AGRICULTURAL POLICY ANALYSIS: CONSIDERING POLICY MEASURE UPDATING IN MILK PRICING AND CROP INSURANCE

A Dissertation

by

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Submitted to the Office of Graduate and Professional Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

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August 2015

Major Subject: Agricultural Economics

ABSTRACT

This dissertation investigates the possibility of updating policy features to reflect more current data within the realm of policies related to milk pricing and crop insurance. Two policy settings are examined. First, the possibility of adjusting Federal Milk Marketing Order price differentials to reflect fuel price increases, spatial supply-demand shifts and seasonality is analyzed using a spatial dairy sector transport and processing optimization model. Second, the effect of including technical progress effects in crop yields is examined within the content of yield guarantees under the crop insurance policy.

This dissertation is composed of three essays. The first two address the milk price differentials study. The first essay presents details on the model that was constructed to examine the milk pricing issue. The model is a spatial transport and processing model that develops a spatial pattern of milk prices. The second essay uses the model from the first essay to investigate U.S. milk pricing. It examines how price differentials are affected by changes in fuel costs, locations of supplies and demand and seasonality. The results show incorporating fuel cost and location shifts raises the magnitude of the differentials by about 115%. We also find that consideration of seasonality affects the differentials. Collectively the results indicate that it may be desirable to revisit the policy determined price differentials.

The third essay examines the effects of crop insurance alterations on farmer's yields risk. In particular, the effects of the pilot Trend Adjusted-Actual Production History program are examined econometrically. The results show the TA-APH program is effective in mitigating risk and that it increases insured acres by 3% for corn and 5% for soybeans. It also shows that the farmers eligible for the program would sign up for a lower coverage level relative to ineligible farmers. However, the overall level of coverage increases. Collectively the evidence shows the TA-APH program is effective in mitigating yields' risk.

DEDICATION

To my parents and sister

ACKNOWLEDGEMENTS

I would like to express my gratitude to my committee chair, Dr. Bruce A. McCarl for his excellent guidance and all types of support throughout the course of this research. Although he is a distinguished professor with a very busy schedule, he is readily available for me anytime. Having the opportunity to work with him has been the most enriching and interesting experience of my life. I would also like to thank the members of my committee, Dr. Ximing Wu, Dr. John Siebert, and Dr. Andrew Johnson for their constructive comments and suggestions.

I am also indebted to United Stated Department of Agriculture through Agricultural Marketing Service – Dairy Division for granting me a scholarship to pursue my doctoral study. Grateful acknowledgements are extended to Cary Hunter at Southwest Federal Order 126, Dallas TX, who provided invaluable suggestions, encouragement, and financial support for the construction of the MilkOrdII model. I would like to extend my special thanks to Corey Freije at Upper Midwest Federal Order 30, Minneapolis, MN and Uthra Raghunathan at USDA AMS Dairy Division, Washington D.C. for providing assistance with the dairy data collection and milk modeling.

I would like to extend my special thanks to Taehoo Kim who is Ph.D. student at Utah State University, whom I have worked with on crop insurance research. His advice and comments are extremely perceptive, helpful and appropriate.

Finally, the entire Ph.D. career and my life as a whole would be empty and meaningless without my family’ love.

To all of you, thank you.

NOMENCLATURE

AMS	Agricultural Marketing Service
DD	Difference in Difference
DDD	Difference in Difference in Difference
FMMO	Federal Milk Marketing Orders
FMO	Federal Marketing Order
NASS	National Agricultural Statistics Service
RMA	Risk Management Agency
SMO	State Marketing Order
TA	Trend Adjustment
TA-APH	Trend Adjusted-Actual Production History
TCP	Transportation Credit Program
USDA	United States Department of America

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1. INTRODUCTION

Policy is often set at a point in time and then become difficult to update or modify in the future. Here we examine two such cases – whether the dairy price differentials set in 2000 under the Federal Milk Marketing Order (FMMO) adequately reflect 2012 conditions and whether a pilot program for crop insurance that adjusts covered yields for technical progress alters farmer participation in crop insurance and the resultant level of risk coverage.

In terms of dairy, the FMMOs were authorized in the Agricultural Marketing Agreement Act of 1937. The FMMO system was and is designed to provide both price support and market stability by establishing minimum prices handlers are pay for raw milk. A key issue facing FMMOs policy makers involves the setting of spatial price differentials for Class I milk. After the differential structure was set up in 2000, there have been very limited changes in their structure but there have been significant changes in the location of supply, and demand plus in transportation costs, which are potentially key factors determining the spatial milk values. Section 3 aims to evaluate the appropriate pricing surface reflective of current dairy economy.

To carry out the analysis in section 3, a linear programming model, MilkOrdII, was developed based on prior work in MilkOrd (Novakovic et al., 1979; Baker, Dixit, and McCarl, 1981; McCarl, Schewart, and Siebert, 1996). This model represents the U.S. dairy sector and is formulated as a multi commodity spatial transport and processing model with economic activity at counties, dairy product plants, stock storages, and consumer markets including export. Section 2 describes the construction of MilkOrdII including assumptions, dimensions, data, and the formulation employed.

Section 4 analyzes a different policy – Federal Crop insurance which is a risk management tool (Shields, 2013). One key element of the insurance coverage is the calculation of covered yields. In particular, the historical practice averages past yields (called Actual Production History or APH yields) but does not account for the non-stationarity in the yields caused by technical progress where current yields may be substantially higher than those say 10 years ago due to technological progress. In response to this problem, Risk Management Agency (RMA) introduced a pilot program with a trend adjustment to account for technical progress in the 2012 crop year called the Trend Adjusted – Actual Production History (TA-APH). Section 4 presents an analysis of the effects the pilot program is having on signup, coverage level, and total coverage. This is done econometrically.

2. A DESCRIPTION OF THE METHODS AND DATA EMPLOYED IN THE U.S. MILKORDII MODEL

In order to do the analysis of federal market order pricing, we need a model that predicts how movements of milk and spatial prices are affected by fuel costs, seasonality and supply / demand location. To do this, we use a dairy sector model that is based on and or updates previous models. In this section, we describe the sector modeling literature, the process leading to the model and the model structure.

2.1 Introduction

Many dairy sector models (Novakovic et al., 1980; Cox and Jesse, 1995; Pratt et al., 1997; Ahn and Sumner, 2009) have been built since the advent of linear programming to simulate efficient spatial organization of the U.S. dairy sector. These were concerned primarily with issues such as market organization and the opportunity for efficiency improvements; optimal plant size, numbers, and location; transportation arrangements. Also, these have been applied to numerous research efforts.

We created an updated model, which is called as MilkOrdII. The work expands on the model as adapted from McCarl's earlier work (McCarl, Schwart, and Siebert, 1996) that created the first version of MILKORD which integrated features from the DAMPS model by Novakovic et al. (1979) plus the dairy processing model of Baker, Dixit, and McCarl (1981). The core objective of MilkOrd had and continued to be the representation of the dairy economy in ways that recognize its geographic (spatial), processing, market level, and regulatory complexity.

2.2 Purpose of MilkOrdII

The general goals of the MilkOrdII are (1) to represent Class I price differentials across the U.S. based on fixed raw milk supply, product demand, and plant capacity data, (2) to allow study of the impact of altered local supply, local demand, and fuel costs on spatial milk movements and values, (3) to incorporate milk production and product consumption seasonality and yield results on seasonal and spatial milk values, (4) to model milk processing based on input-output volume ratios representing a total of 25 dairy products, (5) to contain a number of spatial production and consumption regions, and (6) to generate pooled price reports across all the FMMOs areas.

2.3 Features of MilkOrdII

MilkOrdII integrates and extends the features of many of previous models. These specific features of MilkOrdII are elaborated on below.

2.3.1 Input-output volume ratio at processing

Some previous dairy sector models used milk components such as fat and non-fat solids to account for the balances between raw milk supply, inter plant transfers of dairy products, and final product consumption (Pratt et al., 1998; Cox and Jesse, 1995). MilkOrdII models products and their composition in a different manner. The model incorporates the unit conversions for each process involved in converting raw milk and subsequent intermediate products into final products and alternative intermediate products (Baker et al., 1980). MilkOrdII enables the amount of each dairy product made to be determined based on fixed input-output volume ratios of raw ingredients to final products at the plant level (i.e. a given amount of milk yields a fixed proportional amount of low fat milk and cream). The only exception is for ice cream mix and cottage cheese dressing where a blending problem is included based on milk components plus a maximum on whey contents. MilkOrdII includes 25 products; 23 intermediate or final products, and 2 mixed products.

2.3.2 Model geographic scope

A key component in representing the price surface is spatial disaggregation. FMMO sets minimum prices that cover about 70% of the Grade A milk produced in the United States. California, which accounts for more than 20% of U.S. milk production, uses a state pricing system that is very similar to those developed under the FMMOs. Under Congressional mandate, the FMMOs were consolidated from 31 to 11 on January 1, 2000. In April 2005, the Western Order was terminated and there are currently 10 FMMOs in the United States. The Orders provide classified pricing of milk according to use and provide a pool of all revenue from the sales of regulated milk from which producers receive a single uniform or blend price.

To represent the price differentials at a relatively fine scale while also allowing data specification from current sources, MilkOrdII represents the U.S. in 304 regions in the 48 continental states. In those regions, we model milk supply, processing, and consumption. The regions are set up following NASS crop reporting districts. This is a finer scale than in previous models. In DAMPS (Novakovic et al, 1980), the U.S. was disaggregated into 59 regions including 45 Federal Marketing Order (FMO) areas and 14 State Marketing Order (SMO) areas. Processing and consumption regions consisted of 51 regions, so the surface of milk values could be derived only 51 for regions. Ahn and Sumner (2008) disaggregated the U.S. into only 12 regions (11 consolidated FMMO areas and California area).

2.3.3 Fixed production and consumption model

Many previous models involve price endogenous models (Enke, 1951; Samuelson, 1952) where supply and demand curves cross to determine the equilibrium quantity and price. Solutions to the models are obtained by maximizing consumers' and producers' surplus under the assumption that market behavior is competitive. However, MilkOrdII uses a fixed production and consumption model (Stollsteimer, 1963) of interregional trade with fixed supply, consumption, and plant capacity since our main purpose is to simulate the milk movements, processing, and price differentials reflective of the current dairy economy. MilkOrdII assumes that the seasonal pounds of raw milk supplied and dairy product demanded are exogenous over the simulation time and the commodity price adjusts to meet the equilibrium conditions.

2.3.4 Calculating prices for pooled milk

Based on the model solution, calculations were implemented to compute the pooling amount and blend price for each Marketing Order area. The pooling amount is derived by a simple process with some assumptions. Below indicates a set of assumptions used.

- All supply regions are assumed to try to maximize the revenue, so they are willing to participate in the Federal Order pool, where the locational differentials are relatively high, to get the highest net revenue. The process of pooling manufacturing milk is based on this assumption.
- Maximum pool size is predetermined since all Grade A milk may not be eligible for pooling.
- Class II type plants are assumed to be regulated under FMMO since a significant amount of soft manufactured products are produced within fluid milk plants. Thus, the milk shipped to regulated plants (Class I or Class II type) is assumed to be included in the Order pool.

For the manufacturing milk, we developed a method to find eligible shipments for pooling in each Marketing Order and to determine pooling milk, based on simulated results of Grade A milk assembly. Below indicates a set of the procedure.

1) For each Order, sum the Class I and Class II milk pounds received at plants located in the Order area.
2) Calculate the maximum pool size for each Order.

3) Arrange the Orders in order of highest Class I utilization percent with an assumption that milk is pooled from the highest price to the lowest price.

4) Find eligible qualifying shipments for each Order pool, which is ordered by (3). The following two conditions must be satisfied to be eligible for qualifying shipments.

   - There is Class I or Class II milk assembly from a NASS district (A) shipped to a NASS district (B) located in the Order.
   - There is manufacturing (Class III or Class IV) milk assembly from the NASS district (A) to a NASS district (C).

   Then, the manufacturing milk path from the NASS district (A) to the NASS district (C) is qualified for the Order pool.

5) Arrange the qualifying paths determined by (4), in order of the highest differences between the Class I price differential at the base zone for the Order and the Class I differential at the receiving plant. This is done by the assumption of supply region's revenue maximization.

6) Add up eligible diverted (Class III or Class IV) milk in the individual Order pool according to the order of priority determined by (5) in each individual pool according to the order of priority determined by (3)[1].

For simplification of complex multi-component pricing system, standard class price is used to calculate blend price as the following; a weighted average price is

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[1] Table A-1 presented in Appendix gives a general representation of the pooling algorism.

calculated by summing up all classes of milk of the Class price times the utilization of milk divided by the volume of all milk.

2.4 Assumptions for MilkOrdII

MilkOrdII embodies several assumptions in representing the dairy sector.

- The model assumes transport is well simulated by a process that minimizes the total costs associated with shipping, processing, and marketing milk and dairy products.
- Economic activity in the dairy sector is assumed to be performed homogeneously anytime a given one-month period, and the model represents all 12 months plus carryover of storable products, such as cheese and butter.
- By portraying multiple months, the model can reflect the seasonality of milk production and dairy product consumption.
- All processing and milk supply are represented as being within one of the 304 NASS crop reporting districts.
- All milk supply is assumed to be shipped to any plants to be processed into fluid milk or manufactured into dairy products, which means that there is no surplus milk supply at farm level.
- All milk arriving at a plant is assumed to be used to be processed into fluid milk or manufactured into dairy products, which means that there is no left over milk at the plant level.

- The perishable products are all assumed to be moved into demand including moving out for export. Also, some storable products such as butter, cheese, and non-fat dry milk are stored with consumption deferred into future months.
- Raw milk produced across the country is assumed to be homogenous, which means that the proportion of the fat, non-fat and other components available in raw milk is identical regardless of where the milk is produced.
- Production yields for milk products at plant level are assumed to involve a fixed proportion of outputs to input as a function of input volume excepting for ice cream and cottage cheese where a blending process is involved. The proportion is assumed fixed across all seasons and locations.

2.5 Dimensions and structure of MilkOrdII

This section describes the dimensions and structure of MilkOrdII, declaring sets and their associated elements. Below each major set is displayed with set name and its elements. In the presentation, we use lower case for indexes and upper case for sets. Also, we define several subsets that facilitate understanding the structure of model.

2.5.1 Sets identifying spatial representation

MilkOrdII has two different sets for geographic locations; ‘places’ and ‘orders’. The places correspond to the NASS crop reporting district, and the orders to the FMMOs.

2.5.1.1 Supply, processing, and consumption places

$i, j \in I, J;$ $I, J = 303$ regions for milk supply, dairy plant, and consumer according to NASS districts, the District of Columbia is added into the consumer market dimension.

$i^P \in I^P \subset I;$ $I^P = 6$ regions allowing for supply plants

$i^s \in I^S \subset I;$ $I^S = 15$ regions with facilities for private stock storages

$i^E \in I^E \subset I;$ $I^E = 37$ regions exporting dairy products into the world market

MilkOrdII breaks the continental U.S. into 303 regions $(i, j \in I, J)$ following NASS crop reporting districts as displayed in table A-2. The District of Columbia is added into the consumer market dimension to incorporate it as a location for dairy products demand. Figure 1 represents their geographic locations in the continental states.

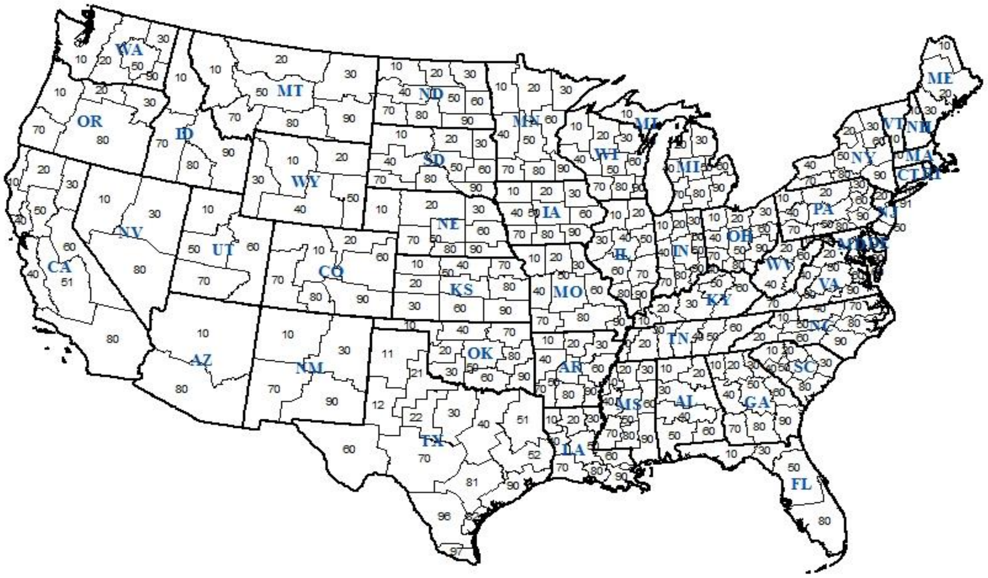

Figure 1. Geographic representation for 303 regions in a set ‘places’

Among the 303 regions, 6 regions ($i^P \in I^P \subset I$; CA51, NY50, PA90, MN60, WI30, and WI60) allow supply plants (Figure A-1). While engaged primarily in manufacturing, ‘supply plants’ help assure an adequate supply of milk for fluid purposes by carrying fluid milk reserves. When milk is needed for fluid purposes, supply plants are required to ship milk to fluid processors rather than use the milk to make manufactured dairy products. Supply plants also provide a “balancing” service by receiving milk that is not needed for fluid purposes on days when bottling plants are not operating. A total of 15 regions ($i^s \in I^S \subset I$; CA40, CA51, CA60, CA80, CO60, MA10, NY91, OR10, PA90, SD30, MN50, WA10, WI20, WI60, and WI80) have storage capacity for private stocks of storable products (Figure A-2). If milk supplies are large relative to demand, then the supply of milk that is not needed for perishable products will increasingly be diverted to the manufacture of storable products. Once the products are made, they can be placed into private storage. When milk supplies are tight relative to demand, then production of hard manufactured products will be correspondingly low, and storable products are released to the commercial market from private storages. MilkOrdII incorporates exports. A total of 37 regions ($i^E \in I^E \subset I$) export dairy products into the world market as represented in Figure A-3. On the other hand, imports are not considered since the amount is relatively trivial to demand.

2.5.1.2 Milk marketing orders

$a \in A$; $A = 12$ segmented areas; 10 FMMOs, California State Marketing Order, and unregulated area

$a^P \in A^P \subset A$; $A^P = 3$ FMMO areas allowing supply plants

$a^F \in A^F \subset A$; $A^F = 10$ FMMO areas

FMMOs are authorized in the Agricultural Marketing Agreement Act of 1937 and establish regulations under which dairy processors purchase raw milk from dairy supply regions. Currently, there are 10 FMMO plus California has its own SMO as enabled under the California Marketing Act of 1937. To depict this situation, MilkOrdII represents 12 Order areas ($a \in A$) including 10 FMMO areas, California SMO area, and an unregulated area as shown in figure 2. Since MilkOrdII is basically disaggregated into 303 regions following NASS crop reporting districts, every 303 region is assigned to one of these12 segmented areas as listed in table A-3. A set of federally regulated areas ($a^F \in A^F \subset A$) is defined as a subset of areas to differentiate the regulated areas from unregulated areas. Another subset ($a^P \in A^P \subset A$) is defined for Marketing Order areas allowing supply plants.

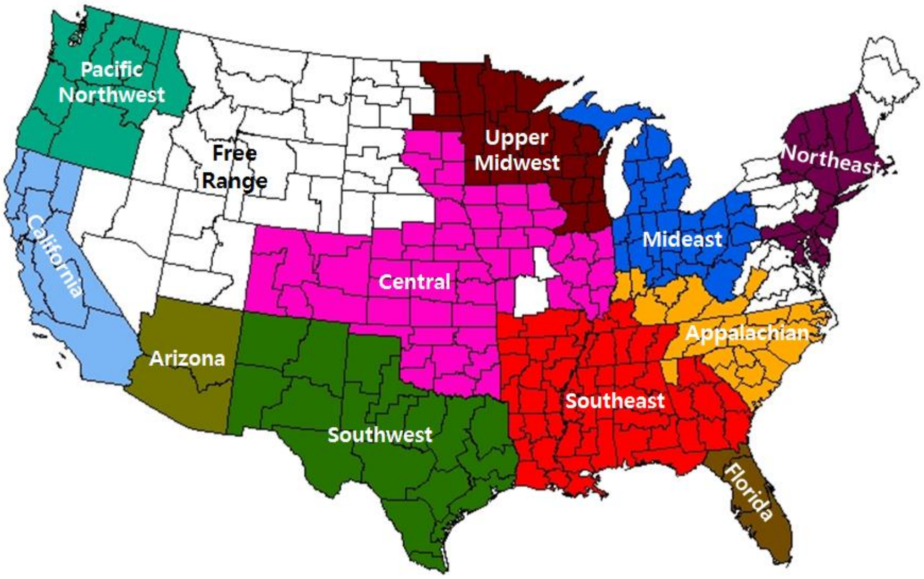

Figure 2. Geographic representation defined in MilkOrdII

2.5.2 Sets identifying temporal representation

$t \in T$; $T = 12$ months in a year

$t^B \in T^B \subset T$; $T^B =$ The beginning month

MilkOrdII contains data for 12 months ($t \in T$) in a year (base: 2012) to investigate the impact of seasonal variation of supply and demand. A subset ($t^B \in T^B \subset T$) is defined to fix the amount of stocks on initial month in simulation year.

2.5.3 Sets identifying the classification of raw milk

$c \in C$; $C = 4$ differentiated milk according to milk usage product

$c^M \in C^M \subset C; C^M = 2$ differentiated milk used for manufactured dairy products

Raw milk shipped into the plant level ($c \in C$) is classified into Class I, Class II, Class III, and Class IV as defined under the current set of Federal Orders:

- Class I is milk used for fluid milk products. This includes whole, low-fat, and skim milk in all container sizes; chocolate and other flavored milk; liquid butter-milk; and eggnog.
- Class II is milk used for soft manufactured products such as ice cream and other frozen dairy desserts, cottage cheese, sour cream, and creams (half and half, lite cream, and heavy cream).
- Class III is milk used to manufacture cream cheese and hard cheeses.
- Class IV is milk used to make butter and non-fat dry milk products.

The Orders specify minimum prices according to the classified pricing system. Although the current system classifies the manufactured products as classes II, III, and IV, MilkOrdII uses manufacturing milk in Class III and Class IV. Since most soft manufactured products (Class II type) are produced in fluid milk plants (Class I type), they are very close to each other. Thus, manufacturing milk is defined as a subset ($c^M \in C^M \subset C$) consisting of Class III and IV.

2.5.4 Sets identifying dairy products

$p \in P$; $P = 23$ final or intermediate dairy products

$p^B \in P^B \subset P$; $P^B = 6$ dairy products used to make mixed products

$p^w \in P^W \subset P$; $P^W = 3$ dry whey products

$p^S \in P^S \subset P$; $P^S = 4$ dairy products available for private stocks

$m \in M$; $M = 2$ mixed products

MilkOrdII represents production of raw milk into total 25 dairy products. A set of final (intermediate) products ($p \in P$) includes 23 products[2], which are fixed proportion blends of intermediate or final products. In terms of intermediate products, some dairy products produced in a plant do not move directly to consumer markets but rather are transferred to another plant in order to make other products. For example, excess cream from a fluid plant can be transferred to a sour cream plant and used to make sour cream. However, cream is also one of final products since it is distributed to consumer markets to satisfy cream demand.

A set of mixed products ($m \in M$), which is distinct from products set, is defined in MilkOrdII. There are two mixed products; one is ice cream mix used to produce ice cream and the other is cottage cheese dressing utilized to make cottage cheese. Since those are made by blending several products and raw milk without fixed input-output volume ratio, eligible products to be used to make each mixed product are defined as a subset ($p^B \in P^B \subset P$). Raw milk used for mixed products is classified into Class II since final products, ice cream and cottage cheese, are classified into soft manufactured (Class II) products. Table A-4 shows which products are utilized to make each mixed

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[2] The dairy products considered in MilkOrdII are fluid milk, skim milk, yogurt, cream, ice cream, sour cream, cottage cheese, Italian cheese, cheddar cheese, condensed skim milk, condensed whole milk, butter, non-fat-dry, powder, whey butter, butter milk, cottage cheese whey, mozzarella cheese whey, cheddar cheese whey, dry butter milk, dry cottage cheese whey, dry mozzarella cheese whey, and dry cheddar cheese whey.

product. Also, since the proportion of dry whey products is restricted in the process of blending, MilkOrdII defines a subset of products $(p^w \in P^W \subset P)$ including dry cheddar cheese whey, dry mozzarella cheese whey, and dry cottage cheese whey.

The dairy products which can be stored are defined a subset of products $(p^S \in P^S \subset P)$, which currently includes butter, cheddar cheese, Italian cheese, and non-fat dry milk. The storable products are stored at different regions as shown in table A-5.

2.5.5 Sets identifying plants and processes

$l \in L$; $L = 9$ different kinds of plants

$r \in R$; $R = 15$ different types of production processes at plant

Raw milk at the plant level is classified into Class I to Class IV according to its destination plant. The model includes 9 different kinds of plants $(l \in L)$; Class I type plant (fluid plant), Class II type plants (yogurt, ice cream, sour cream, and cottage cheese plants), Class III type plants (Italian cheese and cheddar cheese plants), and Class IV type plants (butter and powder plants). There are 15 representative processes $(r \in R)$ at plants level. Table A-6 shows what processes are implemented at each of the dairy plants. Some plants have only one process making final products, but other plants have multiple processes. For example, powder plants have five separate processes; to separate, to make powder, to make whole powder, to condense whole milk, and to condense skim milk.

2.5.6 Set identifying milk components

$ch \in CH$; $CH = 4$ milk components consisting of products and raw milk

Since mixed products are made by blending several products and raw milk, the balance on the characteristic components is considered. Four components $(ch \in CH)$ are considered; butterfat, solid non-fat, water, and weight, but butterfat and solid non-fat are only used to balance the blending procedure.

2.6 Parameters defined in MilkOrdII

MilkOrdII contains parameters for raw milk supply, dairy product demand, maximum capacity, and transportation rates plus some other miscellaneous items. Within the parameters, one can change the basic study data from year 2012 to another year to see the impacts of altered demand/supply, or the impact of increasing fuel price.

2.6.1 Data for raw milk supply

$\overline{QGA}_{i,t}$: The amount of Grade A milk supply from i^{th} place in t^{th} month

$\overline{QGB}_{i,t}$: The amount of Grade B milk supply from i^{th} place in t^{th} month

$\overline{QGU}_{i,t}$: The amount of unregulated milk supply from i^{th} place in t^{th} month

Raw milk production data are developed by the USDA/AMS/Dairy program according to the three Grade categories at the geographic level of the NASS crop reporting districts for May, 2012. To see the impact of raw milk supply seasonality, the production for other months in 2012 is estimated based on published data from USDA-

ERS[3]. Since the seasonal variation of milk supply is different across the U.S., U.S. total variation is not used but 23 selected states variations are applied to the seasonality of each 303 region. In the case of regions in non-selected states, we use an average of monthly variation from neighbored states we can obtain.

2.6.2 Data for dairy product consumption

$\overline{QPD}_{i,t,p}$: The amount of demand (including export) for p^{th} product in i^{th} location in t^{th} month

Since there is no available survey or published consumption data at the level of states or NASS crop reporting districts levels, we use per capita consumption[4] for each product and the population for each region to get the consumption amount for each region. This embodies an assumption of constant per capita consumption across the U.S. To reflect consumption seasonality, U.S. monthly consumption index is calculated for each dairy product based on the published data from USDA-AMS[5] and USDA-NASS[6].

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[3] Data is available via http://www.ers.usda.gov/data-products/dairy-data.aspx#.UnnT_vkU_V8.

[4] Data is obtained from the dataset named as "Dairy products: Per capita consumption, United States (Annual)" available via http://www.ers.usda.gov/data-products/dairy-data.aspx#.UqzvAPRDv8o.

[5] USDA-AMS published monthly consumption of fluid milk products in 10 FMMO areas as well as California. Data is available via http://www.ams.usda.gov/AMSv1.0/getfile?dDocName=STELPRDC5097493&acct=dmktord.

[6] The regional seasonality of fluid milk consumption is applied into each region. Also, they calculated commercial disappearance of cheddar cheese, Italian cheese, butter, and non-fat dry milk by each month. Cottage cheese and whole powder are available from USDA-NASS.

For some products we cannot get available consumption data, monthly U.S. production data available from USDA-ERS[7] is used as a proxy for consumption data with an assumption that monthly production of dairy product roughly matches its consumption and we do not permit long term storage.

2.6.3 *Data for plant capacity*

$\overline{CAP}_{i,c}$: The maximum plant capacity in terms of c^{th} classified milk in i^{th} place

USDA/AMS/Dairy program collected plant capacity data on the basis of how the milk was used at the geographic level of each region on May, 2012. The capacity is assumed invariant during the year. The data has several regions where the plants have a small capacity, which is less than 1 truck load of milk. The small amount of capacity is added evenly to the regions where the same type of plants is located within 100 miles from the region with the small capacity. When there is no candidate region, the capacity is zeroed out.

2.6.4 *Data for distance and transportation costs*

$\overline{AC}_{i,j,t}$: The assembly cost per unit of raw milk from i^{th} place to j^{th} place in t^{th} month

$\overline{DC}_{i,j,p,t}$: The distribution cost per unit of p^{th} dairy product from i^{th} place to j^{th} place in t^{th} month, depending on the facility type of trucks

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[7] Data is available in dataset from USDA-ERS via http://www.ers.usda.gov/data-products/dairy-data.aspx#.UnnT_vkU_V8.

Since each dairy product requires three different type of transportation, the distribution costs are different by transport types[8]. Distance data for each path are derived from MPMileCharter with Microsoft MapPoint. Since populated area, dairy farm area, and plants area are not consistent in each NASS crop reporting district, distance for each path is derived by three types of shipments; raw milk assembly distance between main dairy farm area of shipping NASS district and primary plants area of receiving NASS district, inter-transfer shipments distance between plants area of shipping NASS district and plants area of receiving NASS district, and final product distribution distance between plants area of shipping NASS district and the most populated area of receiving NASS district.

Since raw milk and dairy products are perishable, its shipment is restricted to a maximum distance. Grade A milk and Class I or II products can be shipped at most 1,500 miles, whereas storable products such as Class III or IV products can be shipped almost all across the U.S. (maximum distance is set up at 4,500 miles). Since Grade B milk is in poor sanitary condition, the maximum distance is restricted to 874 miles.

The transportation cost for each path is determined by the distance of each path and diesel price. The specific equation will be shown in equation (33) in section 3.3.2.

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[8] Refrigerated products such as fluid milk or ice cream incur 10 percent more transportation costs than bulk-type products, whereas non-refrigerated products such as powder or cheese incur 10 percent less transportation costs than bulk type products.

2.6.5 Data for input-output conversion rates and processing costs

$\overline{QRI}_{c,l,r}$: The amount of c^{th} classified milk used for a unit of r^{th} process at l^{th} plant

$\overline{QPI}_{p,l,r}$: The amount of p^{th} intermediate product used for a unit of r^{th} process at l^{th} plant

$\overline{QMI}_{m,l,r}$: The amount of m^{th} mixed product used for a unit of r^{th} process at l^{th} plant

$\overline{QPO}_{p,l,r}$: The amount of p^{th} product made from a unit of r^{th} process at l^{th} plant

$\overline{PC}_{i,l,r,t}$: The production cost per unit of r^{th} process at l^{th} plant in i^{th} place in t^{th} month

Unit conversion rate at the processing sector was assembled by USDA/AMS/Dairy program. Costs in dollars per unit processed are divided into processing costs and other costs. Table A-7 presents unitary costs and conversion rates from inputs to outputs for each process. The input output data are set up based on producing one unit of primary output product. For example, 1.052 unit of raw milk input is used to produce one unit of fluid milk output with 0.052 unit of cream.

2.6.6 Data for production of components

$\overline{RCH}_{ch}$: The percentage of ch^{th} component in raw milk

$\overline{PCH}_{p^B,ch}$: The percentage of ch^{th} component in ${p^B}^{th}$ product

$\overline{MCH}_{m,ch}$: The percentage of ch^{th} component in m^{th} mixed product

The composition data for raw milk and products are only used in blending ice cream mix and cottage cheese dressing since MilkOrdII uses fixed input-output conversion rates for the other products. Table A-8 represents the assumed compositions for each product and raw milk type. Only two components are considered in the blending problems: butter fat and solid non-fat.

2.6.7 Data related to private stock

$\overline{MIS}_{i^S,p^S}$: The minimum private stock of $p^{S^{th}}$ product in $i^{S^{th}}$ location

$\overline{QBS}_{i^S,p^S,t^B}$: The amount of private stock of $p^{S^{th}}$ product in $i^{S^{th}}$ location at the beginning of $t^{B^{th}}$ month

$\overline{TS}_{p^S}$: The terminal values of $p^{S^{th}}$ storable product at the ending of final month

The initial amount of stocks is given from actual data[9], but the stock at the ending of each month is determined in the MilkOrdII simulation. Minimum stocks are constrained by the minimum limit, which is specified as 70 percent of actual lowest stocks observed during the 12 months. The final amount of stocks is not specified as an exogenous limit, but it is determined by including terminal values of stocks into the MilkOrdII. To obtain the values, we run MilkOrdII model with the object of minimizing total costs, and observe the shadow prices on stocked products balance in early time periods.

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[9] Data is available in dataset in dairy data from USDA-ERS, via http://www.ers.usda.gov/data-products/dairy-data.aspx#.U1mabPldVhK.

2.6.8 Other parameters

$\overline{PS}_{a^P}$: The minimum percent of class I milk shipped to supply plants in ${a^P}^{th}$ MMOs

$\overline{MCU}_{a^F,c}$: The minimum use (percent) of c^{th} classified milk capacity in ${a^F}^{th}$ MMOs

$\overline{MAW}_m$: The maximum percentage of dry whey products used in the m^{th} mixed product

α : The maximum percent of unregulated milk used for fluid

$load$: The minimum amount of Grade A milk shipped to fluid plants

M : A big positive number

Since MilkOrdII optimizes the dairy sector in a way that minimizes total costs, simulated solutions are not always representative of actual movements. For example, we add some restrictions to force a certain amount of own region raw milk use in a Marketing Order to obtain similar results. The parameter, $\overline{MCU}_{a^F,c}$, is defined by each classified type of plants at each Marketing Order area.

2.7 Decision variables in MilkOrdII

To easily identify the attributes of variables, we use the following convention; variables beginning with the letter ‘Q’ denote production quantities while beginning with the letter ‘X’ denote the flow quantities. Variables of switching class begin with the letter ‘S’.

2.7.1 Variables related to raw milk assembly

$XGA_{i,j,c,t}$: The amount of c^{th} classified Grade A milk shipped from i^{th} place to j^{th} place in t^{th} month

$XGB_{i,j,c^M,t}$: The amount of $c^{M^{th}}$ classified Grade B milk shipped from i^{th} place to j^{th} place in t^{th} month

$XSP_{i,j^P,c,t}$: The amount of supplying milk shipped from i^{th} place to $j^{P^{th}}$ place in t^{th} month, where $c \in \{Class\ I\}$

$XSP_{i^P j,c,t}$: The amount of supplying milk shipped from $i^{P^{th}}$ place to j^{th} place in t^{th} month, where $c \in \{Class\ I\}$

$XUF_{i,i,t}$: The amount of unregulated milk used for fluid milk in i^{th} place in t^{th} month

$SGA_{i,c,t}$: The amount of Grade A milk downgraded to c^{th} classified milk from $c - 1^{th}$ classified milk in i^{th} place in t^{th} month, where $c \in \{Class\ II, Class\ III, Class\ IV\}$

$SGB_{i,c^M,t}$: The amount of Grade B milk downgraded to $c^{M^{th}}$ classified milk from $(c^M - 1)^{th}$ classified milk in i^{th} place in t^{th} month, where $c^M = \{Class\ IV\}$

$SUB_{i,t}$: The amount of unregulated milk converted to manufacturing milk in i^{th} place in t^{th} month, first switched to Class III milk

The classified system dictates prices that differ according to the category of dairy products in terms of milk class, so raw milk shipped to each type of plant is classified into the classes ($c \in C$). On the other hand, raw milk supply is separated into Grade A, Grade B, and unregulated milk on sanitary conditions, which are permitted for different usages. Moreover, since only Grade A milk is pooled to calculate the blend price, the amount of raw milk must be differentiated by class and type.

