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Organic Dairy Profitability in Vermont: Measuring the Impacts of Management and Market Forces on Farm Financial Performance

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ORGANIC DAIRY PROFITABILITY IN VERMONT: MEASURING THE IMPACTS OF MANAGEMENT AND MARKET FORCES ON FARM FINANCIAL PERFORMANCE

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Abstract

The total number of operating dairy farms in the US has decreased by 74.1% over the past 25 years, dropping from 155,339 in 1992 to just 40,219 in 2017. As milk prices have fallen and become more volatile, profit margins have tightened, causing farmers to leave the business due to low profitability. Some Vermont farmers are currently looking for new economic strategies. One approach has been to transition from conventional to organic production in order to take advantage of better prices and new market opportunities. In order to make production decisions, farmers need accurate financial information on the costs and benefits of the various options available. Since 2004, UVM Extension has collected panel data on organic dairy farms in Vermont to help meet this growing need.

As a part of UVM's long-term organic dairy profitability research, this study analyzed 10 years of financial panel data (2006-2017) from an unbalanced panel of approximately 40 organic dairy farms in Vermont. For article 1, a multivariate fixed effects regression model was used to identify key factors influencing farm profitability and estimate their effects on Return on Assets. Variables related to feeding management, farm management, farm characteristics, input costs, and year were shown to be significant. For article 2, industry wide milk price trends were compared with descriptive statistics on Vermont organic dairy profitability outcomes across a 3-year period (2015-2017) in order to test the hypothesis that recent price shifts have a had a noticeable effect on farm profitability. Despite limited data for 2017, results indicated a study-wide reduction in ROA in line with national market trends.

In identifying management and market factors associated with profitability, this thesis provides valuable decision-making information for farmers interested in switching to organic. Results suggest that feeding management and milk quality improvements can improve profitability outcomes on Vermont farms. Vermont farmers will also benefit from the updated cost of production and financial performance data presented here. Evidence from this thesis also supports a need for new supply management policies and a more nuanced approach to organic dairy profitability research.

Dedication

I'd like to dedicate this thesis to Bob Parsons, whose sense of humor through adversity has been a true inspiration for me.

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There are lots of people to thank for their help and support over the past few years. First I'd like to thank my partner Lauren for being incredibly supportive through everything. My family has also been an amazing resource. All of the CDAE grad students have also been a great community of friends. Thanks to UVM and NOFA for letting me take on transitional data management for the organic dairy profitability study. Thanks also to David Conner, Jane Kolodinsky, and Sid Bosworth for serving on my defense committee. I would also like to thank Qingbin Wang for his extremely helpful comments and suggestions. Finally, thanks to the staff at the UVM Cancer Center and Mass General for their competence and kindness.

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1. Introduction

In recent decades, the US dairy industry has been in an economic crisis. The total number of operating dairy farms in the US has decreased by 74.1% over the past 25 years, dropping from 155,339 in 1992 to just 40,219 in 2017 (NASS 2018). This loss of farms has been matched by an equally dramatic increase in farm size among surviving operations as managers expand their herds to benefit from economies of scale and cope with shrinking profit margins. Between 1987 and 2012, the midpoint herd size (the number at which half of cows nationally are in a larger herd) increased from 80 to 800 cows (MacDonald 2016). Low, volatile prices have also made it harder for small farms to stay in business.

In Vermont, the dairy industry generally reflects the larger trends described above. Between 2009 and 2017, the number of dairy farms in Vermont decreased from 1051 to 780. At the same time, the average number of cows per farm increased from 128 to 164, with a simultaneous 66% increase in the number of farms with over 700 cows (USDA NASS 2018). Despite this increase in farm size, Vermont dairy herds are still generally much smaller than the national average. In 2012, 61.1% of Vermont dairy cows were in herds smaller than 499 cows, compared with a national average of only 40% (MacDonald et al 2016).

Given the small average size of dairy farms in Vermont, many have been particularly hard hit by the economic trends described above. For this reason, some Vermont farmers are looking for new economic strategies. One approach has been to transition from conventional to organic production in order to take advantage of better prices and market opportunities. In order to make this type of production decision, farmers need accurate information on the financial costs and benefits of switching to organic as well as the specific management factors associated with success in organic dairy.

Economic literature suggests that management factors and market trends both have a strong effect on dairy farm profitability. However, far less research has been published specifically addressing factors influencing organic dairy profitability, particularly in New England. The objective of this thesis is to provide evidence about which factors most strongly affect organic dairy profitability outcomes in Vermont. As such, the two articles of this thesis aim to answer the following research questions.

1) Are there farm management factors associated with increased profitability on Vermont organic dairy farms?
2) Does milk price play a major role in determining industry wide profitability outcomes?

To address these questions, this thesis provides evidence that farm management variables and milk price are strongly associated with profitability on Vermont farms. In addition, updated data from Vermont organic dairy producers in 2016 and 2017 is published for the first time.

This thesis is comprised of 5 chapters. This introduction makes up the first chapter. Chapter 2 sets out a comprehensive literature review outlining all of the research cited in the rest of the thesis. Economic research into farm management factors associated with profitability is examined, followed by literature describing both the determinants of milk price and its effect on farm profitability over time. This research is synthesized with previous work that has been done in New England to propose a set of research objectives, questions and methods applicable to financial panel data collected from organic dairy farmers in Vermont. Chapter 3 builds on this literature by analyzing 10 years (2006-2016) of organic dairy financial panel data collected by UVM extension. In this chapter, a multivariate fixed effects regression model is used to estimate the effects of various factors on farm profitability as measured by Return on Assets. Variables related to feeding management, farm management, farm characteristics, input costs, and year are shown to be significant. In chapter 4, industry wide organic milk price trends are compared with descriptive statistics from the UVM organic dairy study on costs of production and profitability outcomes across a 3-year period (2015-2017). This analysis provides preliminary evidence that recent price shifts have a had a noticeable effect on farm profitability in Vermont. Chapter 5 synthesizes the results and analyses of the previous chapters, identifying key findings and implications.

In identifying management and industry factors associated with profitability and providing updated financial benchmarking data, this thesis as a whole provides valuable decision-making information for farmers interested in switching to organic dairy production. Vermont policymakers and researchers looking to set policy and research goals will also benefit from the findings of this research.

2. Comprehensive Literature Review

2.1 Introduction

The US dairy industry has struggled for decades with high levels of firm exit and low profit margins (MacDonald 2016). Given this, research into factors associated with farm profitability in this sector has been prioritized for many years. After organic dairy production began to increase in popularity, a number of new economic studies were published, most attempting to identify whether or not organic dairy is actually more profitable than conventional. Relatively little peer reviewed literature, however, has been published on the actual farm management and industry factors associated with profitability on organic dairy farms.

To address this gap in the literature, this thesis utilizes financial panel data from Vermont organic farms to find evidence of management and industry level variables associated with profitability. Article 1 uses a fixed effects multivariate regression model to estimate farm level parameters associated with profitability on organic dairy farms. Article 2 looks at the effects of recent organic milk price decreases on Vermont farms. Taken together, these approaches provide strong evidence for a measurable relationship between farm management factors, milk price, and farm profitability on organic dairy farms in New England.

This literature review provides evidence to support the argument that not enough economic research has been done examining factors associated with profitability on organic dairy farms in New England. This gap informs the objectives and research questions of this thesis. In order to provide sufficient background on the nuances of dairy production systems, this review begins with a short history of dairy in Vermont, followed by a description of conventional, organic, and 100% grass-fed production strategies currently used in the state. In preparation for a critical analysis of dairy profitability literature, a review of financial and management differences between these systems is also included.

In conventional dairy economics research, it is common to isolate specific management and industry factors associated with profitability. A review of recent literature reveals that this is not the case in the context of organic dairy profitability research, most of which simply compares financial performance with that of conventional dairy. To address this gap, the theory and methods used in a conventional context to identify factors associated with profitability must be adapted to organic dairy. To do so, this review builds on previous research in proposing a research approach applicable to organic dairy.

First, economic research into farm management factors associated with profitability is examined, followed by literature describing the determinants of milk price and their effects on farm profitability across years. This research is synthesized with previous work that has been done on Vermont organic dairy to propose a set of research objectives, questions and methods applicable to financial panel data collected from organic dairy farmers in Vermont.

2.1 Dairy Background

Before economic literature relating to dairy profitability can be examined, it is necessary to understand the context. In recent decades, the US dairy industry has been in an economic crisis. Thousands of conventional dairy farms went out of business in the US during the 20 years between 1992 and 2012, dropping from a total of 155,339 in 1992 to just 64,098 (MacDonald et al 2016). This loss of farms has been matched by an equally dramatic increase in farm size among surviving farms.

Both trends have largely come about as a result of improvements in technology that have allowed some farmers to spread their labor, capital and costs over a larger herd, taking advantages of economies of scale. This consolidation has been accompanied by ever decreasing profit margins as feed and input costs have generally increased as well. Finally, milk prices are highly volatile, making it harder for small producers to stay in the market (MacDonald et al 2016). While the total amount of milk being produced has not decreased, rural areas once known for their small and medium sized dairy farms have been hit hard economically by the loss of small farming businesses.

This national trend has also had an impact on dairy farming in Vermont, where dairy has long accounted for 70-80% of total agricultural sales (Parsons 2010). Figure 1 shows how Vermont milk production has steadily increased while the number of dairy farms has decreased.

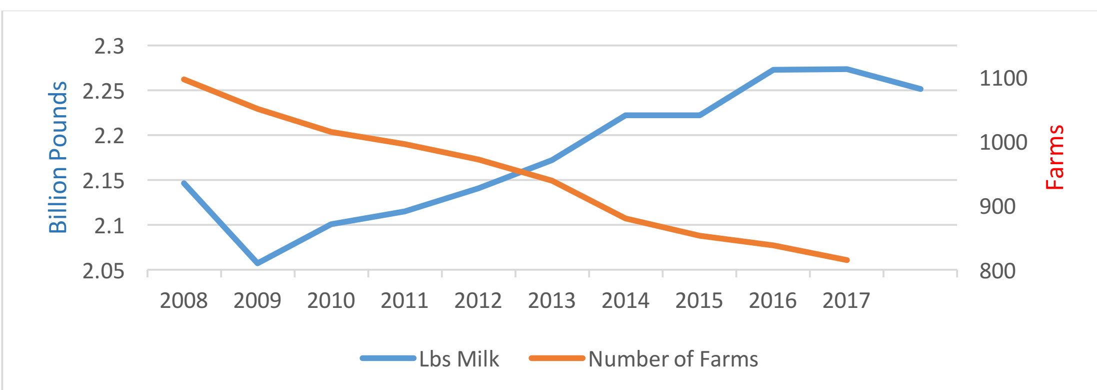

Figure 1. Number of dairy farms and amount of milk produced in Vermont by year.

Note. Source: NASS 2018.

While some Vermont dairy farms have expanded in order to survive in the market, various obstacles to expansion have motivated others to switch to organic production in an effort to stay profitable. By some metrics, the shift to organic by many Vermont dairy farmers has been a success – the number of certified organic dairies in the state has increased from just 2 in the early 1990s to over 200 in 2017 (Bedard 2017). During this time, organic dairy farmers have typically received a significant premium over the conventional milk price. However, high organic grain prices and lower yields under organic management have led to tight profit margins in this sector. Periodic periods of organic milk oversupply have also caused profitability problems, particularly in 2009 and again in 2017 (Maltby 2009, Bedard 2017).

Steadily increasing consumer demand has been an important factor in successful organic dairy performance. While sales of organic whole milk have grown in recent years (with an 7.7% increase between 2016 and 2017) the most recent AMS data from 2018 shows total sales of organic milk dropping by 2.5% by the end of 2017, accompanied by a related decrease in the milk price (USDA AMS 2018). Faced with this data, some observers worry that organic dairy may soon cease to be a more lucrative option than non-organic production.

2.2 Dairy Production Systems

In order to compare the economic performance of various dairy production strategies, it is necessary to understand what exactly makes them different from one another. The most commonly used system of dairy farming in Vermont is confinement production. In this system, cows are confined to large barns and derive little to no nutrition from grazing. Instead, cows are fed a total mixed ration (TMR) made up primarily of farm-grown grain and forage crops along with purchased minerals and supplements. In this type of system, animal nutrition, milk production, and environmental factors can be tightly controlled in order to maximize milk production. Technology typically utilized includes milking parlors, drive through feed alleys, feed mixers and large manure pits emptied by spreaders (Parsons 2010).

Development of alternatives

Well managed confinement dairy farms are optimized to achieve the highest output of milk per cow and returns to scale, explaining their common usage in Vermont dairy production. In recent decades, however, some farmers have chosen to adopt different dairy production systems. Starting in the 1980s, some farmers began to be concerned with environmental and animal health impacts of typical production practices and began farming without synthetic inputs. Many of these early adopters struggled financially due to a lack of market demand. By the 1990s, however, consumer interest in organics had led to the creation of an organic dairy market and processing infrastructure, making it possible for organic practices to be rewarded financially (Saucier, Parsons 2014). This new market opportunity has motivated many conventional farms to transition to organic for economic reasons. As of 2017, there are over 200 certified organic dairy operations in Vermont, making up 25% of all dairy farms in the state (NOFA 2017). In addition to those farms that are certified as organic, a number of other Vermont dairy farms run as pasture-based operations, pursuing low impact production systems without participating in certification (Colby 2012). Other farms have switched to 100% grass fed systems. In the market for dairy products, conventional and organic represent the two common price points for commodity producers, making this distinction the most telling. Recent development of a market for 100% grass-fed dairy has led to a new certification process and price premium for these farms, although they still remain a small minority. (Sustainable Food News 2016).

Organic Dairy Definitions

Since the inception of the National Organic Program (NOP) in 1990, federal regulations have defined the meaning of organic agriculture. Standards for dairy include prohibitions on growth hormones like bovine somatotrophin, use of synthetic fertilizers and pesticides, and limitations on antibiotics usage. Since the introduction of the new NOP 'pasture rule' in 2010, organic dairy cows are also required to spend at least 120 days on pasture and receive at least 30% of dry matter intake from pasture each year (USDA 2018).

2.3 Management and Financial Differences

Federal regulations governing organic production standards make it so that organic and conventional dairy farms are typically managed differently, particularly with respect to crop and feeding management practices. Non-organic dairy farms typically use TMR mixing machinery and maximize grain intake to achieve high production levels. Grain is generally purchased off-farm, while corn silage and hay is produced on farm. Cows do not typically graze, and instead live in climate controlled barns. Feed is delivered as a TMR to a central feeding alley (Parsons 2010).

