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Structural Changes in U.S. Dairy Farming and the Role of Government Policy

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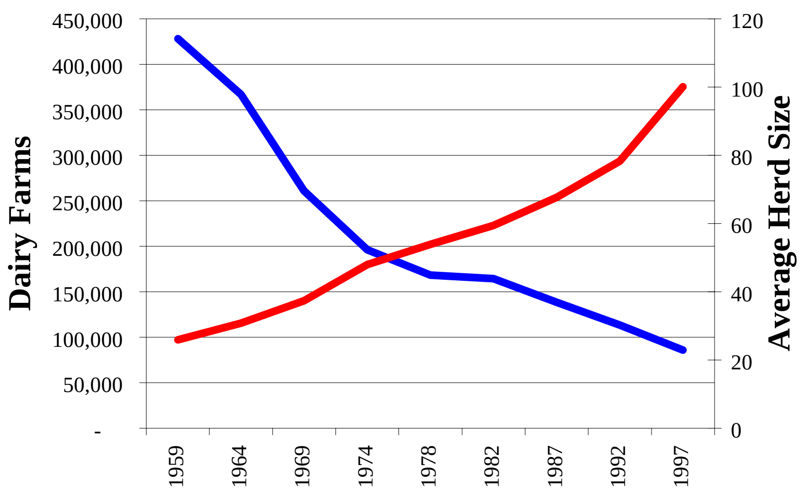
Agricultural policy faces conflicting social goals. On one hand, efficient large-scale agriculture provides an adequate, low cost food supply, but many Americans continue to idealize the smaller family farm, believing that it promotes a democratic society with strong values. The changing structure of agriculture from many small farms to fewer but larger farms is a concern often expressed. Many causes have been suggested to explain the decay in farm numbers and continual growth in average farm size. These include technological changes, lower production costs on larger operations, barriers to expansion due to large required investments in land, buildings, and equipment, opportunities for earning income by working off the farm, and government policies that affect farm profitability. This research examines these factors and their interactions in the dynamic context of the U.S. dairy industry, with an emphasis on government policy intervention.

Keywords: structural change, agriculture, dairy, technology, government policy

Background

Agricultural policy faces conflicting social goals. On one hand, agricultural efficiency is lauded as providing an adequate, low cost food supply to the world. But many Americans continue to idealize the independent family farm in the face of increasing power of multinational corporations, believing that farming promotes a democratic society with strong values. Although goals of efficiency and economic independence need not be mutually exclusive, over the past century the structure of farming has moved towards larger, lower-cost operations. From nearly ½ million dairy farms counted by the 1959 Census of Agriculture to less than 100 thousand in 1997, the pattern of decay is obvious. Also, farms are increasing in size, as the average size of a farm's cowherd is increasing approximately 2% per year over this time. Less obvious are the multiple causes of change that explain this decay in farm numbers and continual growth in average farm size. These include technological changes, lower production costs on larger operations, barriers to entry and expansion due to large required investments in land, buildings, and equipment, opportunities for earning income by working off the farm, and government policies that affect farm profitability. Each of these factors is important in shaping the path of structural change in the U.S. dairy industry.

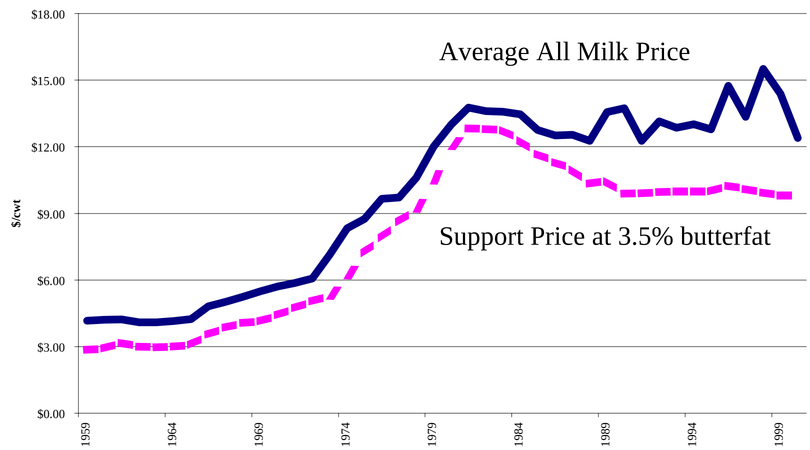
Figure 1 Historic Trends in the U.S. Dairy Industry



Viewed from many perspectives, there are differing opinions as to what type of structure would be most beneficial to society. Not everyone sees the overall trends towards fewer but larger farms to be a problem. But even among those who support increased efficiency and larger operations, there is the admission that the current structural transition will require a number of farms to go out of business. For some this is simply an unpleasant symptom of a necessary change, but for others, farm bankruptcy is a painful part of a process that need not occur. "Dairy farm families of the U.S. are enduring an unprecedented financial crisis," according to a U.S. Senator, and, "the number of family-sized dairy operations has decreased by almost 75 percent in the last 2 decades, with some States losing nearly 10 percent of their dairy farmers in recent months". As one of the latest government attempts to solve the dairy industry's problems of low net farm income, the National Dairy Farmers Fairness Act of 2001, would provide financial assistance to dairy farmers facing financial difficulties in an attempt to reduce bankruptcy rates. To date, the discussion of U.S. dairy policy continues as legislators seek viable solutions.

Partially due a legislative perception that achieving the short run goal of higher farm incomes automatically achieves the long run goal of stable farm numbers, the U.S. government has attempted to support agricultural commodity prices. Although the political process is not the focus here, the influence of government intervention, particularly the Dairy Price Support Program (DPSP), is of great historical interest in shaping the current structure and will continue to affect industry characteristics. Begun in 1949, this program purchases manufactured dairy products to effectively maintain a minimum market price for all milk. The goal of the DPSP is to stabilize and enhance milk prices received by farms. For many years, the DPSP provided a basic amount of price protection and stability at a relatively low cost to the federal government. Political promises in the 1970's lead to increases in the government support price, which provided financial incentives to farmers to increase milk production. Soon the government was purchasing almost $2 billion worth of surplus dairy products to maintain minimum market prices. Controlling the supply of milk was not a viable political option, so the government tried paying farmers to produce less milk (Milk Diversion Program) or to sell their herds altogether (Dairy Termination Program). When these attempts failed to reduce DPSP costs during the mid-1980's, the support price was lowered so that it provided a minimum "safety net". From 1990 on, the DPSP has had a limited influence on prices and farm incomes while the variability of prices received by farmers has increased.

