ORGANIC MILK DEMAND AND SUPPLY IN THE U.S. AND IMPLICATIONS FOR ORGANIC MILK INDUSTRY

A Dissertation

presented to

the Faculty of the Graduate School

at the University of Missouri-Columbia

In Partial Fulfillment

of the Requirements for the Degree

Doctor of Philosophy

by

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MAY 2016

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CONSUMER DEMAND FOR ORGANIC MILK IN THE U.S. AND IMPLICATIONS FOR ORGANIC RAW MILK SUPPLIERS

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DEDICATION

To my daughter Allison, my husband Zhenyu Shen, and my parents Jinpei Su and Shuhua Wu.

ACKNOWLEDGEMENTS

I would like to express my great appreciation to my adviser Dr. Michael Cook for his guidance, time, patience, and encouragement, which have made my achievements, including this dissertation, possible. He has sparked my interest in applied research in organizational economics and cooperative management. He has not only been my academic adviser, but also a great mentor for my everyday life.

I would like to thank my other committee members, Dr. Wyatt Thompson, Dr. Scott Brown, Dr. Isaac Miller, and Dr. David O'Brien, for their guidance, time, and insightful comments regarding this dissertation and throughout my research. In addition, I would like to thank Dr. Abner Womack for his encouragement and recognition of my study and research.

I would also like to thank Kristi Livingston and Amanda Michelle Swaim for their assistance with English, logistics, and budgeting over the last a few years and during the completion of my dissertation.

Finally, I would like to thank my fellow students Jing Zhao, Jingjing Wang, Susan Webb, Andrew Vanengelenhoven, Jasper Grashuis, and Elisavet Levogianni for their help, comments and friendship along with my academic journey.

TABLE OF CONTENTS

TABLE OF CONTENTS.. iii

LIST OF TABLES……………………………………………………………..ix

LIST OF FIGURES……………………………………………………………xi

Abstract...1

Chapter One: Background, Motivation and Research Objectives…………………………………………………………....5

1 Dairy Farm Problems..5

1.1 Low Return 6

1.2 Fluctuating Price for Conventional Milk 10

2 Dairy Farmer Decision Making 16

2.1 How to Produce (Organically or Conventionally) 17

2.2 How Much to Produce (Expand, Reduce, or Status Quo) 18

3 Background..19

3.1 Demand for Organic Food and Organic Milk...19

3.2 Profitability of Organic and Conventional Dairy Farms...........................22

4 Motivation..26

5 Research Objectives..27

Chapter Two: Consumer Demand Theory and Empirical Demand Models…………………………………………………………..…29

1 Consumer Preference and Representation 29

2 Utility Function and its Derivatives....30
2.1 Indirect Utility Function....31
2.2 Expenditure Function....32
3 Demand Functions....33
3.1 Marshallian Demand Function....33
3.2 Hicksian Demand Function....34
3.3 Slutsky Equation....35
4 Relationship of the Functions....36
5 From Consumer Theory to Empirical Consumer Demand Model....38
5.1 Generalized Axiom of Revealed Preference....38
5.2 Aggregate Consumers and Aggregate Products....38
6 Empirical Demand Models for Consumer Analysis....40
6.1 Linear Expenditure Model....41
6.2 Rotterdam Model....43
6.3 Translog Demand System....45
6.4 Almost Ideal Demand System....46
6.5 Linear Approximation of Almost Ideal Demand System (LAIDS)....49
6.6 Quadratic Almost Ideal Demand System (QAIDS)....50
6.7 Challenges for Empirical Estimation....51
6.7.1 Large Number of Parameters....51
6.7.2 Aggregation of Consumers....51
6.7.3 Endogeneity....51
7 Summary....52

Chapter Three: Literature Review for Organic Milk Demand in the U.S……………………………………………………………..………...53

1 Introduction..53

2 Econometric Models 53

3 Data Sources 53

4 Demographic Variables 54

4.1 Income..54

4.2 Education 54

4.3 Children and Household Size..55

4.4 Age of Household Head..55

4.5 Race and Ethnicity 55

4.6 Regions 56

5 Elasticity 56

5.1 Own Price Elasticity 56

5.2 Cross -price Elasticity...56

5.3 Expenditure Elasticity...57

6 Summary...58

Chapter Four: A Vector Error Correction Almost Ideal Demand Model for Organic Milk in the USA……..……………………………………………….………….60