On organic dairy operations, NOP regulations require that cows derive a significant portion of feed from pasture. While most organic dairy farmers still utilize a TMR system, pasture requirements cause them to adopt different feeding strategies than most non organic farms. Typically, this means focusing more effort on pasture maintenance, forage production and hay storage. Organic farms differ in their level of reliance on grain concentrates or pasture (Sorge et al 2016). One hundred percent grass-fed farms do not use any grain, relying entirely on pasture and stored forage crops.

These management differences are reflected in the financial differences between various dairy systems. McBride and Greene (2009), provide a review of key differences in costs and income between conventional and organic dairy farms. In general, per cow costs on organic dairy farms are about 10% higher than on non-organic farms, reflecting costs associated with reduced milk production, smaller herd sizes and higher feed and labor costs (Butler 2002). The largest additional costs, however, can be attributed to high herd replacement and transition costs (farms in transition must continue to sell at the conventional price for the first three years) (McBride and Greene 2009). The primary advantages of non-organic production are lower input costs, increased production per cow, and the ability to produce at a larger scale and spread out fixed costs across a larger herd (Parsons 2010). Given their higher production costs, organic dairy farmers are dependent on high organic milk prices to make up the difference (Rotz et al 2007). Market prices are often not sufficient to ensure profitability in either type of production system.

Grass-fed dairy producers are able to reduce costs by completely avoiding the need to purchase expensive organic grain, though more land is required to produce the same amount of milk possible on a farm that grows field crops. One Vermont grass fed dairy farm reports a need for 20% more land per cow since switching to keep up production levels (Lazor 2016). While giving up purchased grain does reduce feed costs, the need for additional forage production reduces net cost reductions. For this reason, 100% grass-fed dairy farmers continue to be dependent on exceptionally high price premiums.

Which is more profitable?

Given the above research, it is difficult to determine which approach to dairy production is most profitable. Efforts to answer this question have produced a large body of research, which is outlined below. As will be shown, almost none of this research has moved beyond comparative profitability analysis toward a detailed look at specific factors associated with profitability on organic dairy farms. Given that this type of research is common for non-organic dairy, this fact represents a significant gap in the literature. This thesis aims to address this gap.

In order to find theoretical and methodological approaches useful to understanding the *determinants* of organic dairy profitability, it is necessary to turn to the economic literature on conventional dairy. This literature provides evidence that variation in farm financial performance can be linked to production system, farm characteristics, management factors, and economic conditions among other variables.

2.4 Farm Profitability Research

In assessing the research that has been done to compare the profitability of various dairy farming systems, it is important to note that a large percentage of peer reviewed research has focused exclusively on conventional dairy production. Given this fact, much of the literature on organic dairy profitability has been published outside of peer reviewed journals. This review will incorporate both journal and 'grey' literature in presenting relevant research findings.

Research into dairy farm profitability is diverse in its methodology. Experiments (Macdonald 2017, White et al 2002), simulations (Rotz et al 2007, Groover 2004), and single farm case studies (Winsten 2003) have all been used to compare profitability across production systems. However, the most common approach has been survey based economic research. Survey-based techniques are useful because they enable researchers to assess the effects of production system on profitability *while holding other variables equal* across a population of farms. These approaches are dependent upon a sufficiently rich dataset involving a large population (N) and tend to involve cross sectional data analysis. Recent projects have focused on dairy farmers at national (Gillespie and Nehrig 2014, McBride, Green 2009), regional (Tranel 2015, Winsten, Parsons, Hanson 2000) and statewide (Foltz and Lang 2005, Barham, Brock, and Foltz 2006) scales. Other researchers have gone beyond survey techniques to obtain more detailed information on farm finances (Tranel 2015, Kreigl 2005).

Despite this rich comparative literature, none of the above studies have examined the effects of specific management and industry factors on organic dairy farm profitability, focusing instead on comparisons between organic and conventional dairy. In a thorough review of the literature on organic dairy, only a few authors (Hardie et al 2014, Krug 2015) focus on factors associated with increased profitability on organic dairy farms in any detail, leaving this important topic largely untouched.

To address this research gap, it is necessary to turn to research in the conventional dairy context. The most common approach that has been used in evaluating specific factors associated with dairy profitability is the collection and analysis of financial panel data from multiple farms over time. Hsiao reviews the various advantages of panel data (Hsiao 2006). In the case of farm budget data, panel data makes it possible to track farms under the same management and resource conditions over time and variation in weather and input and output prices. These advantages give dairy profitability studies based on panel data unique value. Several recent studies have taken this approach (Krug 2015, Lichtenberg et al 2011, Dalton et al 2008, Kreigl 2005). Research that has utilized panel data to identify and measure the effects of variables associated with profitability is reviewed below.

As with most applied economics research, econometric techniques are commonly used in analyzing panel data collected by survey methods. The most common econometric approach taken when a panel dataset is available is to develop a fixed effects model in order to control for unobserved farm attributes that might affect profitability (Wooldridge 2016). This analysis is based on the assumption that each farm will exhibit unobserved time-invariant factors (fixed effects) that are likely correlated with one or more of the regressors, causing bias in the estimation (Gloy et al 2002, Krug 2015, Hanson et al 2013). Further details on the use of this type of model can be found in article 1. Financial panel data from organic dairy farms in Vermont has been collected since 2006 by UVM and NOFA VT. Given the availability of this data, panel data analysis is the focus of this thesis.

In any econometric model, a variety of independent variables are used to predict and estimate a given dependent variable. In the case of research into variables affecting farm profitability, several dependent variable options exist.

Dependent Variables

An extensive literature exists on this topic, but this review focuses on the most common financial metrics, Net Farm Earnings (NFE) and Return on Assets (ROA).

$$NFE = Total\ Cash\ Receipts + Total\ Accrual\ Revenue - Cash\ Expenses - Accrual\ Expenses - Unpaid\ Labor\ and\ Management\ Cost$$

As shown above, NFE is the combined cash and accrual income of a farm business after all production expenses have been subtracted, including accrual and unpaid labor and management. This approach makes it possible to incorporate the true economic costs of production. For this reason, accounting practices consistent with Generally Accepted Accounting Principles (GAAP) are based on accrual accounting (although cash accounting is often still the standard practice on a farm level) (Moss 2015). However, NFE does not take into account asset levels, making it less useful in identifying the return a farm is receiving for its total investment.

$$ROA = \frac{net\ farm\ earnings - interest}{average\ assets}$$

Return on Assets (ROA) is a variable used to address the limitations of NFE. In this formula. net farm earnings are defined as described above. In order to make the ROA variable independent of debt/equity ratios, yearly interest payments are also subtracted from net farm earnings. Finally, farm assets are averaged from the beginning to the end of each year to get an estimate of the value of the actual assets used in production (Krug 2015). ROA is often favored as an indicator of profitability because it is a relative measure that allows researchers to compare farms of diverse size, number of operators, and financing (Gloy 2002). Because farm assets are accounted for, variations in ROA make it possible to analyze changes in farm profitability as a difference in percent return on an investment. Farms with negative ROA in a given year are losing money, while farms with a positive ROA are generally profitable. Changes in ROA can reflect management changes, price shifts, asset liquidation, and other factors, many of which will be explained in the following section on independent variables.

Independent Variables

Independent variables used in economic analysis of farm financial panel data can be broken into several categories, each representing an important determinant of farm profitability. These categories are shown in the following conceptual model..

$$profitability = f(feeding\ management, general\ management,$$
$$farm\ characteristics, milk\ price, input\ costs, year)$$

Feeding management variables used in dairy profitability analysis have included amount of grain fed (Hardie et al 2014), pounds of milk per cow (Gloy et al 2002, Foltz and Lang 2002), purchased feed costs (Dalton, Parsons 2008, Barham et al 2006), and other indicators (Buza et al 2014, Ramsbottom 2015, Newton 2005). In addition to feeding management, variables measuring general farm management have also been shown to be important. These have included a quantifiable index estimating farmer management ability (Rougoor et al., 1998), participation in extension programs, (Mishra 2009) and demographic indicators *(*Krug 2015, Parsons 2008*)*.

Other independent variables typically found in the literature measure farm characteristics. These include farm size, which is shown to be significant in conventional (Gloy 2001, Hadley 2002) and organic production (Krug 2015). Other farm characteristic variables that have been considered include cow breed, region climate, soil type, elevation, and other factors (Van Holden 2003, Hanaran et al 2018).

Finally, market level variables that change across all farms for each year have also been included in farm profitability models. These include milk price, input costs, weather, and policy shifts (Hanrahan 2018, Gloy 2002). Based on the above research from the conventional dairy context, it is possible to construct a model of organic dairy profitability to address the lack of literature on factors influencing profitability in this sector. This approach is the focus of article 1 of this thesis.

2.5 Organic Dairy Milk Price Effects on Profitability

The literature outlined above presents an argument for the generation of econometric models of organic dairy profitability as a means to understand specific variables associated with farm profitability. However, in order to identify industry wide trends, the time demeaned fixed effects model proposed above is not effective given that it is a 'within' estimator designed to compare individual farms across years. While the sample size of the Vermont dataset is insufficient to draw statistically significant conclusions about a large population of organic dairy farms, this survey represents the most detailed financial data available on organic dairy production in northern New England. For this reason, it is worthwhile to draw preliminary conclusions from the data available, following the example set by Dalton et al (2008). Based on this study, article two of this thesis compares organic dairy profitability outcomes and costs of production across a three-year period between 2014 and 2017. With a focus on milk price as a key determinant of profitability, this descriptive analysis will present 2016 and 2017 study data for the first time, a valuable contribution in itself. In preparation for this analysis, the literature on milk price must be examined. Evidence for milk price as a key factor influencing organic dairy profitability is presented followed by a brief look at likely determinants of the milk price.

Milk price is arguably the most important of the market level determinants of dairy profitability (along with cost of production). Wolf et al (2016) find that while yearly dairy profitability (measured by ROA) is primarily determined by firm effects, industry wide trends do explain a significant amount of variation. Milk price is identified as a component of these effects. This finding is consistent with other analyses of dairy profitability that show a strong relationship between ROA and milk price received (Hanaran 2018, Gloy et al 2002). Other research has argued that cyclical changes in the milk price are also associated with changes in ROA (Nicholson 2015). Given this relationship, it is unsurprising that many popular press and industry reports assume milk price to be the most important factor influencing organic dairy profitability (Bedard 2017).

The above evidence suggests that yearly milk price trends are relevant to organic dairy profitability. If this is the case, an understanding of the factors influencing milk price is important in predicting price shifts over time. The next section identifies changes in demand, supply, and cost of production as primary determinants of milk price.

2.6 Determinants of Milk Price

Conventional milk prices in the US are set by the federal government through the Federal Milk Marketing Order system. This system sets a minimum price for farmers in various geographic areas while also ensuring a consistent and adequate supply of milk.

Prices are based on component values of protein, fats and other solids, and are tied to dairy commodity markets for butter, cheese, nonfat dry milk, and whey. (USDA 2018). While bound to the same minimum price, organic milk processors pay an additional premium to farmers based on the market value added by organic production (McBride and Greene 2009).. A final price benefit of organic dairy production is a relatively stable pay price, made possible by the provision of a fixed annual price contract by many organic processors (McBride and Greene 2009, Su 2014). This compares favorably with the highly variable nature of the conventional price, which can change quickly due to market shifts (MacDonald 2016).

While organic dairy farmers do have some shelter from rapid market shifts, both conventional and organic dairy prices are strongly influenced by the market in any given year. Economic theory suggests that agricultural product prices are largely determined by changes in market demand and supply. Increased consumer demand for a given product will increase prices, while oversupply through excess production will decrease prices all else equal (Tomek 2014). Recent research on the determinants of milk price (both conventional and organic) generally aligns with this theoretical framework (Su 2013).

Given the relative lack of research into determinants of the organic milk price, this review also incorporates similar research involving conventional dairy price. Demand, supply, and cost of production variables are the primary determinants of milk price identified in the literature.

Demand

The concept of demand for a product having an effect on prices instead of vice versa is an example of an inverse demand system (Glasser and Thompson 2000). Given that prices of organic milk are set yearly, pay price is largely determined by demand predictions. An increase in consumer demand is likely to shift prices up, for example, as buyers prepare for increased production (Su 2014). Bailey (2005) provides evidence that conventional farmgate milk price is strongly influenced by both consumer and speculative demand. Seasonal demand shifts have also been identified as price factors in retail dairy sales (Glasser and Thompson 2000).

Based on this understanding of price and demand, a number of recent consumer studies have looked for shifts in demand in order to identify trends with a potential effect on farm profitability. Many have shown that many consumers are willing to pay more for organic milk than conventional (Schroeter 2016, Wong 2010, Bernard and Mathios 2005). These consumers are typically motivated by concern for the environment (Van Loo 2013), and preferences for smaller farm size (Schott 2015).

Supply

Even stronger evidence exists for market supply as a determinant of dairy price. Bailey provides a review of this argument, pointing to several instances in which price drops immediately followed a period of oversupply (Bailey 2005). In the case of conventional dairy, increased trade means that international supply shifts have also begun to influence US prices. Seasonality is another supply factor with an influence on dairy prices. During the spring flush, total milk yields increase, keeping prices down during these months. Seasonal premiums offered by processors aim to offset this yearly effect (Su 2014). Some recent research has argued that cyclical supply-price shifts may have replaced earlier patterns based on seasonal production for conventional farms (Nicholson 2015). However, given that organic dairies are somewhat pasture based, seasonal factors are likely stronger for organic farms (Rinehart 2016). Wolf et al provide evidence that many dairy operations respond to increased profitability by expanding herd sizes, increasing the total milk supply and leading to lower prices (Wolf 2016). A recent report on Vermont organic dairy conditions published by NOFA Vermont argues that recent reductions in the organic price can largely be attributed to supply shifts (Bedard 2017)

Cost of Production

While economic theory does suggest that cost of production will affect milk prices by causing a shift in supply, the relationship is more direct in the case of organic dairy production. Many suppliers, including the CROPP cooperative, include COP estimates in their decision making process for determining contract price (Su 2014, Organic Valley Report 2017, 2018). To this end, many suppliers collect their own COP information from farmers. If costs of production increase too much ahead of prices, milk producers cannot stay in business and buyers suffer financially as well. Given the importance of COP to price setting for major buyers, fuel and feed price indicators are commonly used in industry press as indicators of potential shifts in milk price (Maltby 2017, 2018).

The above literature describes the various factors affecting the milk price. While the analysis in article two will not provide statistically valid evidence of which factors are likely at play in the price changes of 2017, this information will help inform interpretations of profitability data. Even if the cause of a price shift is unknown, by comparing data from the same group of farms over multiple years, it is possible to measure its effects on the profitability of a group of farms (Wolf 2016, Dalton et al

2008). In examining financial data from Vermont farms, article 2 of this study will address a lack of updated research measuring the effects of recent milk price reductions on farm profitability.