Figure 2 Annual Milk Price and Government Support Price



Source: Dairy Yearbook, USDA-ERS

The DPSP is a policy that allows farms complete freedom and flexibility in production practices and management decisions. Additionally, it is often portrayed as a means of saving small family farms and slowing the rate of farm exit because it provides income protection. Given that the program supports the incomes of all dairy farms, one can easily hypothesize that the program's effect would be to maintain more farms in the industry. Policymakers see that the DPSP benefits those farms that need the most financial protection while often missing that the DPSP simply adds additional profit for farms with already strong financial performance. Also, because the benefits are based on the quantity of milk produced by the farm, greater milk production implies greater benefits. So the DPSP provides incentives to expand the size of farms and aids larger farms significantly more than small farms. If this is the case, removing or eliminating the DPSP would be a serious challenge to policymakers because those most negatively impacted by such actions would be the farms that the government is most trying to protect, small family farms with financial difficulties.

Also a contributing cause to structural change is a long-standing argument in agricultural economics of a 'technological treadmill'. As a new technology is introduced, some farms adopt this technology because it appears profitable for them. This technology generally increases production and lowers per unit costs of production for the farms that adopt. It is the lure of greater net farm income from lower production costs that 'pulls' these farms to adopt the technology. Assuming that an individual farm is unable to influence the milk price, the adopting farm is able to increase profit margins since the per unit production costs are lower. As other farms recognize that the new technology is profitable, they too begin to adopt. Eventually the effect on the market is increased supplies, which result in lower prices. Now the farms that have lowered their costs with the new technology are making only a modest rate of return while those farms that did not adopt see their rates of return fall. They must decide whether to keep up by adopting the technology or to exit, finding other opportunities for their capital and labor. In a sense, these farms are ‘pushed’ to expand or exit. A common result of this process is that the early adopter captured profits initially and then uses those proceeds to expand, perhaps buying the assets of the non-adopting and less profitable farms.

Because of this, the dairy industry is a prime example where the effects of government policies contradicted economic incentives and resulted in a policy’s impact being delayed, diluted, and defeated. Using system dynamics, this research attempts to overcome some of the limitations of traditional economic analyses to examine how government intervention in dairy product markets has affected the distribution of farm sizes and numbers in the dairy industry. The principal question to be addressed is, “How has government policy over time altered the path of structural change among dairy farms from what it would have been otherwise?” The hypothesis is that the DPSP will impact structural change by slowing the rate of farm exit, but increasing farm expansions. Other insights into government policy may be gleaned regarding farm income enhancement, milk price stabilization, and the effect of policies indirectly related to dairy but which do have an impact. The goal is to increase the speed of learning in order to avoid costly policy errors.

Prior Research

Looking particularly at structural change, many statistical studies have been performed to try to understand and predict the number of farms of a particular size. Using forecasting methods such as trend extrapolation, negative exponential functions, lognormal distributions, Markov process, and age cohort analysis, economists and statisticians have attempted to predict future trends. For example, Markov analysis divides time and farm sizes into discrete units and calculates from one state to the next given a set of initial conditions and constant transition probabilities. All studies predict that farm numbers will decline and production per farm will increase, but some forecasts fail to capture the growth of farms in the largest size categories. For example, Edwards found a bimodal distribution of farm sizes where farms with 1-49 acres are holding steady, farms over 500 acres are growing, and those left in the middle are declining. Even so Stam, Koenig, Bentley, and Gale imply that none of these statistical methodologies emphasize the causal, dynamic, and nonlinear economic relationships that underlie the observed patterns.

Examining the DPSP and the potential for altering policy goals, research in agricultural economics is quite extensive. Early studies use simple supply and demand curves to demonstrate how support programs influence social welfare, whereas later statistical models estimate the costs to society by comparing scenarios with and without the DPSP. Milk production is anticipated to expand in response to higher support prices, but competition for resources increases the cost of production such that no farm is overly profitable. Gruebele expects increased price instability and more rapid farm exits without government support. In a study by La France and de Gorter, the total social costs are estimated to be over $400 million annually with consumers worse off while farmers benefit from stability and higher prices.

History has also influenced the direction of agricultural economics research regarding the DPSP and related dairy programs. Political pressures during the late 1970's and early 1980's increased the government support price faster than inflation, resulting in incentives for increased milk production. The problem with enhancing farm incomes through the DPSP was that government purchases of dairy products exploded to nearly $2 billion per year. Multiple policies during the 1980's attempted to counter this problem and included paying farmers not to produce, buying and disposing of entire cowherds, stimulating demand through advertising, subsidizing exports, and when all else failed, lowering the support price. Since numerical data is readily available for performing econometric estimation and modeling, multiple statistical studies have been performed. Generally, these studies isolate the impacts of multiple factors and then use those estimated parameters to simulate the system without the impact of the DPSP. These studies estimated that lowering the support price or eliminating it altogether would be an effective means of lowering government purchases. Without the DPSP various authors speculate that price volatility would increase and more farms would exit the industry.

In addition to providing a basic farm safety net, the DPSP reduces price risks associated with the insensitivity of supply and demand for milk to its price. According to both Manchester and Harris, the significant capital investments in modern dairy farming often limit the industry's ability to respond to price changes by slowing both entry and exit of farms, whereas consumers do not change their food purchasing habits easily or quickly. Some economic studies attempt to examine the allocation of resources in the dairy industry without the DPSP, finding that the removal of the DPSP increases variation in milk prices. If the DPSP were removed, particularly at a time when it is actively supporting prices, Chang and Stefanou's results indicate that adjustment would be rapid, almost chaotic, as farms disinvest themselves of financially burdensome capital. Christ advocates continuation of the DPSP in order to alleviate the risk of fixed assets for producers, stabilizes consumer prices, and avoid the high cost of abandoning capital.

As a caveat to many of the studies, econometric models can provide some information when considering the DPSP, but are limited by their use of historical data. Many of the studies are performed outside of the range of available data and are subject to the critique proposed by Lucas and by French—econometric estimates from one policy regime are suspect when used to evaluate a different policy. Additionally, econometric techniques often assume independence of explanatory variables, which severs feedback loops and ignores delays. These drawbacks of statistical models of the U.S. dairy industry are significant when questioning the impact of a new policy regime.

Providing a new approach to an old problem of policy analysis, system dynamics can evaluate the effect of different policy initiatives by incorporating the industry's incentives and feedback structure without being limited to numerical data. Previous studies of agriculture done using system dynamics are few in number but significant in their contribution to understanding. Meadow's hog cycle model investigated the production cycles and price oscillations in commodity markets, particularly hogs, finding that expectations of the future are key to decision making in commodity markets. Davidsen and Asheim investigate the Norwegian fur farming industry and find that farm income and capital investment are strong determinants of farm decision-making and subsequent supplies. Earlier studies that focused particularly on the dairy industry include those by Seddon, who looks at biological and financial decisions on dairy farms, and Budzik, who addresses some similar concerns of the trend towards fewer but larger farms with a focus on individual farm characteristics and government policies such as land use.

