of 2012, lasting three quarters through third quarter of 2012, average margin was \$4.53;[7]

To look at the reaction to these low margin periods, the convention in Bryant et al. (2007) is followed. A partial adjustment specification is used to evaluate how aggregate regional

[7] Data from 2013 was left out of analysis because there is no yield data for a portion of the year, but the first three quarters of 2013 had average margins of \$5.99.

output grows or declines in relation to national IOFC margins (Bryant et al., 2007, 138).

Output in each region, Q_{it} is modeled as the dependent variable. Dummy variables for three quarters are included to adjust for highly seasonal variation in output. Time is t and i indicates the region of the country.

Paralleling the analysis in Bryant et al. (2007), the long-run equilibrium level of dairy production desired at time t is posited as:

$$Q^*_{it} = X_t\beta + \mu_{it} \tag{1}$$

With X_t and β representing vectors of supply determinants and their parameters. The random disturbance is captured by μ_t. The supply determinants included the IOFC margin M_t, calculated from the price of corn, alfalfa, soybean meal, and milk price as specified by the legislation. The national price of beef from slaughtered cows and yield per cow for the region are also included as explanatory variables.

Much of the previous literature, including Bryant et al., used cow numbers as the dependent variable. Here, milk production is used instead to enable a more timely estimation of the response to the type of low margin periods addressed in the farm bill. Cow numbers are not used for a combination of reasons. There have been major changes in dairy policy and geographic structure of the industry since 2000, so it was important to confine the time period to the recent past after those changes (Miller and Blayney, 2006). Herd size information is only available annually. Since the question being researched is focused on responses to low margin periods, which almost always last less than a full year, this makes annual cow numbers of little use to the question posed. Chavas and Klemme found that the majority of long run output adjustment comes from changes in herd size, while changes in yield explain smaller changes in the short-term (Chavas and Klemme, 1986). So the response being measured is only a measurement of the change in output and does not attempt to distinguish between which portion is obtained through changes in regional herd size and which portion is from changes in yield per cow. It's important to note that while changes in yield are not as important to output response as changes in cow numbers, year-over-year changes in the rate of production per cow have raised production per head by almost 20 percent just since 2000.

Still following the approach of Bryant et al. (2007) but with the changes noted, the production by region is assumed to evolve according to the adjustment process shown in equation 2 using γ as the adjustment parameter.

$$Q_{it} - Q_{i,t-1} = (1 - \gamma_i)(Q^*_{it} - Q_{i,t-1}) + \mu_t \tag{2}$$

Equation 1 is substituted into 2 and solved for Q_it. $\tilde{\beta}$ is substituted for $\beta(1 - \gamma)$ and $\tilde{\mu}$ is substituted for $\mu(1 - \gamma)$. Solving for Q_{it} leaves:

$$Q_{it} = X_t\tilde{\beta} + \gamma_i Q_{i,t-1} + \tilde{\mu_t} \tag{3}$$

It is assumed that $0 < \gamma < 1$, or that quantity of milk does not adjust to equilibrium levels instantaneously. For each region γ_i indicates the speed of adjustment. This incorporates the behavior of producers whom adjust their output when they realize that $Q^*_t \neq Q_{t-1}$, but weigh the benefits of producing at the optimum against the costs of adjusting feed, yield, and eventually herd size (Bryant et al., 2007).

Milk price over feed cost margins from time t were used instead of time $t - 1$ partially because of the structure of milk payments to farmers. Farms receive payment for milk shipped in June in July, so price data from June is not realized on the farm until July. Furthermore, a high number of farmers watch milk futures prices, even if they do not actively hedge their production.

$$
\begin{aligned}
Q_t = \beta_0 + \beta_1 LOW_t + \beta_2 M_t + \beta_3 LOW_t \times M_t + \beta_4 S_t + \beta_5 Y_{it} + \\
\beta_6 Q_{i,t-1,2,\ldots,6} + \beta_7 D_1 + \beta_8 D_2 + \beta_9 D_3
\end{aligned}
\tag{4}
$$