1 Introduction..60

2 Vector Error Correction Model (VECM) Almost Ideal Demand System (AIDS) 62

3 Hypotheses and Expected Signs of Coefficients 66

4 Data 68

5 Endogeneity of Prices and Expenditure 73

5.1 Endogenous Prices 73

5.2 Endogeneity of Group Expenditure 75

6 Unit Root and Cointegration Test 75

6.1 Unit Root Test Results 75

6.2 Cointegration Test Results 77

7 Empirical Results for Demand Models and Discussion 78

7.1 Static Estimation 78

7.2 Dynamic Estimation with Vector Error Correction Model 81

7.3 Dynamic Model with Instrument Variables 84

8 Elasticity 88

8.1 Price Elasticity from Static Model 88

8.2 Price Elasticity from Dynamic Models 89

8.3 Expenditure Elasticity 97

9 Impact of Price Change on Consumption 99

10 Habit Formation 100

11 Summary, Limitation, and Future Research 101

11.1 Summary 101

11.2 Limitations and Future Research 104

Chapter Five: Organic Milk Supply and Processors 106

1 Organic Milk Processors 106

2 Organic Milk Supply..108

3 Organic Milk Farm Price 110

Chapter Six: Organic Milk Supply and Demand Coordination: The Case of Organic Valley Cooperative…………………………………………………………..............113

1 Introduction...113

2 Theoretic Framework: Supply and Demand Integrated Management..........................114

3 The Objective of Organic Valley...115

4 Commodity Pools, Membership Policy and Dairy Pool..117

5 Organic Valley Ownership Structure..120

6 Organic Valley Consumer Demand Management 120

6.1 Product Development...121

6.2 Consumer Education..121

6.3 Farmers-in- the-Market Activities (Advertisement) 122

7 Organic Valley Supply Management...122

7.1 Contract Production 122

7.2 Add Members When Demand Increases..123

8 Crises, Solutions, and Outcomes of Organic Valley and Organic Dairy Industry 123

8.1 Rivals' Practices and Outcomes...124

8.2 Organic Valley's Solutions 125

9 Competitive Yardstick Effect of Organic Valley Cooperative on Organic Milk Farm Price 128

9.1 Organic Milk Market Structure 128

9.2 Competitive Yardstick Effect of Organic Valley Cooperative....................................130

10 The Theory Behind the Success of Organic Valley's Supply Control 136

10.1 Informal Institutions and Social Norms Play Important Roles in the Behavior of Farmers...136

10.2 Farmer Coordination Boosts Farm Gate Price in a Cooperative 137

10.3 Market Power Allows a Supply Control...139

10.4 Game Theory Explains the Cooperation of Members in a Cooperative.........................140

Chapter Seven: Summary, Discussion and Implication……… …………………………...142

1 Summary and Conclusion 142

2 Implications for Organic Milk Industry Stakeholders 144

2.1 Implications for Producers 144

2.2 Implications for Manufacturers..146

2.3 Implications for Retailers of Organic milk 147

2.4 Implications for the Organic Milk Industry 149

2.5 Implications for Organic Valley Cooperative 151

3 Policy Implications 152

4 Limitations and Future Research 154

References..155

VITA ……………………………………………………………………………..163

LIST OF TABLES

Table 1. Organic and Conventional Dairy Farm Profitability Analysis for Minnesota 2006-2013 24

Table 2. Conventional and Organic Milk Costs and Returns by Size Group in the U.S., 2010 25

Table 3. Summary of Previous Studies on Organic Milk Demand in the U.S. 59

Table 4. Expected Signs of Coefficients and Elasticities of Fluid Demand Models 67

Table 5. Descriptive Monthly Statistics of Conventional and Organic Fluid Milk Consumption in the U.S. 69

Table 6. Augmented Dickey Fuller Unit Root Test Results for Time Series 76

Table 7. Augmented Dickey Fuller Unit Root Test Results for First Difference of Time Series 77

Table 8. Johansen Tests for Cointegration of the Time Series 78

Table 9. Estimated Parameters of Static LAIDS for Fluid Milk Demand in the U.S. 79

Table 10. Homogeneity and Symmetry Test of Static LAIDS Model 80

Table 11 Estimated Parameters of Constrained Static LAIDS for Milk in the U.S. 81

Table 12. Estimated Parameters of Unrestricted VECM LAIDS for Fluid Milk in the U.S. 82

Table 13. Homogeneity and Symmetry Test of VECM-LAIDS for Fluid Milk in the U.S. 83

Table 14 Estimated Parameters of Restricted VECM LAIDS for Fluid Milk Demand in the U.S. 87

Table 15 Marshallian Uncompensated Elasticity of Fluid Milk for Three Models.......... 95