The raw milk assembly process reflects this and is represented as figure 3. There Grade A milk is indicated with red, Grade B milk is indicated with blue, and unregulated milk is shown with green color. In the model, Grade A milk supply is first assigned to be Class I milk as indicated by a red-dashed line and is eligible for fluid milk processing. Class I milk can be shipped to fluid milk plants ($XGA_{i,j,c=1,t}$). Some milk belonged to Grade A is shipped to a supply plant which in turn reships the milk to fluid milk plants, which is called as ‘supplying milk’. Its assembly has two types of movements; to supply plants ($XSP_{i,j^P,c,t}$) and from supply plants ($XSP_{i^P j,c,t}$). Also, Grade A can be downgraded into Class II milk for use in making other types of products ($SGA_{i,c=2,t}$). Furthermore, Grade A milk can be used for any type of products and can be downgraded into the lowest class, Class IV.

Grade B milk supply is first assigned to be Class III milk as indicated by the blue-dashed line since it can only be used to make manufactured products in Class III or Class IV. Class III milk can be shipped to cheese plants ($XGB_{i,j,c^M=3,t}$) or can be downgraded into Class IV milk ($SGB_{i,c^M=4,t}$) and used for butter or powder.

Unregulated milk is used for either fluid milk or manufactured products, so its movement is represented by two decision variables; one representing milk directly shipped to fluid plants, that is not Grade A milk ($XUF_{i,i,t}$), the other representing milk converted into class III milk ($SUB_{i,t}$).

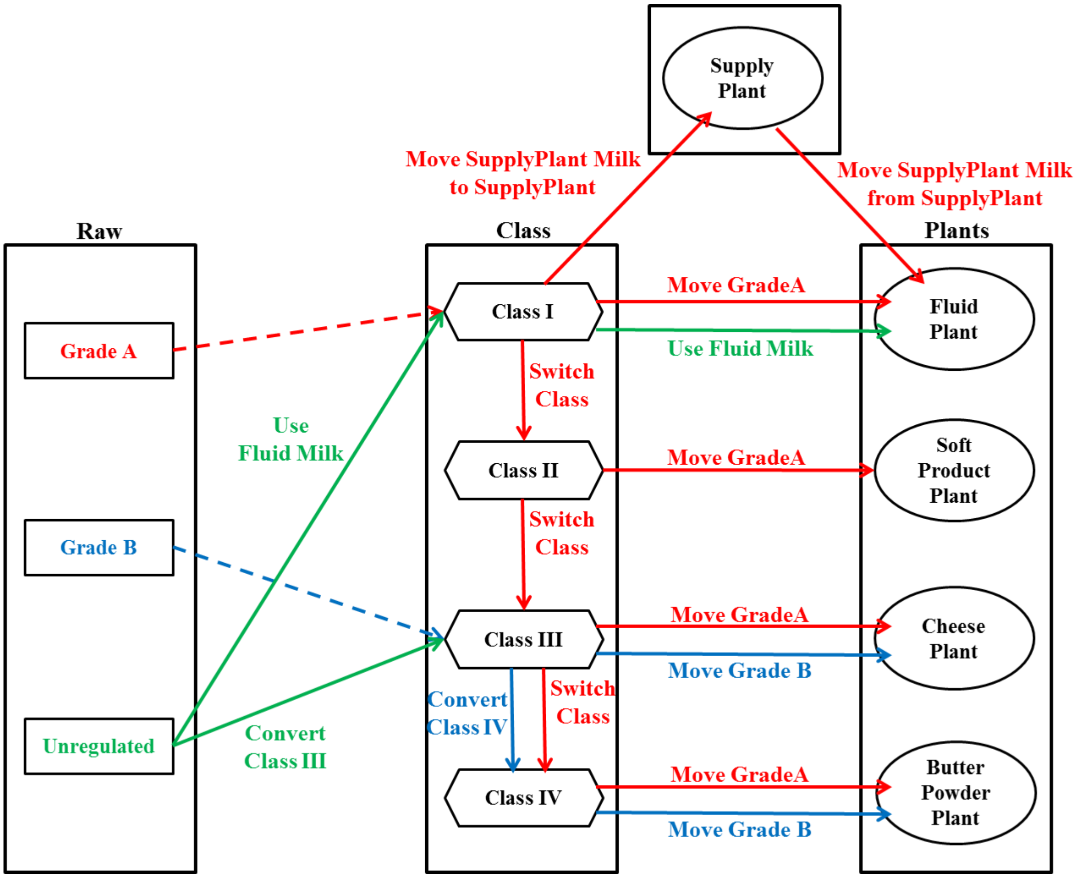

Figure 3. Representation of decision variables related to raw milk assembly

2.7.2 Variables representing plant processing and product usage

$QRP_{i,c,t}$: The amount of c^{th} classified milk which i^{th} place receives in t^{th} month

$QRM_{i,c,m,t}$: The amount of c^{th} classified milk used to make m^{th} mixed product in i^{th} place in t^{th} month, where $c \in \{Class\ II\}$

$QDP_{i,l,r,t}$: The amount of r^{th} process at l^{th} plant in i^{th} place in t^{th} month

$XPD_{i,j,p,t}$: The amount of p^{th} final product shipped from i^{th} place to j^{th} place to satisfy demand in t^{th} month

$XPI_{i,j,p,t}$: The amount of p^{th} intermediate product shipped from i^{th} place to j^{th} place to be used for production in t^{th} month

$QPM_{i,p^B,m,t}$: The amount of ${p^B}^{th}$ product used to make m^{th} mixed product in i^{th} place in t^{th} month

$XSA_{i,j^S,p^S,t}$: The amount of ${p^S}^{th}$ stock product added to ${j^S}^{th}$ stock place from i^{th} place in t^{th} month

$QMI_{i,m,t}$: The amount of m^{th} mixed product made in i^{th} place in t^{th} month

$XFP_{i,p,t}$: The amount of p^{th} product sold with fixed price in i^{th} place in t^{th} month

The processing plant activities portrayed as variables in MilkOrdII are displayed in figure 4. The volume of raw milk by Class received through incoming transport is aggregated into the variable, $QRP_{i,c,t}$. In turn that milk can be used to either make mixed products or dairy products. The amount of raw milk used to make mixed products is represented by the variable, $QRM_{i,c,m,t}$ and uses Class II raw milk since the final products are classified as Class II products. The raw milk into fixed input-output ratio products is given by the amount of process, $QDP_{i,l,r,t}$, multiplied by the volume of input for a unit of the process, $\overline{QRI}_{c,l,r}$. Resultant products are used

- To satisfy consumer demand through the variable, $XPD_{i,j,p,t}$.
- As intermediate products to be used to produce another product, $XPI_{i,j,p,t}$.
- As a product used in the blend to make mixed products, $QPM_{i,p^B,m,t}$.

- As an item shipped to storage, $XSA_{i,j^s,p^s,t}$.
- As an item sold at a fixed price if allowed, $XFP_{i,p,t}$

Also, the amount of mixed products are determined by blending problem, which is represented by $QMI_{i,m,t}$.

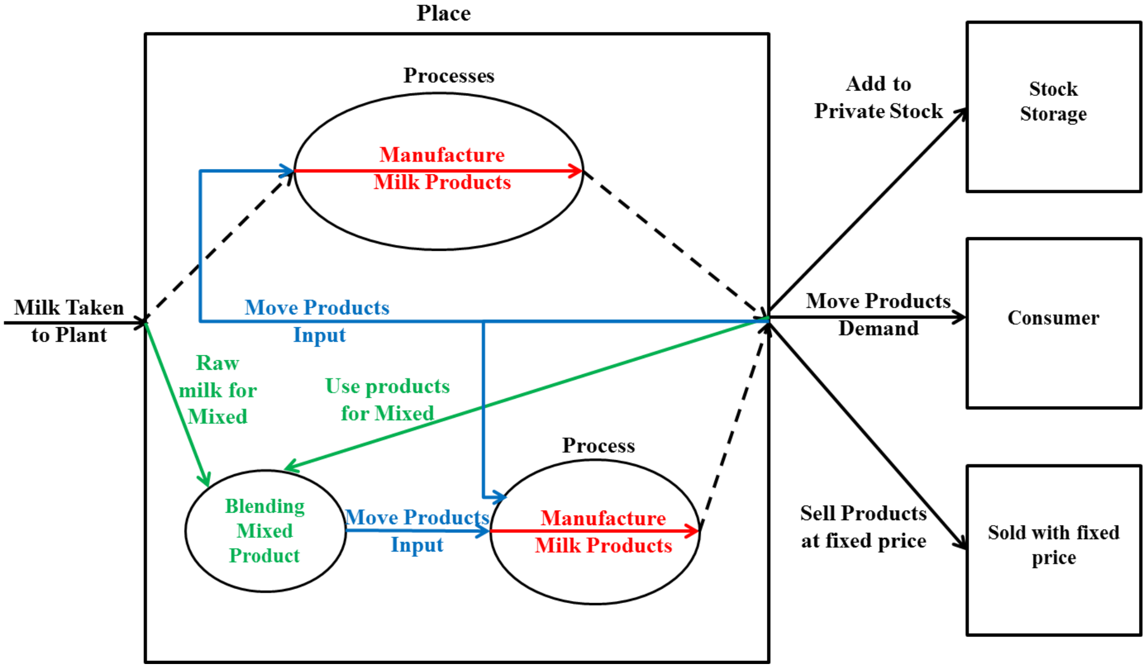

Figure 4. Representation of decision variables related to plants level

2.7.3 Variables related to private stocks

$XSR_{i^s,j,p^s,t}$: The amount of $p^{s^{th}}$ stock product released from $i^{s^{th}}$ stock place to j^{th} place in t^{th} month

$XSA_{i,j^s,p^s,t}$: The amount of $p^{s^{th}}$ stock product added to $j^{s^{th}}$ stock place from i^{th} place in t^{th} month

$QSP_{i^S,p^S,t}$: The amount of $p^{S^{th}}$ stocks stored in $i^{S^{th}}$ place at the end of t^{th} month

The functions of these decision variables are generally displayed in figure A-4. MilkOrdII allows for the month to month carryover of items in private stocks in NASS crop reporting districts which have private storages $(i^S \in I^S)$. The amount of private stock at the ending of the month is determined as follows; the amount of private stock at the beginning of the month plus the amount of products added to private stocks minus the amount of products released from the private stocks.

2.7.4 Artificial and objective function variables

$AGA_{i,t}$: The insufficient amount of Grade A milk supply in i^{th} place in t^{th} month

$ADP_{i,p,t}$: The unsatisfied demand of p^{th} final product in i^{th} location in t^{th} month

Z : The objective function value, i.e. minimized total costs

Several artificial variables, included in MilkOrdII, ensure a feasible solution can be found. To drive the artificial variables out of the optimal solution, a very large “penalty”, which is M, is introduced into the objective function. Since the model is based on fixed amount of raw milk supply and fixed dairy product demands, it is possible that there is not enough milk supply to produce enough dairy products to satisfy consumer demand. To insure a feasible solution, MilkOrdII includes

- Grade A milk artificial variables that allow each region to supply more milk at an extraordinarily high price, $AGA_{i,t}$.
- Product side artificial variables that allow demand to be met at an extraordinarily high price, $ADP_{i,p,t}$.

2.8 Model formulation of MilkOrdII

A mathematical formulation of MilkOrdII is described as an objective function and sets of constraints. The constraints are classified into six types; those related to raw milk supply at farms, raw milk balance at plants, dairy product balance at processing, stock levels, final product demand, and others.

2.8.1 Objective function

$$
\begin{aligned}
(1) \qquad Z = & \sum_{i=1}^{I}\sum_{j=1}^{J}\sum_{c=1}^{C}\sum_{t=1}^{T}\overline{AC}_{i,j,t} * (XGA_{i,j,c,t} + XGB_{i,j,c,t} + XSP_{i,j,c,t} + XUF_{i,j,t}) \\
& + \sum_{i=1}^{I}\sum_{j=1}^{J}\sum_{p=1}^{P}\sum_{t=1}^{T}\overline{DC}_{i,j,p,t} * (XPI_{i,j,p,t} + XPD_{i,j,p,t} + XSR_{i,j,p,t} + XSA_{i,j,p,t}) \\
& + \sum_{i=1}^{I}\sum_{l=1}^{L}\sum_{r=1}^{R}\sum_{t=1}^{T}\overline{PC}_{i,l,r,t} * QDP_{i,l,r,t} \\
& + \sum_{i=1}^{I}\sum_{p=1}^{P}\sum_{t=1}^{T} M * \left(AGA_{i,t} + ADP_{i,p,t}\right) \\
& - \sum_{i^S=1}^{I^S}\sum_{p^S=1}^{P^S}\overline{TS}_{p^S} * QSP_{i^S,p^S,t^E}
\end{aligned}
$$

The objective function is to minimize total costs incurred within the U.S. dairy industry during 1 year, less revenues from terminal values of stocks at the ending of final month. The first part in the equation (1) is the assembly cost to ship Grade A, Grade B, and unregulated, and supplying milk. Assembly rate per unit is identical regardless of the type of raw milk or type of classified milk. The second is the transport cost of dairy products including inter-transfer cost of intermediate products, distribution cost of final products, and shipping cost of storable products. The third is the production cost to manufacture dairy products. The fourth is big penalties related to positive artificial variables. Additionally it includes terminal values for the amount of stocks at the final month to ensure that the model activity is reasonable up until the final month.

2.8.2 Constraints limiting raw milk supply at farm level

Raw milk supply is limited by grade; Grade A, Grade B, and unregulated milk. Also, there is a constraint restricting the maximum unregulated milk uses for fluid milk.

2.8.2.1 Grade A milk supply balance

$$(2) \qquad \sum_{j=1}^{J}\left(XGA_{i,j,c,t} + XSP_{i,j^P \in J,c,t}\right) + SGA_{i,c+1,t} = \overline{QGA}_{i,t} + AGA_{i,t}$$

$$\forall i \in I, \forall t \in T, c \in \{Class\ I\}$$

$$(3) \qquad \sum_{j=1}^{J} XGA_{i,j,c,t} + SGA_{i,c+1,t} = SGA_{i,c,t} \qquad \forall i \in I, \forall t \in T, c \in \{Class\ II, Class\ III\}$$

$$(4) \qquad \sum_{j=1}^{J} XGA_{i,j,c,t} = SGA_{i,c,t} \qquad \forall i \in I, \forall t \in T, c \in \{Class\ I\}$$

The constraints limit Grade A milk supply to that available by place, month, and Class. Since Grade A milk can be downgraded from Class I to Class IV, the constraints are different by each class. Constraint (2) performs Class I milk supply balance: the sum of milk shipped out to fluid plants and supply plants plus the amount of milk downgraded to Class II is equal to the exogenous supply of Grade A milk at the place. For Class I, there is an artificial variable introduced solely for the purpose of always allowing a feasible solution. Constraint (3) indicates that the sum of milk shipped out to Class II (or Class III) type plants plus the amount of milk downgraded to Class III (or class IV) is equal to the amount of milk downgraded from Class I (or Class II). The last constraint (4) performs Class IV milk supply balance: the sum of milk shipped out to butter/powder plants (Class IV type) is equal to the amount of milk downgraded from Class III at the place. All Grade A milk supply is assumed to be transported to some plants to be processed into fluid milk or manufactured into dairy products. Thus, supply balances at farms are restricted by equality constraints.

2.8.2.2 Grade B milk supply balance

(5) $$\sum_{j=1}^{J} XGB_{i,j,c^M,t} + SGB_{i,c^M+1,t} = SUB_{i,t} + \overline{QGB}_{i,t}$$

$$\forall i \in I, \forall t \in T, c^M \in \{Class\ III\}$$

(6) $$\sum_{j=1}^{J} XGB_{i,j,c^M,t} = SGB_{i,c^M,t} \qquad \forall i \in I, \forall t \in T, c^M \in \{Class\ IV\}$$

The set of constraints deal with Grade B milk supply balances. There are two supply sources; Grade B milk supply and converted milk from unregulated milk supply. Since Grade B milk is only used for manufactured products, it is manufactured for Class III type products or can be downgraded to Class IV. Constraint (5) literally states that the sum of milk shipped out to cheese (Class III type) plants plus the amount of milk downgraded to Class IV is equal to the sum of Grade B milk sources. Constraint (6) performs Class IV milk supply balance: the sum of milk shipped out to butter/powder plants (Class IV type) is equal to the amount of milk downgraded from Class III. Based on the assumption of totally exhausted supply, the balances are equality constraints.

2.8.2.3 Unregulated milk supply balance

(7) $$XUF_{i,i,t} + SUB_{i,t} \le \overline{QGU}_{i,t} \qquad \forall i \in I, \forall t \in T$$

(8) $$XUF_{i,i,t} \le \alpha * \overline{QGU}_{i,t} \qquad \forall i \in I, \forall t \in T$$

The set of constraints perform two functions related to unregulated milk supply. Unregulated milk can be either used to make fluid milk or converted to Grade B milk to make manufacturing products. Constraint (7) limits the unregulated milk supply for each place for each month where there is unregulated milk supply: the amount of unregulated milk used for fluid milk plus the amount converted to Grade B milk cannot be greater than exogenous supply of unregulated milk at the place. Constraint (8) restricts the maximum amount of unregulated milk that can be used for fluid milk.

2.8.3 Constraints balancing raw milk at a processing plant

Raw milk balance constraints at the plant level limit use to incoming supply at the front door of plants by place, month and Class. They also deliver shadow prices that are spatial milk values by class of milk. Balance constraints at supply plants are also present as are constraints restricting maximum capacity.

2.8.3.1 Classified milk supply balance

$$(9) \qquad QRP_{i,c,t} = \sum_{j=1}^{J} \left(XGA_{j,i,c,t} + XSP_{j^P \in J,i,c,t} \right) + XUF_{i,i,t}$$

$$\forall i \in I, \forall t \in T, c \in \{Class\ I\}$$

$$(10) \qquad QRP_{i,c,t} = \sum_{j=1}^{J} XGA_{j,i,c,t} \qquad \forall i \in I, \forall t \in T, c \in \{Class\ II\}$$

$$(11) \qquad QRP_{i,c^M,t} = \sum_{j=1}^{J} \left(XGA_{j,i,c^M,t} + XGB_{j,i,c^M,t} \right) \qquad \forall i \in I, \forall t \in T, c^M \in C^M$$

The set of constraints add up total raw milk as the incoming supply. One of these constraints is generated for each Class, month, and place wherever the Class of milk is used. Since each type of raw milk supply is intended for different uses for products, the constraints are different by each Class. Constraint (9) controls the amount of Class I milk at a fluid milk plant, which is equal to the sum of incoming Grade A, Class I milk, shipped from producing regions and the sum of milk shipped from supply plants plus the amount of unregulated milk used to make fluid milk. Constraint (10) simply states that the total amount of Class II milk at a soft product manufacturing plant is equal to the sum of Grade A, Class II milk, shipped from producing regions. Constraint (11) controls the manufacturing milk (Class III and Class IV). Since Grade B milk must be used to manufacture Class III or Class IV type products, the amount shipped from producing regions includes Grade A milk as well as Grade B milk. All raw milk shipped into plants must be used, so the constraints are equalities.

2.8.3.2 Classified milk demand balance

$$\sum_{l=1}^{L}\sum_{r=1}^{R}\overline{QRI}_{c,l,r} * QDP_{i,l,r,t} = QRP_{i,c,t} \qquad \forall i \in I, \forall t \in T, c \in C \backslash \{Class\ II\} \tag{12}$$

$$\sum_{l=1}^{L}\sum_{r=1}^{R}\overline{QRI}_{c,l,r} * QDP_{i,l,r,t} + \sum_{m=1}^{M} QRM_{i,c,m,t} = QRP_{i,c,t} \tag{13}$$

$$\forall i \in I, \forall t \in T, c \in \{Class\ II\}$$

The set of constraints balance milk demand with total received supply. The milk supply by Class is balanced with milk use to make dairy products or blend into mixed products: ice cream mix or cottage cheese dressing. Since the mixed products are used to produce Class II type products, raw milk used for mixed products is classified into Class II. Constraint (13) restricting Class II milk balance differs from the constraint (12) restricting other classified milk balances, only in the manner in which (13) additionally includes the sum of milk used to blend into mixed products. All raw milk must be used, so balances at plants are equality constraints.

2.8.3.3 Supplying milk balance

$$\sum_{j=1}^{J} XSP_{i^P j,c,t} = \sum_{j=1}^{J} XSP_{j,i^P,c,t} \qquad \forall i^P \in I^P, \forall t \in T, c \in \{Class\ I\} \tag{14}$$

The constraint (14) balances raw milk at supply plants by month and region where the supply plants are located. All raw milk taken into supply plants must be shipped out to fluid plants.

2.8.3.4 Maximum capacity constraints

$$(15) \qquad QRP_{i,c,t} \leq \overline{CAP}_{i,c} \qquad \forall i \in I, \forall t \in T, \forall c \in C$$

The constraint (15) limits plant capacity by place, month, and Class of milk that is used at the place. It literally states that the amount of classified milk received cannot be greater than the maximum capacity for the classified milk.

2.8.4 Constraints balancing (mixed) products at a processing plant

Product balance constraints deal with products by place and month. Some products can be used as inputs for other processes or for use in mixed products. Typically, these are called ‘intermediate products’. Thus, there is a set of supply demand balance constraints for the intermediate products. Another set of constraints balance supply and demand for mixed products. Finally, limits on the characteristics of mixed productions are also imposed as is a maximum on whey content.

2.8.4.1 Intermediate product demand balance

$$(16) \qquad \sum_{l=1}^{L}\sum_{r=1}^{R}\overline{QPI}_{p,l,r} * QDP_{i,l,r,t} + \sum_{m=1}^{M} QPM_{i,p^B,m,t} = \sum_{j=1}^{J} XPI_{j,i,p,t}$$

$$\forall i \in I, \forall t \in T, \forall p \in P$$

The constraint (16) balances supply and demand of intermediate products at processing plants. One of these constraints is generated for each product, month, and place at which the product is required for either a process or blending a mixed product.

Some intermediate products will be moved to other plants locally or located in other places. The constraint literally states that the sum of intermediate products required for each process at each plant plus the sum of intermediate products used to make mixed products is equal to the sum of intermediate products transferred to the place.

2.8.4.2 Volume balance at blending problem

$$(17) \quad QMI_{i,m,t} = QRM_{i,c=2,m,t} + \sum_{p^B=1}^{P^B} QPM_{i,p^B,m,t} \qquad \forall i \in I, \forall t \in T, \forall m \in M$$

The constraint (17) balances the total volume of inputs blended into mixed products with the total volume of the resultant blended products. One of these constraints is generated for each mixed product, month, and place where the blending problem is active. Raw milk as well as intermediate products are eligible to blend into the mixed products. The amount of each mixed product after blending in pounds is equal to the pounds of Class II milk plus the pounds of intermediate products used in making the mixed product.

2.8.4.3 Mixed product demand balance

$$(18) \quad \sum_{l=1}^{L} \sum_{r=1}^{R} \overline{QMI}_{m,l,r} * QDP_{i,l,r,t} = QMI_{i,m,t} \qquad \forall i \in I, \forall t \in T, \forall m \in M$$

The constraint (18) balances supply of mixed products with usage. One of these constraints is generated for each mixed product in all places where blending occurs for each month. The constraint is essentially the same as the constraints (16), but balances mixed products. The equation insures the amount of each mixed product needed is equal to the amount of each mixed product obtained from blending.

2.8.4.4 Component balance at blending problem

$$\overline{RCH}_{ch} * QRM_{i,c=2,m,t} + \sum_{p^B=1}^{P^B} \overline{PCH}_{p^B,ch} * QPM_{i,p^B,m,t} = \overline{MCH}_{m,ch} * QMI_{i,m,t} \qquad \forall i \in I, \forall t \in T, \forall m \in M, \forall ch \in CH \tag{19}$$

The constraint (19) requires that the mixed product characteristics (butterfat and solid non-fat) to be met by the items blended into it. One of these constraints is generated for each milk component, mixed product, place, and month. The constraint literally states that the total amount of component contained in raw milk and products blended into each mixed product is equal to the amount of component that needs to be contained in each mixed product.

2.8.4.5 Maximum dry whey contents on blending problem

$$\sum_{p^w \in P^B} QPM_{i,p^w,m,t} \leq \overline{MAW}_m * QMI_{i,m,t} \qquad \forall i \in I, \forall t \in T, \forall m \in M \tag{20}$$

The constraint (20) imposes maximum whey content in blending products. One of these constraints is generated for each mixed product and for each place where blending occurs for each month. Several dry whey products are eligible for use in mixed products, but collectively are restricted to a maximum.

2.8.4.6 Product supply balance

(21)
$$XFP_{i,p,t} + \sum_{j=1}^{J}(XPI_{i,j,p,t} + XPD_{i,j,p,t}) + \sum_{j^s=1}^{J^s} XSA_{i,j^s,p^s \in P,t}$$
$$= \sum_{l=1}^{L}\sum_{r=1}^{R} \overline{QPO}_{p,l,r} * QDP_{i,l,r,t} \quad \forall i \in I, \forall t \in T, \forall m \in M, \forall ch \in CH$$

The constraint (21) balances total product supply with usage. One of these constraints is generated for each product and for each place, where the product is produced, for each month. Outputs from processes can be used for four purposes. First, some items can be sold at fixed price. Second, some products are shipped to other places as intermediate products. Third, some products are sent to consumer demand. Fourth, some products can be placed into private storages. Algebraically, the sum of the above supply is equal to the outputs for each product.

2.8.5 Constraints related to stock levels

(22) $$QSP_{i^S,p^S,t} + \sum_{j=1}^{J} XSR_{i^S,j,p^S,t} = \overline{QBS}_{i^S,p^S,t^B} + \sum_{j=1}^{J} XSA_{j,i^S,p^S,t} + QSP_{i^S,p^S,(t\in(T\setminus T^B))-1}$$

$$\forall i^S \in I^S, \forall t \in T, \forall p^S \in P^S$$

(23) $$\overline{MIS}_{i^S,p^S} \leq QSP_{i^S,p^S,t} \qquad \forall i^S \in I^S, \forall t \in T, \forall p^S \in P^S$$

The constraint (22) balances stock carryover with additions and releases. They are generated for each stock product, for each place with private storages for the stocked product, and for each month. The initial amount of stock for each place is given from actual data, but the amount of ending stocks for each month is determined after optimized simulation. For the first month, the amount of stocks at the end of the month is equal to the initial amount of stocks at the beginning of the month plus the sum of the product added to the storage place during the month minus the sum of the product released from the storage place during the month. From the second month, the constraint is similar with the first month, but the initial stock amount is replaced with the amount of stocks at the end of previous month.

The constraint (23) imposes the minimum limits on private stock. They are generated for each stocked product, for each place with private storage for each month. The minimum limit is specified as 70 percent of actual lowest stocks observed during the 12 months.

2.8.6 Constraints related to final product demand

$$(24) \quad \sum_{j=1}^{J} XPD_{j,i,p,t} + \sum_{j^S=1}^{J^S} XSR_{j^S,i,p^S \in P,t} + ADP_{i,p,t} = \overline{QPD}_{i,p,t} \quad \forall i \in I, \forall t \in T, \forall p \in P$$

The constraint (24) imposes the level of product demand including exports requiring it to be met by incoming shipment, stock withdrawals, and possibly an artificial variable. One of these constraints is generated for each product, month, and place where there is demand for final product.

2.8.7 Real-world constraints

These set of constraints were imposed in order to model an even greater level of ‘real-world’ structure.

2.8.7.1 Class I milk shipped through supply plants

$$(25) \quad \sum_{j=1}^{J} \sum_{i^P \in (I \cap A^P)} XSP_{j,i^P,c=1,t} = \sum_{j=1}^{J} \sum_{i^P \in (I \cap A^P)} \overline{PS}_{a^P} * XGA_{j,i^P,c=1,t} \quad \forall a^P \in A^P, \forall t \in T$$

The constraint (25) imposes a minimum restriction on raw milk shipped through supply plants. One such constraint is generated for the Marketing Order with supply plants. More specifically, 7.5 percent of raw milk shipped to fluid plants must be shipped through supply plants in the California State Marketing Order area. The reason for imposing this constraint is to reflect the reality that supply plants receive raw milk from supply regions and then reship to fluid plants.

2.8.7.2 Minimum capacity use by Marketing Order area

$$\sum_{i\in(I\cap A^F)} \overline{CAP}_{i,c} * \overline{MCU}_{a^F,c} \leq \sum_{i\in(I\cap A^F)} QRP_{i,c,t} \qquad \forall a^F \in A^F, \forall t \in T, \forall c \in C \tag{26}$$

The constraint (26) imposes a minimum use of capacity by Class of raw milk for some Marketing Orders. The capacity data for each classified type is collected based on the maximum, so national capacity is much greater than the required capacity, especially Class II type. Thus, the restriction is needed to replicate observed usage.

2.8.7.3 Minimum restriction on Class I and Class II supply

$$\sum_{j=1}^{J}\sum_{c=1}^{2} XGA_{i,j,c,t} \geq load \qquad \forall i \in I \cap F, \forall t \in T \tag{27}$$

The constraint (27) imposes minimum constraints on outgoing shipments of Class I and Class II milk. One of these constraints is generated for each place located in a FMMO area, for each month.

2.9 Concluding comments

This section describes the MilkOrdII model that was updated from the MilkOrd model (McCarl, Schwart, and Siebert, 1996) and in cases had new features specified here. The model was updated in terms of data with some features added in support of the study to estimate the regional differences in milk value within the context of U.S. Federal Milk Marketing Orders. The base model for this study contains 163,927 constraints and 8,768,678 variables. It was solved using GAMS and took approximately two hours of CPU time to obtain an optimal solution without the use of an advanced basis. The next section examines the spatial and seasonal milk pricing issue using this MilkOrdII model.

3. SPATIAL AND SEASONAL PRICES IN U.S. MILK MARKETS

We turn attention to seeing how Federal Milk Marketing Order (FMMO) price differentials might change in the face of evolving transport cost, supply/demand locations, and seasonality. MilkOrdII model described in section 2 is used for the analysis.

3.1 Introduction

The FMMO policy employs spatially differentiated milk prices implemented through a classified and usage based pricing system along with revenue pooling[10]. Classified pricing differentiates milk according to milk usage product class[11]. Generally speaking, Class I milk is that milk processed for packaged fluid milk products. Class II milk is that milk used to produce soft manufactured dairy products such as yogurt and ice cream. Class III milk is that used to produce hard manufactured dairy products such as cheese. Class IV milk is that used to produce any product not included in the other

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[10] Revenue pooling causes dairy farmers to be paid a weighted average price for all uses of milk in a particular marketing order. The revenue pooling system gives all dairy farmers in a certain marketing order area the same price plus also balances market power between them and milk handlers.

[11] Milk used for products are categorized by four classes under clauses 8(d) and 9(r) of the Dairy Industry Act S.N.S. 2000. Class V milk occurs only when the Canadian Dairy Commissions has issued a permit under the Special Milk Class Permit Program. Thus, it is not considered in the milk classifications used in our research. The Canadian regulation is described on the website via https://www.novascotia.ca/just/regulations/regs/dimilkcc.htm.

classes such as butter and powder. Under the system, prices paid by handlers for milk used in Class II, III, and IV are based on U.S. average wholesale market prices for products belonging to each class as reported by the AMS[12]. These class prices are identical for all locations across the U.S. market. On the other hand, the price for milk used in Class I product varies by location because it is determined by adding a spatially defined, predetermined, and fixed *Class I differential* for each county[13] to the higher of the Class III or Class IV price. This differential reflects the added price needed to attract Grade A milk, which is qualified for fluid consumption, away from another region. Raw milk is classified according to sanitary conditions; Grade A and Grade B, and the costs to produce Grade A milk is greater than Grade B milk, which is only used for manufactured dairy products. Thus, the main reason for the Class I price is to compensate dairy farmers for the additional costs of producing Grade A milk.

The current Class I differential varies across the U.S. with the range of $1.60 - $6.00 per hundredweight (cwt.). The minimum price fluid milk handlers must pay to producers is specified as the higher of the Class III or Class IV milk price plus the differential, which is $1.60 per cwt in the lowest cost regions. The main reason for the addition of the differentials is to compensate dairy farmers for the additional costs of

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[12] A more detailed description of classified milk pricing formula can be found in Jesse and Cropp (2008).

[13] Refer to the website for the current Class I price differential for each 3114 county. It is available via http://www.ams.usda.gov/AMSv1.0/getfile?dDocName=STELDEV3101901 from USDA-AMS.

producing Grade A milk[14] and then getting it to market. The differential in the highest cost regions is \$4.40 per cwt. The spatially differentiated prices are intended to allow deficit areas to attract Grade A milk from surplus areas to satisfy fluid milk demand and to compensate producers for transportation costs, which encourages economic efficiency and orderly marketing in regulated markets.

There is the possibility that the Class I price differentials are in need of revision. In particular, the Class I price differentials currently being used were largely established in January, 2000. Subsequently in May 2008, there were small adjustments of differentials only in selected regions (the Appalachian (FO5), Florida (FO6) and Southeast (FO7) FMO areas)[15]. However, since then there have been significant changes in the locations of supply and demand plus in transportation costs. All of these are potentially key factors in determining spatial milk values. Accordingly, the purpose of this study is to estimate how the Class I price differentials might change to be reflective of the current situation. Additionally, pricing surfaces of other classes of milk are estimated. Second, we separately and jointly examine the impacts of altered transportation costs, and supply demand location adjustments. Third, we evaluate the impact of seasonal variation of milk supply and demand on spatial milk values. Lastly, we analyze the effectiveness of two policy tools, over-order payments and the

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[15] Refer to the website http://www.ams.usda.gov/AMSv1.0/getfile?dDocName=STELPRDC5067132 for detailed information.

Transportation Credit Program, in terms of their ability to reduce the magnitude of spatial and seasonal differentials.

3.2 Background and related literature

The concept of milk price differentials was initially introduced by French and Kehrberg (1960). Late a number of studies looked at the adequacy of the differentials, but there is no study after 2000. There is no study to discern the impact of each factor on regional differentials. Also, the effectiveness of other dairy policy tools such as over-order payment and Transportation Credit Program has not been addressed.

3.2.1 Classified pricing system

The concept of Class I regional differentials was initially introduced by French and Kehrberg (1960). Late a number of studies looked at the adequacy of the differentials. Christ (1980) compared the hauling cost to move Grade A milk to the Class I price differential structure. He concluded that Class I price differentials were in need of an increase to promote regional movement of milk. Subsequently, many researchers analyzed the impact of Class I price differentials using spatial programming models such as the Dairy Market Policy Simulator (DAMPS) by Novakovic et al. (1980) and Interregional Competition mode (IRCM) by Cox and Jesse (1995). Ahn and Sumner (2009) and Yavuz et al. (1996) addressed the topic of Class I price differentials using different models. These models were used to address a variety of economic issues such as market organization and the opportunity for efficiency improvements; optimal plant size, numbers, and location; transportation arrangements.

A representative study to estimate Class I price differentials was done by Pratt et al. (1998) using the U.S. Dairy Sector Simulator Model (USDSS). The USDSS however did not fully reflect the actual situation due to a mismatch between the real locations of processing points (not optimal) and the simulated optimal points since where to locate the plants and how much dairy product to process at each location are determined by the model (Pratt et al., 1997). The vast majority of the current Class I price differentials were established based on the results from USDSS. However, we could not find reports on analyses addressing the adequacy of the current differential structure after 2000 despite the significant changes in the spatial dispersion of milk supplies and dairy product demands plus in transportation costs.