According to economic theory, the coefficient for M_t should be positive, as IOFC margins increase, production should respond accordingly. Likewise, the coefficient for the dummy variable indicating periods of low margins, LOW_t should be negative, as these periods should be characterized by lower quantities of milk supplied. The interaction term, $LOW_t \times M_t$ is included to test whether or not the sensitivity of output to margins increases when those margins are low. This is expected to be positive, if margins decline while they are already low, output reductions are expected to accelerate. Ceteris paribus, an increase in the price of beef for culled cows should increase the culling rate and decrease output of milk. Yield is expected to be positive but fairly small, an increase in yield would be expected to increase milk production.[8]

The coefficient for lagged production is expected to be positive, higher output in the previous period is likely to increase production in this period. Essentially, the goal of dairy

[8]There is a common perception that increased culling rates increases yield. The theory is that the lowest production cows are the individuals culled, leaving a higher average production for the herd. According to Karszes (1998), there was no statistically significant relationship, in the New York farms studied, between culling rates and yield (Karszes, 1998).

policy is to dampen this relationship between what a farmer does today and yesterday and instead increase the response to market conditions. Milk production is highly seasonal so three quarterly dummy variables are included. The fourth quarter is omitted and captured in the intercept. The first and second quarter coefficients should be positive as the "spring flush" increases production, and the third quarter should be negative as warm summers decrease feed consumption and days in milk increase from slightly seasonal breeding patterns.[9]

Results

Because of the limited data range and to include in the discussion effects that are even weakly statistically significant, an acceptable probability level for a Type I error was set at 15%. In this case, a "finding of no significance" is politically significant and could contribute to greater federal outlays on this program than expected. If there is no significant response in production to low margin periods, the duration of the periods will be longer than if there was a reliable and significant production response. Without a reliable drop in production, the market correction that pushes margins back up is delayed. Under the new program, the amount of federal expenditure will depend on the duration of low margin periods, as well as the actual margin deficiency.

Natural logarithms are used for each variable except the dummy variables. Each variable was checked for presence of a unit root, using the Augmented Dickey Fuller test in E-views software. Production in Region 1 was stationary and was modeled as the log of output. Production in the other four regions, yield in each region, and beef prices were modeled

[9]Region 2 is an exception to this, the average yield per cow drops earlier with a slight drop (one tenth of a pound in daily output per cow) in the second quarter.

as a first difference to achieve stationarity. A step-wise approach was used to determine the correct number of lags to include in each region.[10] For consistency and to err on the conservative side, six lags of the dependent variable were included for each region.

The first specification used a linear model with six lags of the dependent variable. These results are available upon request. Breusch-Godfrey tests were conducted for each regional equation to check for serial correlation. The second approach was an autoregressive specification. In Eviews, AR models are estimated using nonlinear regression techniques. The transformation used by the software is asymptotically equivalent to maximum likelihood estimates. Both approaches yielded similar, but not equivalent, results. Using the AR specification, the quarters were highly significant, in the lagged specification this effect was partially absorbed in the quarterly lags.

The main variable of interest pursuant to the recent farm bill is the dummy variable for low margins. The claim of "social sciences leeway" is used to accept even weak evidence of statistically significance. P-values were highest for the Southeast, at 0.91 for Region 2, which produces the least amount of milk. The P-value for region 1, the Northeast, was 0.56 and 0.66 for Region 2, the Midwest. These dropped for the western regions. Region 4, the Southwest, was 0.28. The response in the West, Region 5, was the only region with a statistically significant response, with the p-value equal to 0.05. It is apparent that both the predictability of the response to low margin periods, and the actual response in production increases as we move westward across the country.[11] In region 4, production during the

[10] For regions 1 and 5 the first, second, fourth, fifth and sixth lags were all significant. For regions 2, 3, and 5 the first, fourth and fifth lags were significant.

[11] Using the AR specification, results are not significant at the 15% level, and can only be considered significant at the 30% level. Using the AR specification, the p-values for region 4 and region 5 are 0.30 and 0.16, respectively.

periods when margins dipped below $7.00 dropped by 4.8 percent. In region 5, production dropped by 5.9 percent during those periods. Using 2012 average production, a 4.8 percent reduction in region 4 constitutes a drop of almost 4 million pounds/day. In region 5, a 5.9 percent drop is equivalent to 10.8 million pounds of daily milk production.