Table 16 Hickman Compensated Elasticity for Fluid Milk for Three Models................. 96

Table 17 Estimated Expenditure Elasticities for Three Models 97

Table 18. Certified Organic Dairy Cows Supplying Organic Valley and Horizon Organic 2007-2013 109

Table 19. Organic Milk Pay Price of Organic Valley and Horizon 2007-2013 112

Table 20. Average Annual Profit Margin of Organic and Conventional Fluid Milk in the U.S. 130

Table 21. Farm Price to Retail Price Ratio of Organic and Conventional Fluid Milk (%) in the U.S... 130

LIST OF FIGURES

Figure 1. Average Net Return for Conventional Dairy Farms by Size 2005-2014 in the U.S. 7

Figure 2. Average Return over Operating Costs of Conventional Dairy Farms by Size 2005-2014 in the U.S. 8

Figure 3. Percentage of Profitable Dairy Farms in Different Sizes in the U.S. in 2005..... 9

Figure 4. Annual Conventional All-Milk Price in the U.S., 1990-2015........................... 12

Figure 5. Annual Organic and Conventional Milk Farm Prices 1989-2013..................... 14

Figure 6. Monthly Organic and Conventional Milk Farm Prices 2008-2013................... 15

Figure 7. Coefficients of Variation (CV) for 5-year Moving Average for Conventional and Organic Milk Farm Prices 1989-2013 16

Figure 8. Organic Fluid Milk Sales in the U.S. 2006-2014 in billion lbs......................... 21

Figure 9. Organic Fluid Milk Annual Sales Growth Rate in the U.S., 2007-2014........... 22

Figure 10. Relationship of Functions in Demand Theory... 37

Figure 11. Level and First Difference of Log Retail Prices of Organic and Conventional Fluid Milk 71

Figure 12. Level and First Difference of Budget Shares of Conventional and Organic Fluid Milk Monthly Data 2006-2013 72

Figure 13. Level and First Difference of Log Real Expenditure on Conventional and Organic Fluid Milk Monthly Data 2006-2013.. 73

Figure 14. Uncompensated Price Elasticity of Organic and Conventional Fluid Milk 2006-2013.. 93

Figure 15. Compensated Price Elasticity of Conventional and Organic Fluid Milk 2006-2013.. 94

Figure 16. Change in Expenditure Elasticity of Conventional and Organic Fluid Milk 2006-2013.. 99

Figure 17. Real Annual Average Price Changes from the Previous year for Conventional and Organic Milk in the U.S. 2006-2013... 100

Figure 18. Organic Valley Members 1988-2013 118

Figure 19. Dairy Herd Size of Organic Valley in 2013 119

Figure 20. Organic Valley Nominal Sales 1988-2013... 127

ORGANIC MILK DEMAND AND SUPPLY IN THE U.S. AND IMPLICATIONS FOR ORGANIC MILK INDUSTRY

Abstract

Organic food in the U.S. has attracted great interest from consumers since the late 1990s for health and environmental reasons. Organic dairy is the second largest organic food group after fruit and vegetables. Sales of organic dairy in the U.S. were more than 5 billion dollars in 2014, 15% of the industry. Recently, the average annual growth rate for organic milk sales has exceeded 10%. With the popularity of organic food, organic food has expanded beyond natural food stores to mainstream grocery stores. Since late 2013, organic milk has been in short supply and many stores have not been able to provide enough for their customers. One reason for this shortage has been the unwillingness of conventional dairy farmers to convert to organic operation due to lack of information about future demand. This shows that consumer demand information is crucial for dairy farmers' operational decision making.

Two large organic milk processors coexist in the U.S. One of them is a cooperative and the other is an investor-owned firm. The pricing strategy for organic raw milk is very different than for conventional milk. Since 1989, the price of organic milk has steadily increased with a clear trend. However, the price of conventional milk has fluctuated from year to year, and even from month to month. Compared with conventional milk, the organic milk farm price is more stable and predictable from month to month. I hypothesize that the

duopsony market structure and the cooperative play important roles in the pricing of organic raw milk and protect organic dairy farmers' profitability.

The general objective of this study is to examine the organic dairy industry supply-demand coordination challenge with a specific emphasis on the consumer demand side. Specifically, my first objective is to examine consumer demand for organic and conventional milk in the U.S. and how consumer response to price and income changes. This study provides information about market conditions and how consumer demand for organic milk products affect farm milk price.

The second objective is to describe participants in the organic milk industry from production to processing, to compare price and profitability for organic and conventional dairy farms, and to provide decision-making information for potential organic dairy farmers.