2.7 Conclusions

The above comprehensive review of the literature identifies several major gaps. First, very little econometric analysis has been published measuring the effects of different management variables on organic dairy financial performance. Second, little data has been published documenting the effects of recent downward shifts in the organic milk price on New England farms. Using data from a multi-year financial panel study on Vermont organic dairy farms, this thesis begins to fill in some of these gaps in the published literature by identifying farm and market level variables associated with profitability. Results of this study will be useful for farmers looking to make management decisions, as well as researchers and policymakers who require accurate information on dairy market conditions.

3. Article 1: Factors Affecting Profitability on Vermont Organic Dairy Farms 2006-2016

3.1 Introduction:

In the US, conventional dairy farmers have faced severe economic challenges in recent years (MacDonald et al 2016). In response, some producers motivated by economic or ideological considerations have decided to adopt organic production practices. In Vermont this trend is particularly pronounced - the number of certified organic dairies in the state has increased from just 2 in the early 1990s to over 200 in 2017 (Bedard 2017, USDA NASS 2018). During this time, organic dairy farmers have typically received a significant premium over the conventional milk price. However, high organic grain prices and decreased yields under organic management have tightened margins in this sector. Occasional periods of organic milk oversupply have also caused profitability problems, particularly in 2009 and again in 2017 (Maltby 2009, Bedard 2017).

In response to these concerns, many organic farmers are looking for information on the management practices most strongly associated with profitability in this growing sector. While a good deal of peer reviewed research has been published on the management variables influencing dairy profitability among conventional dairy farms, little of this research has focused on the organic dairy sector specifically. To address this gap in the literature, this paper uses financial panel data from Vermont organic dairy farmers between 2006 and 2016 to identify production variables linked to increased profitability in organic dairy production as measured by Return on Assets. These results will be useful for New England organic dairy farmers looking to increase profitability.

Policymakers, researchers, and extension staff concerned with organic dairy production will also find this data useful in setting research and policy objectives.

3.2 Literature Review:

While a few researchers have focused their efforts on identifying management variables associated with profitability on organic dairy farms (Krug 2015, Hardie 2014), most studies in this area have focused their analysis on conventional dairy farms. To address this gap, this article adapts theories and methods commonly used in analysis of conventional farms to an organic context. The objective of this study is to answer the following research question: *are there farm management variables associated with increased profitability on Vermont organic dairy farms*? In order to answer this question, it is first necessary to review the relevant economic literature.

a. Conceptualization of Problem

Farm management research has long focused on trying to understand the variables influencing farm profitability. To do so, it is necessary to choose an appropriate functional form. Gloy, Hyde, and Leduc (2002) have developed a useful economic model of profit maximization in dairy production. In their production function, milk prices are given (p) and farmer management (α) and input availability (x) combine to determine production quantity. The cost of inputs (w) determine total cost. The constraining condition is that the inputs X cannot be greater than the amount of X available in the farm's asset endowment (X_j). This model is shown below:

$$\text{Maximize } p_i q_i (x;\alpha) - C_i(w, q_i(x;\alpha))$$

$$\text{s.t. } g_j(x_j) < X_j,\ j = 1, 2, \ldots, n.$$

Assuming the validity of this model, it makes sense that farms will vary in their level of profitability. The importance of total farm assets X_j and farmer management α in the model (both highly variable) make a variety of outcomes possible. In order to determine the factors influencing profitability, it is thus necessary to account for variation in farm size, farm management, input costs, and milk price.

Much has been written about the various factors influencing dairy profitability as described above. The next section explores some of this research, using previous studies to generate appropriate dependent and independent variables for an organic dairy profitability model.

Once a set of reasonable variables is identified, this review examines recent quantitative research design and data collection methods that have been used to measure these variables. Finally, econometric methods that have been used to estimate verifiable relationships between production and management factors and profitability are discussed. Based on this literature, this review proposes a time demeaned fixed effects model using panel data to predict the effects of different variables on organic dairy profitability in Vermont.

b. Literature on Variables Affecting Dairy Profitability

Dependent Variable

In order to assess the factors influencing organic dairy profitability it is first necessary to choose an appropriate dependent variable measuring farm profitability. An extensive literature exists on this topic, but this review focuses on the most common financial metrics: Net Farm Earnings (NFE) and Return on Assets (ROA).

$$NFE = Total\ Cash\ Receipts + Total\ Accrual\ Revenue - Cash\ Expenses \\ - Accrual\ Expenses - Unpaid\ Labor\ and\ Management\ Cost$$

As shown above, NFE is the combined cash and accrual income of a farm business after all production expenses have been subtracted, including accrual and unpaid labor and management. This approach makes it possible to incorporate the true economic costs of production. For this reason, GAAP standard accounting practices are based on accrual accounting (although cash accounting is often still the standard practice on a farm level) (Moss 2015). However, NFE does not take into account asset levels, making it less useful in identifying the return a farm is receiving for its total investment.

$$ROA = \frac{net\ farm\ earnings - interest}{average\ assets}$$

Return on Assets (ROA) is a variable used to address the limitations of NFE. In this formula. net farm earnings are defined as described above. In order to make the ROA variable independent of debt/equity ratios, yearly interest payments are also subtracted from net farm earnings. Finally, farm assets are averaged from the beginning to the end of each year to get an estimate of the value of the actual assets used in production (Krug 2015). ROA is often favored as an indicator of profitability because it is a relative measure that allows researchers to compare farms of diverse size, number of operators, and financing (Gloy 2002). Because farm assets are accounted for, variations in ROA make it possible to analyze changes in farm profitability as a difference in percent return on investment. Farms with negative ROA in a given year are losing money, while farms with a positive ROA are generally profitable. Changes in ROA can reflect management changes, price shifts, asset liquidation, and other factors, many of which are explained in the following section on independent variables.

ROA is used here as a dependent variable in farm profitability because it makes it possible to isolate the profitability effects of management factors independent of farm asset endowment, which is the goal of this study. Another important consideration in selecting ROA is to preserve continuity with other analyses of this dataset, particularly in the work of Parsons (2017) and Dalton et al (2006, 2008). By using this dependent variable, it is much easier to compare the results of this analysis to yearly profitability reports and other materials prepared and published by previous researchers.

Independent Variables

The primary independent variables common in the literature on dairy profitability can be divided into the 6 categories shown below.

$$profitability = f(feeding\ management, general\ management,$$
$$farm\ characteristics, milk\ price, input\ costs, year)$$

This function fits in well with the dairy production function described on page 23, with feeding management, general management and farm characteristics comprising α, milk price represented by p_i, and input costs and year variables combined as w. The literature on each variable type is described below.

Feeding Management

One body of dairy profitability research has focused on the effects of feeding strategies – a key category for the purposes of this paper. According to ERS data from 2017, homegrown and purchased feed costs made up 51.3% of total milk production costs in 2017 (USDA-ERS 2017). For this reason, how feed is managed has been shown to have a significant impact on total costs and net revenues. Hardie et al (2014) provide evidence that feeding strategies seem to be major determinants of dairy farm profitability. In their study, an increase in fed grain is correlated strongly with increased milk production per cow and increased profitability. Similarly, pounds milk per cow has been shown to be a significant independent variable in other studies (Gloy et al 2002, Foltz and Lang 2002). Because higher milk output per cow is often a result of increased grain feeding, it is a useful variable when quantifying feeding management practices. To be effective, however, amount of milk produced per cow must be accompanied by information on purchased feed costs, which is also measured in most dairy studies (Dalton, Parsons 2008, Barham et al 2006). Hay and grain accrual income can also be included when available.

Other important feeding management variables are not available in the study dataset and therefore are not considered. Forage quality (Buza et al 2014), stocking rate (Ramsbottom 2015), pasture yield and utilization, (Newton 2005) and value of homegrown forages (ERS 2017) are all feeding variables that have been shown to be significant indicators of farm profitability. The inclusion of this type of data if available would strengthen any dairy profitability model.

General Management

One of the most commonly identified variables influencing dairy profitability is also one of the hardest to define: farmer management ability. Rougoor et al, (1998) argue that much variation in farm profitability can be attributed to the management ability of the farmer. Some variables that have been used to estimate management ability include adoption of financial management practices (Gloy 2002), participation in extension programs (Mishra 2009), and other demographic factors like age, gender, education level, farm location, family size, race, and off farm income *(*Krug 2015, Parsons 2008.

While all of the above variables are useful proxies for management ability, they are not typically available in financial datasets. One piece of data which is often available on a farm level is depreciation. Depreciation tends to increase for farms as they buy new equipment and update facilities (Parsons 2017). For this reason, changes in depreciation costs reflect purchasing and other management decisions. Government payments are another financial category that reflects farm management priorities (MacDonald et al 2016). Those farms that have higher levels of government payments are those who have prioritized participation in conservation or margin support programs, both primary sources of government funds. Other financial farm management metrics that are not commonly included in profitability studies include debt level, repairs, and veterinary costs. Based on economic theory and availability in the dataset these variables are also included in this study.

Farm Characteristics

One of the most common variables included in dairy profitability models is farm size. Many studies have found evidence to suggest that increased farm size is strongly correlated with farm profitability. This has held true in a number of studies on both conventional (Gloy 2001, Hadley 2002) and organic production (Krug 2015) This is due to economies of scale and the ability of larger farms to spread fixed costs across more animals, decreasing costs per cow and enabling smaller profit margins (MacDonald 2016). While most studies include size as a variable, some have utilized farm matching methodology to control for this variable. (Gillespie and Nehring 2004).

Other farm characteristic variables that have been considered include cow breed, region climate, soil type, elevation, and other factors (Van Holden 2003, Hanaran et al 2018). In this model, farm size is considered to account for variations in farm type. Milk production per cow, another common farm characteristic variable, is in this study used as a measure of feeding management.

Milk Price and Input Costs

Milk price and input cost data is important because both determine key elements of the model and directly affect revenues and costs. Milk prices and input costs (including feed, fuel, supplies, custom harvest and labor costs) are included in some way in most of the above models. Milk price data also helps to account for milk quality since received prices include quality and components bonuses.

Year

A final variable often included in dairy profitability analysis is the year data was collected. Due to industry-wide changes in milk prices and input costs, as well as broad weather and climate constraints, inclusion of dummy variables for each year makes it possible to control for industry wide yearly variation (Hanrahan 2018, Gloy 2002).

c. Review of Data Collection Methods for Dairy Profitability

The above variables have all been used effectively in previous analyses of dairy profitability. Having selected appropriate variables, it is next necessary to choose an approach to data collection. While some research has used experimental, farm simulation, and case study approaches to collecting quantitative farm management information, this review focuses on the survey based methods most common in economic research, finally proposing multi-year financial panel data as the best approach to the questions posed by this thesis.

Survey-based techniques are useful because they enable researchers to assess the effects of various factors on profitability *while holding other variables equal* across a population of farms. These approaches are dependent upon a sufficiently rich dataset involving a large population (N) and tend to involve cross sectional data analysis. Most researchers have focused on gathering representative data from as large a group of farmers as possible. Recent projects have focused on dairy farmers at national (Gillespie and Nehrig 2014, McBride, Green 2009), regional (Tranel 2015, Winsten, Parsons, Hanson 2000) and statewide (Foltz and Lang 2005, Barham, Brock, and Foltz 2006)

scales. National survey projects have tended to rely on ARMS and NASS data, while regional and state projects have designed their own survey instruments.
Regional and state level studies have the advantage of less climate and geographic variation, although they are not representative of national economic conditions.

Survey research on organic dairy specifically has focused on profitability differences among various production systems (Gillespe and Nehrig 2014, Winsten, Parsons, Hanson 2000), on factors associated with adoption of organic practices (Gillespie 2009, Hanson 1996), and on costs of organic dairy production (Tranel 2015, McBride, Green 2009).

Despite this rich comparative literature, none of the above studies have examined the effects of specific management and industry factors on organic dairy farm profitability. In a thorough review of the literature on organic dairy, only a few authors (Hardie et al 2014, Krug 2015) focus on this topic in any detail, leaving this important matter largely untouched.

To address this research gap, it is necessary to turn to research in the conventional dairy context. The most common approach that has been used in evaluating specific factors associated with dairy profitability is the collection and analysis of financial panel data from multiple farms over time. Hsiao reviews the various advantages of panel data (Hsiao 2006). In the case of farm budget data, panel data makes it possible to track farms under the same management and resource conditions over time and variation in weather and input and output prices. These advantages give dairy profitability studies based on panel data unique value. Several recent studies have taken this approach (Krug 2015, Lichtenberg et al 2011, Dalton et al 2008, Kreigl 2005). Given the availability of a multi-year financial panel dataset in Vermont, this is the approach taken by this thesis.

d. Econometric Techniques Used to Analyze Financial Panel Data from Dairy Farms

Organic dairy profitability studies based on panel data tend to utilize a few common methodological approaches. Some studies do not use econometric analysis at all, focusing instead on summarizing key variable averages and performing basic financial analysis on farms by cluster (Tranel 2015, Parsons 2008).

The most common econometric approach taken when a panel dataset is available is to develop a fixed effects model in order to control for unobserved farm attributes that might affect profitability. This analysis is based on the assumption that each farm will exhibit unobserved time-invariant factors (fixed effects) that are likely correlated with one or more of the regressors, causing bias in the estimation (Gloy et al 2002, Krug 2015, Hanson et al 2013). A basic fixed effects model is shown below.

$$Y_{it} = B_1X_{it1} + B_2X_{it2} + \ldots + B_kX_{itk} + a_i+u_{it},\ t = 1,2, \ldots, T.$$

Basic Fixed Effects model. Source Wooldridge 2016

In the above model, Y_{it} is the dependent variable measuring farm profitability. The X values represent the various dependent variables in the model (1,2 … k), with i representing each individual farm in the study and t representing the year. a_i represents the unobserved effect or fixed error for each farm, while u represents the idiosyncratic error for each farm in each year.

In the case of dairy production, it is difficult to measure each of the variables influencing profitability given that some variation between farms can be attributed to innate, non-time variant factors like land quality, location and management ability. These factors are also likely highly correlated with the regressors in the model. This can lead to a biased Ordinary Least Squares (OLS) estimator. In order to remove a_i from the model and obtain a nonbiased estimator using OLS, it is necessary to utilize a fixed effects transformation. One common method is a time demeaning fixed effects (FE model).