The lack of a statistically significant effect in the eastern regions for the low-margin dummy variable demonstrates that there has been no reliable effect on output resulting from periods when the national margin is below $7.00. Technically, we fail to reject the null hypothesis that this coefficient is equal to zero. This is reinforced by a consistent result for $Margin$. In each region, there is no evidence that the coefficient for the production response to the specified national margin prices is different from zero. The p-value is greater than 0.40 for each region, and the coefficients are also quite small.

The dummy variable for low margin periods was interacted with the margin series to evaluate the response in milk production to the IOFC margin specifically during low margin periods. This was only statistically significant in region 5. In region 4 the coefficient for $Margin$ is 0.011, but the coefficient for $Margin \times LOW$ is 0.028. In region 5, the coefficient for $Margin$ is 0.009, but the coefficient for $Margin \times LOW$ is 0.031. In the western regions, production increases are much quicker to respond to drops or improvements in low margins than in the rest of the United States.

The coefficient for beef prices was much greater than expected, particularly in region 4. In region 4, the price of beef for cull cows was significant, and the absolute size of the coefficient was greater in absolute terms (-0.07) than for any other variable across all regions except yield. This seemed unlikely, since most other research has found a quite limited reaction to changes in beef prices. Furthermore, it seems implausible that output decisions related to milk price over feed income would be best explained by beef prices for cull cows. A possible explanation for this result is the interaction of the CWT program, which is used here to categorize the regions, and beef prices. As explained earlier in the paper, the CWT program was a farmer-run, private organization that charged an assessment on milk production of participating farmers. Periodically, "herd retirement" programs were conducted to reduce the supply of milk in the U.S. Farmers submitted competitive bids to sell their milk production history. If selected, a herd had to be sold immediately for slaughter. The realized price to the farmer was the combination of the milk production history and the slaughter price for the cows. Higher beef prices would allow a farmer to submit a lower CWT herd retirement bid, increasing the odds of being included in the program. This might amplify the connection between beef prices and production response. Furthermore, the largest two herd retirement programs (of ten) were conducted during 2009 during periods of low margins. The high level of participation in herd retirements by region 4 and the higher level of response of milk production to beef price supports this notion.

Changes in yield were significant in regions 3, 4, and 5. The ideal climate and the advances in dairy infrastructure in region 5 is noticeable, the average production per cow over the entire time period is 17 pounds/day higher than in region 2. As region 4 has grown in significance to the dairy industry, yield per cow has surpassed region 5, beginning around 2009. During the low prices of 2002-03, output per cow dropped and eventually recovered. In 2009 and 2012, the response was instead a slight increase in output per cow, although 2012 included an inflection point during the second quarter. Since yield is calculated as total output in a state divided by milking cows, this change in output per cow is, again, likely a function of the CWT program on which the regions are delineated. Participation in the CWT program lowers the number of cows. The drop in production is captured first in the monthly milk production survey, but the cow numbers are only surveyed annually. It still means there is a significant response captured through this variable, but it is likely at least partially due to a change in cow numbers and not entirely reflective of changes in output per head.

Another issue investigated was how the output response varied with different levels of low-margin periods. The results are inconclusive, but are shown in table . The move from $8.00 margins to $7.00 margins fits economic theory, as margins are eroded, the output becomes more negative (or at least less positive.) One possible explanation of the movement in opposite direction in regions 1 and 2 are that these areas often sell heifers to other regions. During low margin periods, the market for replacement heifers may dry up, and farms in these regions possibly freshen a larger percentage of heifers into their own herds. While this is a possible explanation for the economic meaning of the coefficients, the null hypothesis that these coefficients are equal to zero cannot be rejected.

While the results for low margins are quite inconclusive, under the new program actual margins for participating farmers will be increased through indemnity payments during low margin periods. The coefficients for the move from $8.00 to $7.00 margins in table supports the likely economic result that this would reduce the output response. However, the results from the $LOW6$ and $LOW4$ coefficients contradict this. Possibly, these periods are simply too short in duration to allow a full response in dairy production to be discerned or even implemented at the farm. For instance, there are only 4 quarters between 2000 and 20012 for which the average margin is below $4.00. These periods occurred during the first two quarters of 2009 and the second and third quarters of 2012.