Dynamic Hypothesis

The dynamic hypothesis of this study includes five major components that influence farm exits and expansions: technological changes, lower production costs on larger operations, barriers to expansion due to large required investments in land, buildings, and equipment, opportunities for earning income by working off the farm, and government policies that affect farm profitability. Combined, these influences explain much of the trend towards fewer and larger dairy farms. Technological change has dramatically increased the productivity of dairy cows, labor, and equipment. New and more advanced milking systems have improved productivity and lowered costs. But to achieve this increased efficiency often requires significantly higher capital investments. Meanwhile, the rest of the economy has grown dramatically, and non-farm wages have increased enough to lure farmers, particularly young ones, into other occupations. Finally, government policy has attempted to stabilize and enhance farm income, primarily through a targeted minimum milk price.

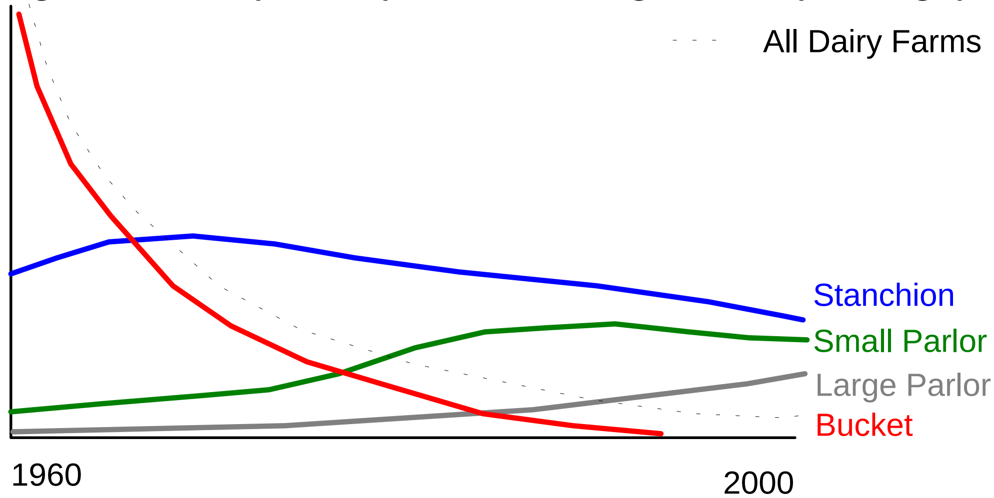
Components of the dynamic hypothesis are illustrated well in the transition between two systems used to milk cows. Early milking systems were small-scale and very labor intensive because all milk was transported manually in canisters or buckets directly to the processor. With the invention of the bulk tank for cooled, on-farm storage of fresh milk, the transition to pipelines and bulk tanks was encouraged because production costs per unit were reduced. The new milking system required significant capital investment to upgrade a farm’s facilities. Many farmers quit because they did not have the financial or personal resources to make the transition, even though the government was supporting and stabilizing milk prices. Many of these farmers found better opportunities for employment in other sectors of the economy, which also hastened the exit of the farm and its resources from the industry.

Model Structure

Many people think of structural change in terms of the farm population, or the number of people on farms, where farm operator turnover is examined as a measure of structural change. However, this study counts farms as a physical stock, rather than focusing on the farm population. A farm is defined as a set of productive resources of a given technology that is used in the production of milk. Multiple farm operators or multiple locations that are part of the same business would be classified as a single farm. This classification allows farms to stay in the industry if the farm is relatively profitable but the operator is retiring without a designated successor or heir. If the farm operator’s income is enough to induce people to choose dairy farming as an occupation, the farm’s resources continue to be utilized for milk production.

Dairy farms are classified based on the technology of the milking system rather than by the size of the farm’s herd, although size is highly correlated with milking system. The categories of milking system as defined by technology are *Bucket* (milk is hauled in canisters), *Stanchion* (portable milking machines but stationary pipeline to a bulk tank), *Small Parlor* (cows move to stationary milking machines, up to 16 cows milked at once), and *Large Parlor* (any stationary system larger than *Small Parlor*). The technology of the milking system advances from low investment *Bucket* styles to *Stanchions* and then *Small* and *Large Parlor* systems. Generally, the farm's herd size increases with the advances in technology to take full advantage of cost savings over a larger volume of milk production. This form of disaggregation by milking system embodies the technological progress seen over time, avoids the ambiguities associated with defining 'small' and 'large' farms, and captures a distinction that is clear in the minds of all persons in the industry.

Figure 3 U.S. Dairy Industry Structural Change Pattern by Milking System



Sources: Mark Stephenson, Roger Blaser

Note that the scale for *Stanchion*, *Small Parlor*, and *Large Parlor* has been expanded to demonstrate the pattern of behavior. If all lines were on the same scale, the distinction between the categories would not be discernable, and all farm categories would lie below the total number of dairy farms.

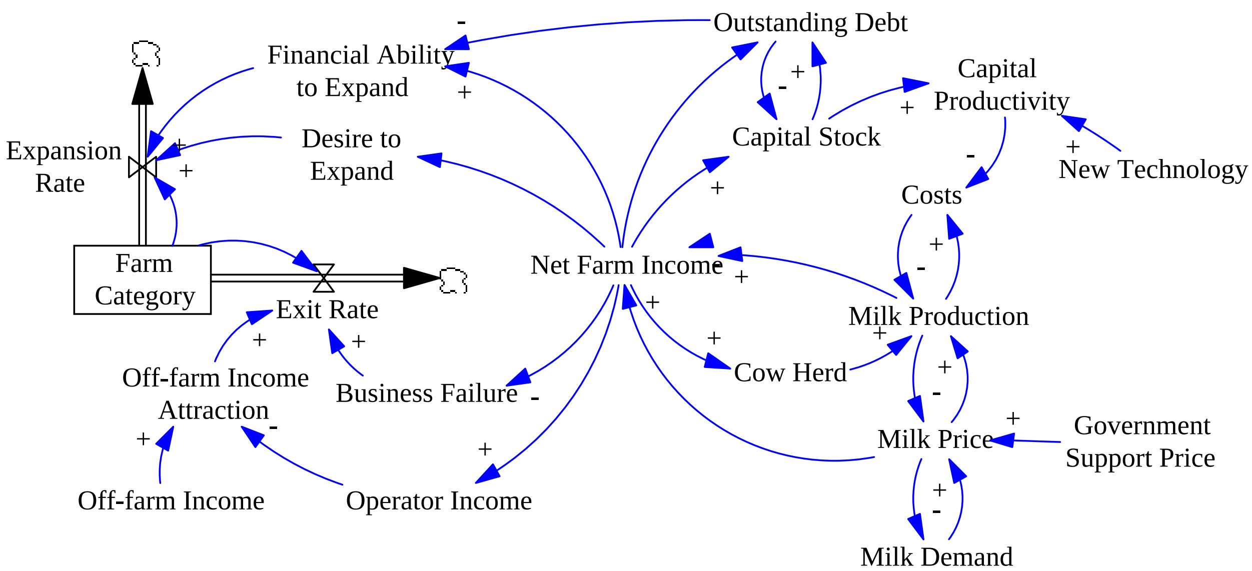
The movement of farms, both between technological categories and out of the industry, is the primary focus of the issue of structural change. It is assumed that when farms expand, they expand to the next most advanced milking system, which is by far the most common transition. In the model, farms are not allowed to move to a "lower" milking system technology because even a transition to a less advanced category would require a financial investment to convert facilities and equipment. This would not be a rational choice because the more advanced technology is generally lower cost even when underutilized, and during poor financial situations, the transition costs of moving to less advanced technology could not be met. Further, this situation is uncommon, although a limited number of dairy farms have made the transition to grazing and/or organic production in such a manner.