3.2.2 Changes in key factors

Transportation costs have risen substantially since 2000 and as such would increase the spread of the FMMO price differentials. In particular, even though there are many considerations underlying transportation rates, the fuel cost (mainly diesel price) is a leading factor and has increased greatly recently more than doubling since 2000 (figure 5). To our knowledge, there is no research on the effects of fuel price changes on Class I price differentials.

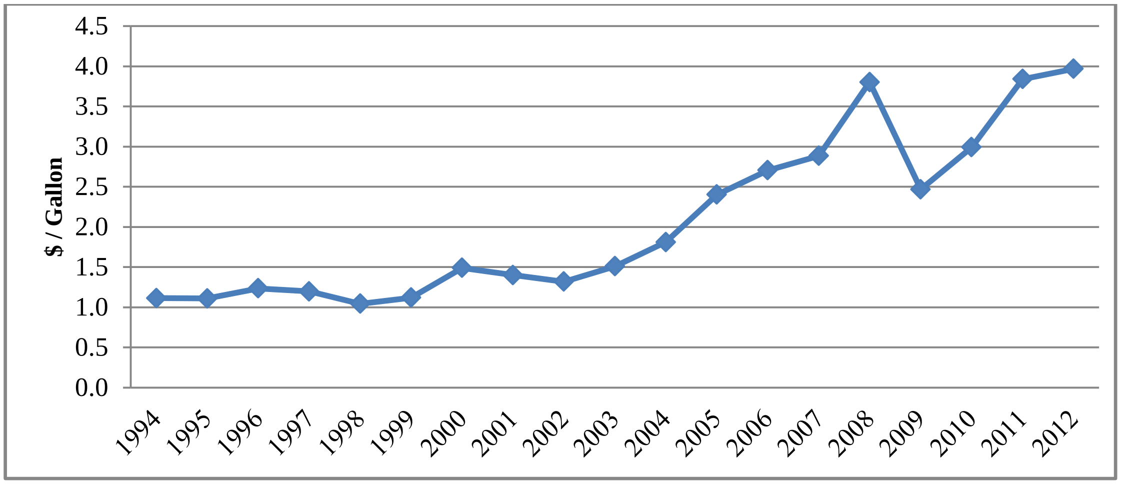

Figure 5. U.S. diesel price from 1994 to 2012

In terms of milk supply, there have been geographic shifts in location. Milk production is moving to the west (Blayney, 2002) due to the fact that there are lower average costs of milk production in the west caused by a variety of organizational and climatic reasons (USDA-ERS, 2012). The left map of figure 6 shows the difference (as a percent change) of supply share between 2000 and 2012. Idaho experienced the largest increase (from 4.3% to 6.7%) followed by California, Texas, and Michigan. These four states produced 30.4% of U.S. milk in 2000 and 36.9% in 2012. On the other hand, the production share in Pennsylvania decreased from 6.7% to 5.2%. The standard deviation of percent change from 2000 to 2012 in lower 48 states milk production is 0.63%, which indicates that regional milk supply has experienced a volatile change during the period.

The regional distribution of demand for dairy products has also changed since 2000. The right map in figure 6 shows the percent change of demand share that is assumed to be a function of population shifts from 2000 to 2012. Texas experienced the largest increase in demand share from 7.46% to 8.29% followed by Florida, Arizona, Georgia, and North Carolina. Population in New York decreased the most from a 6.79% share to 6.28% during the period followed by Michigan, Ohio, Illinois, and Pennsylvania. Pratt et al. (1998) estimated the impact of spatial shifts in demand on the Class I price differentials and forecasted the expected differentials with USDSS, but they did not consider the impact of spatial supply shifts on locational milk values.

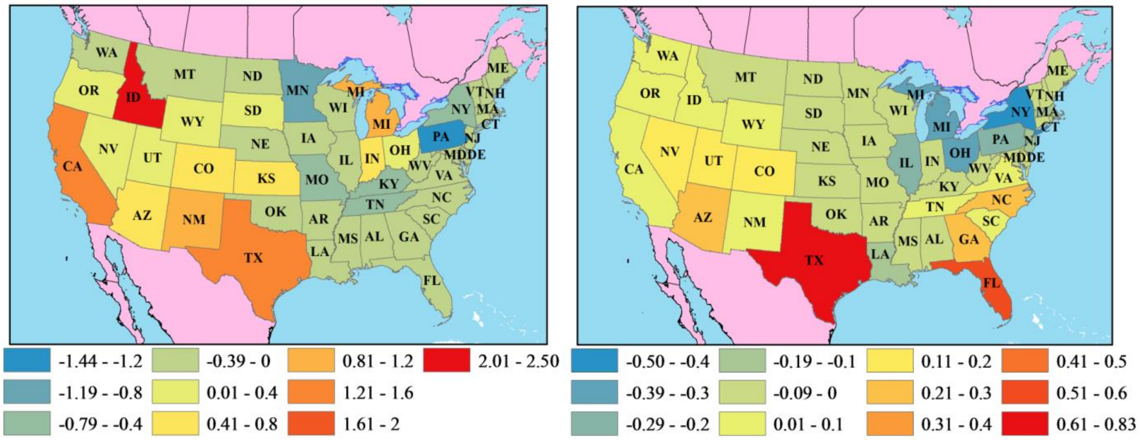

Figure 6. The share change of milk production (left) and population (right) by 48 states from 2000 to 2012 (%)

3.2.3 Seasonal variation of supply and demand

Milk exhibits seasonal variation in raw supply due to breeding patterns and weather conditions, especially excessive heat and humidity (Hahn, 1999). Figure 7 shows the monthly variation of milk yield per day compared to the average 2012 yield for the U.S. as a whole, and for 5 selected areas. The total U.S. milk production increases from January through the early and peaks in late spring and early summer. Then, it gradually decreases and the two lowest yield months are September and October. Additionally due to differences in climates across the county, raw milk supply also shows regionally different patterns. For example, Florida shows the larger fluctuation while Wisconsin produces relative constant milk across the year.

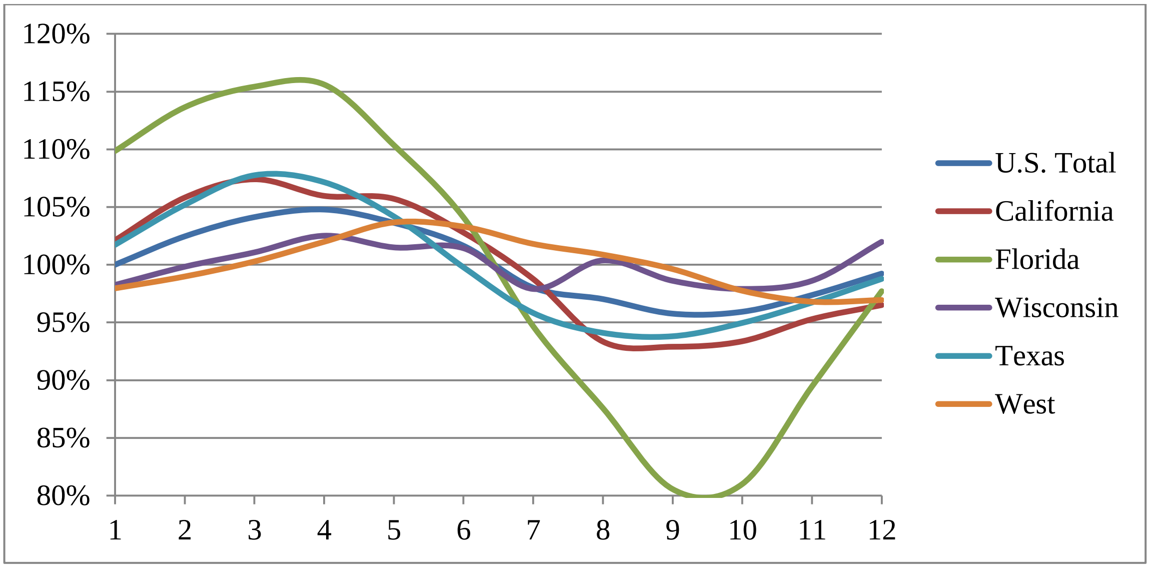

Figure 7. Monthly variation of percentage change from annual average milk yields per cow using 2012 data

The demand for dairy products also exhibits seasonality. Figure 8 shows the monthly variation for selected 4 dairy products from the 4 classes; fluid representing Class I, ice cream for Class II, Italian cheese for Class III, and butter for Class IV. Fluid milk consumption is relatively higher in months when school is in session while ice cream consumption is highest in the summer and lowest in the winter driven by climate conditions. Butter consumption fluctuates and Italian cheese is consumed relatively constantly. Collectively, this supply demand seasonality may well have an influence on monthly differentials for classified milk across the U.S., and in turn could be reflected in the FMMO pricing surface. Testuri, Kilmer, and Spreen (2001) provided insight into the seasonality of Class I price differentials in the Southeastern area of U.S. by using a minimum cost network flow model. However, such a study has not been done across the U.S.

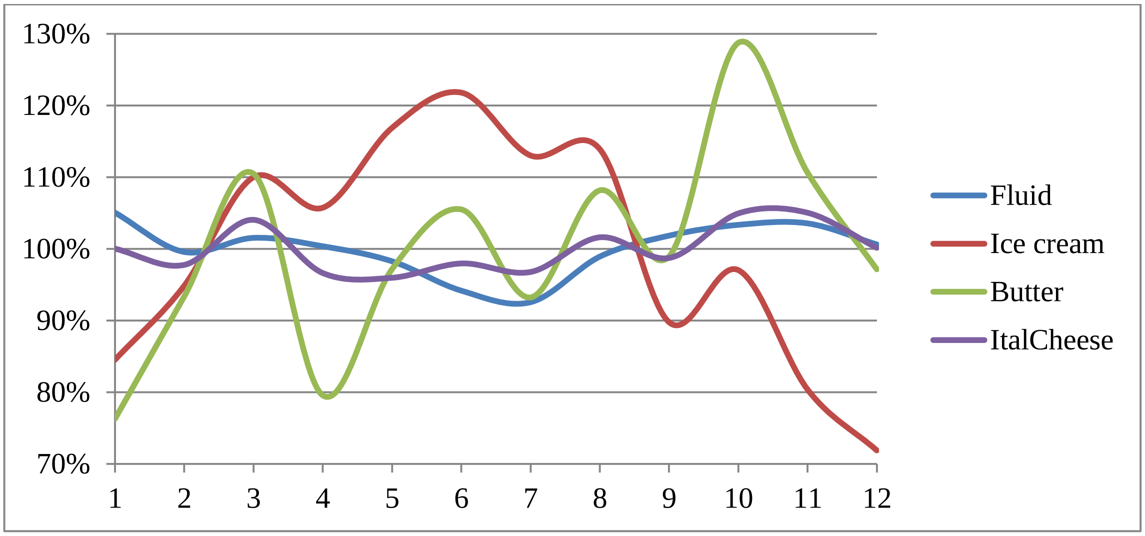

Figure 8. Monthly variation of percentage change from annual averages of consumption per day for 4 selected dairy products using 2012 data

3.2.4 Over-order payment and Transportation Credit Program

The Class I price differentials, which are FMMO specified differences between fluid and manufactured milk prices, are the minimum prices fluid milk handlers must pay to producers. Since the price differentials have not been revised mostly since 2000 this means order minimum prices might be insufficient to pay for moving milk. To stimulate milk shipments, most milk producers participate in producer-owned cooperatives that assemble members' milk and move it to processors or manufacturers. The cooperatives bargain with handlers for milk prices that are above the order-minimum prices. Those prices are called over-order payments (premiums), which adjust the effective price to be higher than the FMMO Order prices. This market correction has become a short-run solution where the FMMO specified differentials do not fully reflect costs. There is no study on evaluating of the effectiveness of over-order payments as a mechanism correcting for the lack of updating in price differentials.

Several FMMOs areas that are deficit in local raw milk production have implemented a Transportation Credit Program (TCP) to subsidize hauling costs to attract raw milk from outside the Marketing Order. The TCP has buyers of milk in the deficit area pay a fee into the Transportation Balancing Fund which is used to help pay for the extra milk during the deficit period. The purpose of the program is first to reduce the magnitude of differentials in high valued areas, and second to reduce the seasonal variation which differentials would need to have. Our study adds to the literature on the dairy policy by evaluating whether the TCP payments can overcome the lack of updating in the price differentials.

3.3 Methods of analysis

This section elaborates the methods used to do our research. First, how to derive the spatially differentiated milk values from the MilkOrdII model is explained. The second shows how to estimate the impact of diesel price on transportation costs. Third, how to discern the effect of each factor on milk price differentials is shown. We also discuss how the effectiveness of FMMO policy tools is analyzed.

3.3.1 Relative shadow prices as price differentials

The primal solution from MilkOrdII gives the least cost spatial pattern for milk movement and processing along with dairy product movement, and stock accumulations plus releases flows given fixed supply, demand, and maximum capacity at disaggregated regions during twelve-month time period. More importantly, the marginal values of milk are provided from the milk demand balance constraint at the plants level[16] as below.

$$(28)\quad \sum_{l=1}^{L}\sum_{r=1}^{R}\overline{QRI}_{c,l,r} * QDP_{i,l,r,t} + \sum_{m=1}^{M} QRM_{i,c=2,m,t} = QRP_{i,c,t} \quad \forall i \in I, \forall c \in C, \forall t \in T$$

Its associated dual solution $\lambda_{i,c,t}$ is represented as:

$$(29)\quad \lambda_{i,c,t} = \partial Z / \partial QRP_{i,c,t} \qquad \forall i \in I, \forall c \in C, \forall t \in T$$

These values, the shadow prices, give the marginal value of more milk at a location in the optimal solution. Since the constraints (28) are for classified milk in each region, the

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[16] Refer to a section 2.8.3.2 for the detailed description of the constraints.

shadow price of classified milk for each region can be obtained as (29). The shadow prices at a fluid processor can be interpreted as follows: If a handler at a location obtained one more unit of milk, then the entire cost involved with distribution of raw milk and dairy products will be reduced by the amount of that shadow price. This concept is consistent with economic theory on how prices are determined in a competitive market (Samuelson, 1952). However, the derived value does not yield the absolute value or Class I price differentials since these reflect only the 'transportation' derived component of locational differentials rather it gives relative differences. Other components, such as milk production cost, and/or marketing margins are not included in the model. Nonetheless, the relative shadow price between different regions can be used as a measure of relative Class I price differentials across the regions under the assumptions of homogeneity of processing costs and milk/product composition across the U.S. Therefore, the simulated shadow prices are used to provide information regarding price differentials between geographic locations. More specifically, the differences of the shadow prices imputed from Class I milk demand constraints between two regions are equivalent to the differences of Class I price differentials between them.

To obtain the locational differentials ($\Lambda_{i,c=1,t}$), the derived Class I milk shadow prices ($\lambda_{i,c=1,t}$) from MilkOrdII are adjusted in a way that:

$$(30) \quad \Lambda_{i,c=1,t} = \lambda_{i,c=1,t} - MIN\left(i,\ \lambda_{i,c=1,t}\right) \qquad \forall i \in I, \forall c \in C, \forall t \in T$$

That is, the minimum Class I shadow price for each month is subtracted from all shadow prices yielding a base value of zero, and other values ranging up to the highest differential. These values, literally interpreted, indicate the relative change in the optimal objective value resulting from a one unit of change in the availability of Class I milk at the location in comparison to other locations or equivalently the optimal relative valuation of Class I milk delivered to a location. As noted above, these differentials reflect only the ‘transportation’ derived component of spatial differentials since other differential components are not included in the model.

3.3.2 Relationship between fuel prices and transport costs

Since one of main purposes here is to study the effect of shifting fuel prices on the pricing surface, we estimate the impact of diesel price on transportation costs. We do this econometrically using the following equation.

$$Transportation\ cost\ per\ unit\ =\ distance\ *\ (\beta+\ \gamma*DieselPrice\ )+\ \alpha \tag{31}$$

This is done on a per unit basis. The equation assumes unitary transportation costs (per unit of weight) between two regions consist of variable costs linearly increasing with distance and fixed costs that are independent of distance. Fuel costs, driver labor costs, and vehicle maintenance costs are assumed to be a function of distance, and we divided them into fuel costs ($\gamma * DieselPrice$) and other factors (β). Fixed costs (α) independent of distance include rolling stock, handling costs, milk testing costs, truck replacement costs, etc.

The California Department of Food and Agriculture surveyed hauling rates for important routes across 13 subareas in the California Marketing Order twice a year from

2006 to 2013. We use that dataset in the estimation since it corresponds to the dimension and interests of our optimization model. For the diesel price data, we use the monthly average highway-diesel price from the U.S. Energy Information Administration. The panel data set consists of 577 observations over 58 routes and 15 months[17]. From the equation (31), the following panel model (32) is derived.

$$Rate_{it} = \alpha + \beta Dist_{it} + \gamma Dist_{it} * DieselPrice_{it} + u_i + e_{it} \tag{32}$$

where $Rate_{it}$ is the transportation cost per hundredweight for an individual route i in month t, $Dist_{it}$ is the transport distance for an individual route i in month t, and $Dist_{it} * DieselPrice_{it}$ is an interaction term with distance and diesel price in dollars per gallon. Since each route has different road and other conditions, the unknown route-specific term u_i is included in the equation, and e_{it} is the idiosyncratic error term. In estimation, we employ a random effects approach[18], and find that every estimate is statistically significant at the 1 % level. In turn, the transportation cost per full load is estimated as the equation (33).

$$Rate\ per\ full\ load\ =\ 134\ +\ Distance\ *\ (\ 1.603 +\ 0.325 * Diesel\ Price\ ) \tag{33}$$

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[17] Although the panel is not balanced, the average number of observations for each route is almost 10. Thus, it does not cause a critical problem to estimate the equation.

[18] To decide on the panel estimation method, we run the Hausman test and Breusch-Pagan Lagrange Multiplier tests, and conclude that the random effects approach is reasonable to use in estimating the model. Also we find that the test for homoscedasticity is not passed, and thus use the STATA option ‘robust’ to control for heteroscedasticity.

These results indicate the fixed cost per truck is \$134 per load, and variable cost of non-diesel inputs is \$1.6 per mile plus 0.325 times the diesel price in dollar per gallon. Thus if the diesel price per gallon increases by \$1, then transportation cost of a full load (which is 48,000 lbs of milk) will increase by \$0.325 per mile. Unitary transportation cost for each path is calculated with the estimated equation (33) given distance between two regions and diesel price.

3.3.3 The effect of each factor on pricing surface

To discern the impact of three factors, five separate simulations are conducted. First, we simulate a case with only changing diesel prices where we convert these to 2000 levels in the equation (33). Second, we simulate a case with only a changing demand pattern. This is done by maintaining total consumption at 2012 levels but rearranging demand shares among the NASS districts based on the population shares in the year 2000. In this manner, we can isolate the impacts of spatial shifts in population over time. Third, we simulate a case with only a changing pattern of raw milk supply reflective of both the 2000 distribution and the 2012 milk supply volume. The fourth case is to change both supply and demand patterns from 2012 to 2000, and the last case is to change all three factors to the 2000 level.

3.3.4 The effectiveness of FMMO policies

The over-order payment data we use are those published by the USDA-AMS[19]. They report the announced cooperative Class I price with the order-minimum prices in 31 selected cities where at least one city is selected in each FMMO area. The data are used to examine the effectiveness of over-order payments by comparing to the MilkOrdII simulated differentials. As of 2012, there are two areas that use the TCP; the Appalachian (FO5) and Southeast (FO7) FMMO areas. In the TCP implementation, the regions eligible for the credit are not places within the implementing Order. Also, the distance from milk producing place to the processing place must be greater than 85 miles. Following the rules, we find the eligible paths connected to two FMMO areas. In order to analyze the impact of the TCP action, we calculate credit rates for each eligible path[20] and assembly rates from (33) are subtracted by the amount of credit rates.

3.4 Results

In the following section, we will first summarize the current milk price differential structure, and then separately discuss the simulation results. Each part will be done under the comparison of current differentials and simulation results from the MilkOrdII model.

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[19] Data is available at http://www.ams.usda.gov/AMSv1.0/getfile?dDocName=STELPRDC5096348.

[20] Credit rates are calculated by following rule *7 CFR 1007* of the Southeast Marketing Area (FO7) as discussed on http://www.fmmatlanta.com/FO%207%20Order%20Lang.html#1000.83.

3.4.1 Current Class I milk price differentials

Since the purpose of this study is to see how the spatial distribution of Class I differentials under various conditions compares to the existing distribution, the current differentials are normalized so that the minimum value is zero[21]. In turn the resultant differential range spans from $0 to $4.40/cwt. Figure 9 depicts a contour map of these across the 303 MilkOrdII regions. The actual differentials generally increase in a 'regular' fashion with distance to the east and south of the Upper Midwest, but there is little regularity to the west.

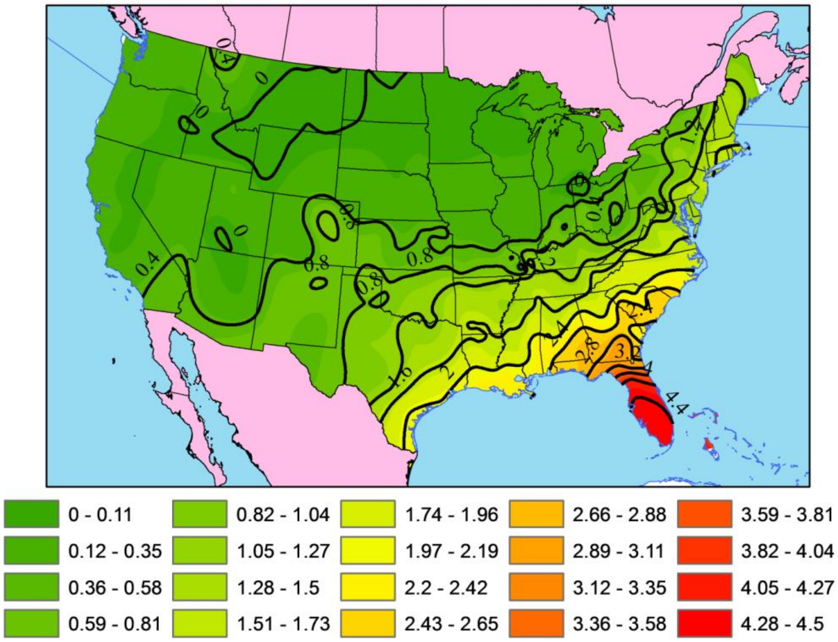

Figure 9. Normalized actual Class I milk pricing surface ($/cwt.)

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[21] Table A-9 lists the current 'normalized' spatial values for Class I milk price differentials at 303 NASS districts.

3.4.2 MilkOrdII differentials under 2012 conditions

The left contour map in figure 10 represents the Class I pricing surface from MilkOrdII under 2012 conditions that is developed by averaging the monthly differentials. These differentials are similar in structure to the current Class I differential structure, with values that increase from low values in the northwest to high values in the southeast. In general, this shows that the MilkOrdII does a good job replicating the general pattern of Class I differential structure.

However, the MilkOrdII-derived Class I pricing surface contains much larger differentials than those existing under the current policy. Table 1 shows the range, weighted average, and standard deviation of the spatial differentials[22]. The range of simulated differentials is $5.08/cwt. greater than that of the actual differentials. The weighted average differential (weighted by the Class I sales estimates) is $4.03/cwt. and is $1.39/cwt. greater than weighted average of the current differentials ($2.64/cwt.). This indicates that the disparity in the MilkOrdII simulated pricing surface is much larger than under the current surface. The results imply that the current Class I price differentials are not fully reflective of today's conditions.

MilkOrdII also generates manufacturing milk spatial differentials for the other classes of milk; the right map in figure 10 is that for Class II, and the maps in figure 11 are for Class III and Class IV. All three pricing surfaces show similar patterns increasing gradually and somewhat uniformly from the west to the southeast. The range of Class II price differentials is $8.32/cwt., and the standard deviation of those is

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[22] Table A-9 lists the MilkOrdII derived 'normalized' spatial values for classified milk.

$1.37/cwt., which indicates that Class II milk values also differ across geographically separate locations. On the other hand, the ranges of the estimated differentials for Class III ($3.05/cwt.) and Class IV milk ($4.03/cwt.) are much smaller than those of Class I and Class II. Furthermore, the weighted average differentials for these other classes ($0.50/cwt. for Class III and $0.57/cwt. for Class IV) and the standard deviation of differentials ($0.47/cwt. for Class III and $0.72/cwt. for Class IV) are much lower, which indicates that Class III and Class IV milk surfaces are fairly uniform across the U.S. The results correspond somewhat to the current pricing system, which uses identical prices for manufacturing milk across the U.S.

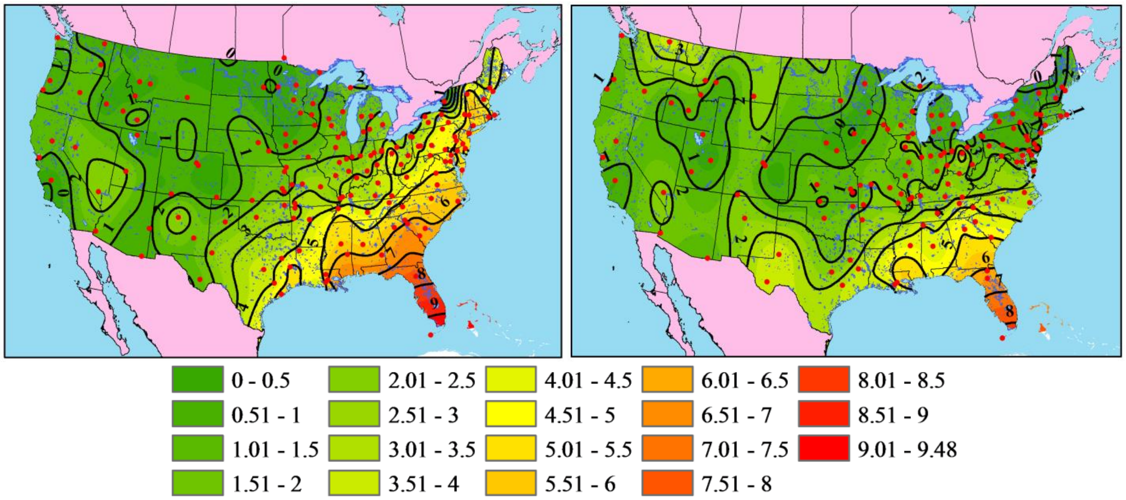

Figure 10. Normalized MilkOrdII based Class I (left) and Class II (right) milk pricing surface, 2012 annual average ($/cwt.)

Note: Red points indicate the regions with plants that use this milk class. 159 regions have Class I type plants, and 134 regions have Class II type plants.

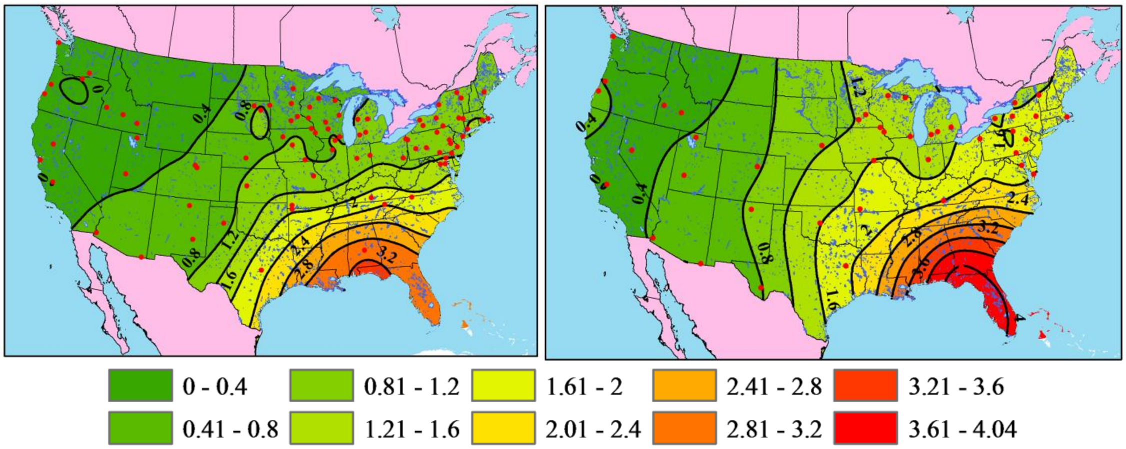

Figure 11. Normalized MilkOrdII based Class III (left) and Class IV (right) milk pricing surfaces, 2012 annual average ($/cwt.)

Note: 86 regions have Class III type plants, and 44 regions have Class IV type plants.

Table 1. Normalized Actual and Annualized MilkOrdII Based Price Differentials for Classified Milk, 2012 Average ($/cwt.)

	"Class I price differentials"			"Manufacturing milk differentials"		
	Actual	Derived from MilkOrdII	Derived-Actual	Class II	Class III	Class IV
Minimum	0.00	0.00	-0.70	0.00	0.00	0.00
Maximum	4.40	9.48	5.08	8.32	3.05	4.03
Range	4.40	9.48	5.08	8.32	3.05	4.03
Weighted AVG.	2.64	4.03	1.39	1.78	0.50	0.57
STD. deviation	0.77	1.93		1.37	0.47	0.72
Count:	303	159	159	134	86	44
Differences < 0			8			
Differences > 0			151			

3.4.3 Contribution of location shifts and fuel price increases to differentials

Since the FMMO differentials were established, there have been significant changes in the spatial dispersion of supplies and demands plus in transportation costs. Here, we try to decompose the effects of these factors contrasting solutions with and without the shifts in spatial patterns of supply and demand plus those in transport costs based on how these items shifted between 2000 and 2012. Table 2 summarizes the Class I milk price differentials estimated from five different cases where the fuel prices and supply demand distributions are at 2000 or 2012 levels[23]. The impacts on pricing surface are reported only for Class I milk.

Table 2. The Statistics of Class I Milk Price Differentials Estimated from Alternative Scenarios with Supply and Demand Distribution plus Fuel at 2000 or 2012 Levels ($/cwt.)

	Actual	Base 2012 supply 2012 demand 2012 fuel	(1) 2012 supply 2012 demand 2000 fuel	(2) 2012 supply 2000 demand 2012 fuel	(3) 2000 supply 2012 demand 2012 fuel	(4) 2000 supply 2000 demand 2012 fuel	(5) 2000 supply 2000 demand 2000 fuel
Range	4.40	9.48	5.50	9.18	9.46	8.42	4.86
Weighted average	2.64	4.03	2.34	4.61	4.85	5.30	3.08
Standard deviation	0.77	1.93	1.11	2.27	1.78	1.73	1.00

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[23] Table A-10 lists the full set of normalized Class I price differentials estimated from five different scenarios.

3.4.3.1 Impact of 2000 versus 2012 fuel price on spatial milk values

A left map in figure 12 represents the estimated Class I milk pricing surface under the base 2012 case. The right map shows the results when the transport costs as a function of fuel costs (diesel) are reverted to 2000 levels. The two surfaces are similar in spatial pattern, but the total differential is much smaller under the 2000 diesel price cutting the range to \$5.50/cwt., which is 58% of that under the 2012 prices and much closer to the \$4.40/cwt. Differentials in the current policy. The weighted average and standard deviation are also closer showing a set of differentials that are much more consistent with the current FMMO differentials. We conclude that the fuel price is a key factor in the MilkOrdII larger differentials and perhaps the FMMO ones should be adjusted for the increasing fuel price with a formula as prices will undoubtedly change in the future.

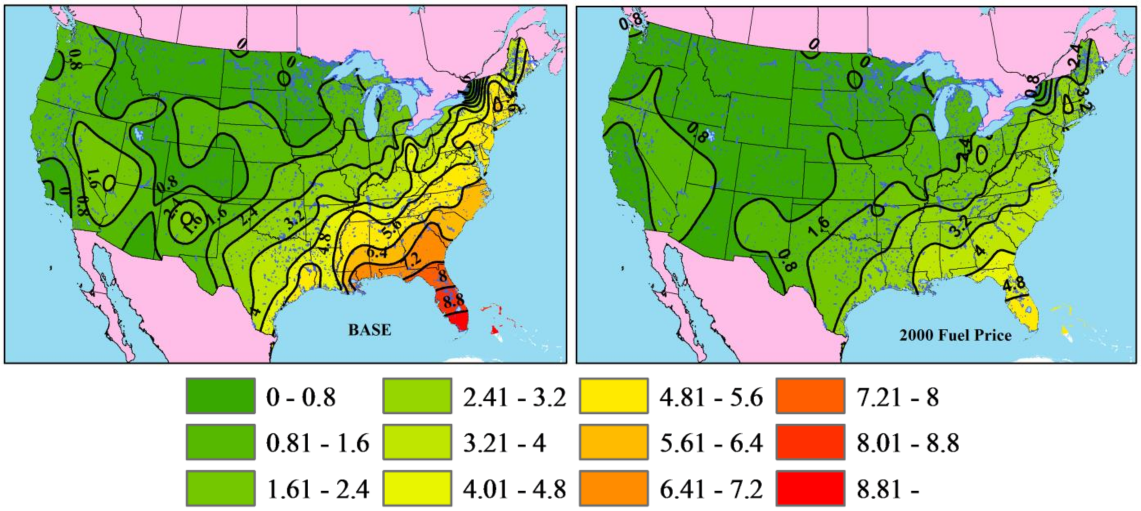


Figure 12. MilkOrdII based Class I milk pricing surface under the 2012 diesel price (left) and the 2000 diesel price (right) (\$/cwt.)

3.4.3.2 Impact of spatial demand shifts on spatial milk values

To see the impact of spatial demand shifts only, the model is simulated with 2012 population distribution versus the 2000 distribution with all other items held at base model levels. The maps in figure 13 show the magnitude of the shifts while figure 14 shows the differential patterns under the two cases. Figure 13 shows losses in the northeast and middle, and gains in the south, southwest, and west.

The Class I milk price differential pattern in figure 14 indicates that the change in demand location does not have large effects on the overall pattern of the price differential surface.