The third objective is to examine a supply chain coordinator in the organic dairy industry, Organic Valley, and its internal decision-making challenges in balancing supply and demand, and stabilizing the price of raw milk in the organic milk value chain.

The first chapter of this dissertation lays out the background, motivation and research objectives of this study. The second chapter provides a detailed theoretical framework of consumer behavior and empirical models for consumer demand studies. The third chapter surveys the literature of organic milk demand. Chapter four develops a vector error correction almost ideal model for organic and conventional fluid milk with monthly aggregate data from the U.S. This chapter considers the time series properties of the data and the endogeneity of price and expenditure. Using the parameters estimated in the model, price and expenditure elasticities are calculated, and implications for the industry are drawn. Chapter five analyzes the structure of the organic dairy industry, and the organic milk farm price. Chapter six examines the role of Organic Valley cooperative in the pricing of organic raw milk and in supply chain coordination, and the challenges organic dairy farmers and their cooperative are facing. Chapter six gives a brief summary of the dissertation and discusses policy and industry implications.

The empirical study of organic milk demand shows that the time series data for organic and conventional fluid milk retail prices, expenditure, and budget shares are nonstationary and cointegrated. For this reason, the vector error correction model is the best fit for the study. In addition, the group's expenditure is found to be endogenous and income is used as an instrument for group expenditure. The estimates from the model suggest that demand for organic, conventional whole, and conventional reduced fat fluid milk is price inelastic. Demand for organic fluid milk is expenditure elastic, and demand for conventional fluid milk is close to unit-expenditure elastic. In the short run, consumers adjust their consumption of fluid milk to a long-term equilibrium.

This study provides a new method for estimating consumer demand for organic and conventional fluid milk by incorporating the time series properties. The results show that increasing the prices of conventional and organic fluid milk can cause the revenue of retailers to increase due to inelastic price responses. Inelastic price demand at the consumer level can also be transmitted to the farm level. As a result, farmers can also benefit from increased prices if price transmission is occurring. Elastic expenditure demand means when income increases, possible expenditure on organic milk will also increase. Therefore, farmers can enhance their management decision making by understanding macroeconomic conditions. Under conditions of increased consumer demand and short supply, in a normal or good economic environment, farmers can achieve higher income and returns by expanding their production.

This study finds that organic raw milk is priced differently from conventional raw milk due to the unique mission of the Organic Valley cooperative, which seeks to provide stable and sustainable farm prices to protect its family farmer members. The cooperative has set up a pricing standard and serves as a price leader in the organic dairy industry.

The profitability per cow comparison between organic and conventional dairy farmers indicates that organic dairy farms have performed much better financially than conventional farms over the last seven years. Considering the relatively small size of organic dairy farms, the relatively higher profitability of organic dairy operations is especially important for small dairy farmers who want to maintain their size and earn a living through farming. Converting to organic operation has the potential for better profitability.

Organic operation has the potential to bring economic benefit to dairy farms, especially small ones. At the same time, organic operation can reduce the use of chemicals and synthetic fertilizers, benefit the environment and promote sustainable agricultural production. For these reasons, policy makers may consider providing more economic support for organic dairy farmers and potential organic dairy farmers.

Chapter One: Background, Motivation and Research Objectives

The dairy industry is one of the most important agricultural sectors in the U.S. It creates direct and indirect economic effects, plays a crucial role in rural communities (Economic Research Service 2016). In the last a few decades, the milk and feed prices have become very volatile (MacDonald, Cessna, and Mosheim 2016). The industry structure has changed. The number of dairy farmers has decreased, and the average herd size increased. Though most farms are still small, they play less important role in the entire industry in terms of production and sales. Small farmers are under pressure to get bigger or get out. Dairy farmers face problems, challenges, opportunities and choices.

1 Dairy Farm Problems

Production agriculture faces many problems, such as industry consolidation, regional monopsonies, prices frequently below cost, and price and income volatility. The dairy industry and dairy farms are no exception. More recently, price instability and inadequacy, low income, a concentrated market, and increased financial risk have been prominent in the dairy sector (Nicholson and Stephenson 2015, Wolf 2011, Chidmi, Lopez, and Cotterill 2005). These problems create challenges and difficulties for farmers' decision making and farm management.