Also, an entry rate is not an essential part of the policy space needed to address the focus of this research according to the literature and industry experts. The creation of a completely new dairy farm that does not build on the resources of at least one existing farm is rarely observed.

Generally, most new farms are created from the purchase or consolidation of previously existing farms. In reality it would be possible for new farms to enter the industry, but they would choose to enter with the most efficient and profitable technology. So the entry of new farms in this context would be limited to *Large Parlor* farms with relatively cowherds and low production costs. The result of this action would be to force smaller farms out even faster since prices would fall further with the increased milk production of these larger, more advanced farms. So if an entry rate were included, the total number of farms would be likely to decline even further as more technologically advanced farms come to dominate the industry.

Given that the scope of the model is national, much of the model is an aggregation of farms, so most auxiliary calculations can be considered the average for a representative farm of a particular category without spatial or geographic characteristics. Finally, it is assumed that each farm category makes decisions based on the same incentives, even if the magnitude of those incentives vary, which allows the use of subscripts in the model. The model does not include the seasonal cycle of production, market prices, and government stabilization that occurs in the dairy industry because seasonal variations do not influence long run decision-making such as expanding or exiting the industry. The following diagram is a simplified representation of the causal influences for the decision-making and behavior of a single farm category.

Causal Diagram 1 Single Farm Category



Within this structure farms have the option to expand the business, continue with the current milking technology, or quit. In Causal Diagram 1 the *Exit Rate* and *Expansion Rate* are both first-order outflows from the stock of farms, and expanding farms enter the stock of the next most advanced *Farm Category*. To better clarify, if two of a farmer's children take over the farm, the categorization of the farm does not change, and there is no entry because the farm already existed; but if the children convert to a milking parlor from stanchions, the farm expands into the next farm category.

One of the key variables that profoundly influences farms decisions and is central to the model is *Net Farm Income*. The amount of farm income reflects the financial health of the farm and is often the target of government policy. According to the industry's definition, *Net Farm Income* is total revenue minus costs excluding debt payments, capital depreciation, unpaid family labor, and return on equity. The impact of the farm's current financial situation and expectations of the future influence not only exit and expansion rates, but the size of a farm's cowherd, capital stock, and borrowing capacity. When *Net Farm Income* falls, the *Exit Rate* will increase because when farms are failing to make debt payments, their resources are not profitable enough to continue operating in the industry. Other farms are not able to pay the farm operator a high enough wage to keep them on the farm instead of taking employment elsewhere. Further, when looking at the *Expansion Rate*, the *Net Farm Income* for both the current and next most advanced category are compared to determine the farm's *Desire to Expand*, where as a farm's *Financial Ability to Expand* is limited by the farm's credit rating, determined by income and debt levels. When *Net Farm Income* increases, there are financial incentives to expand the average herd size and productive capital stock to further utilize the current milking technology. Additionally, strong financial performance, both current and expected, improves the farm's evaluation by a lender and increases the maximum funds available from the lender. To positively influence *Net Farm Income*, the government has set a target milk price, which indirectly supports the income of all farms.

Another important factor in a farm's finances are *Costs*, which represent expenses such as animal feeds, labor expenses, taxes, utilities, etc. Generally, the cost per unit decrease as the total volume of *Milk Production* increases because fixed costs are distributed over more units. *New Technology* reflects the increases in productivity of newly acquired capital over older *Capital Stock* due to technological progress imbedded in new capital. On individual farms capital is often acquired by taking on additional debts to finance the often large lump-sum expenditures required. In the model this is reflected by requiring the farm to take on *Outstanding Debt* to finance the expansion of *Capital Stock* under the current milking technology.

Although milk is used to make multiple types of products that each have their own market and price, the model aggregates that behavior to determine the price received directly by farms for unprocessed milk. Inventory holding behavior in the industry tends to produce oscillations in response to shocks. The primary flow of milk products into inventory is the sum of all milk produced on farms, while outflows are based on a domestic consumption rate that grows due to increased population but still responds to the market price. International trade of milk products is included, but it makes up only a small fraction of the total milk inventory as it is limited by quotas and tariffs. Important to this research is the impact of the DPSP and its purchases of milk products to stabilize *Milk Price*. When the *Milk Price* approaches the *Government Support Price*, manufacturers sell some of their inventories to the government, which limits how far the *Milk Price* can fall by relieving some of the inventory pressure on price.