As the program was unfolding, the recent low margins motivated "‘what-if’' analysis

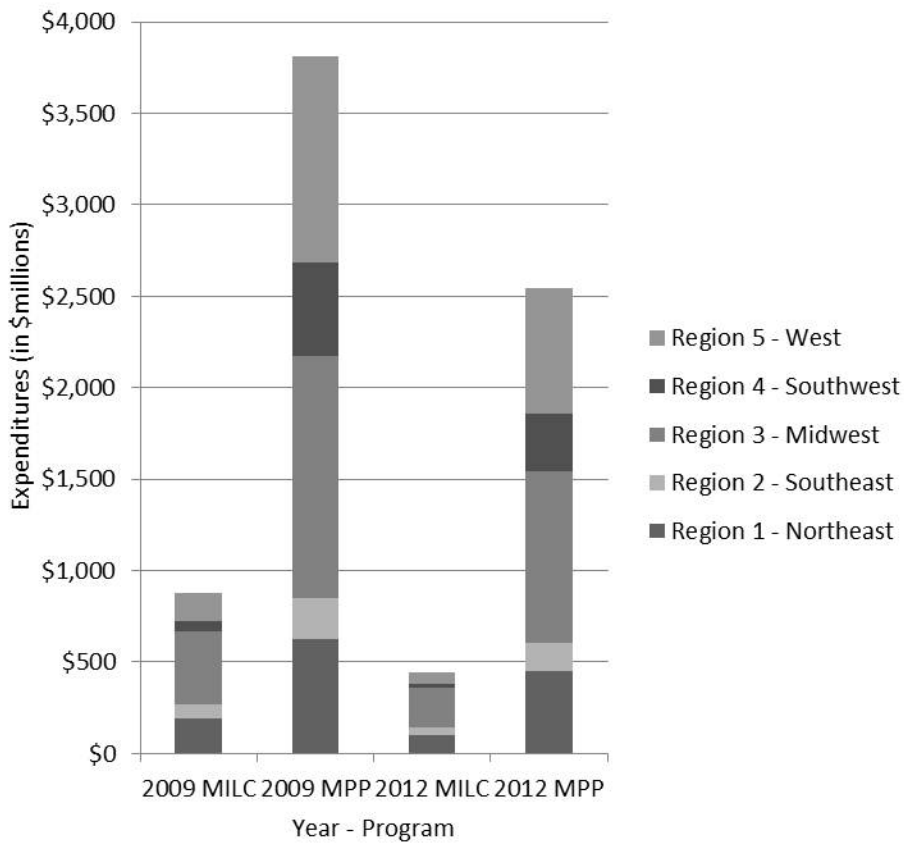

Figure 1: Assumption of 95 percent participation, 90 percent coverage, and optimal choices margin choices.

of how the lack of benefit caps could affect federal expenditures for the Dairy-MPP. For the five-year period prior to implementation, the optimal constant choice for large dairies was to choose $6.50 coverage, for small dairies, the full $8.00 coverage was optimal. MILC participation had been 95 percent of dairies, so that participation rate was assumed. With these parameters, a comparison of MILC expenditures to potential Margin Protection Program (MPP) expenditures, using margins from low years for comparison. As you can see in Figure 1, the potential outlays dwarf previous dairy subsidies. The MILC federal expenditures in 2009 reached above $880 million. Under the new program with optimal farmer choice, the **net** expenditures would have reached $3.8 billion.

However, the actual participation, coverage, and margin levels were much lower than expected in 2015. In 2016, the sign-up period for the program was again extended to increase participation. Using USDA released information on the pounds of milk eligible for MPP payments and 2009 margins a comparison of the current program and past program can be made. Given the limited participation, and frequency of dairies only choosing catastrophic coverage, the **gross indemnities**, had 2015 been a repeat of 2009 margins, would have been $1.4 billion, which would have been offset by the premium payments made by the farmers. While the exact indemnity can be estimated for a given margin level, the two premium schedules makes it impossible to estimate the premiums paid. It is obvious that the relative lack of interest in this program has limited the government expenditure possible.