1.1 Low Return

On average, conventional dairy[1] farmers in the U.S. experienced economic losses from 2005-2014 except for farms with more than 500 cows, as shown in Figure 1. Profitability of individual farms varies and depends on multiple factors including farm management skills. Milk production offers significant economies of scale (Figure 1 and Figure 2). In 2005, only 20% of farms with 50 or fewer dairy cows were profitable, but 88% of farms with more than 1,000 cows were profitable, as shown in Figure 3. MacDonald et al. (2007) found that, on average, farms with 500 or more cows showed profit, while farms with fewer than 500 cows showed economic loss. They also noted that large farms, on average, have a lower cost of production. The cost per hundredweight for milk from a 500-cow farm is half that of a 50-cow farm. The major cost advantages of a large farm derive from the lower cost of labor, as well as the more efficient use of machinery and equipment. There is not much difference in per-unit feed cost. The relatively lower cost per unit and higher return for large farms are major forces driving change in the structure of the dairy farm industry. Consequently, the number of small farms (fewer than 200 cows) is decreasing, and the number of large farms (more than 500 cows) is increasing, especially farms with more than 1,000 cows (MacDonald et al. 2007).

[1] Conventional is a term relative to organic. In organic operation, synthetic chemicals allowed in conventional dairy are not permitted. They include hormones, pesticides and antibiotics. Also, no genetically modified products can be used in organic dairy production. Farmers and ranchers need to follow specific standards set by the USDA and farms need to be certified by accredited agents Organic dairy cows need to be fed organic feed and must have access to pasture for at least 120 days each year. Organic dairy farms also need to maintain records. In contrast, conventional dairy farms do not need to follow these standards or keep records. Likewise, there is no requirement for the cows to have access to pasture.

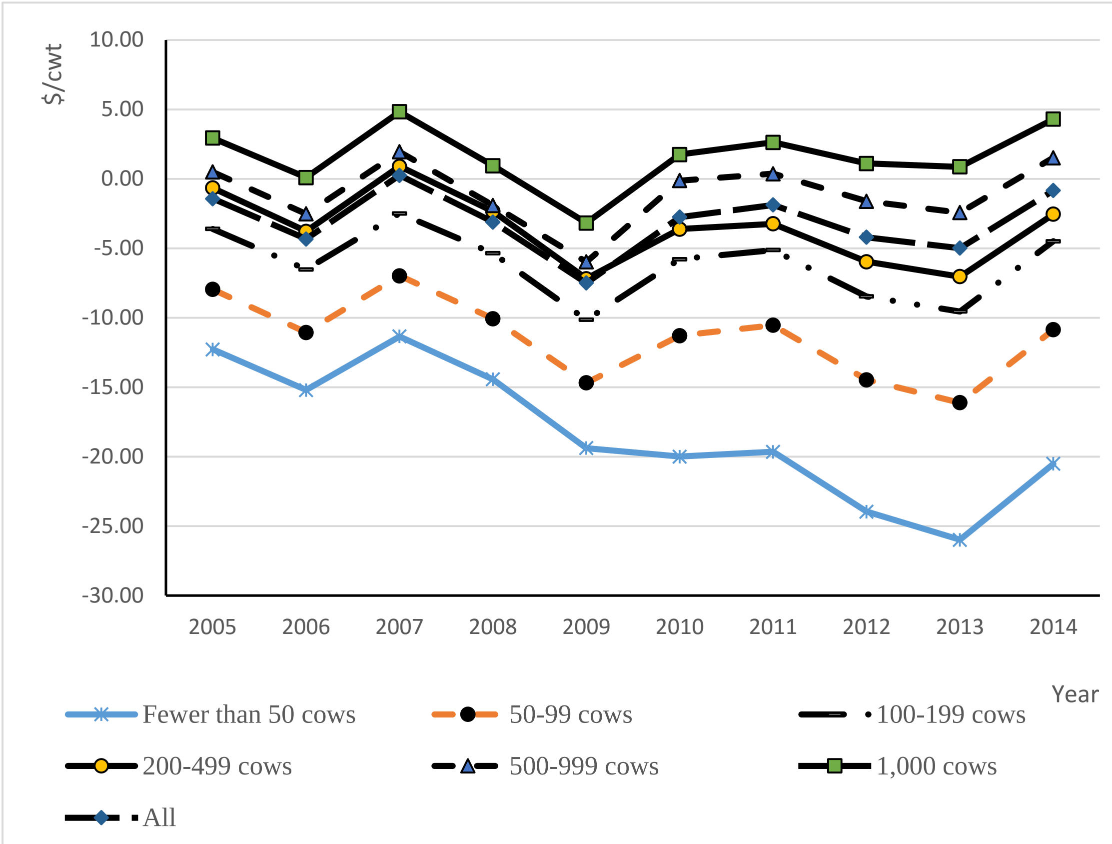

Figure 1. Average Net Return for Conventional Dairy Farms by Size 2005-2014 in the U.S.