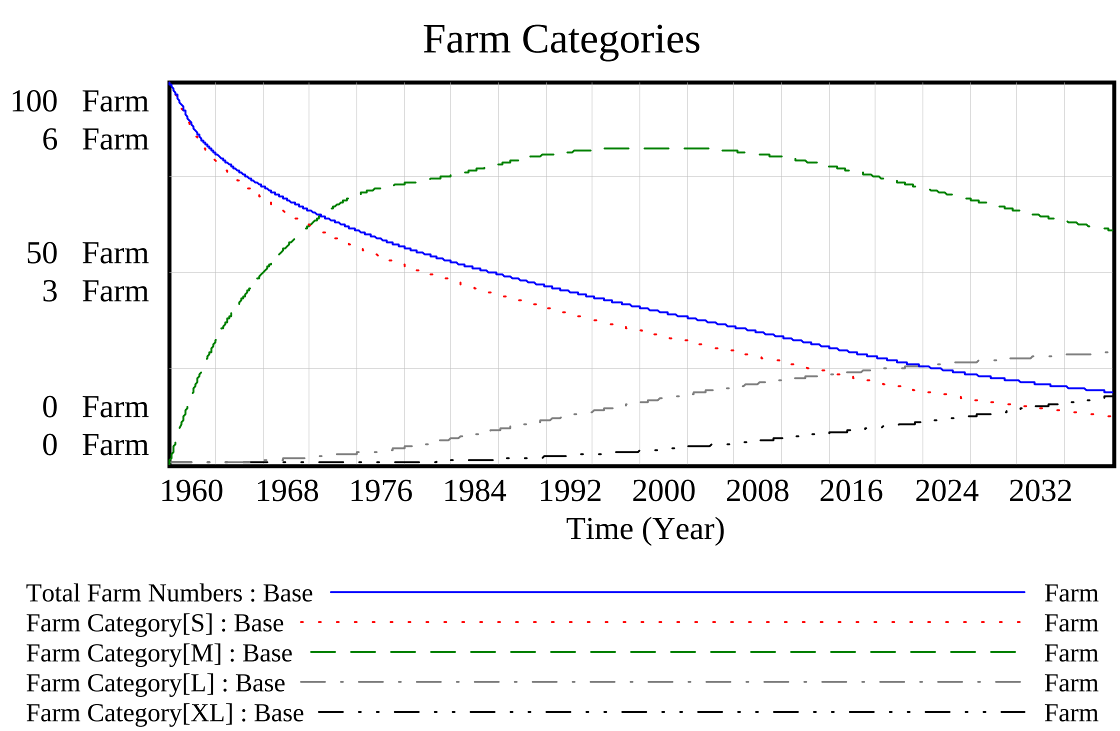
Preliminary Results

Base Simulation

Since the behavior mode over time is not equilibrium but decay, all simulations testing different policies are compared to a Base scenario. (A listing of selected results from the various simulations discussed here can be found in Appendix 1.) The Base run consists has initial conditions of 100 *Bucket* farms and no farms of any other technology beginning in 1960. The patterns of interest are how those 100 farms disperse among the categories or exit the industry. Many exogenous variables are constants in real dollar terms (base = 2000), which allow the model's behavior to be isolated from nominal changes in values. In the Base run, the government's support program is effective at maintaining a market price at or near a $9.90/cwt minimum when market forces would push the price lower. However, the historical pattern of increase and subsequent decrease due to excessive government expenditures has not been included.

Technological progress is imbedded in growth of the labor productivity of capital and genetic milk production potential of cows. The adoption of technology has varied by farm category because smaller farms have found it difficult to purchase new technologies in small quantities. Most capital equipment embodying new technologies can be made for smaller farms, but the return per dollar spent is lower. Smaller farms often do not make the investment because they have fewer cows over which to spread the fixed costs.

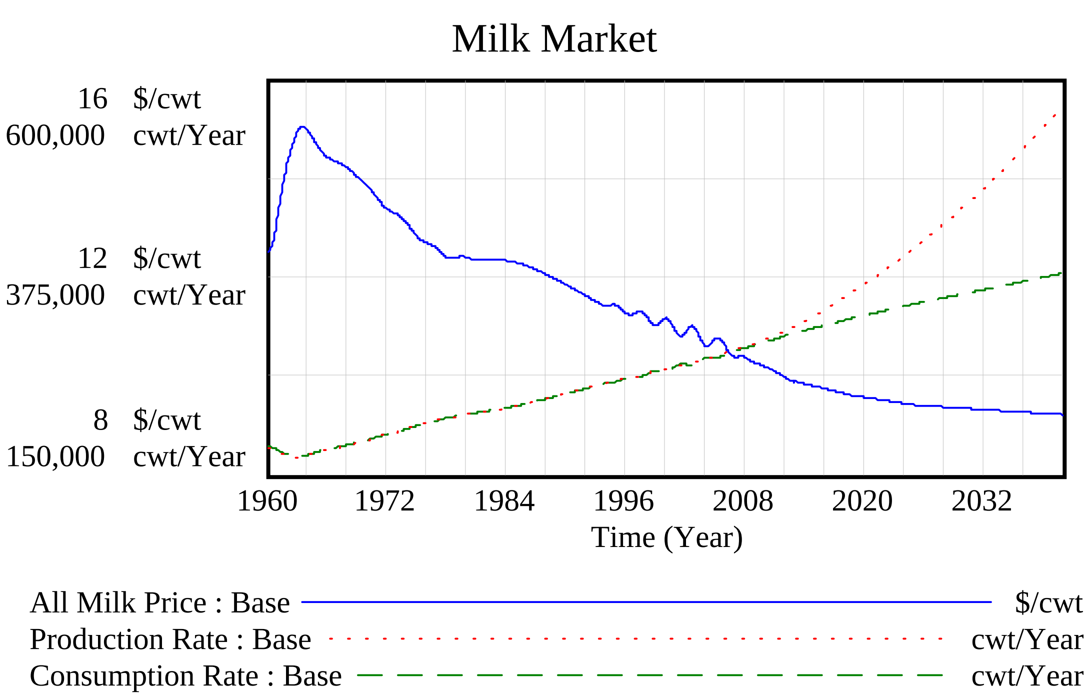
Figure 4 Base Simulation



In the above figure, note that the axes are different for the *Bucket* farms and the other three categories. The category values sum to the *Total Farm Numbers,* which has the same scale as the *Bucket* farms. Beginning in 1960, all 100 farms are utilizing *Bucket* technology. By 2000 there is a peak of 5 farms from the initial 100 farms using *Stanchion* technology as their milking system, but their numbers eventually decline to only 3.7 farms. By the end of the simulation in 2040, 1.7 farms have adopted *Small Parlors*, 1.1 farms are using *Large Parlors*, and in total there are less than 19 of the original 100 farms remaining in the industry.

The *All Milk Price* is the aggregate price paid to farms for the milk that they produce, irrespective of geographic location, quality, or volume premium payments. Milk prices rise initially as the market adjusts to the steady increase in consumption due to population growth. For the industry to expand production to meet the annual growth in consumption there are some delays present, both biological and financial, that limit the flexibility of the industry. But once incentives begin to induce farm expansions, farms with more advanced technology see greater returns due to their lower cost of production. These farms continue to push the utilization of their current milking technology and consider moving to the next level of technology in order to produce more milk at a lower cost. This results in an oversupply of milk to the market, forcing prices lower. This expansion continues as technology drives the cost of production lower until the government must step in to maintain a minimum price above the perfectly competitive market price. When this happens around 2010, farm incomes improve which slows the decline in farm numbers even though government expenditures grow. The following figure shows the patterns of the *All Milk Price* and the levels of production and consumption. The divergence of production from consumption is due to government purchases of surplus dairy products to maintain the price floor.