Conclusions

The regional variation in the response to low margin periods has important political and industry significance, but the results are hardly surprising. Previous research has supported the finding that regions 4 and 5 are much more elastic, both in response to milk and to feed prices. The margin insurance program will shift benefits towards the larger dairies more characteristic of western states, allowing large dairies in those regions more protection from low margins than what was available under MILC. This aligns the farm program more closely with the volume of milk production.

During the years investigated, the market response to low margins has come from regions 4 and 5 and no evidence could be found that dairies in the eastern part of the country slow production in response to low margins. Now, the two western regions will receive larger amounts of federal assistance if margins drop, how will this affect their willingness to slow production?

The margin protection program will likely be a much better tool for protecting farmers from short-term disequilibrium. The speed of response to low margins is important because it will affect the cost of the program. If farmers are able to use insurance to alleviate some of the risk from low margin periods, how costly will it now be before production responds to a margin that is subsidized through an indemnity payment? It is in keeping with economic theory that the response to a subsidized margin will be slower than what it appears to have been in the previous decade analyzed here.

Future research

This work and the majority of previous literature focuses on seasonality, the price of beef from culling decisions, and production per head to explain changes in milk production. Two types of variables may be gaining in significance and have been largely omitted in research to date.

The first is the availability of credit. Bozic et. al included interest rates as an independent variable, Chavas et. al included a variable for risk preference, but neither of these captures the interdependence of dairy expansion or contraction and actual credit availability (Bozic et al., 2011), (Chavas et al., 1990). Much of the contraction in 2009 was related to credit conditions springing from the financial crisis. The severity of the low margins in 2009 left a much weaker dairy industry, with a higher number of distressed loans, and a higher debt to equity ratio. Although margins are at near-record levels now, the hesitancy of bankers to return lending to pre-2009 leniency may serve to dampen the growth response. This paper supports the notion that the majority of adjustment to low margins is coming from the regions characterized by larger, capital-intensive farms. Understanding the adjustment process more completely would be helped by including the effect of changes in the capital markets.

The second variable that is rarely included in production models but of increasing interest is climate-related data. The largest coefficient for explanatory variables was output per cow. Yield per cow is partly explained by the seasonality of the bovine reproductive system, the gains in annual yield can be attributed to technology, but a big part of the lack of response to margins might be partially explained by climatic abnormalities. Unseasonally hot weather both causes an increase in milk prices and prevents the farmer from responding with increased production. Including deviations from normal weather might also help to understand dairy markets and to help shape future policy revisions.

*Acronyms

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Table 1: CWT Cattle Removal by Region. Total cows, the number of cows removed, and the percentage of cows within the region that were removed are shown for the three herd retirements for which data are available.

		Region 1	Region 2	Region 3	Region 4	Region 5
2003	Cows	1,617,400	912,000	2,894,000	1,148,000	2,562,000
	CWT removal	2,848	3,342	6,463	8,190	11,881
	% removed	0.18%	0.37%	0.22%	0.71%	0.46%
2004	Cows	1,553,300	848,000	2,827,000	1,147,000	2,605,000
	CWT removal	3,871	4,066	8,479	16,184	17,878
	% removed	0.25%	0.48%	0.30%	1.41%	0.69%
2008-2nd	Cows	1,475,100	713,000	2,927,000	1,280,000	2,859,000
	CWT removal	2,295	3,750	3,290	17,522	23,773
	% removed	0.16%	0.53%	0.11%	1.37%	0.83%

Table 2: Average number of licensed dairy herds and milk production (in millions of pounds) by CWT region.

Region	2003 Farms	2012 Farms	Farms lost	Percent drop
1	19,155	14,615	-4,540	-23.7%
2	7,455	4,605	-2,850	-38.2%
3	36,460	25,170	-11,290	-31.0%
4	2,810	1,630	-1,180	- 42.0%
5	4,365	3,305	-1,060	-24.3%
U.S.	70,245	49,325	-20,290	-29.8%

Region	2003 Production	2012 Production	Production gain	Percent gain
1	28,146	28,944	798	2.8%
2	13,018	10,989	-2,029	-15.6%
3	52,015	62,977	10,969	21.1%
4	22,572	30,232	7,660	33.9%
5	54,489	67,147	12,658	23.2%
U.S.	170,240	200,289	30,049	17.7%

Table 3: The number of periods for which indemnity payments would have occurred between 2000 and 2013 under the new program. Because quarterly data is used here, the number of quarterly average margin levels below each level are also presented. The number of events refers to the number of contiguous periods below a given margin level.