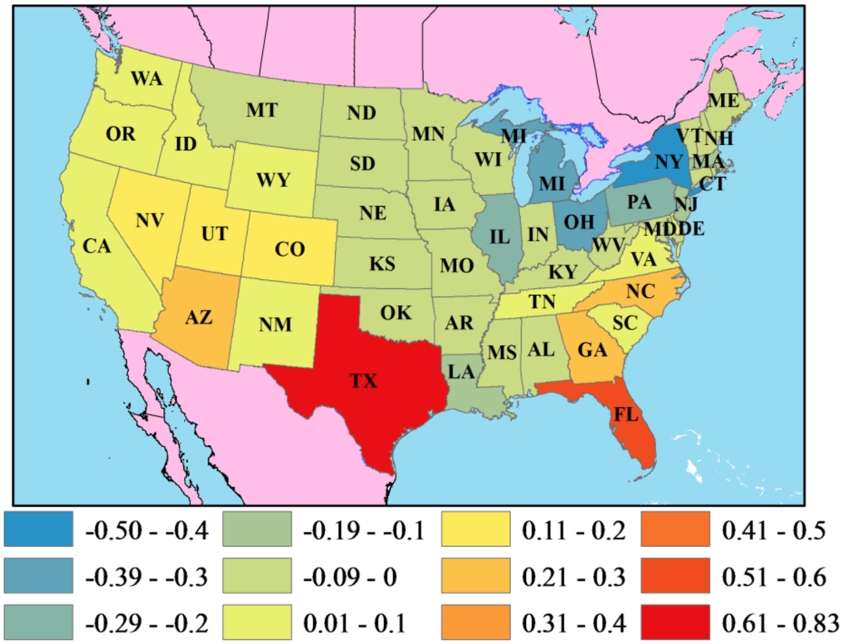


Figure 13. The share change of population in the 48 U.S. states from 2000 to 2012 (%)

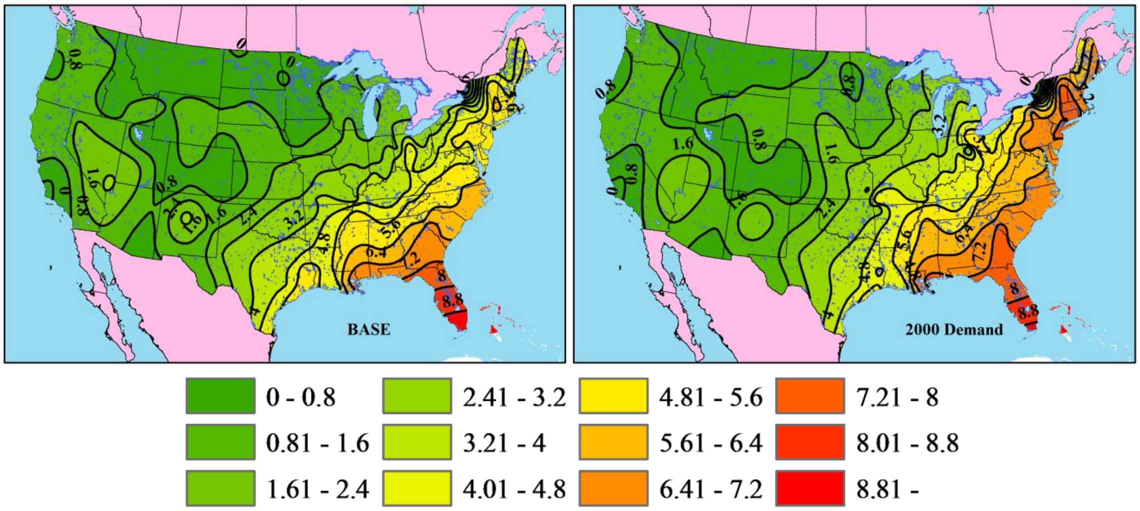


Figure 14. MilkOrdII derived I milk pricing surface under 2012 (base) demand distribution (left) and that from 2000 demand (right) ($/cwt.)

Figure 15 shows the impact of the demand share shifts on the magnitude of the MilkOrdII based Class I milk price differentials. The blue shaded indicates areas where the differentials decrease and the red shaded indicates areas where the differentials increase from 2000 to 2012. Generally, the northeast shows decreased milk differentials especially in Maine, Massachusetts, and New Hampshire where they drop by almost $1.80/cwt. On the other hand, differentials rise in the west, with the largest change in Nevada by $0.84/cwt. This impact corresponds to the share change of demand as shown in figure 13 which shows the share changes in population. The general trend shows that the states with decreasing share and differentials are located in the northeastern U.S. while areas with increasing shares have larger differentials.

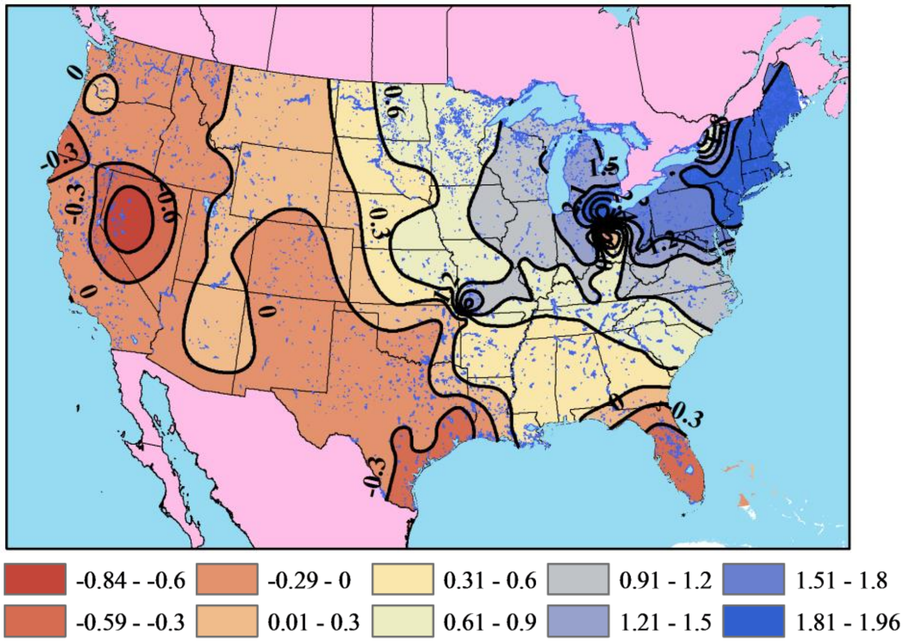


Figure 15. Impact of demand shifts from 2012 to 2000 on Class I milk pricing surface ($/cwt.)

3.4.3.3 Impact of spatial supply shifts on spatial milk values

To examine the impact of spatial supply shifts, a case reallocating regional supply shares from the 2012 spatial pattern to that in 2000 was simulated. The map in figure 16 shows the share shift with milk share decreasing in the southeast, northeast, upper Midwest, and Washington but increasing in Texas, California, Idaho, and some in Michigan, Indiana, and Minnesota.

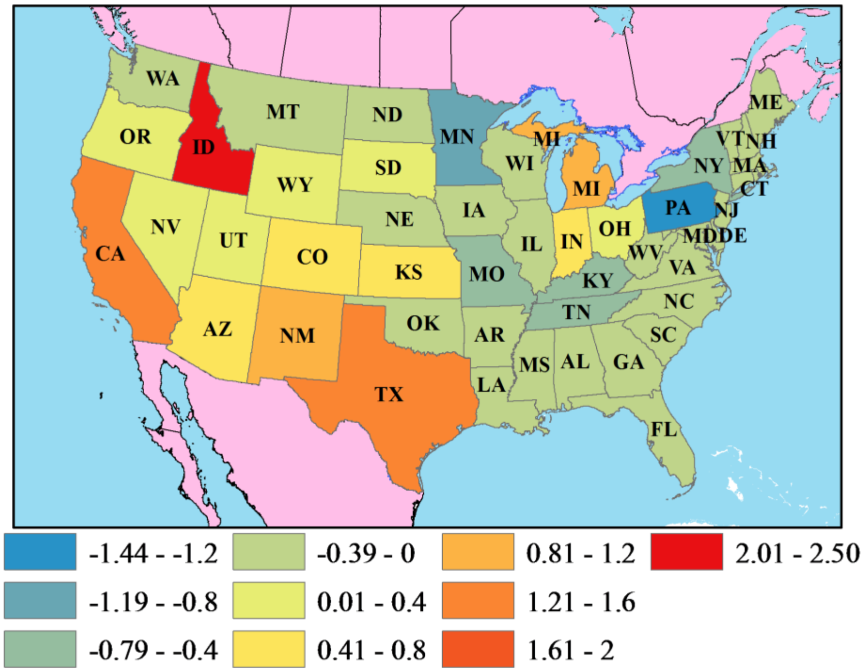


Figure 16. The share change in the amount of milk production across the 48 U.S. states from 2000 to 2012 (%)

The maps in figure 17 show the resultant MilkOrdII derived differentials under the base 2012 supply share case (left map) and the 2000 supply share shift (right map). The results indicate that the change in spatial supply patterns does affect the differentials. Whereas there is no regularity of increasing differentials from the Upper Midwest to the west in the pricing surface derived from base case (2012 supply), the differentials derived from supply shift (2000 supply) increase in a 'regular' fashion to the west. It shows that the supply shifts during the period have a significant impact on the spatial values.

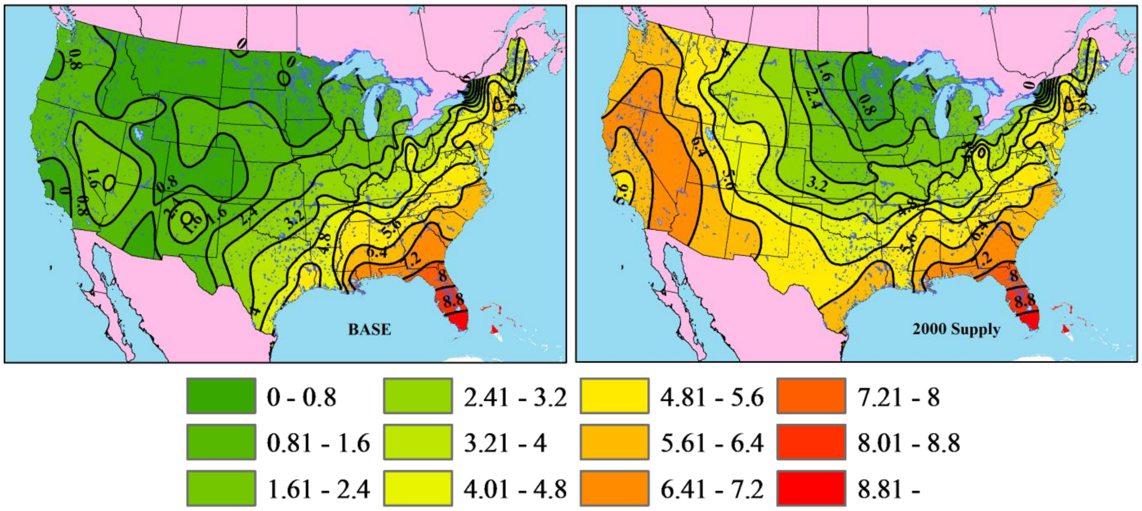


Figure 17. MilkOrdII derived Class I milk pricing surface under the 2012 BASE supply shares data (left) and that from the 2000 supply shares (right) ($/cwt.)

Figure 18 shows the impact of supply shifts on the magnitude of the Class I milk price differentials computing the Class I milk price differentials under the 2000 supply pattern minus those from the base 2012 case. In the graph, the blue shaded indicates areas where the differentials do not change a lot and the red shaded indicates areas of decreased differentials. We should also note we do not shift plant capacity so this influences the results in the northeast. General trend shows that the impact of the supply shifts has the most effect in the west. The eastern half of the U.S. decreases the values less than $1.00/cwt., but the west coast decreases the values more than $5.00/cwt. reflecting the share change in milk production. This impact corresponds to the share change of supply as shown in figure 16.

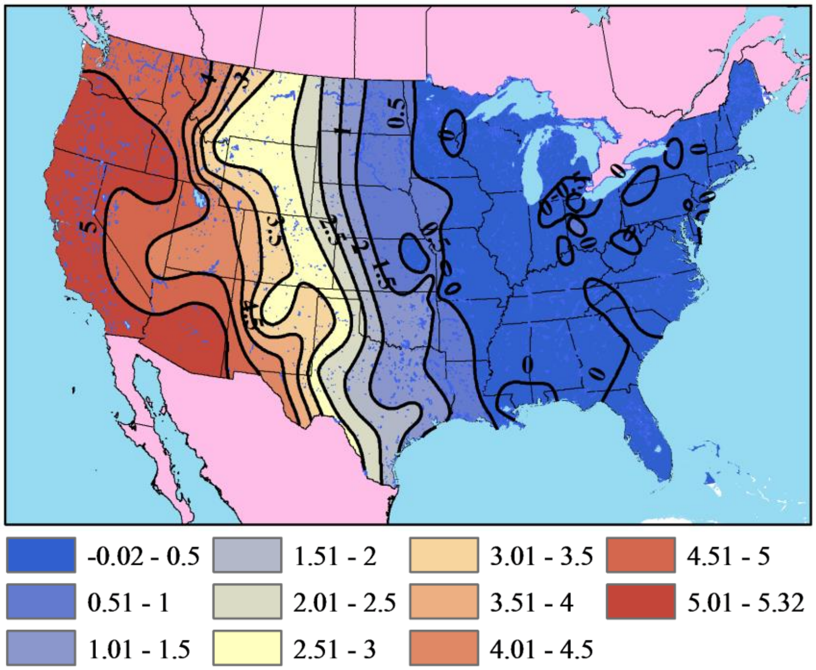


Figure 18. Impact of supply shifts from 2012 to 2000 on the magnitude of the Class I milk price differentials ($/cwt.)

3.4.3.4 Impact of spatial supply and demand shifts

We also examined the joint effects of shifting both supply and demand shares simultaneously. Figure 19 represents the resultant pricing surface. The blue shaded indicates areas where the differentials decrease and the red shaded indicates areas where they increase. As shown in the figure, the eastern U.S. shows relatively unaffected differentials with changes of less than $1.00/cwt., but the western U.S. shows decreasing differentials by more than $2.00/cwt.

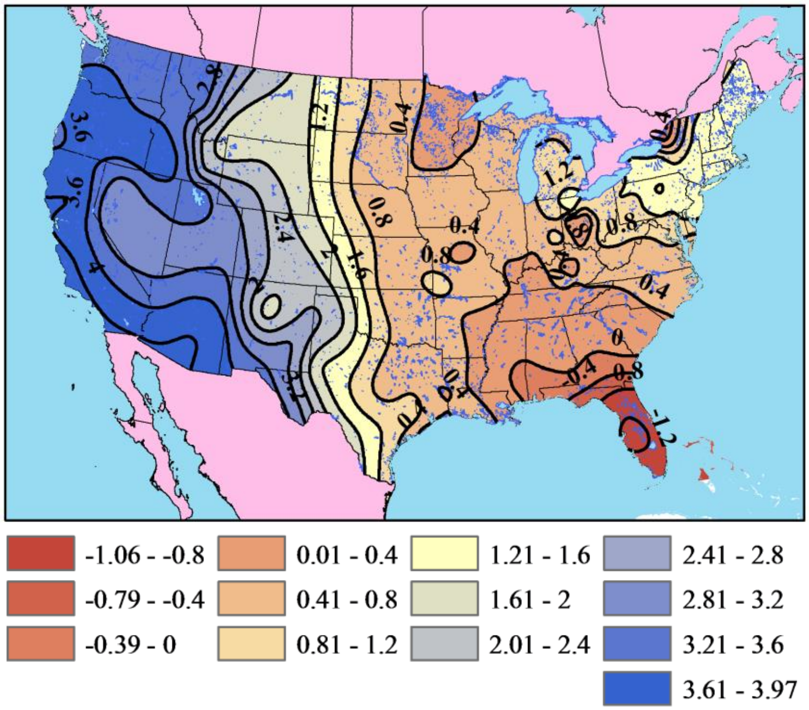


Figure 19. Impact of supply/demand shifts from 2000 to 2012 on Class I milk pricing surface ($/cwt.)

Only Florida shows increasing differentials likely because demand has increased more than supply although many other eastern states also had demand shares increase more than supply shares as shown in figure 20. It is caused by the following two reasons. First, the effect of supply shift has the differentials only decrease from 2000 to 2012 almost across the U.S. Second, only Florida in the eastern U.S. increases the differentials due to demand shift from 2000 to 2012. On the other hand, states in the western U.S. that experience decreasing differentials due to increasing regional shares of supplies have this offset by increasing differentials caused by demand shifts for example in Texas, New Mexico, Arizona, California, Oregon, and Washington.

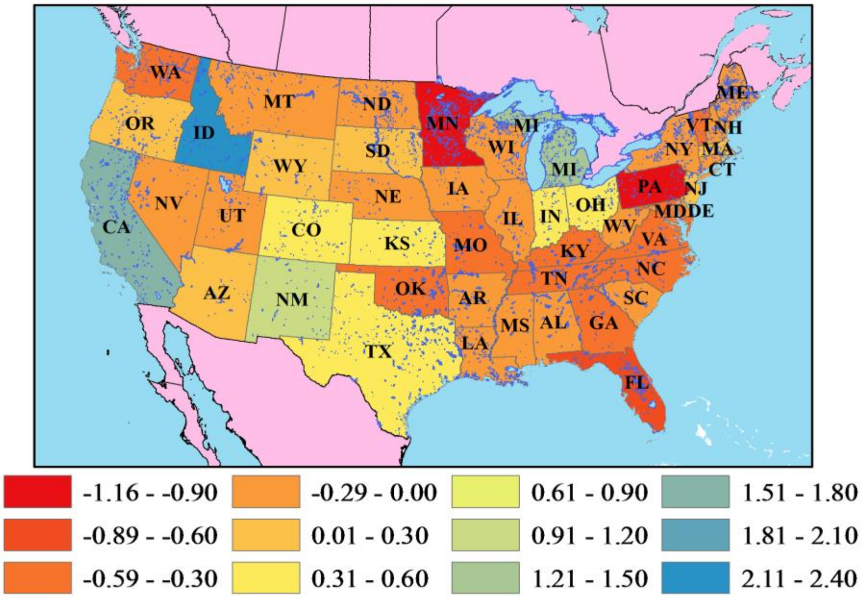


Figure 20. The difference between the share change of milk production and that of population by 48 states from 2000 to 2012 (%)

Overall, we find that the demand/supply shifts have a substantial impact on spatial values, suggesting that the altered local demand/supply are important determinants of price differentials that could be considered if price differentials are to be altered.

3.4.3.5 Impact of simultaneous spatial and fuel price shifts

Now we examine how the spatial and fuel factors jointly determine the pricing surface. When the model is run under reversion of all of these factors back to 2000 levels, the simulated pricing surface (figure 21, left map) becomes fairly similar to the current structure of Class I milk price differentials (figure 21, right map). The resultant MilkOrdII range of differentials is \$4.86/cwt, which is only \$0.46/cwt greater than that of current differential structure. FL80, the highest valued area, shows a decreasing differential from $9.48/cwt to $5.50/cwt after the diesel price is decreased from 2012 to 2000 level. It is further reduced from $5.50 to $4.86 after supply demand shifts to 2000 level. Also, the weighted average ($3.08/cwt) is almost $1 less than weighted average ($4.03/cwt) derived from base case. The value is close to the weighted average ($2.64/cwt) of current FMMO differential structure. The standard deviation of spatial differentials is $1.00/cwt, which is only $0.23/cwt greater than that of current differential structure. It implies that the current differential structure is reflective of the year 2000 conditions, and perhaps those should be updated to reflect the spatial and fuel cost developments.

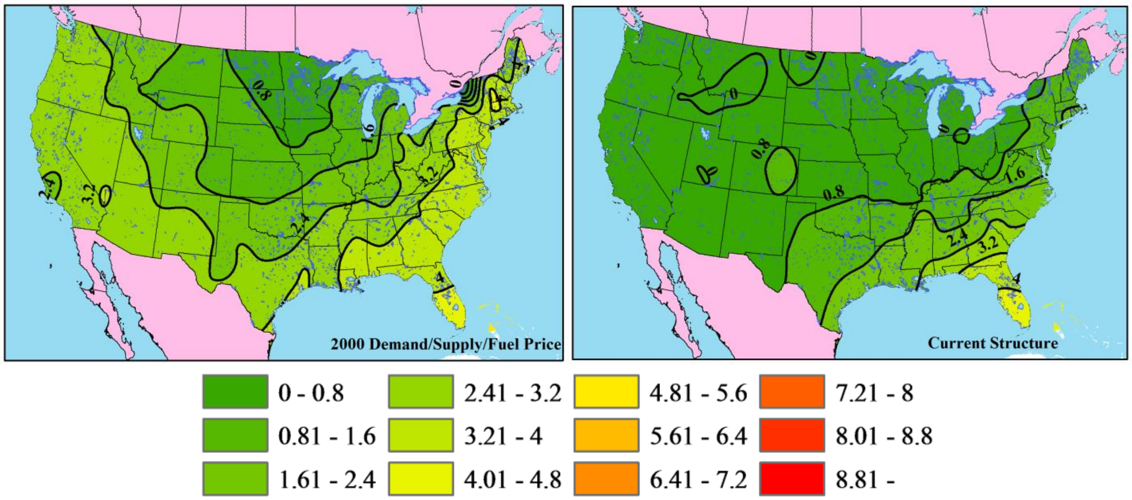


Figure 21. MilkOrdII derived Class I milk pricing surface from 2000 supply/demand/fuel price data (left), and actual Class I milk pricing surface (right) ($/cwt.)

3.4.4 Impact of supply/demand seasonality

Another factor that was investigated herein is that of seasonality. In particular, the analyses above used average annual differentials but now we examine the MilkOrdII generated monthly differentials. The seasonality of milk supply and fluid milk consumption as summarized in figure 22 causes the ranges of the differentials to vary by month.

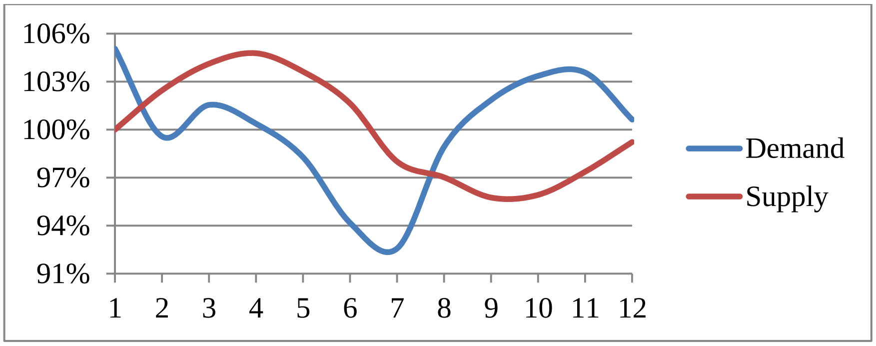


Figure 22. The U.S. monthly variations of fluid milk demand and milk supply

Figure 23 shows the monthly price differential surfaces derived from MilkOrdII. Table A-11 lists the monthly differentials for the 159 NASS crop reporting districts where fluid plants exist. The months with the largest differentials correspond to the months with the highest demands for fluid milk relative to the raw milk supply and are January, September, October, and November. The relatively small ranges of differentials occur in April, May, June, and July. Overall the smallest price differential range occurs in June ($7.28/cwt.) which is 77% of the annual average. The largest ($13.86/cwt.) is in October which is 46% greater than the annual average range.

Accordingly, we find milk seasonality significantly impacts the differentials and indicates that it might be appropriate to establish seasonally varying differentials.

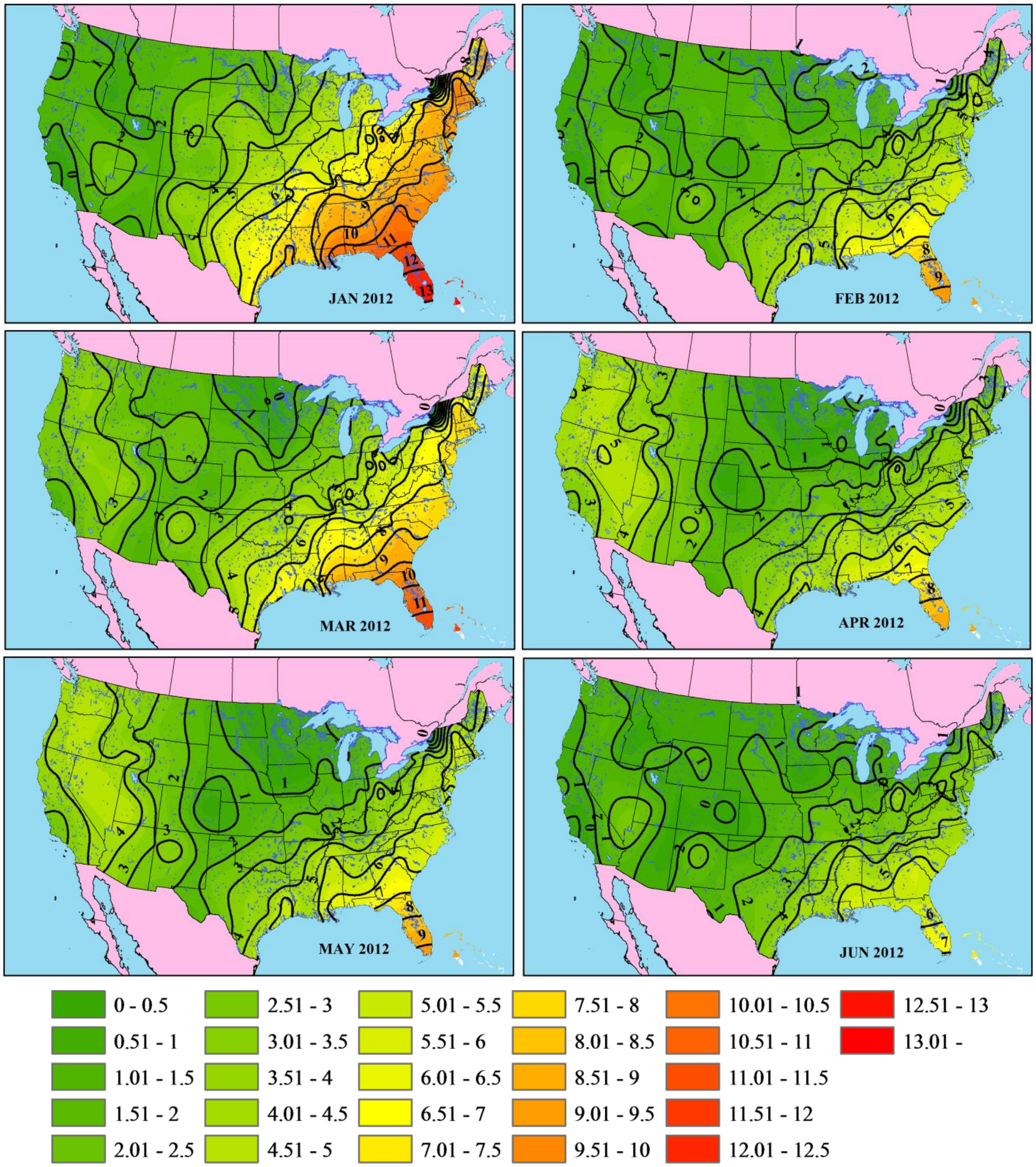


Figure 23. MilkOrdII monthly Class I milk pricing surfaces in 2012 ($/cwt.)

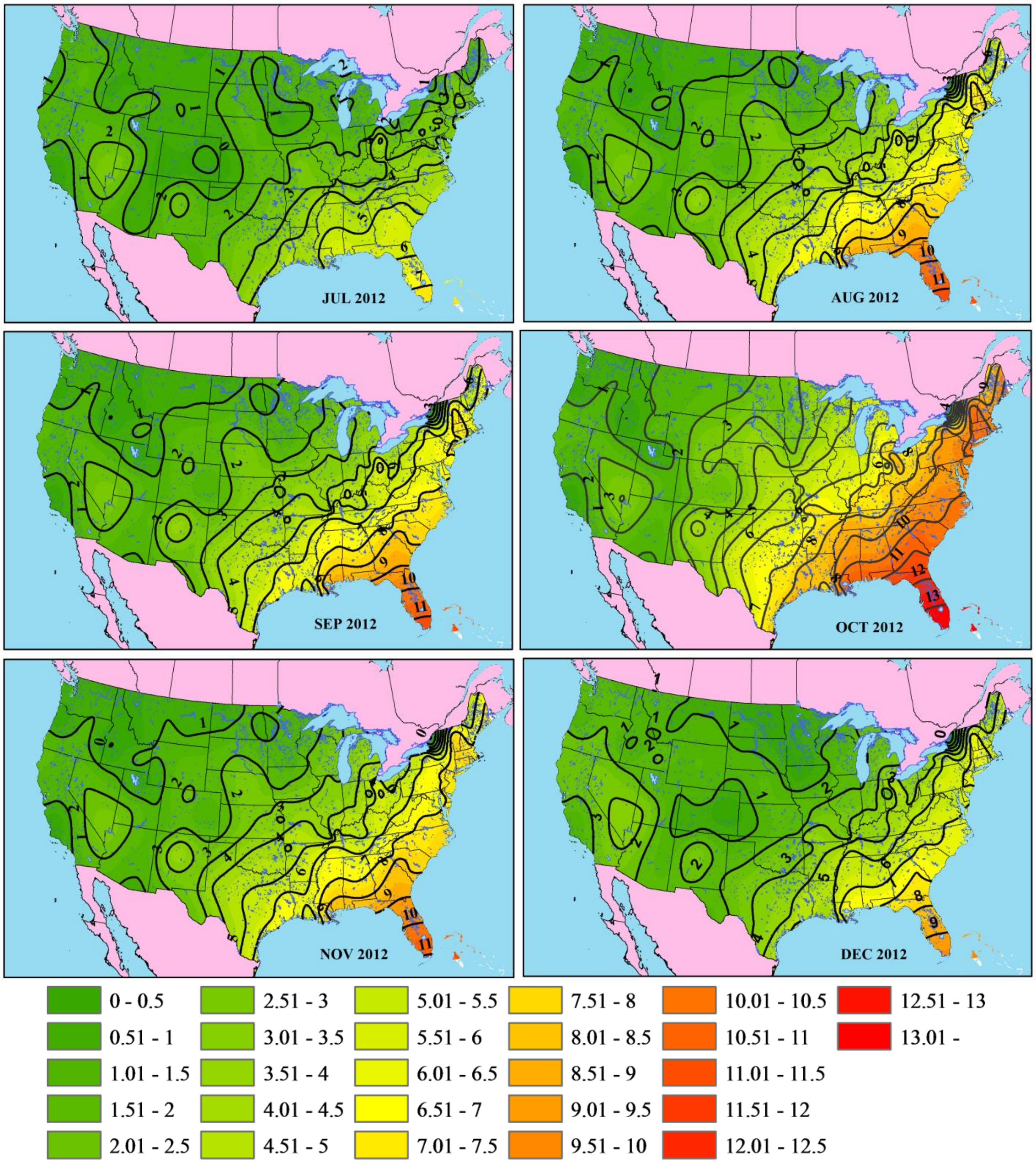


Figure 23. MilkOrdII monthly Class I milk pricing surfaces in 2012 ($/cwt.) (Continued)

Figure 24 shows the standard deviation of monthly Class I milk price differentials across the U.S. The variation in monthly differentials is relatively constant, less than $1.00/cwt. in the central U.S. On the other hand, the eastern U.S. has fluctuating differentials across the year since these areas vacillate from being exporters to importers. When there is enough regional production in surplus months such as May in the areas, their milk values are decreasing because of weak need to attract raw milk from distant areas. However, when there is deficit regional production such as October, the local demand exceeds supply, which causes prices to rise to attract milk and causes greater differentials. Accordingly, the results imply that the degree of effect of seasonality on differentials differs by the regions.

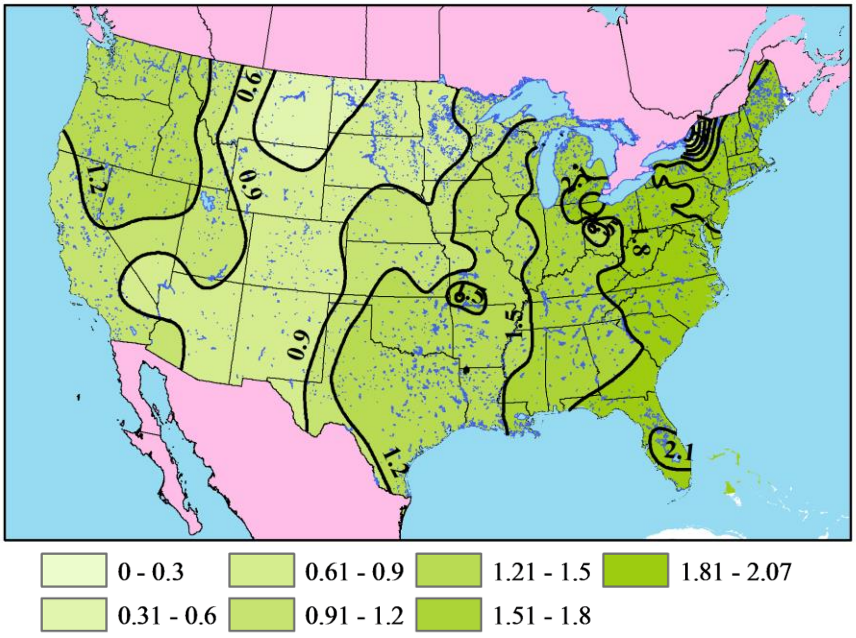


Figure 24. The standard deviation surface of monthly Class I milk price differentials in 2012 across the U.S. ($/cwt.)

3.4.5 Analysis of effects of including cooperative over-order payment

We also investigated whether the existing over order payment tool could be used to correct for the factors that have shifted differentials. Table 3 shows how well the adjusted price that includes the FMMO plus the over-order payments reflect the MilkOrd II estimated price differentials. The differences (column 3) between MilkOrdII derived differentials (column 1) and current FMMO differentials (column 2) for affected cities indicate that almost all cities have lower differential values compared to results estimated from MilkOrdII. Only two cities, Denver and Phonix, have greater Class I price differentials than model generated differentials with these being $0.60/cwt. and $0.15/cwt. Over-order payments (column 4) and announced Class I normalized prices (column 5) are listed. The last column reports the differences between model generated differentials and announced cooperative differentials. Twelve cities show positive differences, indicating that the competitive market values are still lower than simulated values. Negative differences suggest that cooperatives achieve gains by negotiating prices for fluid milk above the estimated Class I price differentials. Washington DC has the largest positive differences, indicating that the negotiated market values should be raised by $2.29/cwt. even though the over-order payment supplement the low actual differential by $1.67/cwt. Milwauke, Wisconsin has the largest negative differences of $2.29/cwt., which indicates that the city has much greater over-order payments compared to the estimated differentials.

Table 3. Comparison on Over-Order Prices with Estimated Differentials of Class I Milk in 31 Selected Cities, Average 2012 ($/cwt.)

		(1)	(2)	(3)	(4)	(5)[a]	(6)[b]
City	Marketing Order	Normalized Class I differentials			Over-Order Payment (OOP)	Actual Diff. Plus OOP	Simulated Less Actual Diff. plus OOP
		Simulated	Actual	Simulated Less Actual			
Boston	FO1	4.78	1.65	3.13	1.80	3.45	1.33
Baltimore	FO1	4.75	1.30	3.45	1.67	2.97	1.78
Philadelphia	FO1	4.98	1.45	3.53	3.09	4.54	0.44
Hartford	FO1	5.30	1.55	3.75	1.80	3.35	1.95
Louisville	FO5	3.33	1.00	2.33	3.20	4.20	-0.87
Charlotte	FO5	5.39	1.80	3.59	3.40	5.20	0.19
Miami	FO6	9.48	4.40	5.08	4.24	8.64	0.84
Atlanta	FO7	5.79	1.80	3.99	3.32	5.12	0.67
New Orleans	FO7	5.78	2.20	3.58	2.20	4.40	1.39
Springfield	FO7	3.10	0.80	2.30	2.65	3.45	-0.35
Memphis	FO7	4.35	1.30	3.05	3.20	4.50	-0.14
Chicago	FO30	1.65	0.20	1.45	3.58	3.78	-2.13
Minneapolis	FO30	0.53	0.10	0.43	2.50	2.60	-2.07
Milwaukee	FO30	1.43	0.15	1.28	3.58	3.73	-2.29
Denver	FO32	0.35	0.95	-0.60	1.39	2.34	-1.99
Des Moines	FO32	0.72	0.20	0.52	2.75	2.95	-2.23
Wichita	FO32	1.64	0.60	1.04	1.94	2.54	-0.90
Kansas City	FO32	1.85	0.40	1.45	2.24	2.64	-0.78
St. Louis	FO32	2.73	0.40	2.33	2.43	2.83	-0.10
Omaha	FO32	1.06	0.25	0.81	2.45	2.70	-1.63
Oklahoma City	FO32	2.53	1.00	1.53	2.15	3.15	-0.61
Indianapolis	FO33	2.63	0.40	2.23	2.93	3.33	-0.70
Detroit	FO33	2.35	0.20	2.15	2.91	3.11	-0.75
Cleveland	FO33	3.13	0.40	2.73	2.93	3.33	-0.20
Cincinnati	FO33	3.31	0.60	2.71	2.93	3.53	-0.22
Pittsburgh	FO33	3.88	0.70	3.18	3.69	4.39	-0.51
Seattle	FO124	1.17	0.30	0.87	0.81	1.11	0.06
Dallas	FO126	3.81	1.40	2.41	0.76	2.16	1.65
Houston	FO126	5.29	2.00	3.29	1.41	3.41	1.89
Phoenix	FO131	0.60	0.75	-0.15	0.50	1.25	-0.65
Washington	U	5.46	1.50	3.96	1.67	3.17	2.29
Average:		3.33	1.02	2.30	2.45	3.48	-0.15
Standard deviation:		2.08	0.88	1.35	0.92	1.35	1.33

a. The values in (5) are announced cooperative differentials, which are calculated as the actual Class I price differentials (2) added to the over-order payments (4).

b. The values in (6) are differences between MilkOrdII generated differentials (1) and announced cooperative differentials (5).