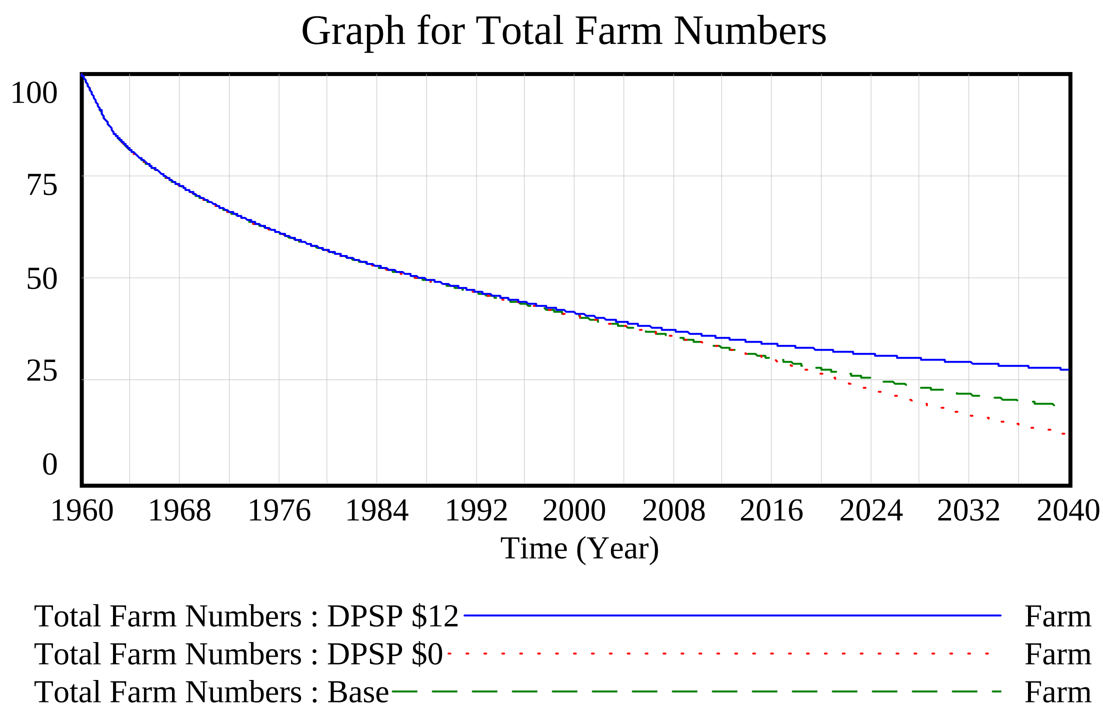
Figure 5 Base Simulation



Government Price Support Simulations

One of the major questions of this research has to do with the impacts of the DPSP on the number of farms in the dairy industry. Has the program been able to achieve its goal of maintaining adequate farm income to alter the path of structural change? Such an inquiry is addressed by changing the support price. With the Base at $9.90/cwt, raising the support price to $12/cwt keeps nearly 27 of the initial 100 farms operating compared to only 19 farms by the end of the simulation. Often discussed by policymakers is the total elimination of the DPSP, and although this model does not capture all of the risk components that the program mitigates for dairy farms, the elimination the DPSP is tested with a minimum support price of $0/cwt. The model shows that an additional 7% of dairy farms would permanently exit the industry by 2040 without government support.

Figure 6 Base and Alternative Support Price Simulations

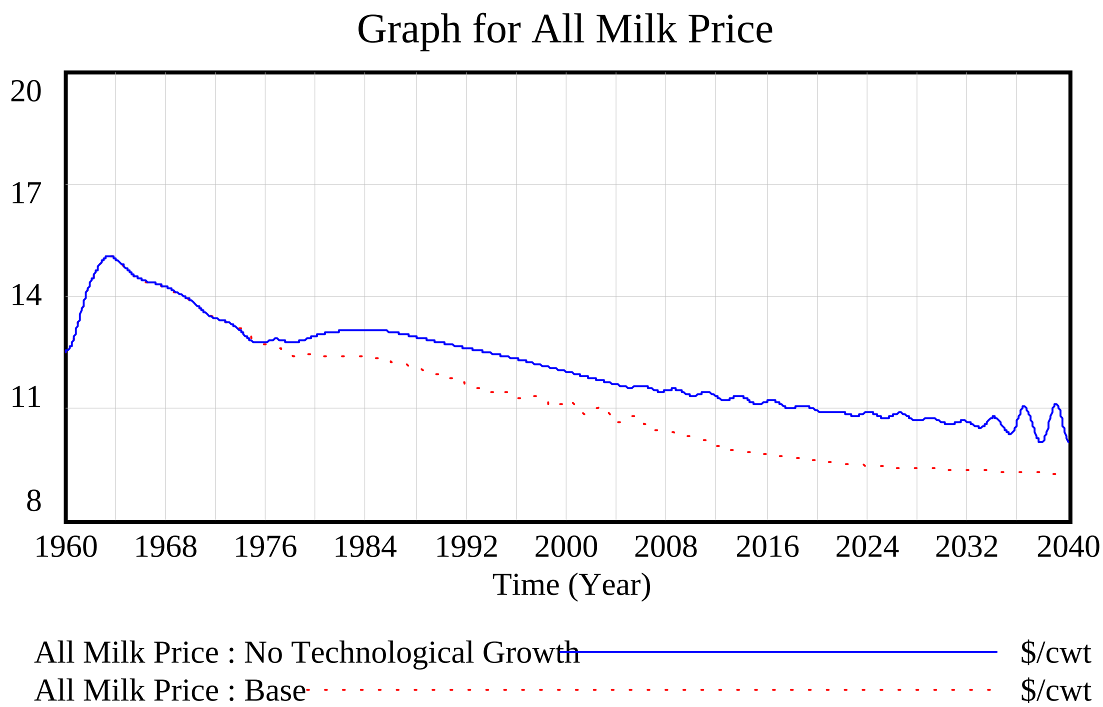


Technology Simulations

Technology and its impact upon structural change is also a major concern of this research. Model simulations were conducted that varied the technological progress observed in the industry. Historically, capital in agriculture has been labor saving, such that a single operator can produce more output in less time. The first simulation is the hypothetical case where these increases in the productivity of labor do not occur. The differences in milking system technologies continue, but within each category, the productivity of labor is constant. This implies that capital purchased in 2010 is just as productive as capital purchased in 1960. The results do not show large changes in farm numbers nor in their behavior mode. Without technological progress, only 2.5% more farms stay in the industry.

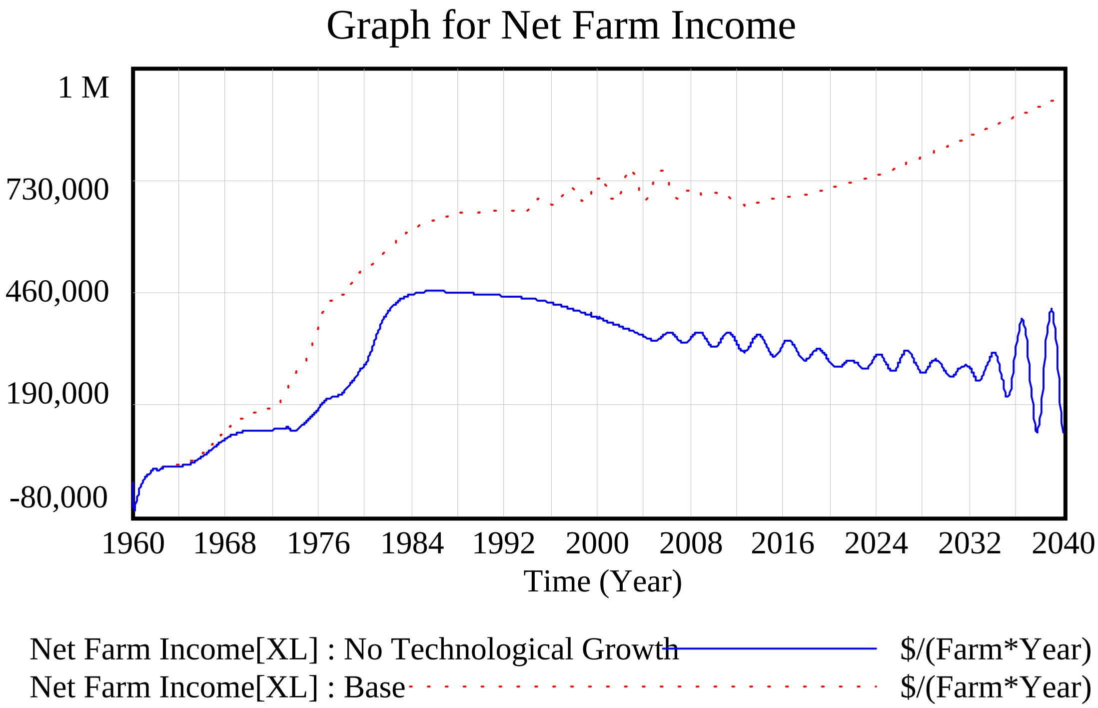
However, technology does have the ability to lower costs, which in turn affects milk prices and farm incomes. The milk price reflects the marginal cost of production and the price required to draw forth adequate supplies to meet consumption demands. Without technological growth, the cost of production does not decline over the course of the simulation for each category. Under this scenario, a farm cannot continue to utilize the same technology set and see any reduction in costs. The decline in the *All Milk Price* is solely due to farms expanding to the next technological category where they can acheive lower production costs.