For each individual farm i, it is first necessary to average all the variables of each farm's model over time, yielding the following equation:

$$\overline{y_i} = B_1\overline{x_i} + B_2\overline{x_i} + \cdots + B_k\overline{x_i} + a_i + \bar{u}_{it}$$

Mean regression model. Source Wooldridge 2016

As can be seen, this transformation does not eliminate a_i. However, when this mean equation is subtracted from the above fixed effects model, a_i is differenced out of the model, shown below.

$$\ddot{y}_i = B_1\ddot{x}_{it} + B_2\ddot{x}_{it} + \cdots + B_k\ddot{x}_{it} + \bar{u}_{it}, \text{ t = 1,2, …, T.}$$

Time demeaned regression model*. Source Wooldridge 2016. Subtracting a variable $\bar{z}$ from a variable z_t yields a time demeaned variable written as $\ddot{z}$.*

Through the above process, the demeaning transformation is able to eliminate the time-invariant unobserved factor a_i. If it is also possible to assume that the remaining idiosyncratic error u_{it} is uncorrelated with the dependent variables x_{it} and that that u_{it} is homoscedastic and serially uncorrelated across t, this fixed effects model can yield an unbiased Ordinary Least Squares (OLS) estimator (Wooldridge 2016). A similar outcome can also be achieved through first differencing (FD), in which each year's equation for each farm is subtracted from that of the year before.

While similar, FE and FD techniques exhibit particular strengths and weaknesses. In the case of positive serial correlation, for example, FD is preferable because Δu_{it} is likely to exhibit uncorrelation even if u_{it} does not. However, in the case of serial correlation of Δu_{it}, FE is likely to be less biased. In many cases it is difficult to tell which estimator is more efficient. If so, it is a good idea to closely examine for serial error term correlation. In the case of datasets with a large T and small n, FE analysis is more sensitive to error term non-normality and heteroscedasticity and is typically avoided (Wooldridge 2015).

Another important consideration with direct ramifications for panel data analysis is that FD estimators lose more information in a situation of unbalanced panel data. With an FD model, each missing year value represents a loss of two years' worth of data rather than 1. When a dataset is unbalanced there is a compelling argument for focusing on a fixed effects model using time demeaning. Based on the above arguments, this is the approach utilized in this paper.

e. Literature Review Conclusion

While the work described above is useful, only one of the studies cited uses data form organic dairy farms, reflecting a gap in the literature. There remains a need for new published studies analyzing panel data to determine variables affecting organic dairy profitability.

In Vermont, the University of Vermont (UVM) and the Northeast Organic Farming Association of Vermont (NOFA VT) have compiled panel data on organic dairy farm finances for over 10 years, with an average yearly N of 35. While early uses of this data were limited to assessing dairy profitability in general, subsequent analysis has started to focus on identifying specific management and demographic factors associated with profitability. Krug identifies use of feed mixing machinery, amount of grain fed, use of Holstein cows, and animal health as significant variables associated with profitability on organic dairy farms in this dataset (Krug 2015). However, a comprehensive analysis of the full 10 years of financial data has not yet been published. Given the quality of this dataset, this type of analysis will be a useful contribution to the literature on organic dairy profitability in northern New England.

The above section argues that one effective way to assess the effect of various variables on farm profitability is to run a time demeaned fixed effects model on a panel dataset. This study performs such an analysis on an updated version of the Vermont organic dairy dataset previously collected by Parsons and other researchers. Specific methods used for data collection and econometric analysis are discussed in the next section.

3.3 Methods

Dataset Background

The dataset used in this thesis comes from a joint research project between UVM and NOFA VT led by professor Bob Parsons. This study has collected financial panel data from a group of organic dairy farmers in Vermont from since 2006. Data was collected by UVM extension staff and outside consultants who utilized a combination of in person farm visits, farm budgets and tax documents to ensure accuracy. Given the difficulties of scheduling interviews and the busy schedules of farmers, various farms have entered and left the study over the years, leading to an unbalanced panel of farms. While a core group of 10 farms has participated in all 10 years of the study, all other farms missed at least one year, with 13 farms participating in less than 3 years. The following table shows the n values for each year of the study.

Table 1. Number of Participants in UVM/NOFA Organic Dairy Profitability Study 2006 - 2016

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
n =	40	28	35	33	31	41	36	36	36	38	36

While useful, the dataset used in this thesis does have some significant drawbacks. The first is the small sample size of farmers for each year. Given the involved nature of data collection, it is likely that certain types of organic dairy operations were more likely to participate, introducing bias. While the data collection team made an effort to randomly sample farms, this was in many cases not possible. Another drawback of this dataset is that it is not representative of any large population of dairy farmers. At most, this dataset can only be interpreted as representative of the experiences of small organic dairy farmers in Vermont. Summary statistics reflect the typical profile of an average study participant.

Independent Variables

The study objective in generating and analyzing a financial panel data model of organic dairy profitability is to assess the relationship between farm management practices and profitability as measured by ROA. Relevant variables were selected based on availability in the dataset, common sense, economic theory, and a review of the literature. These variables can be divided into 6 categories as described in the above literature review.

Table 2. Independent Variables used in the unrestricted regression model.

Variable	*Predicted effect on ROA*	*Unit of analysis*	
Feeding Management:			
Lbs Shipped per Cow	+	*lbs*	
purchased grain and concentrates	+	*$*	
purchased forages	-	*$*	
General Management:			
Repairs	+ or -	*$*	
Depreciation	+	*$*	
Government Payments	+	*$*	
Average Debt Level	-	*$*	
Vet Costs	-	*$*	
Farm Characteristics:			
Number of Cows	+		
Milk Price:			
Average Received Milk Price	+	*$*	
Input Costs:			
Labor	-	*$*	
Fuel and Oil	-	*$*	
Custom Hire	-	*$*	
Bedding	-	*$*	
Breeding	-	*$*	
Utilities	-	*$*	
Supplies	-	*$*	

Data Analysis:

In preparation for analysis, data was collected from each farm and consolidated into spreadsheets by year. These sheets were further consolidated so that each farm in each year made up a separate row in preparation for fixed effects analysis. This data was then analyzed using a pooled OLS regression on the variables described in the above production model. Once this data was recorded, each variable for each farm was time demeaned across the total number of year the farm was a part of the study. The outputs of this demeaning were saved in a separate dataset. At this time, dummy variables for each study year were generated and included in the demeaned dataset. Next, the time demeaned data was put through a standard regression model as described above. Residuals (u) of this regression were recorded and squared, and then regressed on the independent variables to check for heteroscedasticity. Collinearity statistics were also recorded. In accordance with the study plan, variables found to be insignificant at the .05 level were next removed from the model. F tests were performed to see if this restricted model lost any explanatory power. Dummy variables for each year were kept in the model after an F test revealed them to be significant as a group of variables.

Descriptive Statistics

Analysis of the 10-year dataset was used to generate descriptive statistics for the study population during the time period 2006-2016. Each participating farm in each year was used as a data point. Data is divided into farm production, income, expense, and financial benchmark categories.

The farms participating in the Vermont organic dairy study were relatively small, with 66.33 cows on average. The smallest farm in the study milked an average of 19.5 cows, while the largest milked 321. By comparison, the average conventional dairy in northern New England milked 403 cows in 2016 (NDFS 2016). The mean number of pounds shipped per cow was 13,261.31, with a total average yearly herd production of 904,081 pounds. Received milk price ranged between $25.80 and $46.76 per hundredweight, with an average of $32.73. Notably, even the lowest organic price was higher than the 2011-2016 average conventional price of $20.06 per cwt.

Table 3. Vermont Organic Dairy Study Production Variables 2006-2016 (n=392)

	Mean	Median	Minimum	Maximum	Std. Deviation
Average # of cows	66.33	57.00	19.50	321.00	44.61
Lbs shipped total	904081.41	725651.50	203315.00	5496821.00	718495.59
Lbs shipped/cow	13261.31	13230.44	4944.49	22272.73	3098.48
Milk Price	32.73	31.85	25.80	46.76	3.86

In terms of earnings, organic dairy farms in this study received income from a variety of sources. The largest portion of farm earnings by far was milk sales, with an average of $294,813.15 per farm, followed by cull cow sales at $7,882.48. Dairy cow sales totaled $5,769.55. After milk and animal sales, the next highest income source was government payments at $5,687.86. This category includes NRCS cost share programs, certification refunds, and other government support. Other income categories are shown below. In total, total cash receipts per farm averaged $326,307.38. On the accrual side, the average livestock inventory accrual value per farm was $3,866.06. Stored forages made up another significant source of accrual revenue, with an average stored hay value of $2442.08 and stored grain value of $258.27. In the case of stored forages, it is important to remember that accrual revenues from these sources have a large range, with accrual income from grain, for example, ranging from $-65,575.00 to $68,950.00. Total average farm revenue (including accrual income) totaled $332,808.19.

Table 4. Vermont Organic Dairy Income 2006-2016 (n=392)

	Mean	Median	Minimum	Maximum	Standard Dev.
Milk sales (a)	295813.15	237828	62992.00	2138125.00	246340.92
Dairy cattle sales	5769.55	0	0.00	99367.00	14334.37
Cull cow sales	7882.48	5032	0.00	93483.00	10791.19
Bob/Veal calf sales	1462.37	708	0.00	29515.00	2708.51
Crop sales	2206.89	0	0.00	70652.00	5976.09
Government payments	5687.86	1989	0.00	77767.00	9413.94
Patronage dividends	2421.28	1476	0.00	48000.00	4269.40
Custom work	394.85	0	0.00	18618.00	1884.35
Syrup	975.82	0	0.00	30247.00	3299.75
Timber	611.71	0	0.00	29235.00	3009.67
Other	3288.76	1541	0.00	32878.00	4427.21
Total Cash Receipts (b)	326307.38	264351.5	69273.00	2353495.00	265652.31
Accrual Revenue Adjustments					
Livestock inventory	3866.06	900	-61600.00	111650.00	18854.27
Breeding livestock purchases	-1137.38	0	-40700.00	0.00	4557.54
Accounts receivable (c)	1656.53	1000	-33247.00	46959.00	6345.29
Hay	2442.08	396	-37950.00	130340.00	13658.39
Grain	258.27	0	-65575.00	68950.00	8635.72
Total Accrual Revenue (d)	7075.69	1923	-82150.00	243509.00	30834.99
Total Farm Revenue (e)	332808.19	900	77874.00	2384593.00	281077.40

One valuable set of information produced by this 10-year study is average cost of production information for organic dairy in Vermont. While the study group is not perfectly representative, this information is likely to be useful for farmers and extension staff in making farm business decisions. While the complete data is available in table 5, some highlights are worth mentioning. Purchased feed was by far the biggest expense for organic dairy farms, with purchased grain averaging at $81,675.70 and purchased forages at $7,358.14. Cost data on farm-grown forages was not collected in this study, but is reflected in other expense categories. Labor was the next biggest expense at $33,014.14, followed by repairs at $21,174.14 and supplies at $16,403.01. Utilities, fuel, and custom hire were the next highest cash expenses. The primary accrual expense faced by farms was depreciation at $33,610.13. While not reflected on cash balance sheets, this cost is the second highest of any expense category in the study. Average total farm expenses were $277,488.49 during the years of the study.

Table 5. Vermont Organic Dairy Expenses 2006-2016 (n=392)

	Mean	Median	Minimum	Maximum	Std. Dev
Auto and truck expenses	1909.52	1126.5	0.00	13676.00	2367.25
Bedding	6946.44	4477.5	0.00	42892.00	7848.48
Breeding	3122.54	2407	0.00	24000.00	2987.18
Chemicals/pesticides	46.58	0	0.00	4149.00	310.07
Custom hire:	11073.37	5190	0.00	103073.00	15330.98
DHIA	1231.73	1371	0.00	3923.00	1048.50
Fertilizers and lime	2934.62	0	0.00	56308.00	6063.37
Feed - purchased grain and other	81675.70	69919.5	0.00	745347.00	73490.62
Feed - purchased forage	7358.14	85	0.00	228713.00	18038.18
Fuel and Oil	9980.51	7891	983.00	62944.00	8516.33
Insurance	5331.41	4385.5	0.00	29979.00	3686.50
Interest	10064.61	7186	0.00	64415.00	11202.86
Labor	33014.34	21526.5	0.00	384771.00	50371.62
Milk marketing	4411.29	4034.5	0.00	33067.00	3268.90
Real estate taxes	3637.12	3195	0.00	33731.00	3323.98
Rent	4859.88	1287.5	0.00	72245.00	9472.16
Repairs	21174.14	14510	0.00	202306.00	24384.27
Seed and plants	2072.30	0	0.00	42075.00	5998.38
Supplies	16403.01	12293.5	0.00	77298.00	12460.77
Utilities	9726.55	8258.5	920.00	52510.00	6708.99
Vet	3174.41	2439	0.00	16132.00	2849.94
Medicine	273.20	0	0.00	11564.00	1085.66
Miscellaneous	4568.79	3478.5	0.00	26305.00	3745.80
Total Cash Expenses (f)	**244910.99**	**199074.5**	**52566.00**	**1693091.00**	**207676.36**
Accrual Expense Adjustments					
Depreciation	33610.13	23477	204.00	418737.00	41591.10
Accounts payable	-60.68	0	-159274.00	68543.00	13360.76
Pre-paid expenses	-167.18	0	-26450.00	25000.00	4687.87
Supplies	-201.88	0	-13120.00	9120.00	2040.65
Total Accrual Expenses (g)	**33180.90**	**23233**	**156143.00**	**440638.00**	**45431.47**
Total Farm Expenses (h)	**277498.49**	**217894**	**58415.00**	**2089587.00**	**243472.86**

The last category of data collected in the organic dairy study concerns farm financial performance. In general, participating farms were somewhat profitable across the 10 years of the study, as shown in Table 6. Yearly Net Cash Farm Earnings averaged $81,363.53, with Net Farm Revenue (including accruals) somewhat lower at $55,309.70. To accurately compare financial performance across farms with varying degrees of capitalization, average assets and equity were recorded for each farm and year. Mean average assets totaled $957,538.72 for this group of farms, with mean average equity of $730,988.95. Mean Return on Assets for participating farms was positive at 2.4%, with Return on Equity lower at just 1.1%. Over the course of the 10-year study, the lowest ROA achieved was -25.9%, and the highest was 22%.

Table 6. Vermont Organic Dairy Financial Performance 2006-2016 (n=392)

	Mean	Median	Minimum	Maximum	Std. Dev
Net Cash Farm Earnings	81363.53	64448.5	-111065.00	704546.00	71809.19
Net Farm Revenue	55309.70	45398	-95173.00	427335.00	55061.07
Average Assets	957538.72	790702.25	132420.50	4880881.00	582313.30
Average Equity	730988.95	613837.75	61167.00	3198448.00	460847.95
Average Debt	226549.77	183879.25	0.00	1682433.00	232842.12
ROA	2.40%	2.03%	-25.90%	22.03%	0.05
ROE	1.10%	1.47%	-185.81%	40.02%	0.13

3.4 Results:

This study utilizes the time demeaned fixed effects model described above to address unobserved farm attributes affecting profitability. The final regression model used to assess management factors associated with profitability in the 2006-2016 organic dairy finance panel dataset is shown below in figure 2. Parameters depicted as δ are dummy variables representing each study year, and parameters depicted as β have been time demeaned across the years each farm participated in the study.

$$profitability = f(year, feeding\ management, general\ management, farm\ characteristics, milk\ price, input\ costs)$$

$$ROA_{it} = \delta_0 + \delta_1 07 + \delta_2 08 + \delta_3 09 + \delta_4 10 + \delta_5 11 + \delta_6 12 + \delta_7 13 + \delta_8 14 + \delta_9 15 + \delta_{10} 16 + \beta_1 lbshipped + \beta_2 grain + \beta_3 forages + \beta_4 hayaccrual + \beta_5 deprec + \beta_6 gvtpay + \beta_7 interest + \beta_8 numcows + \beta_9 milkprice + \beta_{10} fuel + \beta_{11} utilities + \in_{it}$$

Figure 2. Study Hypothesis

Note. δ variables represent study years.