Among 10 federally regulated areas, FO1 (Northeast), FO6 (Florida), FO7 (Southeast), FO124 (Pacific Northwest), and FO126 (Southwest) are the areas where competitive market values are lower than the model-generated values. FO30 (Upper Midwest), FO32 (Central), and FO33 (Mideast), and FO131 (Arizona) areas have higher competitive market values than the simulated values. The simple average of differential differences decreases from $2.30/cwt. (comparison with the order-specified differentials) to almost zero ($-0.15/cwt., comparison with the announced cooperative differentials), indicating that the over-order payments are functioning as expected, increasing relatively low differentials. The standard deviation of $1.33/cwt. indicates that there are wide variations in the degree of cooperatives' bargaining effectiveness across the Marketing Order areas. The results imply that the negotiated policy tool supplements the low differentials so as to stimulate milk shipments in spite of the spatially varying impacts.

3.4.6 Impact of current TCP on spatial and seasonal Class I price differentials

We also examined whether the Transportation Credit Program (TCP) can overcome the issues with the differentials. Table 4 summarizes the effect of TCP implementation on the spatial and seasonal Class I price differentials. The range of the differentials across the U.S. is reduced to $9.15/cwt. from $9.48/cwt. The standard deviation of differentials is reduced by $0.10/cwt.

Table 4. The Impact of TCP on Spatial and Seasonal Class I Milk Price Differentials ($/cwt.)

	Weighted AVG.			Range		
	No TCP	TCP	Diff.	No TCP	TCP	Diff.
JAN	5.82	5.82	0.00	13.17	13.17	0.00
FEB	3.19	3.25	-0.06	9.60	9.64	-0.04
MAR	4.76	4.59	0.16	11.64	11.40	0.24
APR	3.29	3.23	0.06	9.14	8.85	0.29
MAY	3.64	3.54	0.11	9.42	9.18	0.24
JUN	2.44	2.14	0.29	7.28	6.10	1.18
JUL	2.50	1.89	0.60	7.69	5.98	1.71
AUG	4.46	4.51	-0.05	11.50	11.56	-0.06
SEP	3.17	3.04	0.13	8.47	8.04	0.43
OCT	6.29	6.29	0.00	13.86	13.86	0.00
NOV	4.55	4.55	0.00	11.19	11.19	0.00
DEC	3.74	3.60	0.14	9.79	9.67	0.13
AVG	4.03	3.92	0.11	9.48	9.15	0.33
STDV	1.22	1.34	-0.12	2.07	2.49	-0.42

As shown in figure 25, the impact of TCP is across the U.S even though it is implemented in only two Marketing Order areas, marked on the map by diagonal stripes. The program generally causes the high differentials to be decreased, and the lower ones to be increased. The results indicate that the TCP program does reduce the magnitude of spatially differentiated prices, which implies that it does facilitate the movement of milk to high utilization markets. However, the magnitude of the change is far from enough to remove the need for the growth in differentials in 2012.

Furthermore, the seasonality of differentials becomes greater with TCP. The standard deviation of monthly weighted differentials with TCP is 10% greater than that without TCP. Also, the standard deviation of the monthly range of differentials with TCP is 20% greater than that without TCP. This is caused by the fact that the impact of TCP is different each month. TCP reduces the differentials in high differential areas in surplus months, but in deficit months has a rather minimal effect. This results from a limited plant capacity. Although the areas using TCP are subsidized to receive more milk from the outside, the fluid plants located in the areas cannot receive raw milk exceeding their processing capacity. If a Marketing Order area is already receiving as much as its plant capacity without TCP, milk movement and milk values are not substantially changed after implementing TCP.

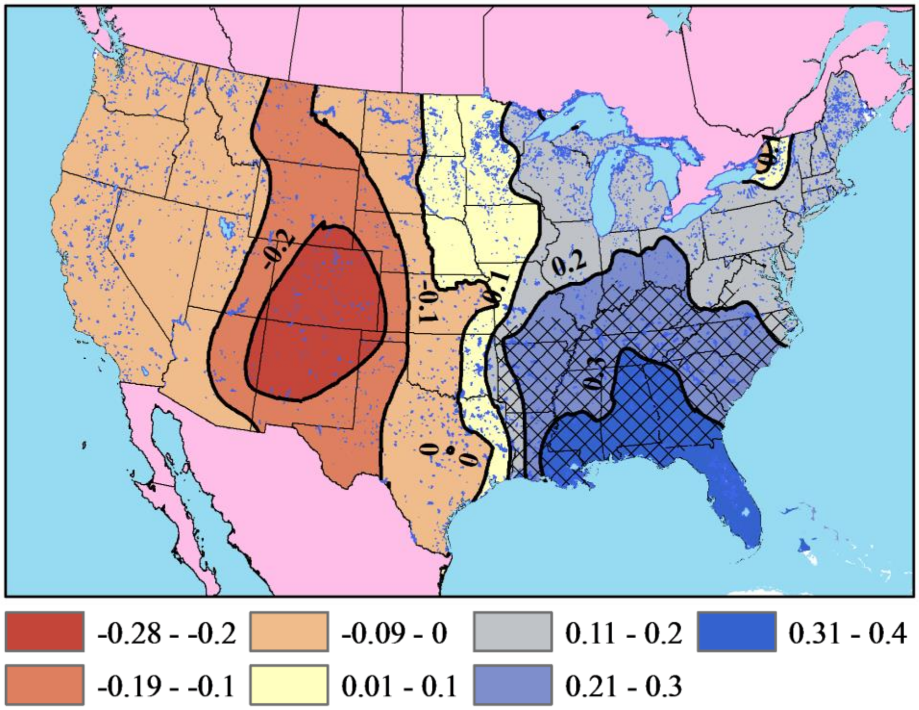
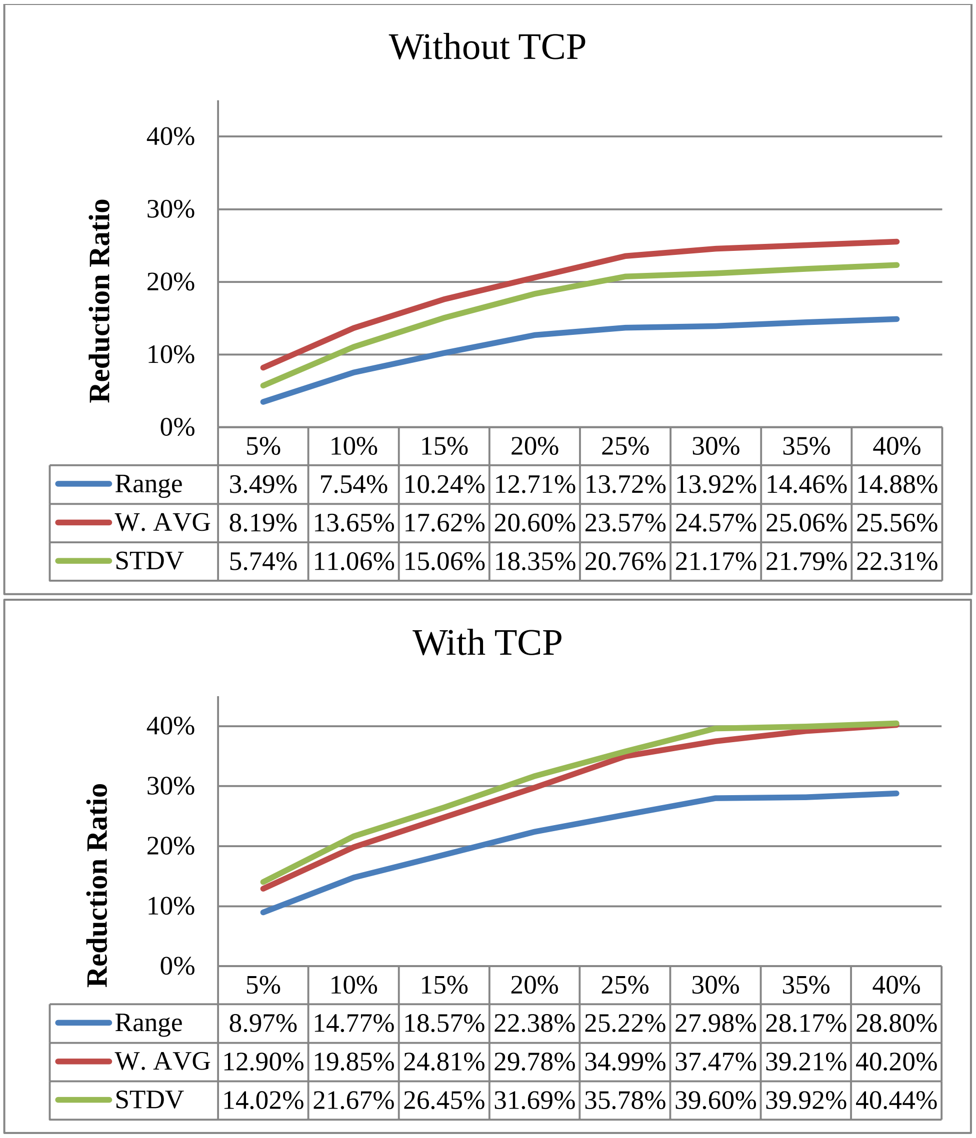


Figure 25. Impact of TCP on Class I milk pricing surface

Note: (+) represents the decreased differentials, and (-) represents the increased ones with TCP.

To reduce the differentials, it is likely that there also has to be an associated increase in capacity in the TCP credit areas with high differentials. To examine this, we simulate several cases with incremental percent increases in fluid plant capacity by 5 percent in the Marketing Order areas implementing TCP with and without the TCP in place. We find that a capacity increment has a greater impact on the spatial differentiated values than the implementation of TCP without capacity increases and that as capacity is increased, the magnitude of differential range decreases at a decreasing rate. The upper graph in figure 26 shows the decreasing rates of statistics on the disparity in the differentials compared to the results from base scenario without the TCP, where we find that more than a 25% increment has little effect. We find that the use of TCP along with capacity increase has greater influence on the differentials as shown in the bottom graph in figure 26, but again it exhibits a diminishing effect.



Without TCP

	5%	10%	15%	20%	25%	30%	35%	40%
Range	3.49%	7.54%	10.24%	12.71%	13.72%	13.92%	14.46%	14.88%
W. AVG	8.19%	13.65%	17.62%	20.60%	23.57%	24.57%	25.06%	25.56%
STDV	5.74%	11.06%	15.06%	18.35%	20.76%	21.17%	21.79%	22.31%

With TCP

	5%	10%	15%	20%	25%	30%	35%	40%
Range	8.97%	14.77%	18.57%	22.38%	25.22%	27.98%	28.17%	28.80%
W. AVG	12.90%	19.85%	24.81%	29.78%	34.99%	37.47%	39.21%	40.20%
STDV	14.02%	21.67%	26.45%	31.69%	35.78%	39.60%	39.92%	40.44%

Figure 26. The impact of TCP along with capacity expansion on spatial Class I milk price differentials

We also explore the effects of the TCP and capacity expansion on seasonality of differentials. Table 5 reports the weighted average differentials and the range of differentials by month, resulted from incremental capacity increases with TCP action.

As expected, the seasonal variation of differentials becomes smaller when capacities rise again at decreasing rate.

Table 5. The Impact of TCP along with Capacity Expansion on the Seasonal Class I Milk Price Differentials ($/cwt.)

	Weighted average of differentials									
	Base	TCP with capacity increase in fluid plants								
		0%	5%	10%	15%	20%	25%	30%	35%	40%
JAN	5.82	5.82	4.94	4.69	4.70	4.08	3.43	2.83	2.77	2.69
FEB	3.19	3.25	2.91	2.45	2.43	2.39	2.41	2.33	2.34	2.32
MAR	4.76	4.59	4.48	4.18	3.38	3.15	2.67	2.81	2.52	2.47
APR	3.29	3.23	2.83	2.74	2.73	2.63	2.55	2.63	2.48	2.46
MAY	3.64	3.54	3.28	2.92	2.87	2.80	2.73	2.73	2.57	2.52
JUN	2.44	2.14	2.11	2.08	2.08	2.08	2.07	2.03	2.05	2.04
JUL	2.50	1.89	1.88	1.88	1.87	1.83	1.84	1.82	1.82	1.81
AUG	4.46	4.51	3.65	3.20	2.88	2.55	2.51	2.41	2.44	2.39
SEP	3.17	3.04	2.62	2.43	2.40	2.40	2.38	2.36	2.35	2.33
OCT	6.29	6.29	5.26	4.83	4.68	4.25	3.59	3.10	2.96	2.92
NOV	4.55	4.55	4.56	4.03	3.49	3.02	2.67	2.65	2.64	2.56
DEC	3.74	3.60	3.05	2.87	2.50	2.48	2.41	2.40	2.36	2.35
STDV:	1.22	1.34	1.11	1.00	0.92	0.73	0.49	0.36	0.30	0.28
	Range of differentials									
JAN	13.17	13.17	11.89	11.39	11.23	10.02	8.93	7.73	7.67	7.63
FEB	9.60	9.64	8.96	7.93	7.83	7.66	7.59	7.28	7.30	7.31
MAR	11.64	11.40	11.16	10.73	9.36	8.68	7.66	7.65	7.55	7.54
APR	9.14	8.85	7.99	7.66	7.64	7.40	7.32	7.10	7.01	7.00
MAY	9.42	9.18	8.66	7.57	7.49	7.35	7.20	6.86	6.82	6.81
JUN	7.28	6.10	6.09	5.99	5.99	5.99	6.00	5.98	6.00	6.00
JUL	7.69	5.98	5.93	5.89	5.93	5.97	6.05	5.93	5.94	5.87
AUG	11.50	11.56	10.29	9.41	8.77	7.79	7.64	7.46	7.50	7.32
SEP	8.47	8.04	7.03	7.03	7.04	7.08	7.09	7.07	7.09	7.09
OCT	13.86	13.86	12.33	11.59	11.12	10.13	8.98	7.95	7.87	7.82
NOV	11.19	11.19	11.08	10.14	8.97	8.08	7.57	7.54	7.50	7.14
DEC	9.79	9.67	8.68	8.04	7.21	7.20	6.94	6.92	6.78	6.77
STDV:	2.07	2.49	2.19	1.99	1.74	1.32	0.91	0.64	0.62	0.60

The results indicate that use of TCP along with capacity expansion has a greater impact on reducing the magnitude of spatially differentiated values as well as that of seasonally varying differentials.

3.5 Discussion and conclusions

This study explores the relative price differentials of classified milk using the MilkOrdII model developed in section 2. We find that the differentials are likely out of date and in need of alteration as the model simulated differentials factoring in location and transport costs are much larger for Class I and II milk. Specifically, the model generated Class I milk differentials span a total range of $9.56/cwt. from the lowest to the highest valued place, which is much greater than that found in the currently used FMMO Class I price differentials ($4.40/cwt.). We also find a large span in Class II milk price but a relative flat surface for manufacturing (Class III and Class IV) milk.

We find the differences between the simulated and currently in use FMMO differentials arises largely because of changes in fuel prices and milk supply demand location in the time since the FMMO differentials were established (for the most part in the year 2000). This indicates that the FMMO differential structure might need to be realigned to reflect these developments.

We decomposed the effects of factors contrasting solutions with and without the shifts in spatial patterns of supply and demand plus those in transport costs to see what their relative contributions are. We find that the fuel price is the largest factor, which may indicate the set of Class I differential values might be reconsidered more often perhaps with a formula including fuel prices. Also, we find that the change in spatial supply patterns has a greater impact on the associated differentials than do spatial demand patterns changes.

We also do an analysis to find how the differentials vary by season and find they are largest in October and smallest in June varying by $6.54/cwt. Thus, we conclude seasonality also has substantial effects and that it may also be desirable to consider establishing Class I differentials on a seasonal basis.

It is a debatable and political issue about how frequent and how big the changes in differential values could be. We examine whether other policy tools would help alleviate the divergence. These include use of the negotiated over-order payment supplement and the Transportation Credit Program.

On the negotiated over order payments, we find that by judiciously using the negotiated rates in a fashion that moved them toward the larger location differentials that they can take the place of changing the overall diffeentials. However, we note this is not currently happening in general but rather in some specific regional cases with adjustments not being uniform in effect.

In terms of the Transportation Credit Program, we find that it also reduces the spatial differentials, but it would also need to be matched by expansions in processing plant capacity.

4. BEHAVIORAL RESPONSE TO UPDATING YIELDS UNDER CROP INSURANCE

The Actual Production History (APH) yields are a critical factor in determining crop insurance guarantees for buy-up policy, but farmers have felt that the APH yields were not fully reflective of their current expectations. In 2012, USDA-RMA introduced a pilot program, which increases APH by a trend factor. Essay three of the dissertation analyzes the effects of the program on the farmers' risk. Since the program was implemented in selected counties for selected crops, the difference-in-difference strategy is used for this study.

4.1 Introduction

Agriculture is a risky enterprise since crop production is greatly influenced by uncertain weather conditions and market prices. Farmers manage part of this risk using the federal crop insurance program.

Federal crop insurance participation rose from 36 percent in 1990 to 83 percent in 2011[24]. Also, acres insured using the buy up policy increased from 78 percent in 2000 to 92 percent in 2011. However, many farmers have expressed frustration with the current method of calculating the Actual Production History (APH) yields used to determine crop insurance guarantees (Edwards, 2014; Smith, 2012; Skees and Reed,

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[24] Several crops are excluded in the insured percentage; including hay, livestock, nursery, and pasture/range/forage. For detailed information on market penetration, see USDA-RMA report (2013a).

1986). Moreover, some researchers indicate that the simple average of 10-year historical yields does not accurately reflect the expectations of this year's yield, due to technical improvements (Adhikari, Knight, and Belasco, 2012; Umarov, 2009; Woodard, 2009). In response, the Risk Management Agency (RMA) introduced the Trend Adjusted – Actual Production History (TA-APH) program as a pilot program in the 2012 crop year in select places to test the concept of a time adjusted yield. This research evaluates the effects of the pilot program. In particular, we examine the effects of the program on the farmer participation rate and coverage levels elected.

Since the program was carried out in selected counties, it provides a natural setting for studying these questions. We compare farmers' response before and after the program enactment for counties (treatment group) eligible for the program and for control counties (control group) ineligible for the program.

4.2 Background

The TA-APH program allows farmers to adjust their covered yields upwards to reflect the temporal advancements in yields due to technological change. This increases a farmer's APH and provides them with higher level of covered yields. The program was approved by the Federal Crop Insurance Corporation (FCIC) in October, 2011 (USDA-RMA, 2011). As of 2012, the program was implemented only in the selected counties in the Corn Belt for corn and soybeans as shaded in figure 27. There are some restrictions on the eligible crops: organic or transitional grown crops, corn grown for silage, and soybeans insured as specialty type are not eligible for the program. The TA-

APH program is available for only buy-up policy including Yield Protection (YP), Revenue Protection (RP), and RP with Harvest Price Exclusion (RP-HPE) policies at all coverage levels, except the catastrophic coverage (CAT) of 50 percent yield guarantee. Group policies such as Area Yield Protection (AYP) and Area Revenue Protection (ARP) are not included since those use the county yields which has been already adjusted by long-term trend. The program has been expanded to more crops and regions since the 2013 crop year.

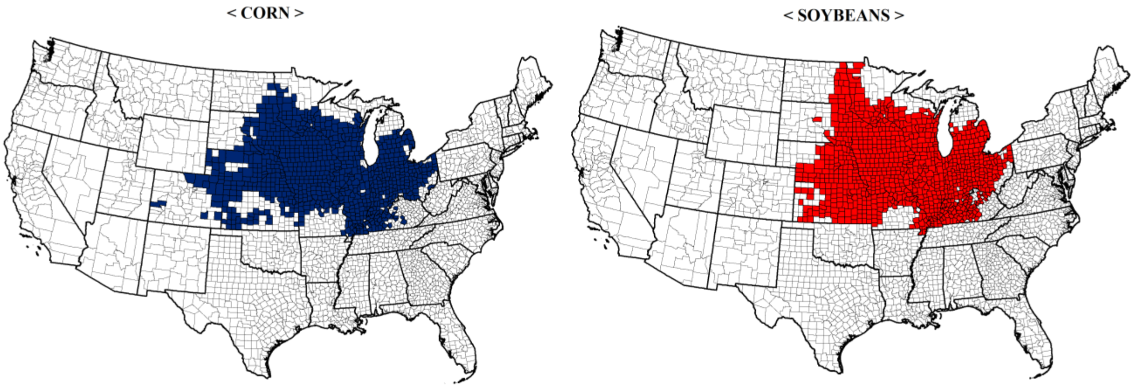

Figure 27. Counties eligible for TA-APH as of crop year 2012 for corn and soybeans

The trend adjustment (TA) factor used in the program is based on county-level yield data from USDA-NASS. It is an estimated annual increase in yield and also controls for weather and spatial trends. All farmers within a county use the same TA factor. The individual yield for each year of history is adjusted by the factor times a multiplier. The usage of the TA factor depends on a farm's number of years of actual yield history. To obtain the full TA factor, farmers need to have at least 4 or more years of yield history. The percentage decreases to 75 percent with 3 years of yield history, and 50 percent with 2 years and 25 percent with 1 year. Also, the calculated TA-APH cannot exceed the highest actual yield in the history plus the TA factor, which is called as “TA Cap”.

4.3 Related literature

Research on crop insurance has evolved with the program. Research initially addressed the lack of participation with substantial work focusing on the effects of premium rates on insurance demand (Shaik et al., 2008; Goodwin, Vandeveer, and Deal, 2004; Serra, Goodwin, and Featherstone, 2003; Coble et al., 1996; Gardner and Kramer, 1986). The studies found that the premium rates did not have an effect on program enrollment. Some studies attributed low participation to adverse selection with only farmers expecting higher indemnities participating (Glauber, 2004; Goodwin, 1993). Smith and Baquet (1996) found that premium rates affect the coverage level chosen by farmers. Later, research examined the importance of premium subsidies. Babcock and Hart (2005) found that coverage level increases as subsidy rates increase. O’Donoghue (2014) found that subsidy increases were not influential in new acre enrollment, but were in coverage rates on enrolled acres. Smith and Glauber (2012) asserted that the crop insurance program probably would not exist without premium subsidies.

Recently, scholars have turned to the influence of APH. Skees and Reed (1986) argued that farmers with a significant upward yield trend face a downward biased APH relative to their “true” expected yield. Woodard (2009) showed that the premium rating is biased upward by 75 percent to 180 percent from a fair premium when the yield shows a positive trend. Umarov (2009) in a simulation experiment concluded that adjusting the yield trend increases the protection level guaranteed by insurance and increases participation rates. Adhikari, Knight, and Belasco (2012) concluded that incorporating a proper yield trend can improve producer welfare. Smith (2012) also evaluated several methods to adjust APH for yield trends.

To our knowledge, no papers have addressed the actual impact of the TA-APH pilot program. USDA-RMA (2012) reported some statistics on farmers’ participation showing that program participation was high; 71 percent and 63 percent of eligible acres for corns and soybeans, respectively. Also, it represented that the farmers who selected higher coverage levels in 2011 generally decreased their coverage but those who selected lower coverage levels in 2011 moved up a step in 2012 with the average coverage level remaining almost unchanged.

We contribute to the literature on the crop insurance by evaluating the pilot program controlling for a non-participating groups, farming experience, liability rates, and subsidy rates. In doing this, we examine the effects on participation rates and coverage levels elected.

4.4 Expected results on coverage level

It is expected that program participation will increase given a yield trend. In respect to the effects on coverage level elected, some argue that farmers keep the previous coverage level unchanged, taking more dollar value of coverages and paying more premiums. Others expect that farmers would elect the lower coverage level for almost the same dollar value of coverages. It is a plausible alternative since farmers receive the higher subsidy rates for lower coverage levels (Edwards, 2014). This section analytically explores how adjusting the APH by the TA factor impacts the coverage level elected under the assumption that the willingness to pay for insurance is not be changed upon the program. Here farmers would pay the same amount of premiums if they consider that the ratemaking of loss cost ratio is actuarially sound (Woodard, Sherrick, and Schnitkey, 2011). First, total premiums including premium subsidies should equal expected indemnities for the actuarial soundness for the crop insurance (Coble et al., 2010).

(34) $$Prem(\theta) = E[I(\theta)]$$

where $Prem$ is total premium and I is indemnity given a selected coverage level, θ.

The expected indemnity is given according to a type of insurance policy. For simplicity, assume that the established price coverage is 100%. Under the YP, insured parties can receive an indemnity when their actual yields fall below the guaranteed yield, so the expected indemnity is calculated as:

(35) $$E[I_{YP}(\theta)] = \int_{0}^{Y_{Max}} [P_e * Max(0, APH * \theta - Y)]dF(Y))$$

where I_{YP} is indemnity under the YP, P_e is expected price of insured commodity, APH is actual production history yield, and $F(Y)$ is cumulative distribution of actual yield, Y.

Under the RP, insures can receive an indemnity when their actual farm revenue falls below a certain percentage of the target level of revenue. Thus, the expected indemnity under the RP is:

$$(36)\qquad E[I_{RP}(\theta)] = \int_{0}^{Y_{Max}} [Max(0, APH * \theta * Max(P_e, P_h) - Y * P_h)] dF(Y)$$

where I_{RP} is indemnity under the RP, and P_h is harvest price of insured commodity. Under the RP, farmers protect the revenue based on the higher of expected price and harvest price. On the other hand, RP-APH policy does not consider the harvest price in the revenue protection.

The premium rate for each coverage level is created by individual history of the ratio of indemnity to liability. A premium rate for each level is then calculated as:

$$(37)\qquad Rate(\theta) = E[\frac{I(\theta)}{L(\theta)}]$$

where $Rate$ is a premium rate given a coverage level. From this equation, expected indemnity equals the premium rate multiplied by expected liability as:

$$(38)\qquad E[I(\theta)] = PRate(\theta) * E[L(\theta)]$$

Combined with equation (34), total premium is calculated as premium rate multiplied by expected liability as:

$$(39)\qquad Prem(\theta) = E[I(\theta)] = Rate(\theta) * E[L(\theta)]$$

The liability for each coverage level is determined as APH multiplied by the coverage level. Then, total premium is specified as:

$$Prem(\theta, APH) = Rate(\theta) * APH * \theta \tag{40}$$

Since total premium is dependent on APH, APH is included in the function of total premium as indicated in equation (40). By assuming that farmers will not change total premiums, total differential of total premiums is zero. To simplify notation, the function of total premium, $Prem(\theta, APH)$ is defined as f. Then,

$$\left[\frac{\partial f}{\partial Rate(\theta)} \cdot \frac{\partial Rate(\theta)}{\partial \theta} + \frac{\partial f}{\partial \theta}\right] \cdot d\theta + \frac{\partial f}{\partial APH} dAPH = 0 \tag{41}$$

After rearranging the terms, the effect of the APH on the coverage level elected is shown to be negative:

$$\frac{d\theta}{dAPH} = -\frac{\frac{\partial f}{\partial APH}}{\left[\frac{\partial f}{\partial Rate(\theta)} \cdot \frac{\partial Rate(\theta)}{\partial \theta} + \frac{\partial f}{\partial \theta}\right]} \tag{42}$$

since every term on the right side in equation (42) is positive. As the TA-APH program makes an increase in APH by the TA factor, the coverage level chosen by farmers is adversely affected and gets lower.

4.5 Data and empirical specification

4.5.1 Data

To study the effects of the TA-APH program on the farmers' participation and coverage level elected, we use data from two sources. The primary data source is the contract records of all types of crop insurance for insurable crops in the U.S. over the period 1989 to 2013 obtained from USDA-RMA. The contract records contain information on crop year, state, county, crop code, RMA code of insurance plan, identifier of CAT or buy-up policies, coverage level elected by the insured, number of policies reported to RMA and policies indemnified, insured acres reported to RMA, liability, total premium (before application of any subsidies), subsidized premium, indemnity, and loss ratio. Planted acres data were collected from USDA-NASS surveys. Some counties show greater insured acres as reported by RMA than the planted acres reported by NASS. The disagreement might be caused by sampling errors. RMA can report insured acres which are admitted by insures due to the Freedom of Information Act whereas NASS uses sample surveys from farm cooperatives to collect county-level data on planted acres (Tronstad et al., 2014). In the case of the discrepancy, every planted acre is assumed to be insured by buy-up policies.

We employ a Difference in Difference (DD) strategy comparing farmers eligible for TA-APH programs as of 2012 (treatment group) to farmers ineligible for the program (control group). The crucial identifying assumption is that farmers' behaviors do not vary systematically across treatment group and control group over time. To avoid the potential, the impact of TA-APH program is estimated only in the crop years from 2010.

To our knowledge, there have been no significant changes in the crop insurance program, which might affect the farmers' behaviors to the crop insurance. Since our main purpose is to find the impact of TA-APH program, we restrict the sample to the type of crop insurance policies eligible for the program, which are buy-up policies including YP, RP, and RP-HPE. Also, the sample consists of only main production regions for each crop since farmers in minor regions might have different characteristics or attitudes for crop insurance program.

Several covariates are constructed to account for the possibilities that farmers within a group have systematically different behaviors in different time periods. The farmer's decision on the crop insurance participation in the current year depends partly on the experience from the previous year. Thus, we include the lag of the loss ratio. Also, subsidy per acre and liability per acre are included as covariates to account for county-level characteristics. The controls are constructed for each county.

Table 6 presents means and standard deviations for the outcome variables and control variables. The insured percent of the control group is higher than that of the treatment group over the analysis period. This occurs since TA factor was first applied in the lower risk Midwest region, whereas the non-participants are elsewhere. The weighted average coverage level shows the opposite where the treatment group elects a higher coverage level. This reflects RMA's restriction on the maximum coverage level depending on the risk (USDA-RMA, 2013b). Farmers in low-risk areas can elect 85 percent coverage, whereas high-risk areas are assigned a maximum of 75 percent coverage. The treatment group’s loss ratios increase dramatically in the crop year 2012 due to the drought and the effect of the TA-APH program.

Table 6. Descriptive Statistics in the Sample by Groups and Crops

Outcome Variables									
		Corn				Soybeans			
		2010	2011	2012	2013	2010	2011	2012	2013
Percent of acres insured by buy-up Policy	total	80.24	83.40	83.74	88.12	78.34	81.10	81.68	86.10
		(22.51)	(21.21)	(20.35)	(17.85)	(22.18)	(20.63)	(19.85)	(17.49)
	treatment	74.08	78.02	78.85	84.70	73.14	75.55	77.68	83.19
		(19.32)	(17.87)	(16.58)	(15.26)	(18.80)	(17.48)	(15.79)	(14.68)
	control	89.72	91.48	90.97	92.95	85.82	88.99	87.19	89.99
		(23.77)	(23.20)	(23.09)	(20.01)	(24.43)	(22.16)	(23.27)	(20.01)
Weighted average of coverage level	total	70.84	71.44	71.75	73.03	71.22	71.67	71.90	72.92
		(6.67)	(6.87)	(6.55)	(6.99)	(5.85)	(5.83)	(5.54)	(5.69)
	treatment	73.97	74.77	74.87	76.63	73.90	74.39	74.43	75.71
		(3.61)	(3.75)	(3.70)	(3.61)	(3.68)	(3.72)	(3.57)	(3.54)
	control	64.93	65.47	66.29	67.10	66.71	67.23	67.92	68.70
		(7.09)	(7.15)	(6.88)	(7.16)	(6.04)	(5.93)	(5.76)	(5.72)
Control Variables									
		2010	2011	2012	2013	2010	2011	2012	2013
Lag of loss ratio	total	0.61	0.67	1.04	2.61	0.43	0.51	0.90	0.97
		(1.11)	(1.12)	(1.76)	(2.98)	(0.74)	(0.74)	(1.10)	(1.19)
	treatment	0.34	0.59	0.62	3.33	0.26	0.38	0.61	1.13
		(0.37)	(0.80)	(0.77)	(2.93)	(0.30)	(0.45)	(0.71)	(1.19)
	control	1.12	0.83	1.79	1.32	0.72	0.71	1.38	0.73
		(1.71)	(1.54)	(2.61)	(2.60)	(1.09)	(1.04)	(1.43)	(1.14)
Liability per acre	total	384.1	573.1	577.8	580.4	246.1	363.0	350.2	360.9
		(111.5)	(172.7)	(176.3)	(176.2)	(73.8)	(113.4)	(116.1)	(120.4)
	treatment	424.9	652.1	658.0	658.6	284.9	424.1	414.8	428.5
		(79.7)	(123.6)	(124.3)	(125.7)	(53.6)	(81.5)	(81.2)	(87.7)
	control	307.3	431.8	437.7	451.8	180.8	262.9	248.1	258.6
		(122.0)	(157.4)	(166.0)	(171.7)	(54.5)	(83.2)	(85.7)	(86.0)
Subsidy per acre	total	25.69	38.91	34.86	35.02	19.87	29.20	27.00	26.60
		(9.17)	(13.34)	(13.20)	(14.24)	(7.19)	(8.82)	(9.85)	(9.32)
	treatment	25.88	40.55	35.22	34.58	17.61	27.76	24.70	24.09
		(7.05)	(10.15)	(9.59)	(10.82)	(4.79)	(6.93)	(6.62)	(6.62)
	control	25.34	35.97	34.22	35.73	23.66	31.55	30.64	30.39
		(12.19)	(17.30)	(17.83)	(18.53)	(8.79)	(10.86)	(12.63)	(11.32)
Observation		1,365	1,380	1,388	1,411	1,502	1,509	1,529	1,550

4.5.2 Percent of insured acres with buy-up policies

For our analysis, we construct an outcome variable representing participation rates reflecting the percentage of insured acres with buy-up policy among the planted acres. Like most studies that employ DD strategy, our regression takes the following form for corn and soybeans:

$$Y_{it} = \alpha_1 + \alpha_2 Treat_i + \alpha_3 Post_t + \beta_1 (Treat_i * Post_t) + \mathbf{X_{it}}\boldsymbol{\delta} + \varepsilon_{it} \tag{43}$$

where *i* denotes county and *t* refers to time. Y is the percentage of insured acres. $Treat$ is 1 for counties eligible for the TA-APH program as of 2012, and 0 for ineligible counties. $Post$ identifies years after program implementation and is 1 after the crop year 2012, 0 before. $\mathbf{X}$ is a set of control variables and ε is the error term. Standard errors are clustered both at the year and state levels (Bertrand, Duflo and Mullainathan, 2004).

Our coefficient of interest, β_1, captures the changes in farmers' participation in counties eligible for TA-APH program with respect to farmers' participation in ineligible counties. To check for threats to internal validity, the Difference in Difference in Difference (DDD) approach is exploited as a work of Ravallion et al. (2005). The regression takes the following specification:

$$\begin{aligned} Y_{ict} = {} & \alpha_1 + \alpha_2 Treat_i + \alpha_3 Post_t + \alpha_4 Crop_c + \alpha_5 (Treat_i * Post_t) \\ & + \alpha_6 (Treat_i * Crop_c) + \alpha_7 (Crop_c * Post_t) + \beta_2 (Treat_i * Post_t * Crop_c) \\ & + \mathbf{X_{ict}}\boldsymbol{\delta} + \varepsilon_{ict} \end{aligned} \tag{44}$$

where c indexes the crop and others are the same as DD specification. $Crop$ is a dummy variable for eligible crops for TA-APH program as of 2012. Wheat and cotton are considered as the control crop ($Crop = 0$) compared to the treatment crop ($Crop = 1$) including corn and soybeans. The DD estimate from equation (43) does not take account for non-program factors that differentially affected the participation in the buy-up policy in treatment group. However, farmers growing non-eligible crops in the treatment group were not affected by the TA-APH program, so the DD estimate for farmers growing control crops in treatment group and in control group provides an estimate of the non-program factors. Subtracting the second DD estimate from the first DD estimate adjusts the simple before/after change in the behaviors of farmers growing the selected crops in eligible counties upon the TA-APH program. It accounts for both general trends in farmers who grow any crops and trends differentially affecting farmers' behavior in the eligible counties. The coefficient of interest is β_2, representing more convincing impacts of the program on the participation rates (Wooldridge, 2010).