Figure 7 Base and No Technological Growth Simulations



Without the technological advances for a given milking system, farm costs are higher due to stable rather than declining labor needs, and farm profitability is lower. Looking at the *Large Parlor* category, the distinction is very clear. (Note that early in the simulation, many *Small Parlor* farms are expanding into the category, which brings down the category average.) Without the growth in technology, hired labor on the farm continues to be a large expense that cuts into the net farm income. The oscillations in income are due to the variation in the milk price because farm expenses are stable in real dollar terms.

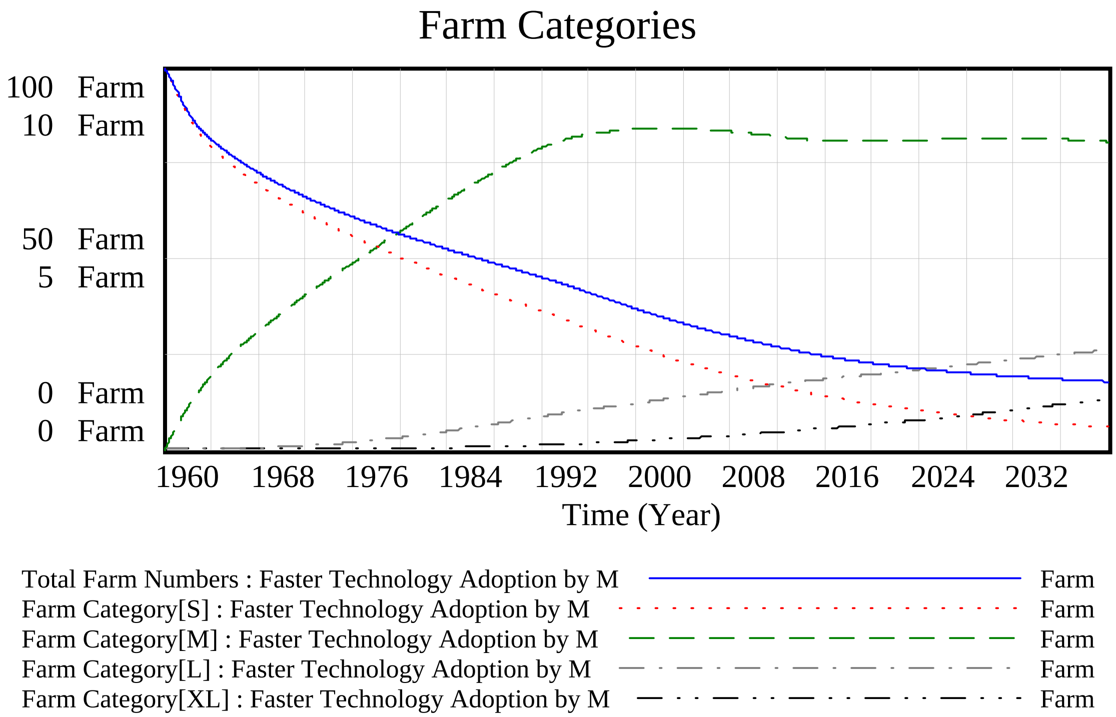
Figure 8 Base and No Technological Growth Simulations



The dairy industry has observed that many new technologies have numerous advantages when used on larger scale farms. What would the industry look like if this were not the case? A scenario that some people hypothesize could change the pattern of structural change is that a new technology could be developed that would benefit smaller farms rather than large. Increasing the rate of technological progress and productivity growth for farms with *Stanchion* milking technology tests this. The faster rate of technological progress and lower unit costs results in lower milk prices, hurting farm incomes for some and forcing these farms to exit sooner.

Although the total decline in farm numbers is less than 1% greater than the Base, the change in the distribution of farms among the categories is noticeable. The number of farms with the least advanced technology, *Buckets*, declines faster, and by the end of the simulation, only half of the farms present at the end of the Base simulation remain. More *Bucket* farms are attracted to *Stanchion* technology because the rapid rate of technological progress and cost declines. It also appears that with the faster growth in labor productivity, the *Stanchion* technology remains competitive with both *Small* and *Large Parlor* farms. Although more farms expand into the *Small Parlor* category from *Stanchion*, it is due less to a desire to expand and more to the financial ability. Fewer *Stanchion* farms want to expand because the income difference between the categories is smaller, but those farms who choose to expand have the financial wherewithal to undertake the transition.

Figure 9 Faster Technological Growth by Stanchion Farms



Other Policy Simulations

There are other policies could be created and/or implemented to impact the number of dairy farms in the U.S. In the past, choices by policymakers may not have been the most effective means of altering the path of structural change. For example, historical consumption of dairy products in the U.S. has been increasing with the population, while the government has attempted to influence consumption by creating a National Dairy Board that devotes industry resources to simulating demand. It has been suggested that this growth in consumption has kept more farms in business since they are not competing as vigorously for market share since the market is expanding. The results of a trial without consumption growth indicate that as farms expand due to cost and technological incentives, fewer total farms are needed because the more technologically advanced farms are able to produce more milk per farm. Similar to arguments supported by Budzik, there is a limit to the number of farms needed to supply stable consumption demand. There are more exits from *Bucket* and *Stanchion* categories, which limits the number of farms that could adopt any form of parlor technology. In total, the lack of consumption growth results in only 11% of farms needed to supply consumption demands instead of 19% by 2040.