As table 7 indicates, all non-dummy parameters in the above model were found to be statistically significant, with the entire model significant at the .01 level. The R^2 of the model is .347, with an adjusted R^2 of .307. F-test comparison with the unrestricted model described in the methodology section demonstrates that the final restricted model does not significantly alter the explanatory power of the model.

Table 7. Estimated parameters of the regression model *(n=392)*

Variable	*B*	*Standard Error*	*Standardized B*	*T-statistic*	*Sig.*
Intercept		*.007*		*-.448*	*0.137*
Feeding Management:					
*Lbs Shipped per Cow****	*1.19E-05*	*.0000016*	*0.398*	*7.494*	*0.000*
*purchased grain ****	*-3.15E-07*	*.0000001*	*-0.233*	*-3.737*	*0.000*
*purchased forages****	*-1.03E-06*	*.0000002*	*-0.259*	*-5.26*	*0.000*
*Hay Accrual****	*6.29E-07*	*.0000002*	*0.184*	*3.948*	*0.000*
General Management:					
*Depreciation****	*-6.61E-07*	*.0000001*	*-0.369*	*-6.672*	*0.000*
*Government Payments***	*8.42E-07*	*.0000003*	*0.141*	*2.463*	*0.014*
*Interest****	*1.40E-06*	*.0000004*	*0.16*	*3.231*	*0.001*
Farm Characteristics:					
*Number of Cows****	*.001*	*0.00028*	*0.324*	*4.49*	*0.000*
Milk Price:					
*Average Received Milk Price****	*0.003*	*.0008913*	*0.295*	*3.606*	*0.000*
Input Costs:					
*Fuel and Oil***	*1.62E-06*	*.0000007*	*-.134*	*-2.375*	*0.018*
*Utilities****	*-2.18E-06*	*.0000007*	*-.169*	*-2.916*	*0.004*
F-Statistic for no fixed effects*	8.751				*0.000*
F-Statistic for restricted v unrestricted model					
R^2	*.347*				
Adjusted R^2	*.307*				

Note. *, **, and *** denote statistical significance at the .10, .05. and .01 levels respectively, ROA = dependent variable.

3.5 Discussion

The R^2 and Adjusted R^2 values for the above model are fairly low at around .3. Given the complex factors affecting farm profitability, this is unsurprising as variables have likely been omitted that would increase the predictive value of the model. This R^2 is similar to that in other dairy farm profitability studies (Krug 2015, Foltz and Lang 2002), although some with non-financial parameters approach .5 (Gloy et al 2002).

Despite their low predictive value, the results do show a significant relationship between farm management factors and profitability as measured by ROA. This is reflected in the F statistic for no fixed effects, which shows significance at the .01 level. Significant relationships between specific management factors and profitability also exist across all variable categories. In Feeding Management, the data reflects past research findings that increased lbs milk per cow is associated with profitability (Gloy et al 2002). Increased lbs per cow is typically associated with increased feeding of grain supplements. Value of both grain and non-grain purchased forages has a negative relationship with profitability, consistent with economic theory that increased input costs per cow is likely to decrease profitability. While not typically included in the literature, hay accrual income is positively correlated with profitability in this dataset, reflecting the positive effects of successful harvest and storage of farm grown forages. In general, results confirm farms that increase per cow milk output and those that reduce purchased feed costs tend to be more profitable.

General management characteristics indicated by depreciation, government payments and debt are also all significant in the regression model. Depreciation is difficult to interpret because this value is based on scheduled accrual reductions, but farms who purchase more new equipment and buildings in a year tend to have increased depreciation for the next 5 years until depreciation is complete. This data shows a negative relationship with profitability. Debt level and government payments both display a significant positive relationship with profitability. While inclusion of these variables is not common in the literature, their significance in this model suggests their consideration in future studies.

Farm size is one of the most commonly included variables in dairy profitability analysis, and typically displays a positive relationship with ROA (Harnahan 2018, Krug 2015, Gloy 2002). This is also the case in this study – each one cow increase in size is associated with a .001 increase in ROA, the strongest estimated relationship in the model. This finding is unsurprising given the broad consensus in the literature that economies of scale represent a profitable management approach for many dairy farmers (MacDonald 2016).

As a direct component of total milk sales, it is unsurprising that average milk price received demonstrates a strong relationship with profitability in this dataset. With a B value of .0003 and a significance of .000, milk price is a key variable in this model. This is consistent with the economic model described in figure 1, which includes milk price as the variable p (Gloy 2002).

The final independent variables in the model are input costs, represented through Utilities and Fuel and Oil costs. Increases in either input are associated with significant decreases in profitability, consistent with the economic model in figure 1. Both included input cost variables are significant at the .01 level.

In general, these results reject the null hypothesis of no relationship between farm management factors and profitability. More importantly, they provide evidence for statistically significant relationships between ROA and particular management variables across several categories. This finding is in line with the findings of previous researchers cited in the literature review.

Study Limitations:

Given the complex factors associated with farm profitability, the variables identified in this research represent only part of the picture. While eliminating fixed effects like management ability and capitalization makes it possible to isolate specific management factors, these very effects are likely some of the most important determinants of farm financial success. In addition, due to a small sample size and imperfect randomization, results cannot be interpreted as representative of national or regional dairy farm populations. However, given the lack of published Vermont-specific econometric analysis, results are likely to be useful in the context of organic dairy in Vermont.

3.6 Conclusions

Research into dairy profitability tends to focus on isolating and identifying the effects of various management factors on farm profitability. Most of this research has been focused on conventional dairy operations, leading to a gap in the literature on organic dairy profitability. This study addresses this gap by analyzing a 10 year panel dataset of Vermont organic dairy farm finances using OLS regression on a time demeaned fixed effects model of dairy profitability. This analysis finds evidence of significant relationships between ROA and feeding management, farm management, farm characteristic, input cost, and milk price variables on Vermont organic dairy farms.

Implications

The above results point to several important implications of this article for researchers, farmers, and policymakers. First, from a research perspective the evidence outlined above indicates that the factors associated with profitability on the organic farms analyzed in this study are consistent with those identified in the previous literature on conventional dairy profitability. While continued econometric research into organic dairy production may identify subtle differences, this thesis demonstrates that conventional dairy research can be useful in designing future studies on organic dairy. In addition, the results presented here demonstrate the limitations of a purely financial approach to farm management research. Future studies would do well to incorporate non-financial variables like feeding efficiency, total land under production, cow breed, DMI intake from various sources, farmer demographics labor utilization. The addition of this type of variable would likely increase the explanatory power of any econometric model for dairy production.

This thesis also has implications for applied farm management. While many key variables were not able to be included in the model, results suggest that shifts in farm management can improve farm profitability outcomes. As shown above, reducing feed costs, improving milk quality (and thus price), and avoiding debt are all associated with increased profitability. While these variables are not easy to change, results may be useful in setting farm management goals and objectives.

Finally, Vermont policymakers may find the results of this research useful. In line with previous research into dairy farming, this thesis provides evidence that milk price is one of the most important variables determining the financial success or failure of dairy farms in Vermont. In looking to maintain the viability of Vermont's traditional dairy industry, policymakers should consider price supports or supply management programs focused on keeping milk prices up for both organic and conventional producers. In addition, increased funding for extension education in pasture and feeding management may help to improve the farm management factors shown above to have a strong influence on farm profitability.

Oversupply and price reductions in 2017 and 2018 have plunged Vermont organic dairy producers into a new profitability crisis. As farmers look for ways to stay in business, economic research measuring factors associated with profitability will remain important for farmers, extension educators, and policymakers. Future research should build upon the work presented here by combining farm finance data with detailed production and demographic information to identify more nuanced management variables associated with increased profitability.

4. Article 2: Financial Analysis of 2017-18 Dairy Crisis Using Data from 2015 – 2017

4.1 Introduction

In recent decades, the US dairy industry has been in an economic crisis. The total number of operating dairy farms in the US has decreased by 74.1% over the past 25 years, dropping from 155,339 in 1992 to just 40,219 in 2017 (NASS 2018). Much of this reduction in farm numbers can be attributed to low profitability in the dairy sector. In response to economic challenges, some farms have converted to organic in an attempt to stay in business. For both organic and conventional dairy farms, up to date research into the factors associated with farm profitability is critical in helping to make business decisions.

In dairy economics research, milk price has been shown to be one of the most important variables determining profitability (Gloy 2002, Wolf 2016). Milk price is also one of the production factors most influenced by broader market conditions. For this reason, milk price is often watched carefully by farmers and policymakers in both conventional and organic contexts. In late 2016, the organic milk price began a sustained decrease that has continued into 2018, tightening profit margins for producers and cooperatives. This market shift is recent enough that dairy economics literature has not yet caught up. This article addresses this gap by analyzing financial data collected from a panel of organic dairy farmers in Vermont during the years 2015, 2016 and 2017 to assess the effects of the recent price reduction on this group of farms. While insufficient data are currently available to draw statistically rigorous conclusions about the population of organic dairy farms in Vermont, preliminary results will be useful to farmers in urgent need of updated market and benchmarking information. Policymakers and researchers also stand to benefit from access to this preliminary data.

This article is structured as follows: in section 2 a detailed literature review explores the market level determinants of organic dairy prices and farm profitability. Based on previous research and publicly available data, this review argues that updated research is needed into the effects of recent organic milk price shifts on profitability in northern New England. This leads directly to the research question central to this article: *does milk price play a major role in determining industry wide profitability outcomes?*

In order to answer this question, three years of data (2015-2017) from the University of Vermont's organic dairy profitability study are analyzed in this article. Section 3 describes the methods of data collection and analysis used. In section 4, results of this analysis are reported. While limited in their representational value by small sample sizes for each year, these results are useful for preliminary analysis. Section 5 provides a discussion of recent trends in the organic dairy industry and how they relate to the study findings. Finally, section 6 presents the conclusions and implications of the article.

4.2 Literature Review

This literature review provides a context through which to examine changes in the yearly financial data collected by UVM and NOFA VT between 2015 and 2017. As described above, the focus of this project is to assess how the recent milk price shift has affected profitability on Vermont organic dairy farms. Before moving into a discussion of milk price, however, it is necessary to examine the economic literature for evidence that dairy profitability is actually influenced by yearly price trends. This section argues that market conditions have a strong, measurable effect on profitability outcomes.

In order to further set the groundwork for an analysis of the recent milk price shift, this review next describes the various factors affecting the organic milk price in general. Determinants of milk price (supply, demand, price cycles and the cost of production) are described, based on relevant economic theory and previous research. For each category, recent data from the USDA Economic Research Service is compared alongside current academic and popular press materials to illustrate current trends and how they have affected the organic milk price in the US during the period covered by this study. The lack of recent peer reviewed materials on these topics reveals an urgent need for quality research into the causes and effects of this price reduction. Finally, this review examines the data collection and analysis methods that have been used previously in this type of research, arguing for detailed financial panel data as the best tool for examining the effects of broad market trends on organic dairy profitability over multiple years

Is Dairy Profitability Determined by Milk Price?

Recent research has shown that industry wide trends like milk price have an effect on profitability. Wolf al (2016) find that while yearly dairy profitability (measured by ROA) is primarily determined by firm effects, industry wide trends do explain a significant amount of variation. Large farms are much more likely to be influenced by industry wide trends. This finding is consistent with other analyses of dairy profitability that show a strong relationship between ROA and milk price received (Hanaran 2018, Gloy et al 2002). Other research has argued that cyclical changes in the milk price are also associated with changes in ROA (Nicholson 2015).

Given this relationship, it is unsurprising that many popular press and industry reports argue that milk price plays a key role in organic dairy profitability (Bedard 2017). As of early 2018, news reports commonly identify decreasing organic milk prices as having a negative effect on farm profitability, (Bloomberg 2018, WSJ 2018).

The above evidence suggests that yearly milk price trends are relevant to organic dairy profitability. If this is the case, an understanding of the factors influencing milk price is important in predicting the effects of price shifts over time. This next section identifies changes in demand, supply, and cost of production as primary determinants of milk price.

Milk Price Determinants

Conventional milk prices in the US are set by the federal government through the Federal Milk Marketing Order system. This system sets a minimum price for farmers in various geographic areas while also ensuring a consistent and adequate supply of milk. Prices are based on component values of protein, fats and other solids, and are tied to dairy commodity markets for butter, cheese, nonfat dry milk, and whey. (USDA 2018). While bound to the same minimum price, organic milk processors pay an additional premium to farmers based on the market value added by organic production (McBride and Greene 2009). Because organic dairy farms tend to be pasture based, they are also likely to produce milk with higher valuable components like fat and other solids (Butler, 2007). A final price benefit of organic dairy production is a relatively stable pay price, made possible by the provision of a fixed annual price contract by many organic processors (McBride and Greene 2009, Su 2014). This compares favorably with the highly variable nature of the conventional price, which can change quickly due to market shifts (Wolf et al 2016).

While organic dairy farmers do have some shelter from rapid market shifts, both conventional and organic dairy prices are strongly influenced by the market in any given year. Economic theory suggests that agricultural product prices are largely determined by changes in market demand and supply. Increased consumer demand for a given product will increase prices, while oversupply through excess production will decrease prices all else equal (Tomek 2014). Recent research on the determinants of milk price (both conventional and organic) generally aligns with this theoretical framework (Se 2013).

Given the relative lack of research into determinants of the organic milk price, this review also incorporates similar research involving conventional dairy price. Demand, supply, and cost of production variables are the primary determinants identified in the literature.

Demand

The concept of demand for dairy having an effect on prices instead of vice versa is an example of an inverse demand system (Glasser and Thompson 2000). Given that prices of organic milk are set yearly, pay price is largely determined by demand predictions. An increase in consumer demand is likely to shift prices up, for example, as buyers prepare for increased production (Su 2014). Bailey (2005) provides evidence that conventional farmgate milk price is strongly influenced by both consumer and speculative demand. Seasonal demand shifts have also been identified as price factors in retail dairy sales (Glasser and Thompson 2000).