Data Source: downloaded from ERS milk cost and return dataset http://www.ers.usda.gov/data-products/milk-cost-of-production-estimates.aspx

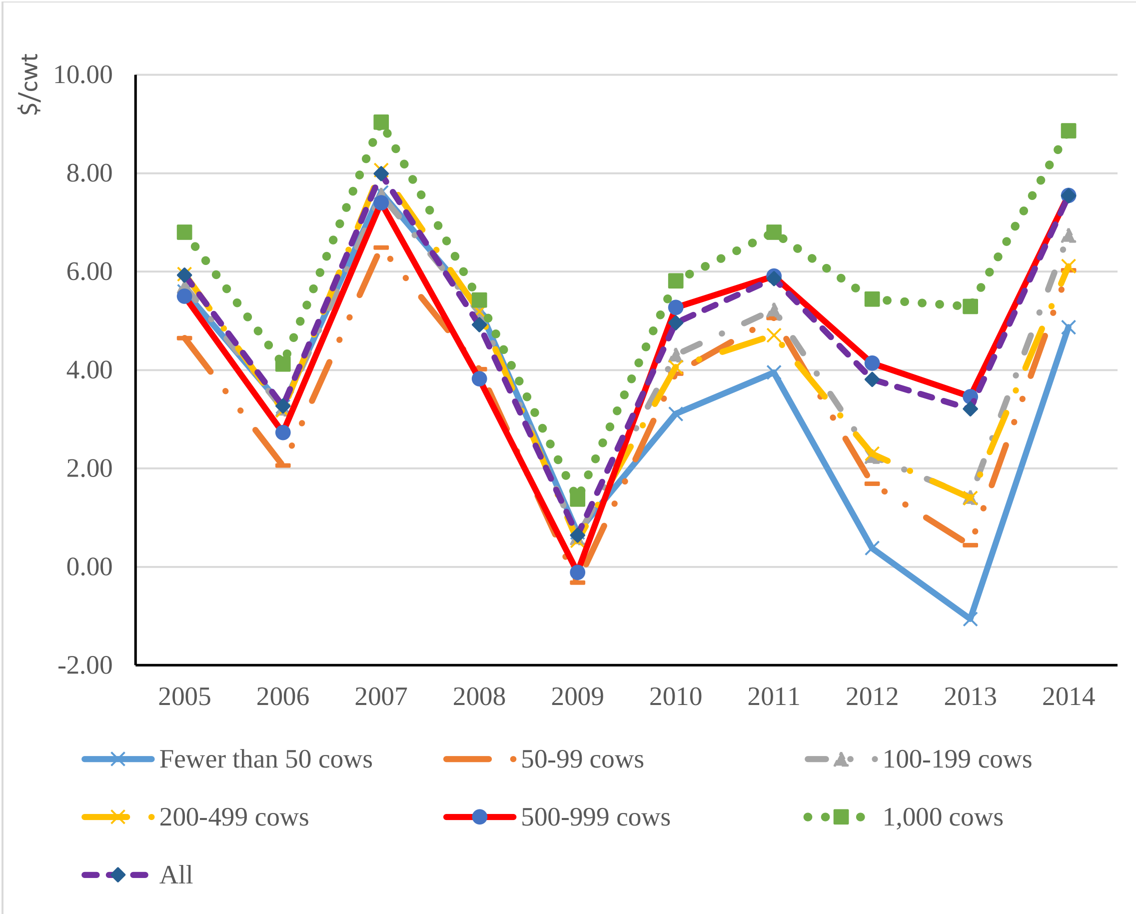

Figure 2. Average Return over Operating Costs of Conventional Dairy Farms by Size 2005-2014 in the U.S.

Return is calculated by total return minus operating costs in dollars per cwt milk. The overhead cost is not counted.