4.5.3 Coverage level elected

We construct the outcomes of coverage level elected by farmers to evaluate the intensive margins of TA-APH program's effect. Two different outcomes are employed for the analysis. The first one is the weighted average of coverage level elected by farmers, and the regression specification is the same as the equation (43). The outcome is calculated as the following way:

$$\text{(45)}\quad \text{Weighted average of coverage level} \\ = \frac{\text{sum of (coverage level} * \text{acres elected by coverage level)}}{\text{total insured acres}}$$

The second outcome is used to see the program's effects on farmers' decision of specific coverage level. The outcome is the probability of each coverage level elected by farmers, and it is constructed as the following way:

$$\text{(46)} \quad \text{Probability of each coverage level elected} = \frac{\text{acres elected by coverage level}}{\text{total insured acres}}$$

Since some counties are restricted by 75 percent as the maximum coverage level, we dropped the counties where there was no policy sold at higher than 75 percent to obtain the consistent estimates. The controls used in this regression are values for each coverage level. The DD specification is very similar to base DD design as indicated in equation (43), but it is analyzed for each coverage level.

4.5.4 Common trend assumption and robustness check

An important assumption for the DD analysis is common trends for the outcome variable prior to the TA-APH program. Figure 28 sheds light on this for the participation outcome for both corn and soybeans. We see that the control group has a higher participation in buy-up policy than the treatment group at all times, but the gap has consistently decreased. The trends are fairly similar from 2006 to 2013 and show that the common trend assumption is close to satisfied except for the striking differential changes occurred from 2009 to 2010 and from 2011 to 2012. Thus, we use a period from the crop year 2010 to 2013 for our analysis, and the placebo test will use the period from the crop year 2006 to 2009. The second differential change might be caused by the TA-APH program. Figure 29 shows the trends in the weighted average coverage level for treatment and control groups from 2006 to 2013. Those seem to be similar until the enactment of the TA-APH program, the crop year 2012.

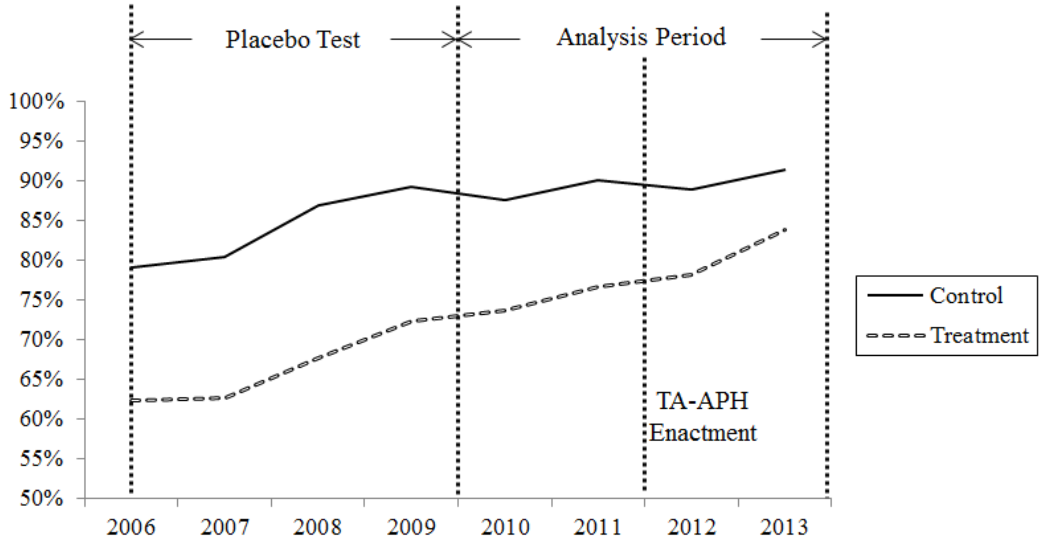

Figure 28. Trends in percent of insured acres by buy-up policy

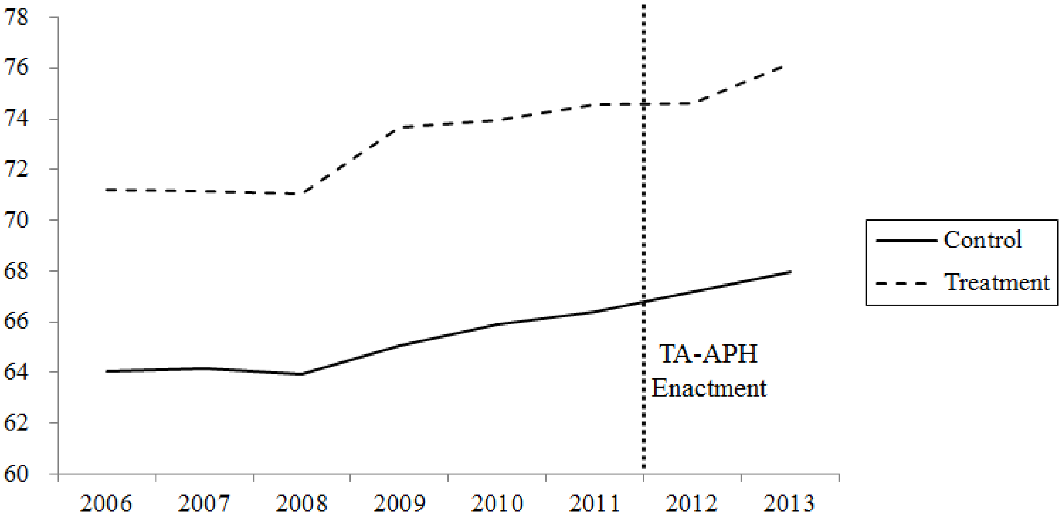

Figure 29. Trends in weighted average level of coverage

We conduct several robustness checks to validate our results. The DD analysis does not take account of non-program factors that differentially affected the farmers' behaviors in eligible counties. Thus, DDD analysis is used by further refining the treated groups and control groups along with the selected crops. We also show that the usual parallel trends assumption required of DD designs appears valid for outcomes we examine. A placebo test imposing an enactment of the program four years before it actually began reveals no effects for the relevant treatment and control groups, further showing support that our results driven by the TA-APH program.

4.6 Results

4.6.1 The TA-APH program effect on participation rates

Table 7 shows results for the effect of TA-APH program on the percentage of acres insured by buy-up policy. Column (1) contains estimates from a specification without any control variables specified in DD equation (43). As expected from table IV-1, the sign on the TA-APH program effect is negative showing diminished participation and should be interpreted as the results if the program was enacted in counties with low participation rates in the crop insurance compared to other counties. However, the coefficient switches after including binary variables for the *Post* and *Treated* in column (2). Column (3) is the complete model including county level controls. The *Post* dummy captures the effect of the TA-APH program in the period after the enactment, compared to the period before. The *Treated* dummy captures the effect of farmers eligible for the program (treatment group) to non-eligible farmers (control group). The

*Post*Treated* dummy captures the differential effect of the TA-APH program on the farmers eligible for the program.

We find that the program is associated with an increase of 4 percentage points in the probability of insured acres with the buy-up policy. The effect on soybean farmers of 5.1 percentage points is larger than corn farmers of 3.1 percentage points. The estimate of the lag of loss ratio is a positive and significant effect on the participation in current year. It corresponds to our expectation that farmers experiencing a serious loss in the previous year might be more willing to participate in crop insurance. The specification in columns (3) to (5) include county level controls for loss ratio in the previous year, level of liability per acre, and level of subsidy per acre.

As can be seen from comparing columns (2) and (3), the estimates are robust to inclusion of controls. One of the main concerns in these estimations is that the residuals are serially correlated, which results in underestimated variance (Bertrand, Duflo, and Mullainathan, 2004). We employ the Newey-West formula for estimating standard errors to overcome serial correlation as well as heteroskedasticity (Newey and West, 1994). The level of significance remains unaffected for the estimate of interests, as shown in columns (6) and (7).

Table 7. The Effects of TA-APH on Insurance Participation Rates

	(1)	(2)	(3) All	(4) Corn	(5) Soybeans	(6) Corn	(7) Soybeans
Post*Treated	-0.025***	0.046***	0.040***	0.031***	0.051***	0.031**	0.051***
	(0.004)	(0.010)	(0.012)	(0.011)	(0.018)	(0.014)	(0.013)
Post		0.013**	0.009	0.025**	0.002	0.025**	0.002
		(0.006)	(0.008)	(0.011)	(0.011)	(0.012)	(0.011)
Treated		-0.137***	-0.113***	-0.106**	-0.106***	-0.106***	-0.106***
		(0.036)	(0.034)	(0.045)	(0.037)	(0.013)	(0.011)
Lag of loss			0.009***	0.008**	0.009	0.008***	0.009***
ratio			(0.003)	(0.003)	(0.006)	(0.001)	(0.003)
Liability/acre			0.000	0.000	0.000	-0.000***	0.000
			0.000	(0.000)	(0.000)	0.000	0.000
Subsidy/acre			0.000	0.000	0.001	-0.000*	0.001**
			(0.001)	(0.001)	(0.001)	0.000	0.000
Constant	0.836***	0.889***	0.853***	0.923***	0.819***	0.923***	0.819***
	(0.022)	(0.004)	(0.029)	(0.030)	(0.048)	(0.014)	(0.015)
Observations	11,634	11,634	10,585	5,016	5,569	5,016	5,569

Note: Estimated standard errors in Columns (6) and (7) are corrected by Newey-West formula.
*** p<0.01, ** p<0.05 * p<0.10.

4.6.2 The TA-APH program effect on coverage levels

Table 8 presents results on coverage levels elected by farmers. The sign on the interaction term in the simplest specification is significantly positive, which reflects the tendency of program participants to increase coverage levels over the analysis period. Upon the inclusion of two binary variables, the estimate of the TA-APH program is negative, in spite of insignificant effect on the coverage level as shown in column (2).

The complete model in column (3) suggests that the TA-APH program has a significantly negative effect on the coverage level elected by farmers. The farmers eligible for the program choose a lower level of coverage by 0.66 percent compared to the ineligible farmers. The loss ratio in the previous year has a positive impact on the coverage level elected in the current year as expected. Columns (4) and (5) show the results for corn and soybeans. After the TA-APH program, the eligible farmers growing soybeans are likely to elect a 1.3 percent lower level of coverage level and corn farmers elect a 0.9 percent drop. The sign of other controls conforms to the general pricing policy in crop insurance even though some coefficients are close to zero and statistically insignificant; the level of coverage increases with a higher subsidy per acre and liability per acre. By estimating Newey-West serial correlation consistent standard errors, we get corrected standard errors as shown in columns (6) and (7). There we see no impacts on the significance level.

Table 8. The Effects of TA-APH on Coverage Level Elected by Farmers

	(1)	(2)	(3) All	(4) Corn	(5) Soybeans	(6) Corn	(7) Soybeans
Post*Treated	5.149***	-0.268	-0.660***	-0.854**	-1.302***	-0.854**	-1.302***
	(0.791)	(0.242)	(0.239)	(0.354)	(0.272)	(0.359)	(0.262)
Post		1.413***	0.785***	-0.114	0.342**	-0.114	0.342
		(0.224)	(0.208)	(0.375)	(0.154)	(0.340)	(0.237)
Treated		8.090***	6.926***	7.103***	4.175***	7.103***	4.175***
		(0.956)	(0.861)	(0.832)	(0.735)	(0.283)	(0.224)
Lag of loss ratio			0.192***	0.446***	0.009	0.446***	0.138*
			(0.057)	(0.059)	(0.006)	(0.038)	(0.079)
Liability/acre			0.009***	0.013***	0.026***	0.013***	0.026***
			(0.002)	(0.001)	(0.003)	(0.001)	(0.001)
Subsidy/acre			0.022	0.063**	0.057	0.063***	0.057***
			(0.032)	(0.028)	(0.035)	(0.007)	(0.008)
Constant	70.249***	66.164***	62.870***	57.933***	59.586***	57.933***	59.586***
	(0.865)	(0.565)	(0.964)	(0.925)	(1.572)	(0.428)	(0.392)
Observations	10,948	10,948	10,585	5,016	5,569	5,016	5,569

Note: Estimated standard errors in Columns (6) and (7) are corrected by Newey-West formula.
*** p<0.01, ** p<0.05 * p<0.10.

Table 9 shows the results from the other version of regression with the outcome of percent of each coverage level elected. For corn farmers, we see positive significant effects of the TA-APH program on the probability of electing 55, 60 and 75 percent levels with them increasing by 6.3 percent, 5.7 percent, and 8 percent, respectively. For soybean farmers, there is no significant effect on the decision of high coverage level, but TA-APH has positive effects on the probability of choosing 50 and 60 percent coverage levels. The coefficients of higher coverage levels (85 percent in corn and 75, 80, and 85 percent in soybeans) are negative but insignificant, which is consistent with the report from USDA-RMA (2012). The loss ratio in the previous year has a significant positive impact on the probability of choosing 80 and 85% levels for corn and 85% for soybeans, with a significant negative impact on lower coverage levels suggesting that farmers elect the high coverage level when they experience higher losses in the previous year.

Table 9. The Effects of TA-APH on the Percent of Each Level of Coverage Elected

	Corn							
	50%	55%	60%	65%	70%	75%	80%	85%
Post*Treat	0.024	0.063*	0.057*	0.026	0.01	0.080**	0.012	-0.039
	(0.025)	(0.033)	(0.030)	(0.027)	(0.025)	(0.032)	(0.068)	(0.057)
Post	-0.04	-0.065**	-0.060**	-0.049*	-0.007	-0.059*	-0.037	0.009
	(0.025)	(0.033)	(0.030)	(0.027)	(0.025)	(0.031)	(0.068)	(0.057)
Treat	-0.223***	-0.123***	-0.159***	-0.164***	-0.061***	-0.145***	-0.101*	-0.001
	(0.020)	(0.032)	(0.026)	(0.022)	(0.021)	(0.027)	(0.061)	(0.035)
Lag of loss ratio	0.000	0.000	-0.001**	-0.002***	-0.008***	-0.004***	0.011***	0.018***
	0.000	0.000	0.000	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Liability/acre	0.000***	0.000	0.000	-0.000***	-0.000***	-0.000***	0.000***	0.000***
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Subsidy/acre	0.002***	0.000***	0.001***	0.002***	0.004***	0.002***	-0.004***	-0.007***
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Constant	0.180***	0.119***	0.160***	0.249***	0.351***	0.441***	0.297***	0.077**
	(0.021)	(0.030)	(0.028)	(0.025)	(0.025)	(0.030)	(0.061)	(0.037)
Observations	3,316	1,606	2,976	3,630	3,735	3,723	3,369	2,591

	Soybeans							
	50%	55%	60%	65%	70%	75%	80%	85%
Post*Treat	0.029**	0.01	0.022**	0.018	0.013	-0.015	-0.004	-0.083
	(0.014)	(0.011)	(0.010)	(0.014)	(0.017)	(0.018)	(0.023)	(0.060)
Post	-0.035**	-0.011	-0.025**	-0.044***	-0.023	0.052***	0.001	0.07
	(0.014)	(0.011)	(0.010)	(0.014)	(0.017)	(0.017)	(0.022)	(0.060)
Treat	-0.114***	-0.042***	-0.081***	-0.090***	-0.048***	-0.032**	-0.022	-0.039
	(0.012)	(0.010)	(0.009)	(0.011)	(0.014)	(0.015)	(0.018)	(0.037)
Lag of loss ratio	-0.001**	-0.000***	0.001	0.001	0.000	-0.007**	0.001	0.007**
	(0.001)	0.000	(0.001)	(0.002)	(0.003)	(0.003)	(0.003)	(0.003)
Liability/acre	0.000***	0.000	0.000***	-0.000***	-0.000***	-0.000***	0.001***	0.001***
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Subsidy/acre	0.003***	0.001***	0.002***	0.004***	0.006***	0.002***	-0.005***	-0.007***
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Constant	0.096***	0.042***	0.071***	0.161***	0.286***	0.337***	0.214***	0.114***
	(0.014)	(0.010)	(0.009)	(0.016)	(0.020)	(0.019)	(0.020)	(0.038)
Observations	3,546	1,693	3,272	4,204	4,400	4,380	3,667	2,615

Notes: Standard errors are clustered at the state and year levels and corrected by Newey-West serial correlation consistent standard errors. Control variables are constructed by each coverage level at each county (weighted by insured acres). *** p<0.01, ** p<0.05 * p<0.10.

4.6.3 Robustness checks

A potential concern with our estimation is that the farmers' behavior may be affected by other unobserved policies that were also changing around the same time as TA-APH program implementation. To address this concern, we include cotton and wheat into the base equation. Columns (3) and (4) in table 10 show the results while columns (1) and (2) show the results without these. There we find the estimates for participation are exactly same. For coverage level, we find consideration of the additional crops increases marginally from 0.66 percent to 0.90 percent. Those provide evidence that our results are indeed driven by the enactment of TA-APH program.

We conducted a placebo difference in difference as an internal validity test. We pretend the program was enacted four years earlier in 2008 and see if there is any effect after this "fake" program. The main reason to adopt the period from 2006 to 2009 is that the outcome trends of treatment and control group are very similar as in the figures showing common trends. Also, to the best of our knowledge, there was no critical change in the crop insurance program which differentially affected the farmers' behaviors in the crop year 2008. As we see from columns (5) and (6), the estimates of program effects are close to zero and statistically insignificant for both participation and coverage level.

Table 10. Robustness Checks for Both Crops

	DD		DDD		Placebo	
	(1)	(2)	(3)	(4)	(5)	(6)
	Extensive	Intensive	Extensive	Intensive	Extensive	Intensive
Treated	-0.113***	6.926***	0.000	3.189***	0.001	4.204***
	(0.034)	(0.861)	(0.002)	(0.681)	(0.003)	(0.745)
Post	0.009	0.785***	0.003	0.944***	0.002	-2.122***
	(0.008)	(0.208)	(0.003)	(0.208)	(0.006)	(0.383)
Crop			-0.130***	-2.005***	-0.252***	-3.001***
			(0.018)	(0.578)	(0.031)	(0.600)
Treated*Post	0.040***	-0.660***	0.002	0.096	-0.010**	-0.916***
	(0.012)	(0.239)	(0.002)	(0.222)	(0.005)	(0.217)
Post*Crop			0.007	-0.318	0.105***	1.462***
			(0.008)	(0.216)	(0.019)	(0.261)
Treated*Crop			-0.113***	3.278***	-0.108*	1.765*
			(0.035)	(0.911)	(0.055)	(0.989)
Treated*Post*Crop			0.040***	-0.905***	-0.017	0.445
			(0.012)	(0.280)	(0.022)	(0.282)
Lag of loss ratio	0.009***	0.192***	0.006***	0.227***	0.005*	0.492***
	(0.003)	(0.057)	(0.002)	(0.049)	(0.003)	(0.087)
Liability per acre	0.000	0.009***	0.000	0.012***	0.000	0.016***
	0.000	(0.002)	0.000	(0.002)	0.000	(0.003)
Subsidy per acre	0.000	0.022	0.000	0.016	0.001	-0.008
	(0.001)	(0.032)	(0.001)	(0.020)	(0.001)	(0.036)
Constant	0.853***	62.870***	0.988***	64.131***	1.003***	64.014***
	(0.029)	(0.964)	(0.008)	(0.888)	(0.008)	(0.949)
Observations	10,585	10,585	18,737	18,737	17,629	17,629

Note: Standard errors are clustered at the state and year levels. *** p<0.01, ** p<0.05 * p<0.10.

4.6.4 Quantifying the effects on insurance protection

Our primary objective is to see whether the TA-APH program mitigates financial risk. As discussed in the previous section, the effect on insured acreage is significantly positive. It apparently indicates that the TA-APH shows a good performance on the reduction of farmers' risk. On the other hand, the coverage level is significantly decreased. Such a result leaves in question whether the program has a positive effect on mitigating risk. To investigate this, we further analyze the guaranteed level of yields quantified with adjusted APH but lower coverage versus the original APH and coverage level. The revenue policies such as RP and RP-HPE combines the yield guarantee component with a price guarantee to create a target revenue guarantee. However, the price guarantee component is not considered since it is stochastic variable as well as extrinsic to the main analysis.

For the analysis, we used the county level data of corn and soybean yield from 2004 to 2013 in Iowa to obtain APH yields for the crop year 2014 with an assumption that each county is a representative farmer. The APH yield was adjusted using the 2014 TA factor for each county reported from Johanns (2014). Columns (1) to (3) in table 11 show the statistics of TA factor, calculated APH yield and TA-APH yield for corn and soybeans in the whole counties in Iowa. On average, the APH yield is increased by 11.35 bu/acre and 2.70 bu/acre for corn and soybeans, respectively, after adjusting trends. For comparison, the farmers are assumed not to change the coverage level elected in 2013 if farmers do not have options to apply for TA-APH program. Then, the guaranteed yield (column 6) is quantified as the coverage level (column 5) multiplied by the APH (column 2). As shown in the previous section, farmers are projected to lower the coverage level by 0.854% and 1.302% for corn and soybeans, respectively, due to the effect of TA-APH program. Combined with the effects, the estimated yield guarantee under the TA-APH program is quantified as the decreased coverage level multiplied by the TA-APH (column 3). For corn, the estimated guarantee under the program (column 7) is 7.56 bu/acre higher than under the original APH (column 6), which translates into an increase in protection level of 5.8%. The yield guarantee of soybeans is also increased by 1.45 bu/acre, amounting to a 3.8% increase. The results suggest that the coverage level decrease is not great enough to reduce the guaranteed yield, drawing a conclusion that the TA-APH program decreases yields' risk. On the other hand, it is also fair to say that it increases the payout rate for the insurance provider and may require an increase in either premiums or subsidy levels.

Table 11. The Effects of TA-APH on the Guaranteed Yield (Year 2014)

Corn (TA-APH Effect: -0.854%)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
					Coverage		Guaranteed Yield		
	TA factor	APH	TA-APH	Change	Level[a]	APH[b]	TA-APH[c]	Change	% Change
AVG	2.12	163.90	175.25	11.35	79.81%	130.97	138.54	7.56	5.78%
MIN	1.60	123.44	133.10	8.16	75.95%	95.26	101.64	5.16	3.85%
MAX	2.36	181.22	195.68	15.32	82.74%	145.88	154.09	10.89	8.55%
STDV	0.22	15.38	16.06	1.60	1.60%	13.97	14.48	1.25	0.92%

Soybeans (TA-APH Effect: -1.302%)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
					Coverage		Guaranteed Yield		
	TA factor	APH	TA-APH	Change	level	APH	TA-APH	Change	% Change
AVG	0.49	48.83	51.52	2.70	78.80%	38.50	39.95	1.45	3.77%
MIN	0.42	39.70	42.18	2.31	73.51%	30.52	31.88	1.09	2.89%
MAX	0.56	55.70	58.67	3.08	81.99%	44.16	45.75	1.77	4.75%
STDV	0.04	3.38	3.50	0.22	1.62%	3.05	3.13	0.17	0.41%

a. The value is calculated as the weighted average of coverage levels by insured acres in 2013.
b. The value is calculated as the unadjusted APH (2) multiplied by coverage level (5).
c. The value is calculated as the adjusted APH (3) multiplied by the coverage level affected by TA-APH. Every value is measured as bu/acre.

4.7 Discussion and conclusions

The analysis shows the APH yield would increase by 11.35 bu/acre and 2.70 bu/acre for corn and soybeans, respectively, after using the trend adjustment. In turn we find that access to that adjustment causes farmers to lower the coverage level by 0.9% and 1.3% for corn and soybeans, respectively. Combined with the increased yields, the estimated yield guarantees for corn and soybeans increase by 5.8% for corn and 3.8% for soybeans. The results suggest that the TA-APH program decreases farmer’ yields risk along with the positive effects on participation rates, 3% and 5% for corn and soybeans respectively, but increases insurance provider’s payout rates.

An important caveat is that along with the increases in participation, the new acres could come from previously insured acres by CAT or from noninsured acres. We are not able to distinguish the origin of these. However, the impact of the TA-APH program on farmers’ risk management still appears to be positive since the magnitude of decreasing coverage level is minor as well as the participation in the buy-up policy is significantly increased.

In terms of limitations, we think that the data are quite limited and the conclusions are tentative. We were only able to use county-level data but would have preferred to use individual farmer-level data. Also we note that the idiosyncratic behavior of individual farmers cannot be controlled for. We may also have a bias in the DD approach since the covered area is also the principal U.S. crop producing area and it may be desirable to look at counties more carefully, for example looking at adjacent covered and non-covered counties allowing a more controlled DD estimation.

5. SUMMARY AND CONCLUSIONS

This dissertation investigates the possibility of updating dairy and crop insurance policy features to reflect recent market developments. First, the possibility of adjusting milk pricing spatial price differences for fuel price increases, spatial supply demand shifts, and seasonality is analyzed. Second, the effect of including technical progress effects on yields within the content of yield guarantees under the crop insurance policy is examined.

In the dairy policy analysis, a simulation model is needed that can simulate the values and costs under varying assumptions. To do this, we develop a model and then use it to carry out an analysis of possible changes in Federal Milk Marketing Order. We find the model does do a satisfactory job of simulating prices coming close to the current surface under 2000 conditions. We also find, considering current conditions, that the Class I milk price differentials derived from the model exhibit a much greater range than the ones currently used in the policy implementation. This is particularly affected by the changes in fuel prices but also by changes in local demand/supply conditions. We also find Class II milk price differentials are substantially different from those now used but that Class III and Class IV milk prices show little spatial differential, corresponding to the current uniform prices for those items. We also find seasonality is a factor with the range of price and cost difference in October being almost twice as large as that found in June. Thus, it might be desirable to revisit the differentials adjusting them for fuel prices, location of supply/demand and seasonality.

We also find that there are two policies in place that can alleviate the need to adjust FMMO policy in particular negotiated over-order payment supplement, where the negotiated rates are moved toward the larger location differentials, reduces the differentials. Also the TCP, currently used in two Marketing Order areas, also reduces the spatial differentials, but we find it would also need to be matched by expansions in processing plant capacity.

There are some limitations on the analysis of milk pricing issue. First, the component composition of raw milk is not homogenous across the region and by time, but the MilkOrdII assumes homogeneity. This might bias the results because different compositions of milk are worth different amounts and would alter transport patterns. Second, maximum processing capacity is assumed to be constant across the year. However, plants can adjust the amount of production using overtime or other means to meet the seasonal demand or supply. This might bias the seasonal pricing results. Third, consumption data for each region is obtained from per capita consumption at the national level multiplied by the population for each region. However, per capita consumption is likely not constant across the U.S. Further research could also contribute through expanding MilkORdII model into a price endogenous model including supply and demand equations. Moreover, entering the margin data at the plants, wholesale, retail market level prices would be helpful since the model provides a competitive market price of raw milk and dairy products. Also, future work could examine absolute Class I milk price differentials if the model fully included the milk production costs.

We also explore the impact of updating the calculation of yields under crop insurance to reflect technical progress as implemented under the trial TA-APH program. In an econometric analysis over data from a trial program, we find that under the program farmers increase the rate of insured acres by 3 percentage points for corn and 5 percentage points for soybeans. We also find farmers decrease their coverage levels by 0.9 percent in corn and 1.3 percent in soybeans but the level of guaranteed yield grows the overall coverage rate in terms of quantity insured. These results confirm that the TA-APH program was indeed effective in achieving yields' risk reduction. However, it increases insurer's payout levels perhaps necessitating premium or subsidy increases, which might increase the farmers' financial risk.

In terms of limitations on the insurance study, we think that our data is limited since we used county-level not individual farmer-level data. Also idiosyncratic behavior of individual farmers cannot be controlled for. Future research could be done on refining the outcome variable for the analysis of intensive margins. Instead of weighted average level of coverage, the decision of each individual farmer could be used, and the ordered logistic model with DD design is expected to find more robust impact (Puhani, 2012).

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APPENDIX

Table A-1. The Pooling Algorithm of Manufacturing (Class III and Class IV) Milk

```
Begin with an Order with the highest Class I utilization.
    Begin with the first eligible shipment for the Order pool.
        If the amount of milk in the path is less than maximum pooling amount,
            All of the milk in the eligible path is included in the Order pool.
            Make the candidate milk zero out.
            Update pooling information.
            If there is no next eligible path for the Order pool,
                EXIT and continue to next Order.
            Otherwise,
                Continue to next eligible path for the Order pool.
        Otherwise,
            Pool Class III milk to the Order.
                If the Class III milk is less than the required pooling amount,
                    All of Class III milk is pooled to the Order.
                    Make the candidate milk zero out.
                    Update pooling information.
                Otherwise,
                    Only necessary amount is pooled to the Order.
                    Make the candidate milk reduced by the pooling amount.
                    Update pooling information.
                    EXIT and continue to next Order.
            Pool Class IV milk to the Order.
                Only necessary amount is pooled to the Order.
                Make the candidate milk reduced by the pooling amount.
                Update pooling information.
                EXIT and continue to next Marketing Order.
            Continue to next eligible path for the Order pool.
Continue to next Marketing Order.
```

Table A-2. List of Elements (Total 303 NASS Districts) Contained in a Set ‘Places’

State	Number	List of places (NASS districts) for each state														
Alabama	6	AL10,	AL20,	AL30,	AL40,	AL50,	AL60									
Arkansas	9	AR10,	AR20,	AR30,	AR40,	AR50,	AR60,	AR70,	AR80,	AR90						
Arizona	2	AZ10,	AZ80													
California	8	CA10,	CA20,	CA30,	CA40,	CA50,	CA51,	CA60,	CA80							
Colorado	6	CO10,	CO20,	CO60,	CO70,	CO80,	CO90									
Connecticut	1	CT10														
Delaware	3	DE20,	DE50,	DE80												
Florida	4	FL10,	FL30,	FL50,	FL80											
Georgia	9	GA10,	GA20,	GA30,	GA40,	GA50,	GA60,	GA70,	GA80,	GA90						
Iowa	9	IA10,	IA20,	IA30,	IA40,	IA50,	IA60,	IA70,	IA80,	IA90						
Idaho	4	ID10,	ID70,	ID80,	ID90											
Illinois	9	IL10,	IL20,	IL30,	IL40,	IL50,	IL60,	IL70,	IL80,	IL90						
Indiana	9	IN10,	IN20,	IN30,	IN40,	IN50,	IN60,	IN70,	IN80,	IN90						
Kansas	9	KS10,	KS20,	KS30,	KS40,	KS50,	KS60,	KS70,	KS80,	KS90						
Kentucky	6	KY10,	KY20,	KY30,	KY40,	KY50,	KY60									
Louisiana	9	LA10,	LA20,	LA30,	LA40,	LA50,	LA60,	LA70,	LA80,	LA90						
Massachusetts	1	MA10														
Maryland	5	MD10,	MD20,	MD30,	MD80,	MD90										
Maine	3	ME10,	ME20,	ME30												
Michigan	9	MI10,	MI20,	MI30,	MI40,	MI50,	MI60,	MI70,	MI80,	MI90						
Minnesota	9	MN10,	MN20,	MN30,	MN40,	MN50,	MN60,	MN70,	MN80,	MN90						
Missouri	9	MO10,	MO20,	MO30,	MO40,	MO50,	MO60,	MO70,	MO80,	MO90						
Mississippi	9	MS10,	MS20,	MS30,	MS40,	MS50,	MS60,	MS70,	MS80,	MS90						
Montana	7	MT10,	MT20,	MT30,	MT50,	MT70,	MT80,	MT90								
North Carolina	8	NC10,	NC20,	NC40,	NC50,	NC60,	NC70,	NC80,	NC90							
North Dakota	9	ND10,	ND20,	ND30,	ND40,	ND50,	ND60,	ND70,	ND80,	ND90						
Nebraska	8	NE10,	NE20,	NE30,	NE50,	NE60,	NE70,	NE80,	NE90							
New Hampshire	1	NH10														
New Jersey	3	NJ20,	NJ50,	NJ80												
New Mexico	4	NM10,	NM30,	NM70,	NM90											
Nevada	3	NV10,	NV30,	NV80												
New York	9	NY20,	NY30,	NY40,	NY50,	NY60,	NY70,	NY80,	NY90,	NY91						
Ohio	9	OH10,	OH20,	OH30,	OH40,	OH50,	OH60,	OH70,	OH80,	OH90						
Oklahoma	9	OK10,	OK20,	OK30,	OK40,	OK50,	OK60,	OK70,	OK80,	OK90						
Oregon	5	OR10,	OR20,	OR30,	OR70,	OR80										
Penssylvania	9	PA10,	PA20,	PA30,	PA40,	PA50,	PA60,	PA70,	PA80,	PA90						
Rhode Island	1	RI10														
South Carolina	6	SC10,	SC20,	SC30,	SC40,	SC50,	SC80									
South Dakota	9	SD10,	SD20,	SD30,	SD40,	SD50,	SD60,	SD70,	SD80,	SD90						
Tennessee	6	TN10,	TN20,	TN30,	TN40,	TN50,	TN60									
Texas	15	TX11,	TX12,	TX21,	TX22,	TX30,	TX40,	TX51,	TX52,	TX60,	TX70,	TX81,	TX82,	TX90,	TX96,	TX97
Utah	4	UT10,	UT50,	UT60,	UT70											
Virginia	7	VA20,	VA40,	VA50,	VA60,	VA70,	VA80,	VA90								
Vermont	1	VT10														
Washington	5	WA10,	WA20,	WA30,	WA50,	WA90										
Wisconsin	9	WI10,	WI20,	WI30,	WI40,	WI50,	WI60,	WI70,	WI80,	WI90						
Virginia	3	WV20,	WV40,	WV60												
Wyoming	5	WY10,	WY20,	WY30,	WY40,	WY50										
Total	303															

Table A-3. Assignment of 303 NASS Crop Reporting Districts in a Set ‘Places’ into 12 Areas in a Set ‘Orders’

orders	# of places	places							
FO1	24	CT10	DE20	DE50	DE80	MA10	MD20	MD30	MD80
		MD90	NH10	NJ20	NJ50	NJ80	NY20	NY30	NY50
		NY60	NY80	NY90	NY91	PA80	PA90	RI10	VT10
FO5	23	GA10	IN70	IN80	KY30	KY50	KY60	NC10	NC20
		NC40	NC50	NC60	NC70	NC80	NC90	SC10	SC20
		SC30	SC40	SC50	SC80	TN60	VA40	VA70	
FO6	3	FL30	FL50	FL80					
FO7	52	AL10	AL20	AL30	AL40	AL50	AL60	AR10	AR20
		AR30	AR40	AR50	AR60	AR70	AR80	AR90	FL10
		GA20	GA30	GA40	GA50	GA60	GA70	GA80	GA90
		KY10	KY20	LA10	LA20	LA30	LA40	LA50	LA60
		LA70	LA80	LA90	MO70	MO80	MO90	MS10	MS20
		MS30	MS40	MS50	MS60	MS70	MS80	MS90	TN10
		TN20	TN30	TN40	TN50				
FO30	23	IL10	IL20	MN10	MN20	MN30	MN40	MN50	MN60
		MN70	MN80	MN90	ND30	ND60	ND90	WI10	WI20
		WI30	WI40	WI50	WI60	WI70	WI80	WI90	
FO32	55	CO10	CO20	CO60	CO70	CO80	CO90	IA10	IA20
		IA30	IA40	IA50	IA60	IA70	IA80	IA90	IL30
		IL40	IL50	IL60	IL70	IL80	IL90	KS10	KS20
		KS30	KS40	KS50	KS60	KS70	KS80	KS90	MO10
		MO20	MO40	MO60	NE30	NE50	NE60	NE70	NE80
		NE90	OK10	OK20	OK30	OK40	OK50	OK60	OK70
		OK80	OK90	SD20	SD30	SD50	SD70	SD90	
FO33	31	IN10	IN20	IN30	IN40	IN50	IN60	IN90	KY40
		MI10	MI20	MI30	MI40	MI50	MI60	MI70	MI80
		MI90	OH10	OH20	OH30	OH40	OH50	OH60	OH70
		OH80	OH90	PA10	PA40	PA70	WV20	WV40	
FO124	11	ID10	OR10	OR20	OR30	OR70	OR80	WA10	WA20
		WA30	WA50	WA90					
FO126	19	NM10	NM30	NM70	NM90	TX11	TX12	TX21	TX22
		TX30	TX40	TX51	TX52	TX60	TX70	TX81	TX82
		TX90	TX96	TX97					
FO131	2	AZ10	AZ80						
CAL	8	CA10	CA20	CA30	CA40	CA50	CA51	CA60	CA80
free Range	52	ID70	ID80	ID90	MD10	ME10	ME20	ME30	MO30
		MO50	MT10	MT20	MT30	MT50	MT70	MT80	MT90
		ND10	ND20	ND40	ND50	ND70	ND80	NE10	NE20
		NV10	NV30	NV80	NY40	NY70	PA20	PA30	PA50
		PA60	SD10	SD40	SD70	SD80	UT10	UT50	UT60
		UT70	VA20	VA50	VA60	VA80	VA90	WV60	WY10
		WY20	WY30	WY40	WY50				