Supply

Even stronger evidence exists for market supply as a determinant of dairy price. Bailey provides a review of this argument, pointing to several examples of years in which price drops immediately followed a period of oversupply (Bailey 2005). In the case of conventional dairy, increased trade means that international supply shifts have also begun to influence US prices. Seasonality is another supply side factor with an influence on dairy prices. During the spring flush, total milk yields increase, keeping prices down during these months. Seasonal premiums offered by processors aim to offset this yearly effect (Su 2014). Wolf et al provide evidence that many dairy operations respond to increased profitability by expanding herd sizes, increasing the total milk supply and eventually leading to lower prices (Wolf 2016). A recent report on Vermont organic dairy conditions published by NOFA Vermont argues that recent reductions in the organic price can largely be attributed to supply shifts (Bedard 2017)

Cost of Production

While economic theory does suggest that the cost of production will affect milk prices by causing a shift in supply, the relationship is more direct in the case of organic dairy production. Many suppliers, including the CROPP cooperative, include COP estimates in their decision making process for determining contract price (Su 2014, Organic Valley Report 2017, 2018). To this end, many suppliers collect their own COP information from farmers (NODPA listserv advertisements 2018). If costs of production increase too much ahead of prices, milk producers cannot stay in business and buyers suffer financially as well. For this reason, fuel and feed price indicators are commonly used in industry press as indicators of potential shifts in milk price (Maltby 2017, 2018).

The above literature makes it possible to interpret market trends in the context of recent organic price reductions. The next section of this review examines key demand, supply, and input cost trends relevant to the organic dairy price during the period 2012-2018. Based on the data, this section argues that recent price shifts are likely the result of sustained market oversupply.

Organic Dairy Price Trends:

In examining national level market price data, it is important to differentiate between retail and farmgate prices. While evidence has shown that these two price indicators tend to be strongly correlated (Schnepf 2013), farmgate prices tend to be less than half the retail price. This is primarily due to processing, distribution, and marketing costs (Bailey 2005). While related, retail and farmgate prices are variables that do change somewhat independently. For this reason, any analysis of recent organic dairy prices should include both metrics if possible.

Organic dairy retail price trends have been tracked on a semi-weekly basis by the USDA Economic Research Service (ERS) since 2012. In this article, this national data will be considered a valid indicator of trends in organic daily retail prices. Figure 1 shows the average retail price for several organic dairy products. Consumer prices, while fairly unstable, do not seem to be decreasing as of April 2018.

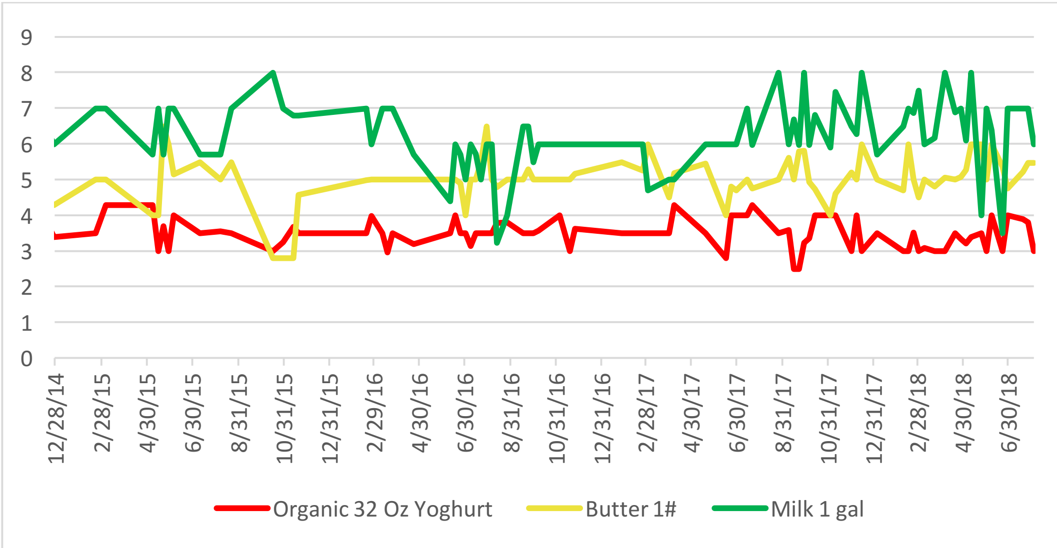

Figure 3. Weighted average retail prices for selected organic dairy products 2014-2018
Source: ERS Custom Report, 2018

While retail prices for organic dairy products in general do not display a strong visual trend, 2018 data does suggest a decrease in the liquid milk price. Farmgate fluid milk price data, on the other hand, reflects a sharp decrease in price beginning in 2016.

Unlike retail price (measured by ERS) and conventional milk price (set by the FMMO), organic dairy farmgate prices are not nationally tracked. Instead, estimates of cwt prices for organic milk have to come from another source. Many milk processor contracts are secret, and general price data is not available for non-cooperative buyers like Horizon. Given the fact that a large number of Vermont organic farms sell to the CROPP cooperative and the availability of data, national base prices from the cooperative are used here to estimate farmgate prices by year. While this approach is not representative of the market as a whole, price data from CROPP is the best available information. These farmgate price trends are shown in figure 4.

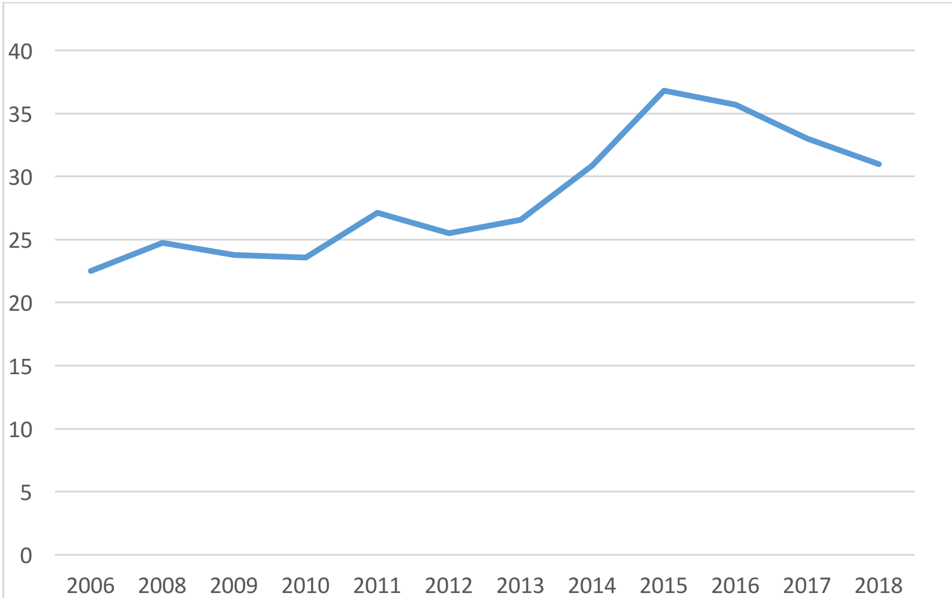

Figure 4. Average Organic Valley Farmgate Milk Price 2006-2018

Source. Organic Valley Annual Reports 2006-2018

As a look at the data shows, CROPP farmgate milk prices have been following a downward trajectory since 2015. In their annual reports, Organic Valley has blamed this decrease on an inability to sell all of their milk supply at the organic price, an explanation that is further examined in the below section on demand trends (Seimon 2017).

This price decrease is consistent with reports of lowering prices in the popular press. Given the strong effects of milk price on farm profitability demonstrated in article 1 of this thesis, this shift is likely to be associated with decreased profitability across the industry. For this reason, it is useful to identify the causes of this sudden decrease in organic milk price. To answer this question, the following sections will address demand, supply, and production cost trends between 2013 and 2018.

Organic Milk Demand Trends:

In recent years, much has been written in the popular press about increasing demand for organic dairy products. As organic dairy has shifted from a niche product to one available in almost every grocery store, its share of the total dairy market has reflected a similar increase (from 1.92% in 2007 to nearly 5% as of 2014) (Greene et al 2015). This increase has been demonstrated across multiple categories of organic products, with dairy currently making up the largest percentage of organic sales at 21% (Greene 2017)

As of early 2018, however, news stories and industry reports have shifted toward a narrative of excess supply and dropping organic prices along with reductions in demand and consumer shifts to plant-based milk products (Bloomberg 2017, WSJ 2018, Bedard 2017). Given the slow pace of academic publication, however, much of the research into organic dairy markets still identifies sustained and increasing market demand. This lack of recent published research means that raw data represents the best source of information on this topic

The most accurate data available on current trends in demand for organic milk can be found in the USDA ERS market news data portal. Some of this data is shown in figures 5 and 6. As can be seen, total sales of organic fluid milk have generally increased since 2013. Since 2017, sales data have exhibited early signs of a stagnation in milk demand. However, general trends continue to be positive. Once organic milk is broken out into categories, clearer trends emerge. While whole milk sales continue to increase year after year, reduced fat organic milk sales have declined, with the sharpest drop apparent in skim milk sales. While organic milk demand across all categories may continue to increase, decreasing demand for skim milk is concerning to processors who produce skim milk as a byproduct of butter and cheese production.

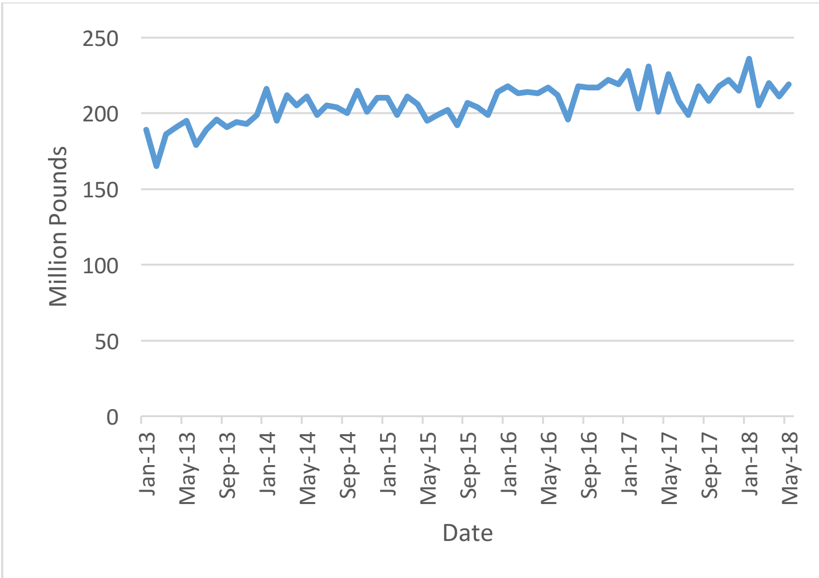

Figure 5. Total US Organic Milk Sales, All Liquid Categories
Source: USDA ERS Data 2013-2018

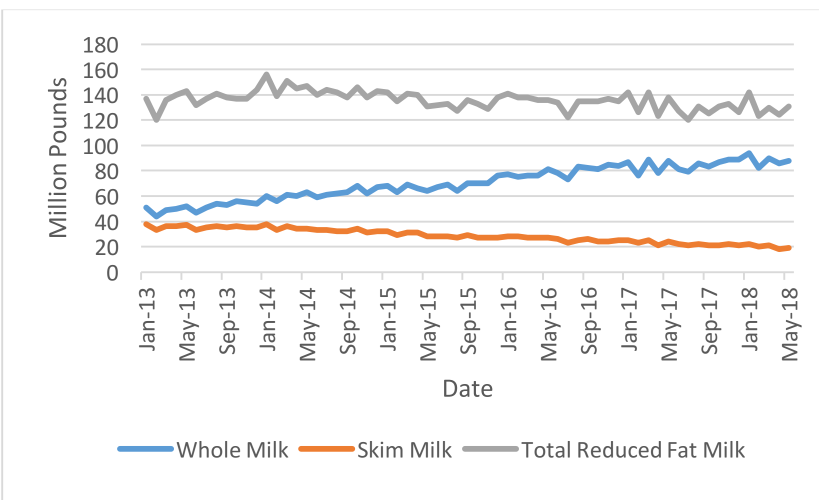

Figure 6. Organic Whole, Skim, and All Reduced Fat Milk Sales 2013-2018
Source: USDA ERS 2013-2018

Organic Milk Supply Trends

As the economic literature above suggests, shifts in supply can have a large impact on milk prices. Current trends suggest that this may be the case in 2018. Accordingly, oversupply is the theme of much recent organic dairy industry press. In the 2017 CROPP annual review, CEO George Siemon argues that excessive optimism about growth in dairy demand led to production increases. When supply exceeded demand, the cooperative was not able to sell its inventory as planned and had to reduce producer prices. After managing oversupply for several years, the cooperative finally turned a negative profit in 2017 (the first time since 1997) (CROPP 2018). Horizon, the other major organic dairy processor also announced major price reductions in 2017, in addition to proposing voluntary production restrictions from farmers (Bedard 2017). Both of these price reductions were identified as caused by oversupply.

One metric for assessing organic milk supply is the total number of organic cows, While updated data on the size of the US certified organic dairy herd is unavailable, data from the USDA census of organic agriculture reflects a sharp increase in organic dairy cows between 2015 and 2016, shown in figure 7. Given that newly purchased cows take two years to produce milk, this trend is consistent with oversupply issues in 2017. Data from 2017 will be released in 2019, and will paint a clearer picture of organic milk supply.

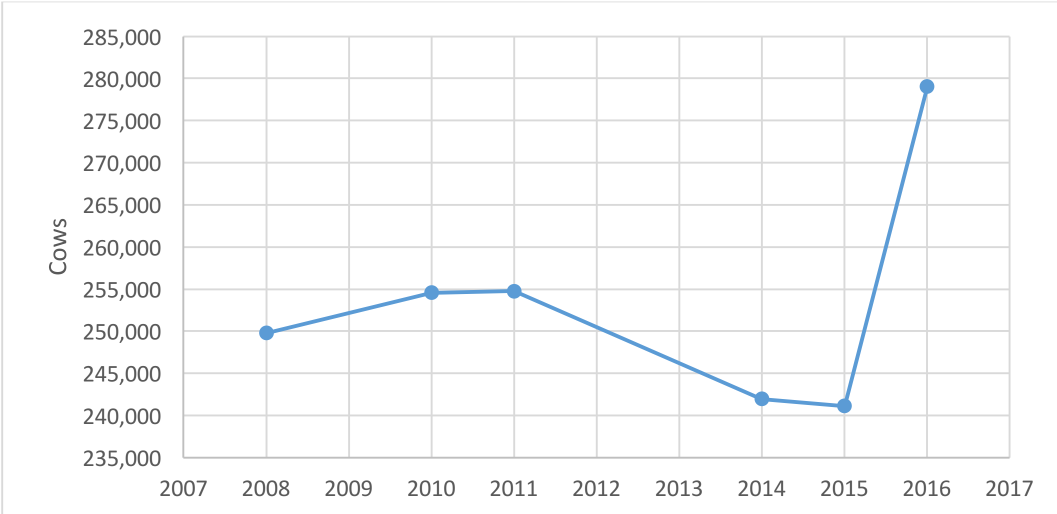

Figure 7. Total number of certified organic dairy cows in US 2007-2016

Source: ERS 2018 and NASS 2018
Note. Some yearly data not available.