Data Source: downloaded from ERS milk cost and return dataset http://www.ers.usda.gov/data-products/milk-cost-of-production-estimates.aspx

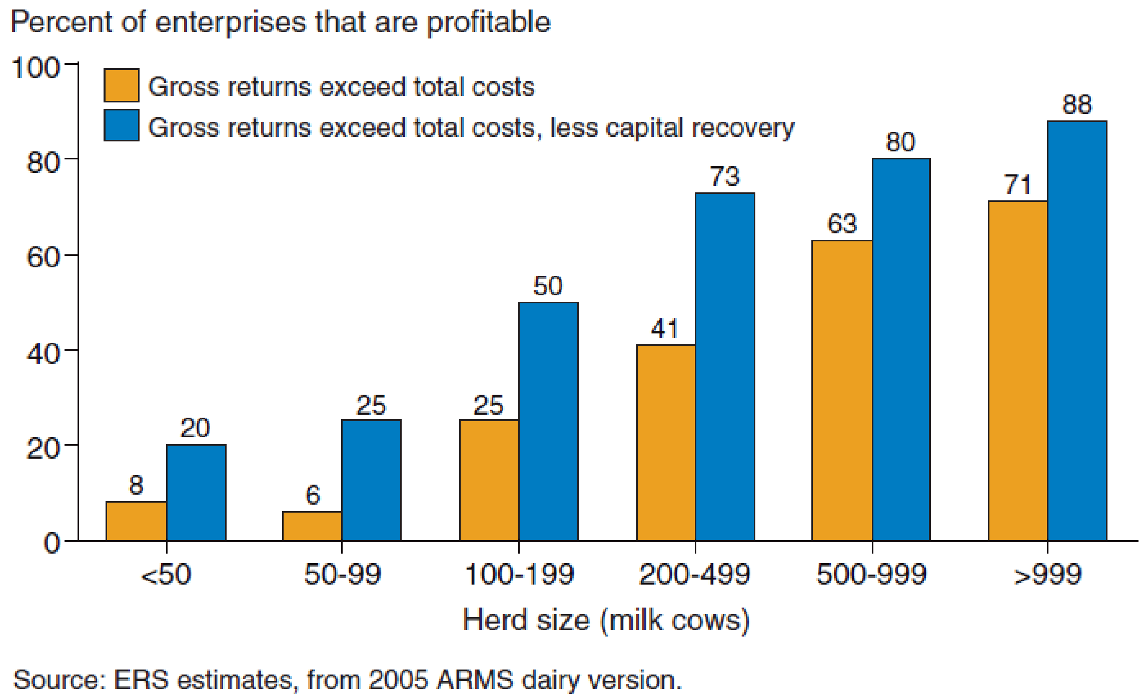

Figure 3. Percentage of Profitable Dairy Farms in Different Sizes in the U.S. in 2005

The figure is adopted from (MacDonald et al. 2007)

Net return is the major determining factor for farm investment (MacDonald et al. 2007). While farmers not already in the dairy industry may consider low return in determining whether they want to enter the dairy industry, established dairy farmers determine whether they should maintain, expand, contract, or cease their operation based on their current and potential farm profitability. In the last 10 years, the average cost of milk production has increased annually, almost doubling by 2014. The conventional milk price increased in some years, while decreasing in other years, resulting in fluctuating net return over the same period. Dairy net return largely depends on milk price. Milk price is associated with variability in milk supply and consumer demand. As consumer demand for milk changes, milk prices change, and so does farm net return.

According to survey data from the Agricultural Risk Management Service (ARMS), due to low net return for small dairy farms, more than half of farms with 100 cows or fewer were expected to exit the sector over the following 10 years (MacDonald et al. 2007). This suggests that farms with fewer than 100 cows are facing serious challenges. For this reason, under current market conditions and policies, small conventional dairy farms need to seriously consider their future. One possible option for conventional dairy farmers is to convert to organic operation if they want to stay in dairy farming. This is because small organic dairy farms have better economic returns than their conventional counterparts.

1.2 Fluctuating Price for Conventional Milk

Irregular, directionless price movement is defined as volatility (Gilbert and Morgan 2011). Price volatility increases uncertainty, and is the case for conventional milk prices around the world (van Winsen et al. 2011, Nicholson and Stephenson 2015). On the contrary, price stability means that prices don't change significantly from one period to the next. Many nations invest heavily to implement government policies dedicated to reducing the volatility of commodity prices and stabilizing farm income (Gilbert and Morgan 2010, Nicholson and Fiddaman 2003). In the U.S., these programs have historically included the Dairy Price Support Program and the Milk Income Loss Contract Program, as well as the current Dairy Margin Protection Program.

Figure 4 shows monthly data for the conventional all-milk price from January 1990 to October 2015. Prices were relatively stable from 1990 to the first half of 1996. Afterwards, prices experienced big swings. There were peaks and drops, and clear cyclic patterns in addition to seasonal movement. The price change cycle is about 3.3 years

(Nicholson and Stephenson 2015). Beginning in 2000, the nominal price rose to $19.3/cwt in May 2004, decreased to $11.30 in June 2009, rose to $25.7 in September 2014, and has been decreasing since late 2014. On December 29, 2015, the Jan 2016 Class III milk futures price was only $13.56/cwt. High prices occurred in 2004, 2007, 2011, and 2014, and low prices in 2002, 2003, 2006, 2009, and 2015-2016, representing very erratic changes in a short period of time.