Margin level	Two-month periods	Quarterly periods	Separate events
$8.00	33	20	7
7.50	23	15	5
7.00	18	11	4
6.50	12	9	4
6.00	10	6	3
5.50	7	5	2
5.00	7	5	2
4.50	6	5	2
4.00	6	4	2

Table 4: List of variables

Variable	Description
Q	Quantity of milk output by region
X	Vector of inputs
M	IOFC National Margin
S	Slaughter prices for cull cows
Y	Yield, Milk output per cow
LOW	Dummy variable indicating periods of low margins
D	Dummy variable for quarters
i	Denotes the region
t	Denotes the quarter
γ	Describes the speed of adjustment in output

Table 5: Distributed Lag Specification. Coefficients that are statistically significant at a 15% significance level are in bold. The adjusted R^2 for each equation is given at the bottom of the table. P-values are included below each coefficient.

Region	1	2	3	4	5
	$\ln(Q_1)$	$\Delta \ln Q_2$	$\Delta \ln Q_3$	$\Delta \ln Q_4$	$\Delta \ln Q_5$
Intercept	1.566	0.071	-0.007	-0.015	**-0.046**
P-value	0.39	0.43	0.81	0.71	0.10
LOW	0.024	-0.006	0.014	-0.048	**-0.059**
	0.56	0.91	0.66	0.28	0.05
$Margin$	0.011	-0.007	0.000	0.011	0.009
	0.42	0.70	0.97	0.49	0.44
$LOW \times Margin$	-0.004	0.013	-0.010	0.028	**0.031**
	0.54	.88	0.56	0.23	0.05
$Beefprice$	-0.018	0.003	0.001	**-0.070**	0.000
	0.51	0.93	0.98	0.05	0.97
$Yield_i$	0.039	0.058	**0.145**	**0.234**	**-0.137**
	0.42	0.67	0.08	0.04	0.13
First Quarter	0.029	-0.024	0.011	0.039	**0.062**
	0.17	0.78	0.57	0.24	0.00
Second Quarter	0.023	-0.001	**0.038**	0.046	**0.078**
	0.44	0.99	0.08	0.16	0.00
Third Quarter	**-0.044**	**-0.204**	-0.005	**-0.055**	0.016
	0.06	0.04	0.76	0.07	0.32
$Q_{i,t-1}$	**1.292**	0.083	.010	0.055	-0.041
	0.00	0.66	0.53	0.71	0.79
$Q_{i,t-2}$	**-0.697**	-0.238	**-0.441**	-0.132	-0.186
	0.02	0.23	0.10	0.43	0.22
$Q_{i,t-3}$	**0.551**	0.265	**0.301**	0.061	0.151
	0.09	0.16	0.04	0.71	0.34
$Q_{i,t-4}$	-0.354	-0.156	-0.038	-0.150	-0.112
	0.27	0.48	0.83	0.33	0.48
$Q_{i,t-5}$	0.052	0.078	-0.126	-0.154	-0.210
	0.86	0.69	0.46	0.26	0.19
$Q_{i,t-6}$	0.047	-0.121	0.002	-0.116	-0.029
	0.81	0.55	0.99	0.41	0.86
R^2	0.89	0.98	0.98	0.94	0.88

Table 6: Output response to different levels of low margins. This table presents the coefficient and p-value for regressions run in each region for the dummy variable for low margins. $LOW8$ had a value of 1 if the observed average margin for a quarter fell below \$8.00 and so on for \$7.00, \$6.00, and \$4.00 margins. P-values are included below the coefficient.

Region	1	2	3	4	5
$LOW8$	0031.	-0.043	0.025	-0.009	-0.043
	0.41	0.48	0.50	0.85	0.21
$LOW7$	0.024	-0.006	0.014	-0.048	**-0.059**
	0.56	0.91	0.66	0.28	0.05
$LOW6$	0.049	0.50	0.039	-0.039	-0.029
	0.26	0.43	0.31	0.45	0.40
$LOW4$	0.039	0.032	0.076	-0.030	-0.043
	0.56	0.88	0.24	0.73	0.24