Some macroeconomic variables can play an important role in the financial health of the industry even if they are exogenous to the system. It is the policy of the U.S. Federal Reserve Bank to set interest rates, and this can directly impact the dairy industry’s financial outlook. Interest rate changes are significant when rates change dramatically, as what occurred in the early 1980’s when interest rates were was well into double digits compared to only a few years earlier. A higher interest rate discourages farms from closing the gap between their actual and desired levels of capital as quickly because of the expense of borrowing. Higher interest rates also lead to higher interest payments and less income per farm that can be devoted to capital investments or operator income. The interest rate of the Base scenario is 2% plus a risk premium based on the debt-to-asset ratio of the farm. A scenario was investigated with a base interest rates of 15% in addition to the farm's risk premium. If such a ratio were sustained over time, total farm numbers decline by 6.5% more over the course of the simulation with most of this decline attributable to the least technologically advanced farms exiting the industry.

Another macroeconomic variable that influences dairy industry structure is the wage rate paid by off farm employment. The opportunity cost of farming, or the value of the next best alternative, is reflected in the relative wages between farm and off farm employment. When farming cannot return an adequate income to a farm operator compared to working elsewhere, the industry will gradually lose farms as the attraction to off farm employment becomes too great. Off farm wages do impact the total number of farms, particularly the smaller farms with less advanced technology. A 20% change in the off farm wage rate induces a change from the Base scenario of nearly 5% of total farms. So instead of 19 farms left at the end of the simulation, only 14 are left when off farm wages increase 20% since farming is a less attractive form of employment.

Feed prices are a significant component of production costs for dairy farms, so government intervention in other commodity markets such as corn and soybeans could impact dairy. For example, the 1996 Freedom to Farm Act dramatically increased the production of feed grains in this country, which in turn lowered the prices paid for animal feeds. One question is how a significant change in feed prices impacts dairy farm numbers. The results of permanently stepping feed prices down by 20% in 1961 are as is expected—slightly more farms are able to stay competitive when feed prices decline. A 20% change in feed prices can induce up to a 5% change in the total number of farms in the industry by 2040, although the distribution of farms in the various technology categories remains approximately the same.

Another concern of many policymakers is the impact of the tax rates upon farms. Although taxes are a relatively small portion of a farm's operating expenses, policymakers find tax rates to be an easy and politically advantageous lever to utilize. Because it adds an additional cost to the operation of the business, tax rate adjustments change the amount of farm income that can be devoted to reinvestment, paying down debt, or personal farm family income. With higher tax rates and lower farm incomes, fewer farms survive. But policy changes do not have a significant impact upon farm numbers. An increase in the tax rate of 25% decreases farm numbers by only 1.1% over the course of the simulation.

Conclusions

This study attempts to incorporate many factors of structural change into a model to develop better understanding of agricultural policy. Including technological changes, lower production costs on larger operations, barriers to expansion due to large required investments in land, buildings, and equipment, opportunities for earning income by working off the farm, and government policies that affect farm profitability, the pattern of fewer but larger farms emerges. This research examines these factors and their interactions in the dynamic context of the U.S. dairy industry, with an emphasis on government policy intervention.

This research demonstrates that the DPSP slows the exit of farms from the dairy industry while still providing farms with the freedom and flexibility to expand. When the government's price support is set higher, farm incomes and numbers are maintained as claimed by policymakers. There are fewer business failures and farming is a more attractive employment prospect, which lowers the farm exit rate. However, the key to understanding the full effect of the DPSP is that the benefits are not exclusive to a single farm category. Farms with more advanced milking technology and larger cowherds see much more dramatic increases in income due to the larger volume of milk they produce at a lower cost. First, this implies that less technologically advanced farms will not be content to stay small because, relatively speaking, there is more money to be made if they were to expand. Also, the advanced farms are provided the financial resources to purchase more capital and take advantage of the increased productivity of newer capital, further increasing the competition between farms. For all farms, a high government support price encourages increased output, which leads to higher government expenditures to maintain the minimum milk price, an expensive proposition for taxpayers. From a political perspective, politicians often claim that the DPSP saves small family farms, but this study demonstrates that such an objective is only moderately achieved. A higher support price may be a short run solution to the problem of low farm incomes; however, the system reacts to the policy with a hastening of the long run increase in the size of farms. This counter-intuitive behavior of encouraging larger farm sizes and increased use of capital technology demonstrates the unintended consequences of using the DPSP as a means of altering structural change.

Factors such as feed costs, taxes, and interest rates do influence farm incomes and do impact the total number of farms in the industry by influencing net farm income. Consumption growth helps farms to stay competitive since the market is expanding enough that there is less competition among farmers. Off farm wages attract farm operators away from the industry, simply increasing the rate of exit until farm returns rise high enough to compensate those who remain. However, all of these factors are unable to alter the fundamental behavior mode of exponential decay in farm numbers, and again, the trend towards fewer but larger farms continues.

Technology appears to be the best policy lever to alter the distribution of farms in various categories. The farm category with the fastest rate of technological progress is the most advantageous and attractive to be a member of. These farms are able to lower costs faster than the rest of the farms in the industry. Their profit margins are widening even as milk prices are falling. For farms in other categories with a slower rate of productivity gain, they are caught in a trap of revenue falling faster than their costs of production. The technological treadmill often forces these farmers to adopt new technologies just to maintain adequate income. If Americans felt that altering the distribution of farm sizes and technologies was a goal, money could be devoted to research and development of technology aimed at a specific farm type or category. By increasing their rate of technological progress, society would be offering these farms a competitive advantage in the market place such that the farm enterprises would thrive. Investment in technology would also have the additional social benefit of lowering milk prices and inducing greater consumption of dairy products that would increase the nutritional content of the average American diet. However the government's support price must be lowered to keep pace with the falling cost of production or taxpayers will bear a significant burden of purchasing surplus dairy products. The advances in technology will be diluted by the economic incentives to expand production provided by the DPSP since farms with less efficient production technology will remain in the industry.

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Appendix 1 Simulation Results Summary

Simulation Description	Final Number of Farms	Distribution by Milking System			
		Bucket	Stanchion	Small Parlor	Large Parlor
Base	18.6	12.2	3.7	1.7	1.1
DPSP $0 – No Support Price	11.9	8.0	1.7	1.3	0.9
DPSP $12 – High Support Price	27.7	15.3	8.0	3.0	1.4
No Technology Growth	21.0	16.2	1.7	1.3	0.6
Faster Technological Growth by Stanchion Farms	17.8	5.8	8.1	2.6	1.3
No Consumption Growth	10.8	6.5	2.2	1.2	0.9
Increase Interest Rates to 15%	12.3	7.4	2.2	1.6	1.1
Increase Off-farm Wage Rate 20 %	13.6	7.7	3.0	1.7	1.1
Decrease Off-farm Wage Rate 20%	22.3	14.7	4.4	2.0	1.2
Increase Feed Costs 20%	14.1	9.3	2.5	1.4	0.9
Decrease Feed Costs 20%	23.4	14.6	5.4	2.2	1.2
Increase Farm Tax Rate 25%	17.5	11.2	3.5	1.7	1.1

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