Table A-4. Assignment of Inputs Used for Blending Mixed Products

Input for blending	Ice cream mix	Cottage cheese dressing
Class II	X	X
Skim milk	X	X
Cream	X	X
Non-fat dry milk	X	X
Condensed skim milk	X	X
Butter whey	X	X
Dry cheddar cheese whey	X	
Dry cottage cheese whey	X	
Dry mozzarella cheese whey	X	

Table A-5. Mapping Between Stock Products and Stock Places

	Butter	Cheddar cheese	Italian cheese	Non-fat dry milk
CA40	X	X	X	X
CA51	X	X	X	X
CA60	X	X	X	X
CA80	X	X	X	X
CO60	X	X	X	X
MA10	X	X	X	X
NY91	X	X	X	X
OR10	X	X	X	X
PA90	X	X	X	X
SD30		X	X	X
MN50	X			X
WA10	X			X
WI20		X	X	X
WI60		X	X	X
WI80		X	X	
Total	11	13	13	15

Table A-6. Processes by Type of Plants

		plants								
		fluid-	sourc-	yogur-	cottg-	icecr-	chedc-	italc-	butter-	powder-
process	makeFluid	X								
	makeYogurt		X							
	mkSourcrm			X						
	makeCotage				X					
	makeIcecrm					X				
	makeChed						X			
	makeMoz1							X		
	makeMoz2							X		
	makeButter								X	
	makePowder									X
	makeWhlpowd									X
	dryWhey				X		X	X	X	
	separate								X	X
	condWhole									X
	condSkim									X

Table A-7. Costs and Conversion Rate for Each Process

Plant	Process	Process Cost	Other Cost	Input 1	Input 2	Output 1	Output 2	Output 3	Output 4
Fluid	Make Fluid	0.03	0.034	Raw milk		Fluid Milk	Cream		
				1.052		1	0.052		
Yogurt	Make Yogurt	0.025	0.14	Raw milk		Yogurt	Cream		
				1.072		1	0.063		
sour cream	Make Sour cream	0.025	0.14	Raw milk	Cream	Sour Cream			
				0.5	0.5	1			
Cottage Cheese	Make Cottage Cheese	0.025	0.14	Raw milk	Cot/Che Drs	Cottage Cheese	Cot/ Whey	Cream	
				3.33	0.5	1	2.84	0.303	
	Dry Whey	0.133	-	Cot/ Whey		Dry/Cot/ Whey			
				8.345		1			
Ice Cream	Make Ice cream	0.025	0.14	IceCrmMix		Ice Cream			
				1		1			
Cheddar Cheese	Make Cheddar Cheese	0.186	-	Raw milk		Cheddar Cheese	Ched/ Whey	Whey Butter	
				9.901		1	8.876	0.025	
	Dry Whey	0.133	-	Ched/Whey		Dry/Ched/Whey			
				14.8		1			
Italian Cheese	Make Italian Cheese 1	0.0256	-	Raw milk		Italian Cheese	Moz/ Whey	Cream	Whey Butter
				12.1		1	9.917	0.43	0.03
	MakeItalian Cheese2	0.0256	-	Raw milk	Non Fat Dry	Italian Cheese	Moz/ Whey	Whey Butter	
				6.952	0.108	1	5.688	0.017	
	Dry Whey	0.133	-	Moz/ Whey		Dry/Moz/ Whey			
				12.8		1			

Table A-7. Costs and Conversion Rate for Each Process (Continued)

Butter	Separate	-	-	Raw milk 1	Skim milk 0.908	Cream 0.092
	Make Butter	0.086	-	Cream 2.048	Butter 1	Butter Milk 1.007
	Dry Whey	0.133	-	Butter Milk 11	Dry/Butter/Milk 1	
Powder	Separate	-	-	Raw milk 1	Skim milk 0.908	Cream 0.092
	Condense Whole	-	-	Raw milk 3.55	Conden/Whole 1	
	Condense Skim	-	-	Skim Milk 3.55	Conden/Skim 1	
	Make Powder	0.133	-	Conden/Skim 3.15	Non Fat Dry 1	
	Make Whole Powder	0.133	-	Conden/Whole 3.15	Whole Powder 1	

Table A-8. Composition of Inputs and Outputs Related to Blending Problem

Input products: for blending	Butter fat	Solid non fat	Water	Weight
Class II	0.037	0.087	0.876	1.000
Skim milk	0.000	0.090	0.900	1.000
Cream	0.400	0.054	0.546	1.000
Non-fat dry milk	0.011	0.959	0.030	1.000
Condensed skim milk	0.003	0.282	0.715	1.000
Dry cheddar cheese whey	0.000	0.970	0.030	1.000
Dry cottage cheese whey	0.080	0.870	0.050	1.000
Dry mozzarella cheese whey	0.002	0.970	0.028	1.000
Output products: mixed	Butter fat	Solid non fat	Water	Weight
Ice cream mix	0.120	0.100	0.780	1.000
Cottage cheese dressing	0.100	0.291	0.560	1.000

Table A-9. Normalized Actual and MilkOrdII Model Generated Differentials for Classified Milk at U.S. Geographic Plant Locations (Average 2012, $/cwt.)

NASS District	Marketing Order	Class I milk Normalized			Manufacturing milk Simulated, Normalized		
		Actual	Simulated	Difference	Class II	Class III	Class IV
AL10	FO7	1.60			3.92		
AL20	FO7	1.70					
AL30	FO7	1.80	5.41	3.61	4.03		
AL40	FO7	2.20				3.05	
AL50	FO7	2.40					
AL60	FO7	2.70	6.25	3.55			
AR10	FO7	1.10	2.61	1.51		1.53	
AR20	FO7	1.10					
AR30	FO7	1.10					
AR40	FO7	1.30	2.93	1.63	2.29		
AR50	FO7	1.30	3.85	2.55			
AR60	FO7	1.30					
AR70	FO7	1.60					
AR80	FO7	1.60					
AR90	FO7	1.60					
AZ10	FO131	0.30	0.84	0.54			
AZ80	FO131	0.75	0.60	-0.15	1.07	0.47	0.42
CA10	CAL	0.20					
CA20	CAL	0.20					
CA30	CAL	0.10					
CA40	CAL	0.20	1.06	0.86	1.49	0.12	
CA50	CAL	0.10	1.05	0.95	1.48	0.16	
CA51	CAL	0.10	0.10	0.00	0.52	0.00	0.00
CA60	CAL	0.10					
CA80	CAL	0.50	1.45	0.95	1.89	0.60	0.43
CO10	FO32	0.30					
CO20	FO32	0.85	0.68	-0.17	1.19	0.51	0.76
CO60	FO32	0.95	0.35	-0.60	0.77	0.56	
CO70	FO32	0.40	0.79	0.39	2.07		
CO80	FO32	0.30					

Table A-9. Normalized Actual and MilkOrdII Model Generated Differentials for Classified Milk at U.S. Geographic Plant Locations (Continued)

		Class I milk			Manufacturing milk		
NASS	Marketing		Normalized		Simulated, Normalized		
District	Order	Actual	Simulated	Difference	Class II	Class III	Class IV
CO90	FO32	0.75	0.60	-0.15			
CT10	FO1	1.55	5.30	3.75	1.14	1.20	
DE20	FO1	1.45	5.13	3.68	1.05	1.13	
DE50	FO1	1.45			1.51		
DE80	FO1	1.45					
FL10	FO7	2.70					
FL30	FO6	3.00			6.08		
FL50	FO6	3.80	7.68	3.88	6.42		
FL80	FO6	4.40	9.48	5.08	8.32		
GA10	FO5	1.80					
GA20	FO7	1.80	5.79	3.99	4.89		
GA30	FO7	1.80					
GA40	FO7	2.20					
GA50	FO7	2.20					
GA60	FO7	2.20					
GA70	FO7	2.70					4.03
GA80	FO7	3.00					
GA90	FO7	3.00					
IA10	FO32	0.15	0.22	0.07	0.00	0.72	
IA20	FO32	0.15					
IA30	FO32	0.15	0.78	0.63	1.24	0.73	1.31
IA40	FO32	0.20	0.50	0.30			
IA50	FO32	0.20	0.72	0.52	0.77	0.87	
IA60	FO32	0.20					
IA70	FO32	0.20					
IA80	FO32	0.20					
IA90	FO32	0.20	1.62	1.42		0.82	1.60
ID10	FO124	0.30					
ID70	U	0.00	0.23	0.23	0.68	0.06	0.24
ID80	U	0.00	0.78	0.78	1.10	0.11	0.29

Table A-9. Normalized Actual and MilkOrdII Model Generated Differentials for Classified Milk at U.S. Geographic Plant Locations (Continued)

		Class I milk			Manufacturing milk		
			Normalized		Simulated, Normalized		
NASS District	Marketing Order	Actual	Simulated	Difference	Class II	Class III	Class IV
ID90	U	0.00	1.30	1.30		0.21	
IL10	FO30	0.20	1.71	1.51	2.16	0.78	
IL20	FO30	0.20	1.65	1.45	1.81	0.85	
IL30	FO32	0.20					
IL40	FO32	0.20	2.21	2.01	1.19		
IL50	FO32	0.20	2.09	1.89			
IL60	FO32	0.20	2.65	2.45	1.55		
IL70	FO32	0.20	2.39	2.19			
IL80	FO32	0.40	2.68	2.28	1.47		
IL90	FO32	0.40					
IN10	FO33	0.20	1.93	1.73	2.02		
IN20	FO33	0.20	2.02	1.82	1.26	0.98	1.40
IN30	FO33	0.20	2.44	2.24	1.03	1.06	
IN40	FO33	0.40					
IN50	FO33	0.40	2.63	2.23	1.48		
IN60	FO33	0.40	2.72	2.32	1.41		
IN70	FO5	0.70	3.35	2.65			
IN80	FO5	0.70					
IN90	FO33	0.70					
KS10	FO32	0.40					
KS20	FO32	0.60					
KS30	FO32	0.60					
KS40	FO32	0.40					
KS50	FO32	0.40			1.54	0.87	
KS60	FO32	0.60	1.64	1.04	0.92		
KS70	FO32	0.40	1.86	1.46			
KS80	FO32	0.40	1.89	1.49	1.14		
KS90	FO32	0.60	1.80	1.20	0.91		
KY10	FO7	1.10	3.43	2.33	2.46		
KY20	FO7	1.00	3.42	2.42	2.50		

Table A-9. Normalized Actual and MilkOrdII Model Generated Differentials for Classified Milk at U.S. Geographic Plant Locations (Continued)

		Class I milk			Manufacturing milk		
NASS	Marketing	Normalized			Simulated, Normalized		
District	Order	Actual	Simulated	Difference	Class II	Class III	Class IV
KY30	FO5	1.00	3.33	2.33	2.25	1.73	2.01
KY40	FO33	0.70					
KY50	FO5	1.00	3.66	2.66	2.55		
KY60	FO5	1.30	4.20	2.90	2.89		
LA10	FO7	1.60	4.21	2.61			
LA20	FO7	1.60					
LA30	FO7	1.60					
LA40	FO7	1.80					
LA50	FO7	1.80					
LA60	FO7	2.20	5.41	3.21			
LA70	FO7	2.20					
LA80	FO7	2.20	5.10	2.90	4.41		
LA90	FO7	2.20	5.78	3.58	4.98		
MA10	FO1	1.65	4.78	3.13	0.99	1.16	1.65
MD10	U	1.00	4.51	3.51	2.02		
MD20	FO1	1.30	4.75	3.45	1.47	1.20	
MD30	FO1	1.40					
MD80	FO1	1.40	4.66	3.26	1.45	1.41	1.76
MD90	FO1	1.40					
ME10	U	1.00					
ME20	U	1.20	5.00	3.80	1.55		
ME30	U	1.40	4.18	2.78	0.70	1.13	
MI10	FO33	0.20	1.94	1.74	2.25		
MI20	FO33	0.20					
MI30	FO33	0.20					
MI40	FO33	0.20	1.58	1.38	0.70	0.84	
MI50	FO33	0.20	1.91	1.71	0.45	0.87	
MI60	FO33	0.20					
MI70	FO33	0.20	1.80	1.60	0.75	0.86	1.30
MI80	FO33	0.20	2.24	2.04	0.79	0.97	1.32

Table A-9. Normalized Actual and MilkOrdII Model Generated Differentials for Classified Milk at U.S. Geographic Plant Locations (Continued)

			Class I milk			Manufacturing milk	
NASS	Marketing		Normalized			Simulated, Normalized	
District	Order	Actual	Simulated	Difference	Class II	Class III	Class IV
MI90	FO33	0.20	2.35	2.15	0.94		1.37
MN10	FO30	0.05	0.03	-0.02			
MN20	FO30	0.05	0.52	0.47			
MN30	FO30	0.05	0.64	0.59			
MN40	FO30	0.10			1.41	0.64	
MN50	FO30	0.10	0.69	0.59		0.68	
MN60	FO30	0.10	0.53	0.43	0.65	0.69	
MN70	FO30	0.10					
MN80	FO30	0.10				0.69	1.23
MN90	FO30	0.10	0.50	0.40	0.35	0.63	1.31
MO10	FO32	0.20	1.89	1.69			
MO20	FO32	0.20					
MO30	U	0.20				0.95	
MO40	FO32	0.40	1.85	1.45	1.30		
MO50	U	0.40	2.60	2.20	2.01		
MO60	FO32	0.40	2.73	2.33	1.62		
MO70	FO7	0.80	3.10	2.30	1.83	1.43	1.70
MO80	FO7	0.80			1.54		
MO90	FO7	0.80			1.95		
MS10	FO7	1.30					
MS20	FO7	1.30					
MS30	FO7	1.60					
MS40	FO7	1.60					
MS50	FO7	1.70	5.53	3.83	4.42		
MS60	FO7	1.70					
MS70	FO7	1.80					
MS80	FO7	1.80					
MS90	FO7	2.20	6.07	3.87			
MT10	U	0.20	0.52	0.32	2.22		
MT20	U	0.00					

Table A-9. Normalized Actual and MilkOrdII Model Generated Differentials for Classified Milk at U.S. Geographic Plant Locations (Continued)

			Class I milk			Manufacturing milk	
NASS	Marketing		Normalized			Simulated, Normalized	
District	Order	Actual	Simulated	Difference	Class II	Class III	Class IV
MT30	U	0.00					
MT50	U	0.00	0.44	0.44	0.87		
MT70	U	0.00	0.24	0.24	1.23		
MT80	U	0.00	0.67	0.67	2.13		
MT90	U	0.00					
NC10	FO5	1.80				1.70	
NC20	FO5	1.80	5.28	3.48	4.02		
NC40	FO5	1.80	5.39	3.59	3.31		
NC50	FO5	1.80			3.51		
NC60	FO5	2.00					
NC70	FO5	1.80			3.15		
NC80	FO5	2.00	5.94	3.94	3.33		
NC90	FO5	2.40					
ND10	U	0.00					
ND20	U	0.00					
ND30	FO30	0.00					
ND40	U	0.00					
ND50	U	0.05					
ND60	FO30	0.05	0.03	-0.02			
ND70	U	0.00					
ND80	U	0.05					
ND90	FO30	0.05					
NE10	U	0.20					
NE20	U	0.15					
NE30	FO32	0.15	1.35	1.20	0.38		1.17
NE50	FO32	0.20				0.73	
NE60	FO32	0.25	1.06	0.81	0.47		
NE70	FO32	0.20					
NE80	FO32	0.20					
NE90	FO32	0.25					

Table A-9. Normalized Actual and MilkOrdII Model Generated Differentials for Classified Milk at U.S. Geographic Plant Locations (Continued)

		Class I milk			Manufacturing milk		
NASS	Marketing	Normalized			Simulated, Normalized		
District	Order	Actual	Simulated	Difference	Class II	Class III	Class IV
NH10	FO1	1.40	4.64	3.24	0.74		
NJ20	FO1	1.55	5.50	3.95	1.22	1.10	
NJ50	FO1	1.50	5.34	3.84	1.07	1.08	
NJ80	FO1	1.45	5.00	3.55	0.81		
NM10	FO126	0.75	2.55	1.80	2.41		
NM30	FO126	0.75				0.65	0.86
NM70	FO126	0.50					
NM90	FO126	0.50	1.46	0.96		0.56	
NV10	U	0.10	1.73	1.63			0.10
NV30	U	0.30					
NV80	U	0.40	2.37	1.97	2.19		
NY20	FO1	0.70	0.00	-0.70	0.26	0.84	1.46
NY30	FO1	0.70				0.91	
NY40	U	0.60	3.16	2.56	0.29	0.92	1.53
NY50	FO1	0.90	4.09	3.19	0.48	0.93	1.75
NY60	FO1	1.10	4.72	3.62	0.50	1.01	1.83
NY70	U	0.50	3.16	2.66	0.65	0.90	
NY80	FO1	1.10	4.53	3.43	1.01	0.97	
NY90	FO1	1.40	5.48	4.08	1.21	1.10	
NY91	FO1	1.55	5.56	4.01	1.41		
OH10	FO33	0.20	2.74	2.54	1.12		
OH20	FO33	0.40	3.12	2.72	1.30		
OH30	FO33	0.40	3.13	2.73	1.07	1.00	1.96
OH40	FO33	0.40	2.61	2.21	1.05		
OH50	FO33	0.40	4.76	4.36	3.45		
OH60	FO33	0.40	3.42	3.02		1.05	
OH70	FO33	0.60	3.31	2.71	2.06		
OH80	FO33	0.60			2.18		
OH90	FO33	0.40	3.46	3.06	1.76		
OK10	FO32	0.80					

Table A-9. Normalized Actual and MilkOrdII Model Generated Differentials for Classified Milk at U.S. Geographic Plant Locations (Continued)

			Class I milk			Manufacturing milk	
NASS	Marketing		Normalized			Simulated, Normalized	
District	Order	Actual	Simulated	Difference	Class II	Class III	Class IV
OK20	FO32	0.80					
OK30	FO32	1.00					
OK40	FO32	0.80					
OK50	FO32	1.00	2.53	1.53	1.46		1.58
OK60	FO32	1.20					
OK70	FO32	1.00	2.77	1.77	1.66		
OK80	FO32	1.20					
OK90	FO32	1.20					
OR10	FO124	0.30	0.59	0.29	1.05	0.06	0.35
OR20	FO124	0.15				0.01	
OR30	FO124	0.00					
OR70	FO124	0.30	0.96	0.66	1.03	0.20	0.59
OR80	FO124	0.15	1.42	1.27	1.87		
PA10	FO33	0.50	3.06	2.56	0.82	0.92	
PA20	U	0.70	4.67	3.97	0.74	1.06	1.62
PA30	U	0.90					
PA40	FO33	0.50	3.71	3.21		1.00	
PA50	U	0.70	4.84	4.14	0.95	1.12	
PA60	U	1.10	5.04	3.94	0.99	1.07	1.81
PA70	FO33	0.70	3.88	3.18	1.54		
PA80	FO1	1.30	4.73	3.43	0.94	1.14	1.63
PA90	FO1	1.45	4.98	3.53	0.81	1.10	
RI10	FO1	1.65	5.18	3.53	1.66	1.21	
SC10	FO5	2.00	5.53	3.53	4.25		
SC20	FO5	2.00					
SC30	FO5	2.40					
SC40	FO5	2.40	6.36	3.96			
SC50	FO5	2.40	6.17	3.77			
SC80	FO5	2.70	6.44	3.74	5.00		
SD10	U	0.05					

Table A-9. Normalized Actual and MilkOrdII Model Generated Differentials for Classified Milk at U.S. Geographic Plant Locations (Continued)

			Class I milk		Manufacturing milk		
NASS	Marketing		Normalized		Simulated, Normalized		
District	Order	Actual	Simulated	Difference	Class II	Class III	Class IV
SD20	FO32	0.05				0.70	
SD30	FO32	0.10				0.87	
SD40	U	0.10					
SD50	FO32	0.10					
SD60	FO32	0.10					
SD70	U	0.20					
SD80	U	0.10					
SD90	FO32	0.15					
TN10	FO7	1.30	4.35	3.05			
TN20	FO7	1.30					
TN30	FO7	1.30					
TN40	FO7	1.30	4.22	2.92	3.28		
TN50	FO7	1.30					
TN60	FO5	1.60	4.71	3.11	3.65	1.98	
TX11	FO126	0.80	1.74	0.94		0.68	
TX12	FO126	0.80	2.35	1.55	3.84		
TX21	FO126	1.00					
TX22	FO126	1.00					
TX30	FO126	1.20					
TX40	FO126	1.40	3.81	2.41	2.33	1.88	
TX51	FO126	1.40	3.94	2.54	2.49		1.95
TX52	FO126	1.70	5.04	3.34	3.58		
TX60	FO126	0.65	1.31	0.66	3.79		0.78
TX70	FO126	1.20					
TX81	FO126	1.85	4.06	2.21	3.40		
TX82	FO126	2.05					
TX90	FO126	2.00	5.29	3.29			
TX96	FO126	1.85					
TX97	FO126	2.05					
UT10	U	0.30	0.27	-0.03	0.71	0.23	0.45

Table A-9. Normalized Actual and MilkOrdII Model Generated Differentials for Classified Milk at U.S. Geographic Plant Locations (Continued)

		Class I milk			Manufacturing milk		
			Normalized		Simulated, Normalized		
NASS District	Marketing Order	Actual	Simulated	Difference	Class II	Class III	Class IV
UT50	U	0.30					
UT60	U	0.30			0.31		
UT70	U	0.00	2.01	2.01	0.82	0.32	0.69
VA20	U	1.20	4.62	3.42	1.65	1.29	
VA40	FO5	1.20					
VA50	U	1.50	5.02	3.52			
VA60	U	1.50	5.46	3.96	2.79		2.00
VA70	FO5	1.60					
VA80	U	1.50	5.48	3.98			
VA90	U	1.60					
VT10	FO1	1.00	5.22	4.22	0.20	0.92	1.62
WA10	FO124	0.30	1.17	0.87	1.62	0.41	0.33
WA20	FO124	0.15				0.05	
WA30	FO124	0.30	0.59	0.29	3.73		
WA50	FO124	0.15	1.11	0.96			
WA90	FO124	0.15					
WI10	FO30	0.10	0.96	0.86		0.61	
WI20	FO30	0.10				0.64	1.27
WI30	FO30	0.10				0.67	1.34
WI40	FO30	0.10	0.85	0.75		0.64	
WI50	FO30	0.10	1.26	1.16		0.66	
WI60	FO30	0.10	1.18	1.08	0.99	0.68	
WI70	FO30	0.15			1.27	0.69	1.36
WI80	FO30	0.15	1.67	1.52	1.56	0.72	
WI90	FO30	0.15	1.43	1.28	1.83	0.76	1.53
WV20	FO33	0.70					
WV40	FO33	0.60	4.36	3.76			
WV60	U	0.60					
WY10	U	0.00					
WY20	U	0.05					

Table A-9. Normalized Actual and MilkOrdII Model Generated Differentials for Classified Milk at U.S. Geographic Plant Locations (Continued)

		Class I milk			Manufacturing milk		
NASS	Marketing		Normalized		Simulated, Normalized		
District	Order	Actual	Simulated	Difference	Class II	Class III	Class IV
WY30	U	0.00					
WY40	U	0.30					
WY50	U	0.30					
WV60	U	0.60					
WY10	U	0.00					
WY20	U	0.05					
WY30	U	0.00					
WY40	U	0.30					
WY50	U	0.30					
	Minimum:	0.00	0.00	-0.70	0.00	0.00	0.00
	Maximum:	4.40	9.48	5.08	8.32	3.05	4.03
	Range:	4.40	9.48	5.78	8.32	3.05	4.03
	Weighted Average:	2.64	4.03	1.39	1.78	0.50	0.57
	Standard Deviation:	0.77	1.93		1.37	0.47	0.72
	Count:	303	159	159	134	86	44
	Differences < 0:			8			
	Differences > 0:			151			

Table A-10. Class I Milk Price Differentials Estimated from Five Different Scenarios ($/cwt.)

	Actual	(B) S: 2012 D: 2012 F: 2012	(1) S: 2012 D: 2012 F: 2000	(2) S: 2012 D: 2000 F: 2012	(3) S: 2000 D: 2012 F: 2012	(4) S: 2000 D: 2000 F: 2012	(5) S: 2000 D: 2000 F: 2000
AL30	1.80	5.41	3.13	5.93	5.44	5.46	3.14
AL60	2.70	6.25	3.60	6.71	6.28	6.26	3.60
AR10	1.10	2.61	1.50	3.10	3.31	3.18	1.81
AR40	1.30	2.93	1.69	3.39	3.75	3.55	2.02
AR50	1.30	3.85	2.23	4.30	4.32	4.26	2.44
AZ10	0.30	0.84	0.58	0.97	5.90	4.55	2.64
AZ80	0.75	0.60	0.38	0.47	5.78	4.43	2.64
CA40	0.20	1.06	0.73	0.96	6.37	5.02	2.88
CA50	0.10	1.05	0.70	0.95	6.32	4.97	2.83
CA51	0.10	0.10	0.19	0.00	5.41	4.06	2.34
CA80	0.50	1.45	0.95	1.35	6.78	5.43	3.11
CO20	0.85	0.68	0.38	0.62	3.49	2.73	1.56
CO60	0.95	0.35	0.18	0.28	3.15	2.39	1.36
CO70	0.40	0.79	0.44	0.68	4.35	3.38	1.93
CO90	0.75	0.60	0.33	0.57	3.43	2.71	1.54
CT10	1.55	5.30	3.05	7.19	5.31	6.66	3.84
DE20	1.45	5.13	2.95	6.94	5.13	6.41	3.70
FL50	3.80	7.68	4.45	7.38	7.67	6.62	3.82
FL80	4.40	9.48	5.50	9.18	9.46	8.42	4.86
GA20	1.80	5.79	3.35	6.37	5.81	5.89	3.39
IA10	0.15	0.22	0.11	0.89	0.78	0.77	0.42
IA30	0.15	0.78	0.44	1.73	0.98	1.28	0.72
IA40	0.20	0.50	0.27	1.18	1.03	1.03	0.57
IA50	0.20	0.72	0.41	1.60	1.29	1.43	0.80
IA90	0.20	1.62	0.93	2.58	1.82	2.13	1.21
ID70	0.00	0.23	0.12	0.16	5.39	4.06	2.30
ID80	0.00	0.78	0.44	0.72	5.41	4.14	2.30
ID90	0.00	1.30	0.75	1.25	4.81	3.71	2.10
IL10	0.20	1.71	0.98	2.80	1.76	2.30	1.31
IL20	0.20	1.65	0.95	2.82	1.71	2.33	1.33

Table A-10. Class I Milk Price Differentials Estimated from Five Different Scenarios (Continued)

	Actual	(B) S: 2012 D: 2012 F: 2012	(1) S: 2012 D: 2012 F: 2000	(2) S: 2012 D: 2000 F: 2012	(3) S: 2000 D: 2012 F: 2012	(4) S: 2000 D: 2000 F: 2012	(5) S: 2000 D: 2000 F: 2000
IL40	0.20	2.21	1.27	3.17	2.32	2.69	1.54
IL50	0.20	2.09	1.20	3.23	2.21	2.74	1.57
IL60	0.20	2.65	1.53	3.54	2.79	3.07	1.76
IL70	0.20	2.39	1.38	3.44	2.48	2.96	1.70
IL80	0.40	2.68	1.55	3.53	2.83	3.09	1.77
IN10	0.20	1.93	1.11	3.11	2.00	2.61	1.49
IN20	0.20	2.02	1.16	3.29	2.01	2.76	1.58
IN30	0.20	2.44	1.40	3.77	2.48	3.27	1.88
IN50	0.40	2.63	1.52	3.90	2.68	3.40	1.95
IN60	0.40	2.72	1.57	3.97	2.77	3.49	2.00
IN70	0.70	3.35	1.94	4.19	3.42	3.72	2.14
KS60	0.60	1.64	0.94	1.95	2.91	2.48	1.42
KS70	0.40	1.86	1.07	2.59	2.44	2.47	1.40
KS80	0.40	1.89	1.09	2.59	2.51	2.50	1.43
KS90	0.60	1.80	1.03	2.33	2.95	2.64	1.51
KY10	1.10	3.43	1.98	4.15	3.57	3.75	2.15
KY20	1.00	3.42	1.97	4.23	3.48	3.75	2.15
KY30	1.00	3.33	1.92	4.27	3.37	3.79	2.17
KY50	1.00	3.66	2.11	4.50	3.66	4.02	2.31
KY60	1.30	4.20	2.43	5.11	4.19	4.63	2.66
LA10	1.60	4.21	2.43	4.53	5.02	4.76	2.74
LA60	2.20	5.41	3.14	5.76	5.62	5.72	3.30
LA80	2.20	5.10	2.97	5.43	5.56	5.56	3.21
LA90	2.20	5.78	3.36	6.21	5.95	6.12	3.54
MA10	1.65	4.78	2.76	6.73	4.79	6.20	3.58
MD10	1.00	4.51	2.61	6.12	4.53	5.61	3.24
MD20	1.30	4.75	2.74	6.39	4.76	5.86	3.39
MD80	1.40	4.66	2.69	6.30	4.67	5.78	3.34
ME20	1.20	5.00	2.88	6.95	5.01	6.42	3.70
ME30	1.40	4.18	2.41	6.13	4.18	5.60	3.23

Table A-10. Class I Milk Price Differentials Estimated from Five Different Scenarios (Continued)

	Actual	(B) S: 2012 D: 2012 F: 2012	(1) S: 2012 D: 2012 F: 2000	(2) S: 2012 D: 2000 F: 2012	(3) S: 2000 D: 2012 F: 2012	(4) S: 2000 D: 2000 F: 2012	(5) S: 2000 D: 2000 F: 2000
MI10	0.20	1.94	1.12	3.00	1.99	2.47	1.40
MI40	0.20	1.58	0.91	2.94	1.65	2.44	1.39
MI50	0.20	1.91	1.10	3.32	1.99	2.81	1.61
MI70	0.20	1.80	1.03	3.18	1.88	2.67	1.53
MI80	0.20	2.24	1.29	3.64	2.28	3.14	1.80
MI90	0.20	2.35	1.35	3.77	2.39	3.27	1.87
MN10	0.05	0.03	0.01	0.74	0.47	0.47	0.23
MN20	0.05	0.52	0.30	1.25	0.85	0.92	0.50
MN30	0.05	0.64	0.37	1.53	0.72	1.05	0.58
MN50	0.10	0.69	0.39	1.43	0.67	0.78	0.43
MN60	0.10	0.53	0.30	1.36	0.54	0.77	0.42
MN90	0.10	0.50	0.28	1.34	0.52	0.77	0.43
MO10	0.20	1.89	1.09	2.65	2.45	2.51	1.43
MO40	0.40	1.85	1.07	2.59	2.44	2.47	1.41
MO50	0.40	2.60	1.49	3.37	2.86	3.03	1.73
MO60	0.40	2.73	1.58	3.64	2.88	3.17	1.82
MO70	0.80	3.10	1.79	4.47	3.22	4.04	2.32
MS50	1.70	5.53	3.19	5.85	5.70	5.62	3.24
MS90	2.20	6.07	3.51	6.40	6.16	6.03	3.48
MT10	0.20	0.52	0.31	0.51	4.61	3.52	1.97
MT50	0.00	0.44	0.27	0.50	3.64	2.71	1.52
MT70	0.00	0.24	0.14	0.26	3.75	2.76	1.55
MT80	0.00	0.67	0.39	0.83	3.26	2.53	1.41
NC20	1.80	5.28	3.05	6.09	5.27	5.61	3.23
NC40	1.80	5.39	3.12	6.31	5.40	5.84	3.36
NC80	2.00	5.94	3.44	6.95	5.95	6.47	3.73
ND60	0.05	0.03	0.01	0.73	0.70	0.69	0.37
NE30	0.15	1.35	0.77	1.93	1.89	1.79	1.01
NE60	0.25	1.06	0.60	1.74	1.61	1.59	0.90
NH10	1.40	4.64	2.68	6.61	4.65	6.08	3.51

Table A-10. Class I Milk Price Differentials Estimated from Five Different Scenarios (Continued)

	Actual	(B) S: 2012 D: 2012 F: 2012	(1) S: 2012 D: 2012 F: 2000	(2) S: 2012 D: 2000 F: 2012	(3) S: 2000 D: 2012 F: 2012	(4) S: 2000 D: 2000 F: 2012	(5) S: 2000 D: 2000 F: 2000
NJ20	1.55	5.50	3.16	7.38	5.50	6.85	3.95
NJ50	1.50	5.34	3.07	7.22	5.34	6.69	3.86
NJ80	1.45	5.00	2.88	6.86	5.00	6.33	3.65
NM10	0.75	2.55	1.47	2.34	5.36	4.48	2.59
NM90	0.50	1.46	0.83	1.33	5.26	4.29	2.51
NV10	0.10	1.73	1.07	0.89	6.67	4.60	2.84
NV80	0.40	2.37	1.41	2.21	6.93	5.58	3.20
NY20	0.70	0.00	0.00	0.68	0.00	0.00	0.00
NY40	0.60	3.16	1.83	4.96	3.17	4.43	2.57
NY50	0.90	4.09	2.36	5.96	4.09	5.42	3.14
NY60	1.10	4.72	2.72	6.66	4.73	6.14	3.54
NY70	0.50	3.16	1.83	4.93	3.16	4.39	2.54
NY80	1.10	4.53	2.62	6.36	4.54	5.83	3.37
NY90	1.40	5.48	3.15	7.37	5.49	6.84	3.94
NY91	1.55	5.56	3.20	7.44	5.56	6.91	3.98
OH10	0.20	2.74	1.58	4.12	2.77	3.61	2.07
OH20	0.40	3.12	1.80	4.62	3.16	4.11	2.36
OH30	0.40	3.13	1.80	4.67	3.17	4.16	2.39
OH40	0.40	2.61	1.51	3.21	3.11	3.15	1.81
OH50	0.40	4.76	2.75	5.25	4.90	4.96	2.86
OH60	0.40	3.42	1.97	4.93	3.45	4.43	2.55
OH70	0.60	3.31	1.91	4.58	3.36	4.09	2.35
OH90	0.40	3.46	2.00	4.89	3.49	4.39	2.53
OK50	1.00	2.53	1.46	2.52	3.87	3.38	1.94
OK70	1.00	2.77	1.59	3.01	3.75	3.40	1.95
OR10	0.30	0.59	0.37	0.51	5.89	4.49	2.52
OR70	0.30	0.96	0.63	0.56	6.08	4.57	2.59
OR80	0.15	1.42	0.84	1.34	6.65	5.26	2.98
PA10	0.50	3.06	1.78	4.74	3.07	4.21	2.44
PA20	0.70	4.67	2.69	6.41	4.68	5.88	3.40