This data, combined with reports from the major organic dairy processors and the industry press, suggests strongly that the organic dairy market has been in a state of oversupply since 2016, leading to the dramatically decreased farmgate milk prices shown in figure 4.

Cost of Production Trends:

Cost of production is the final commonly identified determinant of milk price. Updated data is available for prices of some key inputs and is analyzed below. Based on the evidence from article 1 of this thesis, the two most important input costs associated with profitability are grain feed and fuel. National level data for both of these inputs is available through the ERS, and is considered here. Feed costs are estimated using the Iowa organic feed corn price, and are available on a biweekly basis. While feed prices are likely somewhat higher in the northeast, data from this region is not readily available.

However, general price trends are likely to be similar. Given the importance of diesel fuel in mechanized farming practices, the diesel price will serve as an estimate of general fuel costs over time. Price data for each input is shown below.

Figure 8. IA Organic Corn Price (per bushel) 2012-2018
Source. ERS Organic Data Custom Reports

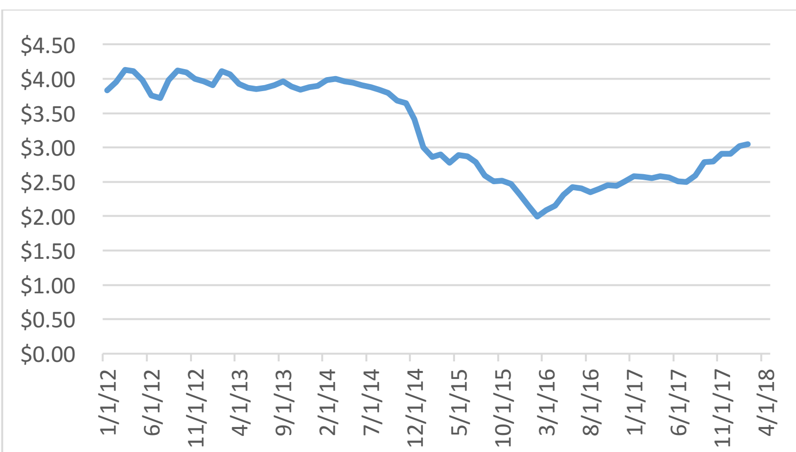

Figure 9. US Diesel Fuel Cost (per gallon) 2012-2018

Source. Iowa Feed and Fuel Database

As can be seen, prices for both inputs followed a decreasing trend between 2012 and 2015. In 2016, both feed corn and diesel fuel reached a 6-year minimum before beginning to trend upward. Given that the current period of decreasing organic milk prices roughly coincides with increasing production costs, it is clear that price reductions are likely not the result of decreasing feed or fuel costs. As costs increase, however, organic dairy cooperatives may have no choice but to increase prices through quota reductions or financial losses for the cooperative Organic Valley Annual Report 2016, 2017).

Review of Explanations for Current Dairy Price Shift

The above sections present recent trends in the organic dairy industry, along with common explanations for the current price shift. While oversupply is typically identified as the primary culprit given the lack of related shifts in demand or COP, quantitative research is still necessary in order to correctly estimate the actual cause of recent reductions in the milk price. Unfortunately, little peer reviewed research has yet covered these recent trends. While updated data is generally available from the ERS, this type of analysis is beyond the scope of this article. Even less work has been published to address the effects of recent price reductions on farm profitability since 2016. As the beginning of the above literature review suggests, changes in price are likely to reduce profitability on organic dairy farms. Based on the above literature, this paper analyzes profitability data from Vermont organic dairy farms in order to learn more about the relationship between milk price and profitability in northern New England.

Methods Review

As described in article 1 of this thesis, much economic research into dairy profitability has relied on econometric analysis of large datasets. Recent projects have focused on dairy farm profitability at national (Gillespie and Nehrig 2014, McBride, Green 2009), regional (Tranel 2015, Winsten, Parsons, Hanson 2000) and statewide (Foltz and Lang 2005, Barham, Brock, and Foltz 2006) scales.

While much of the research that has been done has utilized broad survey data, studies focused on farm finance have also utilized other methods of collecting financial data for analysis. Tranel obtained detailed profitability and budget data on Midwest organic dairy operations directly from the CROPP cooperative (Tranel 2015), while Kreigl followed up on a broad regional survey with a smaller number of farm visits to collect detailed financial data (Kreigl 2005). This type of approach makes it possible to collect and analyze highly specific financial factors and performance measures. In order to track profitability over multiple years, many studies have utilized panel data (Krug 2015, Lichtenberg et al 2011, Dalton, Parsons et al 2008, Kreigl 2005).

While some of this type of research has utilized econometric techniques, other research into organic dairy profitability has instead focused on basic descriptive analysis of readily available farm financial data from each year. Many of these analyses are based on a comparison of financial ratios, income, and costs of production. Wolf et al use panel data from conventional dairy farms in three states to compare profitability, solvency, and liquidity across farms and years (Wolf et al 2016). A number of white papers using similar techniques have been published using data from various regions of the US. (Barham 2006, Kreigl 2005). This approach has also been used in the context of organic dairy in Northern New England. In Vermont, an ongoing organic dairy profitability study through UVM and NOFA VT has compared organic dairy financial indicators across years since 2004 (Dalton et al 2006, 2008, Parsons 2017). Because this article utilizes the same dataset as other Vermont studies, the methodology used is also similar. However, the focus of this article is on the effects of price changes on farm profitability. Typical agricultural finance variables will be used as indicators of farm profitability, including Return on Assets, Return on Equity, Debt/Asset ratio, and Net Farm Income. Accurate definitions of each of these variables can be found in Moss (2013) and in article 1 of this thesis.

Non-econometric techniques have been utilized to good effect by the above researchers. However, the general standard in the field of applied economics is that descriptive analysis is not sufficient to provide proof of relationships. However, the lack of published material focusing on the effects of decreasing organic milk prices on dairy profitability starting in 2016 means that even a basic analysis of current data will be useful in preparing future econometric research on this topic. This paper presents updated data on Vermont organic dairy from 2015, 2016, and 2017 and compares financial indicators and descriptive statistics across these years in order to estimate any effects of price change on profitability.

4.3 Methods

The dataset used in this thesis comes from a joint research project between UVM and NOFA VT led by professor Bob Parsons. This study collected financial panel data from a group of organic dairy farmers in Vermont from 2006-2017. Data was collected by UVM extension staff and outside consultants who utilized a combination of in person farm visits, farm budgets and tax documents to ensure accuracy. Given the difficulties of scheduling interviews and the busy schedules of farmers, various farms have entered and left the study over the years, leading to an unbalanced panel of farms. While a core group of 10 farms has participated in all 10 years of the study, all other farms missed at least one year, with 13 farms participating in less than 3 years. The following table shows the n values for each year of the study.

Table 1. Number of Participants in UVM/NOFA organic dairy Profitability Study 2006 - 2016

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
n =	40	28	35	33	31	41	36	36	36	38	36	12

As of November 2018, data has only been finalized for 23 of the approximately 30 farms participating in the 2017 tax year study. While data collection and processing is still ongoing, for the purposes of this thesis this limited data is all that is available for 2017. Future publications of this data will include a larger n value, but preliminary results may be useful in the interim. Given the greatly reduced sample size currently available for this year, slightly different methods were used. Rather than comparing averages across the entire study sample, analysis focused on a restricted panel of 10 farms that participated in all three years between 2015 and 2017. This approach reduces the risk of variance caused by differences in the specific farms sampled.

Aside from the changes in methods outlined above, this section follows the example set by Dalton and Parsons in their 2008 comparative analysis of the first 3 years of study data (2004-2006). First, average farm size and earnings is reported for the years 2015, 2016, and 2017, followed by cost structure and financial performance indicators for these years. This descriptive data is used to evaluate the research question: *does milk* *price play a major role in determining industry wide profitability outcomes?* To do so, profitability changes across each year within the study are compared with milk price indicators during the same time period

4.4 Results

In this section, descriptive statistics are analyzed in a preliminary manner in order to identify potential changes in farm profitability due to price shifts within the sample. While statistically significant conclusions about effects of price shifts on the entire population of Vermont organic dairy farmers cannot be drawn, this analysis provides a useful first step for future research on this topic.

Farm Size and Earnings:

Over the three years between 2015 and 2017, the average number of milk cows did not change significantly across the 10 farms in the panel, staying between 54 and 55 cows. Production per cow displayed a bit more variability, but remained similar to the 13,717 average for 2016 across the full sample of 35 farms. Total milk produced in the reduced panel was highest in 2016 at 7307.45 cwt, reducing slightly in 2017.

Table 8. Farm, herd size, and milk production for farms in 2015-2017

	2015	2016	2017
Average number of milk cows	54.7	55.3	54.2
Annual milk sold (cwt per farm)	6238.28	7307.45	6904.79
Average milk shipped per cow (lbs)	11701.54	12592.61	12251.00
Average received milk price ($)	38.27	38.84	37.90
Milk sales per farm ($)	233286.2	287027.3	265486.98
Total farm revenue ($)	256948.4	330312.5	275326.89
Total farm expenses ($)	207712.3	263369	237983.11
Net farm revenue ($)	49236.1	66943.5	37343.78182

As predicted in the literature review, price per cwt did decrease in 2017 for the farms in the panel, dropping by $1 per cwt between 2016 and 2017. This is in line with the industry level trends described above. This reduction is likely the cause of simultaneous decreases in total milk sales per farm ($) between 2016 and 2017. However, total milk sales were actually lowest in 2015, reflecting low total quantity sold rather than price. As figure 10 shows, total milk sales and total cash expenses were both lowest in 2015. Net farm earnings reflects the biggest change during the 3 year period, with the farms in the panel dropping from positive net farm revenues of around $50,000 to $37,343 in 2017. This low NFR is not sufficient to cover operator labor and management costs, leading to financial losses in 2017.

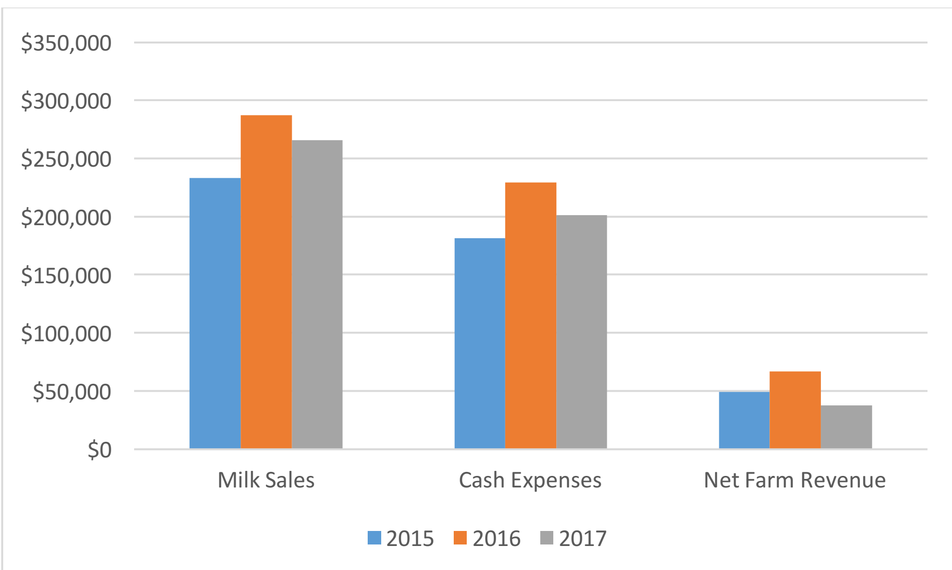

Figure 10. Milk Sales, Cash Expenses and Net Farm Revenue for selected Vermont organic dairy farms 2015-2017 (n=10)

Table 9 breaks received income into categories. Along with the price reductions mentioned earlier, a few other major changes occurred in 2017. First, income from animal sales was relatively lower in this year across all animal categories. Second, income from government payments shifted dramatically, increasing by a factor of 6.

Possible explanations for these results will be explored in the discussion. Finally, accrual revenue decreased sharply in 2017. The reduction in total farm revenue can largely be attributed to these accrual income changes.

Table 9. Organic dairy income by source for 2015-2017 ($/cwt nominal)

	2015	2016	2017
Income:			
Milk sales	38.28	38.84	37.90
Dairy cattle sales	0.75	0.48	0.13
Cull cow sales	1.05	1.56	0.69
Bob/veal calf sales	0.23	0.16	0.07
Crop sales	0.22	0.13	0.06
Government payments	0.24	0.24	1.53
Patronage dividends	0.21	0.19	0.25
Custom work	0.13	0.12	0.15
Syrup	0.42	0.69	0.46
Timber	0.04	0.00	0.00
Other	0.43	0.39	0.34
Total Cash Receipts	41.99	42.80	42.13
Accrual Revenue Adjustments:			
Livestock inventory	-0.13	-0.05	0.42
Breeding livestock purchases	-0.33	-0.10	0.00
Accounts receivable	-0.09	0.11	-1.61
Hay	0.67	0.56	-1.05
Grain	0.05	0.02	-0.92
Total Accrual Revenue	0.16	0.54	-2.25
Total Farm Revenue	42.16	43.34	39.87

Cost Structure

Cost of production data from the 10 farms in this study reveals that general production costs per cwt did not change much between 2015 and 2017, with total cwt cash expenses hovering around $29. Consistent with the above COP indicators, fuel prices decreased during the years covered by this analysis, although feed prices did not change much for the farms in this sample. Consistent with previous research (including Dalton et al 2008), the primary cost centers in this sample across all three years were purchased feed, labor, repairs, supplies, interest, custom hire, and utilities. On the accrual side, increases in depreciation expenses led to a general increase in accrual expenses during the years of the study.