Table A-10. Class I Milk Price Differentials Estimated from Five Different Scenarios (Continued)

	Actual	(B) S: 2012 D: 2012 F: 2012	(1) S: 2012 D: 2012 F: 2000	(2) S: 2012 D: 2000 F: 2012	(3) S: 2000 D: 2012 F: 2012	(4) S: 2000 D: 2000 F: 2012	(5) S: 2000 D: 2000 F: 2000
PA40	0.50	3.71	2.15	5.33	3.72	4.80	2.78
PA50	0.70	4.84	2.79	6.58	4.85	6.06	3.50
PA60	1.10	5.04	2.90	6.88	5.05	6.35	3.66
PA70	0.70	3.88	2.24	5.51	3.89	4.99	2.87
PA80	1.30	4.73	2.73	6.46	4.74	5.93	3.43
PA90	1.45	4.98	2.87	6.85	4.98	6.31	3.64
RI10	1.65	5.18	2.98	7.13	5.19	6.61	3.81
SC10	2.00	5.53	3.20	6.29	5.53	5.82	3.35
SC40	2.40	6.36	3.68	7.03	6.36	6.59	3.80
SC50	2.40	6.17	3.57	6.93	6.17	6.46	3.72
SC80	2.70	6.44	3.73	7.12	6.44	6.68	3.85
TN10	1.30	4.35	2.52	4.96	4.54	4.71	2.70
TN40	1.30	4.22	2.44	4.80	4.24	4.32	2.48
TN60	1.60	4.71	2.72	5.53	4.71	5.05	2.91
TX11	0.80	1.74	0.99	1.62	4.64	3.91	2.24
TX12	0.80	2.35	1.35	2.17	4.84	4.10	2.35
TX40	1.40	3.81	2.20	3.54	5.02	4.45	2.56
TX51	1.40	3.94	2.27	3.94	4.98	4.54	2.61
TX52	1.70	5.04	2.93	4.71	6.09	5.48	3.16
TX60	0.65	1.31	0.73	1.18	5.09	4.15	2.41
TX81	1.85	4.06	2.35	3.78	5.76	5.15	2.97
TX90	2.00	5.29	3.07	4.95	6.34	5.72	3.30
UT10	0.30	0.27	0.15	0.28	4.70	3.50	2.00
UT70	0.00	2.01	1.13	1.99	6.24	4.99	2.87
VA20	1.20	4.62	2.67	6.26	4.64	5.74	3.31
VA50	1.50	5.02	2.90	6.10	5.02	5.61	3.23
VA60	1.50	5.46	3.15	6.52	5.46	6.04	3.48
VA80	1.50	5.48	3.17	6.47	5.49	5.99	3.45
VT10	1.00	5.22	3.01	7.15	5.22	6.62	3.81
WA10	0.30	1.17	0.90	1.03	5.88	4.53	2.62

Table A-10. Class I Milk Price Differentials Estimated from Five Different Scenarios (Continued)

	Actual	(B) S: 2012 D: 2012 F: 2012	(1) S: 2012 D: 2012 F: 2000	(2) S: 2012 D: 2000 F: 2012	(3) S: 2000 D: 2012 F: 2012	(4) S: 2000 D: 2000 F: 2012	(5) S: 2000 D: 2000 F: 2000
WA30	0.30	0.59	0.43	0.44	5.24	3.89	2.22
WA50	0.15	1.11	0.68	0.95	5.77	4.41	2.52
WI10	0.10	0.96	0.55	1.85	1.01	1.29	0.73
WI40	0.10	0.85	0.48	1.79	0.95	1.33	0.75
WI50	0.10	1.26	0.72	2.33	1.30	1.79	1.02
WI60	0.10	1.18	0.67	2.38	1.23	1.88	1.07
WI80	0.15	1.67	0.96	2.66	1.69	2.14	1.22
WI90	0.15	1.43	0.82	2.53	1.49	2.03	1.16
WV40	0.60	4.36	2.52	5.52	4.39	5.03	2.90
Range:	4.40	9.48	5.50	9.18	9.46	8.42	4.86
W. AVG:	2.64	4.03	2.34	4.61	4.85	5.30	3.08
STDV:	0.77	1.93	1.11	2.27	1.78	1.73	1.00

Table A-11. Monthly Class I Price Differentials Estimated from MilkOrdII in 2012

NASS	Monthly Normalized Class I milk price differentials, $/cwt.												Stdv.
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
AL30	8.9	5.2	7.1	4.6	5.0	4.4	4.6	7.0	5.2	9.3	6.9	5.6	1.7
AL60	9.7	6.1	8.0	5.5	5.9	5.1	5.2	8.0	6.1	10.3	7.8	6.4	1.7
AR10	5.8	2.6	3.9	2.2	2.3	2.1	2.2	4.0	2.5	6.2	4.0	2.6	1.4
AR40	6.1	2.9	4.2	2.5	2.6	2.5	2.6	4.2	2.8	6.5	4.3	2.9	1.4
AR50	7.1	3.9	5.3	3.3	3.5	3.2	3.3	5.3	3.8	7.5	5.2	3.8	1.5
AZ10	1.6	1.5	1.6	2.7	2.8	0.5	0.7	1.6	1.6	1.7	1.5	1.4	0.7
AZ80	1.0	0.9	1.4	2.7	2.5	0.9	1.1	1.0	1.0	1.1	1.0	1.6	0.6
CA40	0.9	0.9	2.5	4.0	3.8	1.0	1.1	1.3	1.3	1.3	1.3	2.2	1.1
CA50	1.0	0.9	2.7	4.2	4.0	0.9	1.1	1.2	1.2	1.2	1.2	2.1	1.2
CA51	0.0	0.0	1.5	3.0	2.8	0.0	0.2	0.3	0.3	0.3	0.3	1.3	1.1
CA80	1.3	1.3	2.8	4.4	4.2	1.4	1.6	1.7	1.7	1.7	1.7	2.6	1.1
CO20	2.9	1.2	1.9	1.0	1.1	0.4	0.3	1.8	1.0	2.9	1.8	0.8	0.8
CO60	2.6	0.9	1.6	0.7	0.8	0.1	0.0	1.5	0.6	2.5	1.5	0.5	0.8
CO70	2.1	1.2	2.0	2.5	2.6	0.4	0.3	1.8	1.0	2.0	1.8	0.8	0.8
CO90	2.8	1.1	1.9	0.9	1.1	0.4	0.3	1.7	0.9	2.8	1.7	0.7	0.8
CT10	9.3	4.8	7.5	4.1	5.3	3.4	2.8	6.9	5.0	10.0	7.4	6.2	2.2
DE20	9.0	4.6	7.2	3.9	5.0	3.2	2.9	6.8	4.9	9.8	7.2	5.9	2.2
FL50	11.4	7.8	9.8	7.3	7.6	5.5	5.9	9.7	6.6	12.0	9.4	8.1	2.1
FL80	13.2	9.6	11.6	9.1	9.4	7.3	7.7	11.5	8.5	13.9	11.2	9.8	2.1
GA20	9.2	5.6	7.5	5.0	5.4	4.8	5.0	7.4	5.6	9.8	7.3	5.9	1.7
IA10	2.6	0.6	0.8	0.0	0.1	0.2	0.5	1.5	0.5	3.0	1.6	0.3	1.0
IA30	3.9	0.9	1.8	0.2	0.2	0.6	0.8	1.8	0.7	4.4	2.0	0.8	1.4
IA40	2.9	0.9	1.0	0.3	0.3	0.5	0.7	1.8	0.8	3.3	1.8	0.6	1.0
IA50	3.7	0.9	1.6	0.3	0.4	0.5	0.6	1.9	0.8	4.2	2.0	0.7	1.3
IA90	4.7	1.7	2.7	1.1	1.1	1.4	1.6	2.7	1.6	5.2	2.8	1.6	1.4
ID70	0.4	0.3	2.3	3.6	3.6	0.3	0.4	0.0	0.0	0.0	0.0	1.0	1.4
ID80	0.9	0.8	2.7	4.0	4.0	0.9	1.0	0.6	0.6	0.7	0.6	1.5	1.3
ID90	1.8	1.4	2.8	4.0	4.0	1.5	1.6	1.2	1.2	1.7	1.2	2.1	1.0
IL10	5.0	1.6	3.0	0.9	1.2	1.2	1.4	3.0	1.5	5.5	3.1	1.9	1.5
IL20	5.0	1.6	2.9	0.9	1.1	1.1	1.3	3.0	1.4	5.5	3.1	1.9	1.5
IL40	5.3	2.3	3.3	1.7	1.7	2.0	2.2	3.3	2.2	5.8	3.4	2.2	1.4
IL50	5.4	1.9	3.4	1.3	1.6	1.5	1.7	3.4	2.0	5.9	3.5	2.3	1.5

Table A-11. Monthly Class I Price Differentials Estimated from MilkOrdII in 2012 (Continued)

NASS	Monthly Normalized Class I milk price differentials, $/cwt.												Stdv.
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
IL60	5.9	2.8	3.9	2.2	2.1	2.2	2.3	3.9	2.7	6.3	3.9	2.7	1.4
IL70	5.7	2.2	3.7	1.6	1.9	1.8	2.0	3.8	2.3	6.3	3.8	2.6	1.5
IL80	5.9	2.8	4.0	2.1	2.2	2.2	2.3	4.0	2.7	6.4	4.0	2.7	1.5
IN10	5.2	1.8	3.2	1.2	1.4	1.4	1.6	3.3	1.7	5.8	3.3	2.2	1.5
IN20	5.5	1.7	3.5	1.0	1.5	1.4	1.6	3.3	1.7	6.1	3.6	2.4	1.7
IN30	6.0	2.1	4.1	1.4	2.0	1.4	1.6	3.8	2.1	6.6	4.1	2.9	1.8
IN50	6.1	2.4	4.1	1.7	2.3	1.7	1.9	4.1	2.4	6.6	4.2	3.0	1.7
IN60	6.2	2.4	4.3	1.7	2.3	1.7	2.0	4.2	2.4	6.8	4.3	3.1	1.7
IN70	6.8	3.1	4.9	2.5	2.8	2.5	2.7	4.9	3.1	7.3	4.9	3.5	1.7
KS60	4.6	1.7	3.1	1.2	1.6	1.1	1.3	3.1	1.5	4.9	3.2	1.5	1.3
KS70	4.5	2.2	2.8	1.6	1.6	1.7	1.8	3.1	2.1	5.0	3.1	1.8	1.2
KS80	4.6	2.2	2.9	1.6	1.6	1.7	1.8	3.1	2.1	5.0	3.1	1.9	1.2
KS90	4.6	2.0	3.1	1.4	1.6	1.5	1.6	3.1	1.8	4.9	3.3	1.7	1.2
KY10	6.9	3.2	5.0	2.6	2.9	2.6	2.8	5.0	3.2	7.4	4.9	3.6	1.6
KY20	6.9	3.2	5.0	2.5	3.0	2.6	2.8	5.0	3.2	7.4	4.9	3.6	1.7
KY30	6.7	3.1	4.9	2.4	3.0	2.4	2.6	4.9	3.1	7.3	4.9	3.6	1.7
KY50	7.2	3.4	5.3	2.7	3.2	2.6	2.8	5.3	3.3	7.8	5.3	4.0	1.8
KY60	7.8	3.9	6.0	3.3	3.9	2.9	2.9	5.8	3.9	8.5	5.9	4.7	1.9
LA10	7.4	4.2	5.7	3.7	3.9	3.4	3.6	5.7	4.2	7.9	5.6	4.2	1.5
LA60	8.7	5.2	7.0	4.9	4.9	4.8	4.9	7.0	5.2	9.1	6.8	5.3	1.5
LA80	8.3	4.9	6.6	4.7	4.6	4.6	4.7	6.6	4.9	8.8	6.5	5.0	1.5
LA90	9.1	5.7	7.4	5.1	5.2	5.1	5.1	7.4	5.5	9.6	7.3	5.8	1.6
MA10	8.8	4.2	7.0	3.5	4.7	2.8	2.3	6.4	4.4	9.6	7.0	5.6	2.3
MD10	8.3	4.2	6.4	3.5	4.3	2.9	2.8	6.1	4.2	9.0	6.4	5.1	2.0
MD20	8.5	4.4	6.7	3.8	4.5	3.1	3.1	6.3	4.5	9.2	6.6	5.4	2.0
MD80	8.4	4.3	6.6	3.6	4.5	3.0	2.9	6.2	4.4	9.1	6.5	5.3	2.0
ME20	9.0	4.4	7.2	3.7	4.9	3.1	2.5	6.6	4.7	9.8	7.2	5.8	2.3
ME30	8.2	3.6	6.4	2.9	4.1	2.2	1.7	5.8	3.8	9.0	6.4	5.0	2.3
MI10	4.9	2.2	2.8	1.4	1.6	1.8	2.0	3.0	2.0	5.3	3.0	2.1	1.2
MI40	5.2	1.2	3.2	0.4	1.2	0.8	1.0	2.9	1.0	5.7	3.3	2.2	1.8
MI50	5.6	1.5	3.5	0.7	1.5	1.0	1.2	3.2	1.4	6.1	3.7	2.5	1.8

Table A-11. Monthly Class I Price Differentials Estimated from MilkOrdII in 2012 (Continued)

NASS	Monthly Normalized Class I milk price differentials, $/cwt.												Stdv.
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
MI70	5.4	1.3	3.4	0.6	1.4	1.0	1.2	3.1	1.3	6.0	3.5	2.4	1.8
MI80	5.9	1.8	3.9	1.0	1.9	1.3	1.5	3.6	1.7	6.5	4.0	2.8	1.8
MI90	6.0	1.9	4.1	1.2	2.0	1.4	1.6	3.7	1.8	6.6	4.1	2.9	1.8
MN10	1.9	0.8	0.1	0.1	0.1	0.7	0.9	0.8	0.6	2.3	0.9	0.1	0.7
MN20	2.5	1.1	0.7	0.6	0.6	1.0	1.2	1.5	0.9	2.9	1.5	0.7	0.7
MN30	3.3	1.0	1.2	0.5	0.6	0.9	1.1	1.4	0.9	3.7	1.4	0.6	1.0
MN50	2.7	1.4	0.7	0.7	0.7	1.3	1.5	1.5	1.3	3.2	1.5	0.7	0.8
MN60	3.0	1.0	0.9	0.6	0.6	1.0	1.2	1.1	0.9	3.5	1.1	0.5	1.0
MN90	3.1	1.0	0.9	0.5	0.5	0.9	1.1	1.0	0.8	3.5	1.2	0.5	1.0
MO10	4.6	2.1	2.9	1.6	1.6	1.7	1.8	3.1	2.0	5.1	3.2	1.9	1.2
MO40	4.6	2.1	2.8	1.6	1.6	1.6	1.8	3.1	2.0	5.0	3.1	1.8	1.2
MO50	5.3	2.9	3.7	2.2	2.2	2.4	2.6	3.8	2.8	5.8	3.9	2.6	1.2
MO60	5.9	2.9	3.9	2.3	2.2	2.3	2.4	3.9	2.8	6.4	4.0	2.8	1.4
MO70	6.7	2.8	4.8	2.1	2.7	1.9	2.1	4.6	2.8	7.3	4.8	3.6	1.8
MS50	8.7	5.5	7.0	4.9	5.2	4.8	4.9	7.0	5.5	9.2	6.9	5.5	1.5
MS90	9.4	5.9	7.8	5.3	5.7	5.1	5.3	7.8	5.9	9.9	7.6	6.1	1.6
MT10	1.3	0.6	2.0	3.3	3.3	0.6	0.7	0.4	0.3	1.2	0.4	1.2	1.1
MT50	1.2	0.9	1.5	2.7	2.7	0.6	0.5	0.6	0.7	1.1	0.7	0.9	0.8
MT70	1.1	0.4	1.7	2.9	2.8	0.3	0.4	0.2	0.1	0.9	0.2	0.9	1.0
MT80	1.9	1.2	2.0	2.0	2.0	0.8	0.8	1.1	1.0	1.9	1.1	1.3	0.5
NC20	8.8	5.0	7.1	4.4	4.9	4.0	4.1	6.9	5.1	9.5	7.0	5.6	1.8
NC40	9.0	5.1	7.2	4.5	5.1	4.0	4.0	7.0	5.1	9.7	7.1	5.8	1.9
NC80	9.6	5.6	7.8	5.0	5.7	4.4	4.5	7.6	5.7	10.3	7.7	6.4	1.9
ND60	1.9	0.8	0.1	0.1	0.1	0.7	0.9	0.8	0.6	2.3	0.9	0.1	0.7
NE30	3.7	1.7	1.9	1.2	1.2	1.4	1.6	2.6	1.6	4.1	2.7	1.4	1.0
NE60	3.4	1.5	1.6	0.9	0.9	1.1	1.3	2.3	1.3	3.8	2.4	1.1	1.0
NH10	8.6	4.1	6.9	3.3	4.6	2.7	2.1	6.2	4.3	9.5	6.9	5.4	2.3
NJ20	9.4	5.0	7.7	4.3	5.5	3.6	3.0	7.1	5.2	10.2	7.6	6.3	2.2
NJ50	9.3	4.8	7.5	4.1	5.3	3.4	2.9	7.0	5.0	10.1	7.4	6.2	2.2
NJ80	8.9	4.4	7.1	3.7	4.9	3.1	2.8	6.6	4.7	9.7	7.1	5.8	2.2
NM10	3.9	3.1	4.0	3.1	3.2	2.5	2.3	3.8	3.0	4.2	3.8	2.7	0.6

Table A-11. Monthly Class I Price Differentials Estimated from MilkOrdII in 2012 (Continued)

NASS	Monthly Normalized Class I milk price differentials, $/cwt.												Stdv.
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
NM90	3.4	1.7	2.5	1.7	1.8	1.5	1.6	2.4	1.6	3.7	2.7	1.8	0.8
NV10	1.7	1.4	3.5	5.0	4.8	1.4	1.5	1.9	1.9	1.9	1.9	2.8	1.3
NV80	2.5	2.5	3.2	4.7	4.4	2.6	2.7	2.8	2.8	3.0	2.8	3.4	0.7
NY20	1.8	1.0	0.0	0.0	0.0	0.8	0.8	0.8	0.8	2.2	0.8	0.0	0.7
NY40	7.1	2.6	5.2	1.9	3.0	1.3	1.3	4.7	2.8	7.8	5.2	4.0	2.1
NY50	8.0	3.5	6.2	2.9	4.0	2.2	2.1	5.7	3.7	8.7	6.1	4.9	2.2
NY60	8.7	4.2	7.0	3.4	4.6	2.8	2.2	6.3	4.4	9.5	6.9	5.5	2.3
NY70	7.0	2.7	5.2	2.0	3.0	1.3	1.3	4.7	2.8	7.7	5.1	3.9	2.1
NY80	8.5	4.0	6.6	3.3	4.4	2.7	2.5	6.1	4.2	9.2	6.6	5.4	2.2
NY90	9.4	4.9	7.6	4.3	5.5	3.6	3.0	7.1	5.2	10.2	7.6	6.3	2.2
NY91	9.5	5.0	7.7	4.3	5.5	3.6	3.1	7.2	5.3	10.3	7.6	6.4	2.2
OH10	6.3	2.4	4.4	1.7	2.3	1.8	1.9	4.1	2.3	6.9	4.4	3.3	1.8
OH20	6.8	2.7	4.9	2.0	2.8	1.9	2.1	4.5	2.7	7.4	4.9	3.7	1.9
OH30	6.8	2.7	4.9	2.0	2.8	1.8	1.9	4.6	2.7	7.5	4.9	3.7	1.9
OH40	5.8	2.6	3.9	2.1	2.3	2.0	2.2	4.0	2.5	6.2	4.0	2.6	1.4
OH50	8.2	4.7	6.4	4.0	4.3	3.9	4.0	6.3	4.6	8.6	6.2	4.8	1.6
OH60	7.1	3.1	5.2	2.4	3.1	2.0	2.2	4.8	3.1	7.8	5.2	4.0	1.9
OH70	6.7	3.1	4.8	2.4	3.0	2.4	2.6	4.8	3.1	7.3	4.8	3.6	1.7
OH90	7.0	3.2	5.2	2.5	3.1	2.2	2.4	4.9	3.2	7.7	5.2	3.9	1.8
OK50	5.5	2.6	4.1	2.2	2.5	1.7	1.8	4.1	2.5	5.8	4.2	2.4	1.4
OK70	5.7	2.8	4.2	2.4	2.7	2.3	2.4	4.2	2.7	6.0	4.3	2.5	1.3
OR10	0.7	0.6	2.7	4.0	4.0	0.7	0.7	0.4	0.4	0.4	0.4	1.3	1.4
OR70	1.0	0.6	2.7	4.2	3.9	0.6	0.8	1.1	1.1	1.3	1.1	2.0	1.2
OR80	1.5	1.4	3.5	4.8	4.8	1.5	1.6	1.2	1.2	1.2	1.2	2.1	1.4
PA10	6.9	2.7	5.0	2.0	2.8	1.4	1.4	4.6	2.7	7.5	4.9	3.7	2.0
PA20	8.5	4.2	6.7	3.6	4.5	2.9	2.8	6.3	4.4	9.2	6.6	5.4	2.1
PA40	7.5	3.4	5.6	2.7	3.5	2.1	2.0	5.3	3.4	8.2	5.5	4.3	2.0
PA50	8.7	4.4	6.8	3.8	4.7	3.0	2.9	6.4	4.6	9.4	6.8	5.6	2.1
PA60	8.9	4.5	7.1	3.8	5.0	3.1	3.0	6.6	4.7	9.7	7.1	5.8	2.2
PA70	7.7	3.5	5.8	2.9	3.7	2.2	2.2	5.4	3.6	8.4	5.8	4.5	2.0
PA80	8.6	4.3	6.7	3.6	4.6	2.9	2.8	6.3	4.5	9.3	6.7	5.5	2.1

Table A-11. Monthly Class I Price Differentials Estimated from MilkOrdII in 2012 (Continued)

NASS	Monthly Normalized Class I milk price differentials, $/cwt.												Stdv.
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
PA90	8.9	4.4	7.1	3.7	4.9	3.1	2.7	6.6	4.7	9.7	7.0	5.8	2.2
RI10	9.2	4.6	7.4	3.9	5.1	3.2	2.7	6.8	4.8	10.0	7.4	6.0	2.3
SC10	9.1	5.3	7.3	4.7	5.1	4.3	4.4	7.2	5.3	9.7	7.2	5.8	1.8
SC40	9.9	6.1	8.2	5.5	6.0	5.1	5.2	8.0	6.2	10.6	8.0	6.6	1.8
SC50	9.7	5.9	8.0	5.3	5.8	4.9	5.0	7.8	6.0	10.4	7.8	6.5	1.8
SC80	10.0	6.2	8.2	5.6	6.0	5.2	5.3	8.1	6.2	10.6	8.1	6.7	1.8
TN10	7.5	4.4	5.7	3.9	4.0	3.8	3.9	5.7	4.3	7.9	5.7	4.3	1.4
TN40	7.7	4.0	5.9	3.4	3.8	3.3	3.5	5.8	4.0	8.2	5.7	4.4	1.7
TN60	8.2	4.4	6.4	3.8	4.2	3.7	3.8	6.4	4.4	8.9	6.3	5.0	1.8
TX11	4.5	1.9	3.1	1.5	1.8	1.3	1.2	3.0	1.8	4.8	3.3	1.7	1.2
TX12	5.0	2.6	3.8	2.2	2.5	1.9	1.8	3.6	2.5	5.3	3.9	2.3	1.2
TX40	6.7	3.9	5.4	3.5	3.8	2.9	3.1	5.4	3.8	7.1	5.4	3.6	1.4
TX51	6.9	4.0	5.5	3.6	3.9	3.1	3.2	5.5	4.0	7.3	5.5	3.7	1.4
TX52	7.9	5.1	6.7	4.8	5.1	4.1	4.3	6.6	5.1	8.4	6.6	4.8	1.4
TX60	3.7	1.4	2.4	1.4	1.5	1.2	1.4	2.3	1.3	3.9	2.6	1.6	0.9
TX81	7.0	4.1	5.6	3.8	4.1	3.2	3.3	5.6	4.1	7.4	5.7	3.8	1.4
TX90	8.2	5.4	6.9	5.0	5.3	4.4	4.5	6.9	5.4	8.6	6.9	5.0	1.4
UT10	0.6	0.5	1.9	3.1	3.0	0.5	0.6	0.2	0.2	0.4	0.2	1.2	1.1
UT70	2.2	2.1	3.5	4.7	4.8	2.2	2.3	2.1	2.1	2.3	2.1	2.8	1.0
VA20	8.4	4.3	6.5	3.6	4.4	3.0	2.9	6.2	4.3	9.1	6.5	5.2	2.0
VA50	8.7	4.6	6.9	4.0	4.8	3.5	3.6	6.6	4.7	9.4	6.8	5.6	1.9
VA60	9.2	5.0	7.4	4.5	5.3	3.8	3.9	7.1	5.2	9.8	7.3	6.0	2.0
VA80	9.1	5.2	7.3	4.6	5.2	4.1	4.1	7.1	5.2	9.8	7.2	5.9	1.9
VT10	9.2	4.7	7.4	3.9	5.2	3.3	2.7	6.8	4.9	10.0	7.4	6.0	2.3
WA10	1.3	1.2	3.2	4.6	4.5	1.2	1.3	0.9	1.0	1.0	0.9	2.0	1.4
WA30	0.7	0.6	2.7	4.0	4.0	0.7	0.6	0.4	0.4	0.4	0.4	1.2	1.4
WA50	1.2	1.1	3.2	4.5	4.5	1.2	1.1	0.9	0.9	0.9	0.9	1.8	1.4
WI10	3.6	1.3	1.5	0.9	0.9	1.2	1.4	1.6	1.2	4.1	1.7	1.0	1.0
WI40	3.8	0.9	1.7	0.5	0.5	0.8	1.0	1.8	0.8	4.3	1.9	1.1	1.2
WI50	4.4	1.4	2.3	0.6	0.8	1.0	1.2	2.2	1.2	4.9	2.5	1.5	1.4
WI60	4.6	1.1	2.5	0.3	0.5	0.7	0.9	2.2	0.9	5.1	2.7	1.6	1.6

Table A-11. Monthly Class I Price Differentials Estimated from MilkOrdII in 2012 (Continued)

NASS	Monthly Normalized Class I milk price differentials, $/cwt.												Stdv.
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
WI80	4.7	1.8	2.6	1.1	1.4	1.4	1.6	2.7	1.7	5.2	2.8	1.9	1.3
WI90	4.7	1.4	2.7	0.7	0.9	0.9	1.1	2.7	1.2	5.3	2.8	1.7	1.5
WV40	7.9	4.1	6.1	3.4	4.0	3.1	3.2	5.9	4.1	8.6	6.1	4.8	1.8
Range:	13.2	9.6	11.6	9.1	9.4	7.3	7.7	11.5	8.5	13.9	11.2	9.8	2.1
W. AVG:	5.8	3.2	4.8	3.3	3.6	2.4	2.5	4.5	3.2	6.3	4.5	3.7	1.2
STDV:	2.9	1.7	2.3	1.6	1.7	1.4	1.4	2.4	1.8	3.1	2.4	2.0	

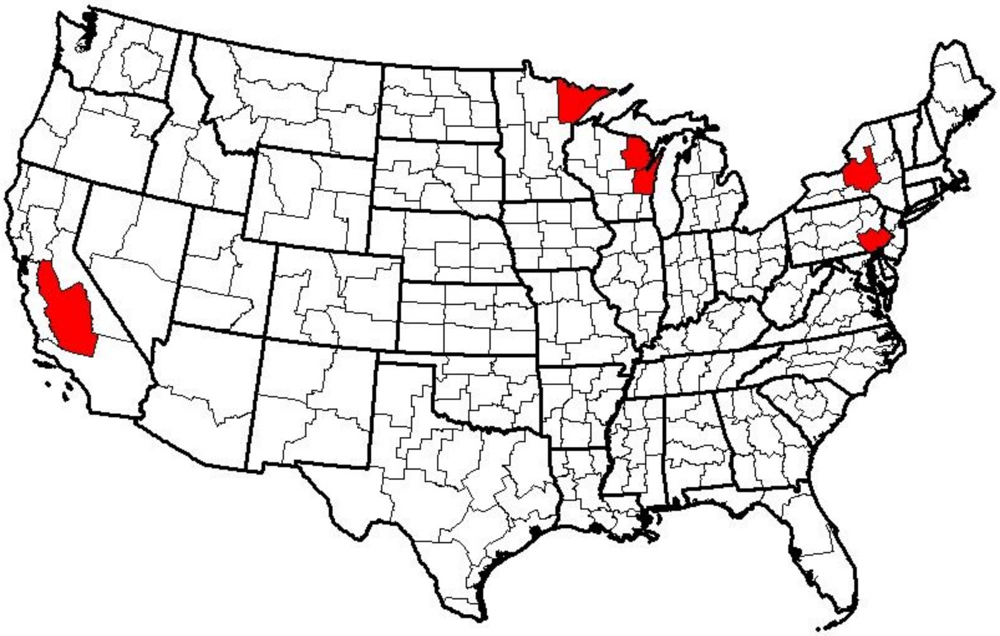

Figure A-1. Regions allowing supply plants

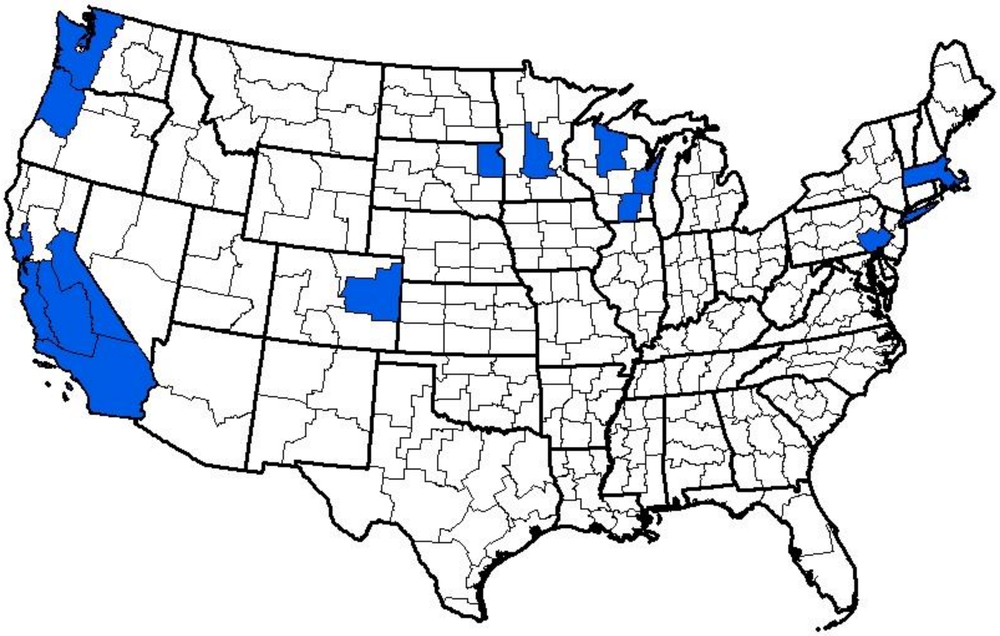

Figure A-2. Regions with facilities for non-perishable dairy products storage

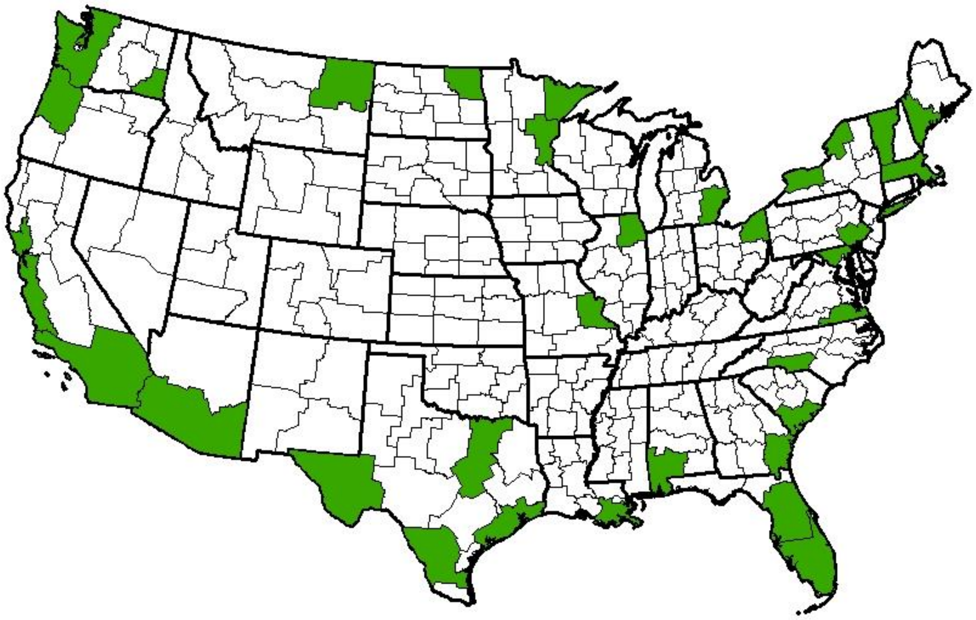

Figure A-3. Regions exporting dairy products into world market

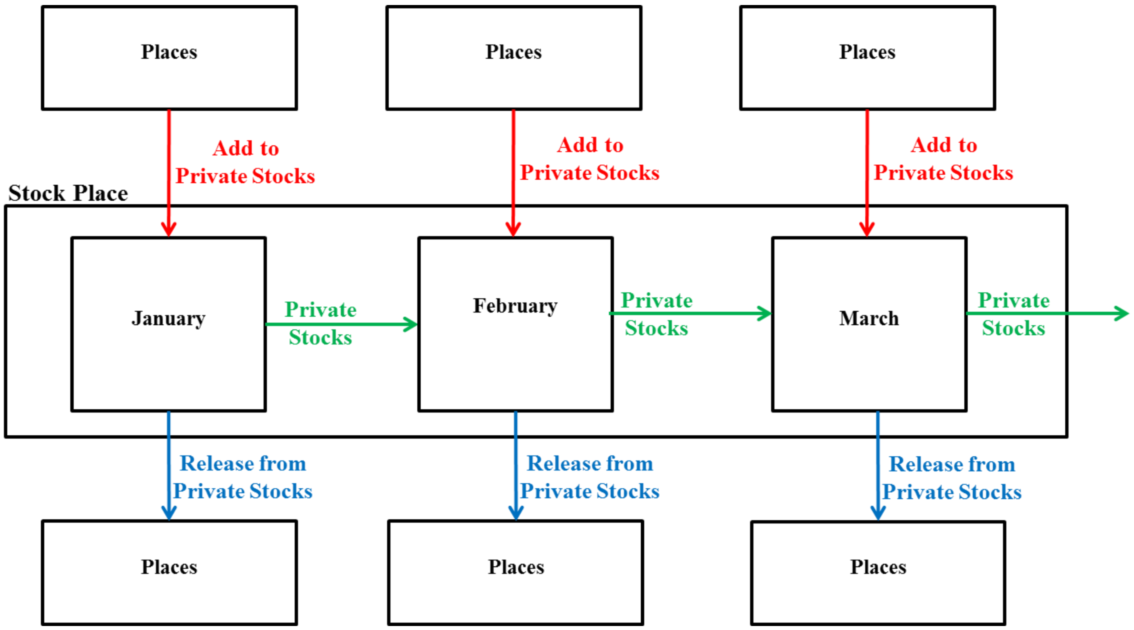

Figure A-4. Representation of decision variables related to private stocks