Table 10. Operating costs and expenses for organic dairy farms 2015-2017 ($/cwt nominal)

Expenses	2015	2016	2017
Auto and truck expenses	0.25	0.22	0.17
Bedding	0.50	0.38	0.67
Breeding	0.35	0.43	0.42
Chemicals/pesticides	0.03	0.01	0.00
Custom hire:	1.01	1.83	1.92
DHIA	0.16	0.17	0.15
Fertilizers & lime	0.34	0.09	0.15
Feed - purchased grain & other	9.93	9.35	9.86
Feed - purchased forage	0.27	1.30	0.86
Fuel and Oil	1.02	0.72	0.61
Insurance	0.83	0.68	0.69
Interest	1.21	1.13	1.08
Labor	3.16	3.71	3.87
Milk Marketing	0.57	0.68	0.69
Real estate taxes (farm portion)	0.64	0.63	0.55
Rent	0.19	0.35	0.59
Repairs	2.89	2.30	2.49
Seed and plants	0.06	0.04	0.24

Supplies	2.15	2.11	1.68
Utilities	1.51	1.36	1.37
Vet	0.45	0.39	0.35
Medicine	0.00	0.00	0.02
Miscellaneous	0.61	0.52	0.69
Total Cash Expenses	28.14	28.39	29.12

Table 11. Accrued expenses for organic dairy production 2015-2017 ($/cwt nominal).

Accrual Expense Adjustments	2015	2016	2017
Depreciation	4.55	5.41	5.34
Accounts payable	-0.12	-0.18	0.00
Pre-paid expenses	0.00	-0.05	0.00
Supplies	-0.01	0.00	0.00
Total Accrual Expenses	4.43	5.17	5.34

Returns and Firm Performance

While some trends can be observed in revenue and cost data, many farmers, researchers, and policymakers are interested in profitability numbers. As noted above, milk prices decreased between 2016 and 2017. While cash receipts per cwt did not actually change, accrual revenue and accrual income from milk decreased while accrual expenses increased across the participants in the study between 2015 and 2017. This shift in accruals led to a general decrease in various profitability indicators. Net cash farm earnings, net farm revenue, and net farm earnings were all lowest in 2017.

This trend does not change when assets and liabilities are taken into consideration. While total farm assets and debt asset ratios did not change significantly across the three years, ROA and ROE are both negative for 2017. Profitability changes across years are shown in figure 21. Results indicate that profitability was substantially lower in 2017 than in the other years of the study.

Table 12. Returns to organic dairy farming 2015-2017 (average $/cwt nominal)

Income	2015	2016	2017
Milk sales	38.28	38.84	37.90
All other sales	3.71	3.96	4.23
Cash Receipts:	41.99	42.80	42.13
Total accrual revenue	0.16	0.54	-2.25
Total Farm Revenue	42.16	43.34	39.87
Expenses			
Total cash expenses	28.14	28.39	29.12
Total accrual expenses	4.43	5.17	5.34
Total Farm Expenses	32.57	33.56	34.47
Performance			
Accrual income from milk	5.62	5.39	2.37
Net cash farm income	13.85	14.41	13.00
Net farm revenue	9.59	9.78	5.41
Family living	7.46	7.17	5.50
Net farm earnings	2.13	2.60	-0.10
Off farm income	1.99	1.88	0.88
Net family earnings	4.13	4.49	0.79
Average assets ($/farm)	1031127.025	957897.825	969648.1386
Average equity ($/farm)	876022.875	768246.875	768537.3527
Debt/Asset ratio (%)	19.36%	21.56%	21.42%
Return on assets (%)	1.86%	3.55%	-0.31%
Return on equity (%)	1.31%	3.75%	-0.63%

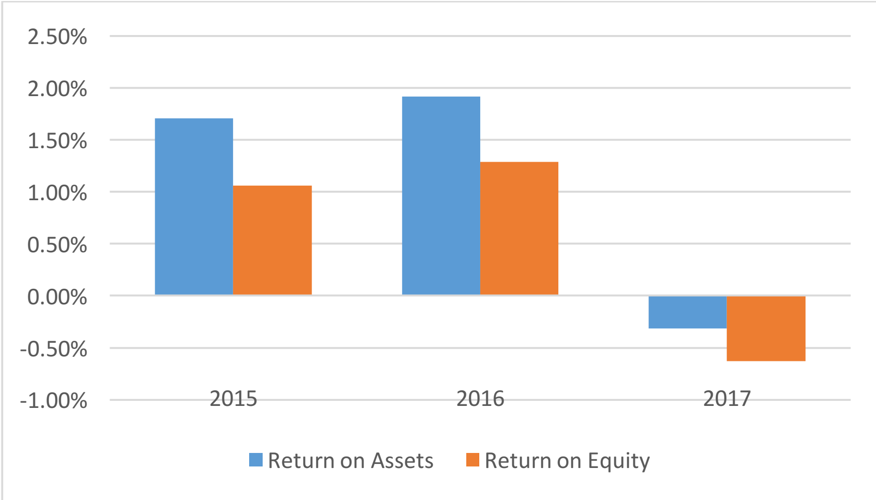

Figure 11. Farm profitability indicators for selected Vermont organic dairy farms 2015-2017 (n=10)

4.5 Discussion

The above data provides preliminary evidence that can be used to postulate organic dairy industry trends and their causes. As the results show, profitability outcomes were greatly reduced in 2017 for the farms in this study compared to 2015 and 2016. Analysis of the above data provides preliminary evidence that reductions in milk price, along with downward shifts in accrual income and expenses are of primary importance in explaining reduced profitability levels in 2017. While not conclusive, these results support the hypothesis that industry-level reductions in organic milk prices over the past three years have led to reduced farm profitability in Northern New England.

In looking at price trends in the data, it is interesting to note that prices received by the farmers in the study did not decrease as much as the Organic Valley price data shown in figure 4 on page 59. In the Organic Valley dataset prices dropped by almost $5 between 2016 and 2017, compared with a decrease of only about $1 in the Vermont sample. Farms in the study produced 400 lbs more milk per cow in 2016 than 2017, consistent with reports of an industry oversupply in 2016. Based on reports from Organic Valley, milk prices are likely to continue to be lower in the 2018 tax year (Organic Valley Annual Report 2018). Total milk sales ($) are 7.5% lower in 2017 than 2016. Only part of this change can be explained by reduced production (down by about 5%). Much of the rest is likely due to reduction in milk price of 2.4% between 2016 and 2017. More data would be need to infer causality, but the literature suggests that positive correlation is consistent with previous research.

In addition to differences in total milk production and prices, 2017 was marked by an increase in accrual costs and a sharp decrease in accrual revenue. Accrual costs increased by only 3%, while accrual revenues decreased by 516% between 2016 and 2017. Accrual revenues from grain, hay, and accounts receivable were all negative in 2017. Given that cash expenses did not change much between 2016 and 2017, the reduction in accrual income is likely one of the primary drivers of reduced profitability in 2017. Without more data these changes are difficult to interpret. However, it is likely that reduced milk prices have affected accounts receivable at the end of the year, with lower milk prices beginning with new production contracts in January 2018. Reductions in hay and grain accruals may be related to dry weather conditions in 2017 that reduced forage yields on some farms (Bedard 2017). As the above data suggests, the primary shifts between 2016 and 2017 can be identified as milk price reductions, increased accrual costs, and decreased accrual revenues. As a result of these shifts, net farm revenue decreased by 44.7%, leading to negative average ROA for the first time since 2006. Given that the farms in the reduced sample tend to have profitability outcomes somewhat below the full study average, more data is needed in order to draw strong conclusions. As more data is finalized from the 2017 tax year, it will become possible to draw stronger conclusions about Vermont industry trends for organic dairy.

In interpreting changes in the variables displayed above, market level data is also useful in informing interpretation of results. A comparison of results with national industry trends reveals that downward shifts in profitability for the farms in the panel have occurred concurrently with major organic milk price reductions. As described above, consumer demand and retail price for organic dairy products have remained fairly constant, although reductions in skim milk sales are likely to contribute to lower prices. Market level oversupply is likely the primary culprit for reduced prices, given the sudden supply increase in 2016 right before the price crisis began. Little has been written in the literature addressing the industry wide causes and effects of negative accruals, but their importance in this limited dataset suggests that future research may benefit from a focus on this factor in explaining profitability shifts in 2017.

In 2018, farmers are looking for information on the causes and effects of the continuing reduction in organic milk prices that started in 2017. Preliminary results suggest that the price reduction and associated shifts in accrual income and costs are likely responsible for decreased profitability numbers. As more data becomes available, it will be possible to test these conclusions in a more rigorous manner. In the interim, the information and analysis presented above will be useful for farmers looking to make immediate decisions as well as policymakers and researchers seeking to identify state level trends in organic dairy profitability.

4.6 Conclusions

While the data presented in this article is limited by the extremely small sample size, the absence of any other current available data makes it worth reporting. Ongoing data collection and analysis will soon increase the study sample size and allow for more compelling conclusions. Due to its presentation of updated financial data, this study on Vermont organic dairy farms provides valuable insight into the effects of the market changes that happened between 2015 and 2018, particularly changes in the milk price. The national organic dairy statistics cited in this article suggest that market oversupply is the primary cause of the milk price reductions that started in 2017. Vermont data presented in this thesis shows that, for the sample group, farm profitability decreased in 2017. Milk sales, accrual revenue, and other income streams all decreased sharply from 2015 and 2016 levels. While causality cannot be inferred from the data presented, the results of this study have a number of key implications for farmers, researchers, and policymakers in Vermont.

Implications

The data presented in this article provides useful information on market level trends in organic dairy as well as preliminary evidence about how the current organic dairy price crisis is actually affecting profitability on Vermont farms. Farmers, researchers, and policymakers all stand to benefit from engagement with this data. Struggling dairy farmers will be able to compare their financial information with a state level benchmark to identify any specific management areas where there is room for improvement. While there is little producers can do to increase their base-level price, increases in quality may make up some of the difference in pay price. Policymakers will benefit from evidence that organic dairy producers are struggling in current market conditions, and may choose to support increased economic aid for farmers in this sector, particularly supply management or other milk price supports. Finally, researchers will be able use the data presented here in order to inform future research on organic dairy economics and determinants of farm profitability. For example, preliminary evidence suggests that reductions in milk price have a strong negative effect on farm profitability. However, some farm do remain profitable during periods of low prices. Given this, future research would benefit from examining the factors leading some farms to be more resilient to price shifts.

As of 2018, the organic dairy profitability study is still being conducted by UVM and NOFA VT. While results will not be available until fall of 2019, 2018 data will likely reflect similar trends unless prices unexpectedly increase. An upcoming full 2017 report will attempt to identify the characteristics of farms that have been most successful in weathering recent pay price reductions, perhaps using sensitivity analysis as described above. Farm size, debt load, management practices, and enterprise structure will all be considered.

As the organic dairy price crisis continues to develop, there remains a need for further research and policy aimed at helping organic dairy farmers stay in business. Given the severity of the situation, imperfect research is better than nothing. This study represents one of the first attempts to analyze the economic facts of the current organic dairy crisis. Despite limitations in sample size, the facts presented here will be useful to anyone who works with organic dairy farmers in Vermont or New England.

5 Conclusions

In 2018, Vermont organic dairy farmers face a difficult economic situation. Organic milk prices remain low, dairy markets are still in a state of oversupply, and profitability numbers are down. In this context, continuing research into the factors influencing organic dairy profitability is extremely important. Unfortunately, most of the published research on dairy profitability either ignores organic dairy altogether or focuses on comparisons with conventional production systems. This thesis addresses this gap by analyzing 11 years of financial panel data collected from Vermont organic dairy farmers to answer questions about the role of farm and industry level factors in determining farm profitability. Using a time demeaned fixed effects regression model to analyze 10 years of farm panel data, article 1 provides statistically significant evidence that feeding management, milk price, farm size and other variables are associated with profitability as measured by ROA. Article 2 provides preliminary evidence that industry-wide reductions in the organic milk price since 2016 have had a negative effect on the farms in the panel. Taken together, these articles present information that will be useful to farmers, researchers, and policymakers.

Limitations

While the results and conclusions of this thesis are useful in furthering the goal of understanding the economics of organic dairy farming in Vermont, the methods and approach of the study do have some major limitations. First, data accuracy is limited by imperfect record keeping and farmer estimation of some key asset and cost categories. The relatively small sample size of farmers for each year is another concern. Given the involved nature of data collection, it is likely that certain types of organic dairy operations were more likely to participate than others, introducing bias. While the data collection team made an effort to randomly sample farms, this was in many cases not possible. Another drawback of this dataset is that it cannot be considered representative of any large population of dairy farmers. At most, this dataset can only be interpreted as representative of the experiences of small organic dairy farmers in Vermont. In addition, the financial focus of the dataset available limits the variables that can be used for analysis. A stronger study would include non-financial farm management variables like acreage in production, cow breed, and specific feeding management practices along with demographic variables. Other limitations include the unbalanced nature of the panel dataset, the reliance of article 2 on descriptive statistics, and an incomplete dataset for the year 2017. Despite these limitations, the results and conclusions of this thesis are still useful. Many of the concerns outlined above can be leveled at a large number of agricultural economics studies, reflecting difficulties in collecting accurate farm-level data over time.

Implications

As mentioned in the conclusions of each article, the results of this study have a number of key implications for a variety for stakeholder groups. For the research community, the findings of this thesis are useful in several ways. First, as mentioned above, this research suggests that financial data alone is not enough to create a model of organic dairy profitability with a high level of explanatory power. Future research should attempt to include non-financial variables like acreage in production, cow breed, specific feeding management practices and demographic indicators along with financial variables. The inclusion of these variables would also align with the dairy economics literature. In addition, future research into organic dairy profitability might also benefit from the use of sensitivity analysis to identify the characteristics of those farms that are resilient to price shifts.

The results of this study also have important implications for farm managers. The analysis of 10 years of farm financial panel data presented in this thesis indicates that changes in farm management can have a positive effect on profitability. Article 1 provides evidence that reducing feed costs, improving feed efficiency, improving milk quality, and reducing debt are all management strategies that can work for Vermont farmers looking to improve their profitability. In addition, the importance of milk price shown in both articles suggests that joining the higher priced grass-fed market may represent an opportunity for those farmers who excel in pasture management.

Finally, the information and analysis presented in this thesis has major implications for state and federal level policymakers. Article 1 shows that milk price is one of the primary factors affecting farm profitability. In article 2, the damaging effects of recent downward shifts in the organic milk price are clearly demonstrated. For policymakers interested in preserving Vermont's dairy economy, these facts present an argument for developing policy solutions aimed at supporting organic dairy prices. Supply management or price support structures may represent one approach to this goal. In addition, evidence showing the importance of feeding management should motivate policymakers to support increased funding for extension education in this area.

While more work needs to be done in collecting and analyzing financial data from organic dairy farms in New England, the results presented in this thesis represent a valuable contribution to this body of inquiry. As organic milk prices continue to fall and farms struggle to stay in business, the need for evidence-based farm management advice will remain increasingly important. In order to help keep organic dairy farming financially viable in New England, researchers and policymakers should heed the conclusions of this thesis as they design innovative research studies and policy initiatives aimed at addressing the contemporary crisis in organic dairy.

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