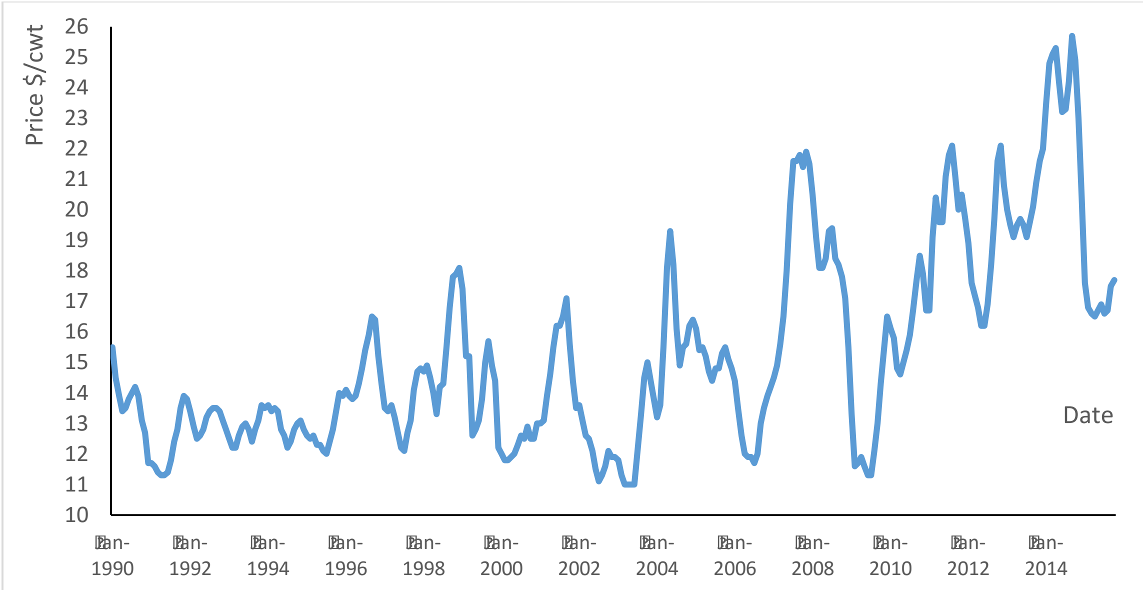

Figure 4. Annual Conventional All-Milk Price in the U.S., 1990-2015

Data were downloaded from the University of Wisconsin Dairy Marketing and Risk Management Program.

http://future.aae.wisc.edu/data/monthly_values/by_area/10?tab=prices

Variation in the conventional milk price affects all participants in the supply chain from farmers, processors, and retailers to end consumers. Price volatility increases the difficulty of farm management, risk management, and business expense planning (Wolf 2011). Cyclical changes in price are due to producers' delayed response to the profitability of the industry. When profitability is high, producers expand their production, and contract their herds when profitability is low. These responses contribute to the price variation of conventional milk. To reduce price fluctuation due to the price cycle, supply chain coordination is recommended. Forecasting future demand is important for producers' decision making about farm management and operations (Nicholson and Stephenson 2015).

Dairy production is a capital-intensive industry. Farmers prefer stable cash flow to pay back their loans. In general, farmers prefer a stable pay price, which makes farm management decision making relatively easier. With a stable pay price, farmers primarily need to focus on cost management to maintain an adequate margin, which is the most important factor for the survivability of a farm business and what farmers are good at.

Contrary to the volatility of the conventional milk price, the organic milk farm price is relatively stable (Figure 5 and Figure 6). The organic milk farm price is fixed and there is no price uncertainty over the course of a year. One measurement of volatility is the coefficient of variation (CV) (Gilbert and Morgan 2011, Tothova 2011). As shown in Figure 7, the annual CV of organic milk is 2-6%, and the CV of the conventional all milk price is 3-16%. From 2004-2012, the average CV for the organic milk price was 11%, and 18% for the conventional milk price. Variation in the conventional milk farm price is higher than for organic milk. These changes can be seen in Figure 5, Figure 6 and Figure 7; the average annual conventional milk farm price both rises and falls during the study period, whereas the organic milk price increases or stays flat almost every year except 2009 and 2010.

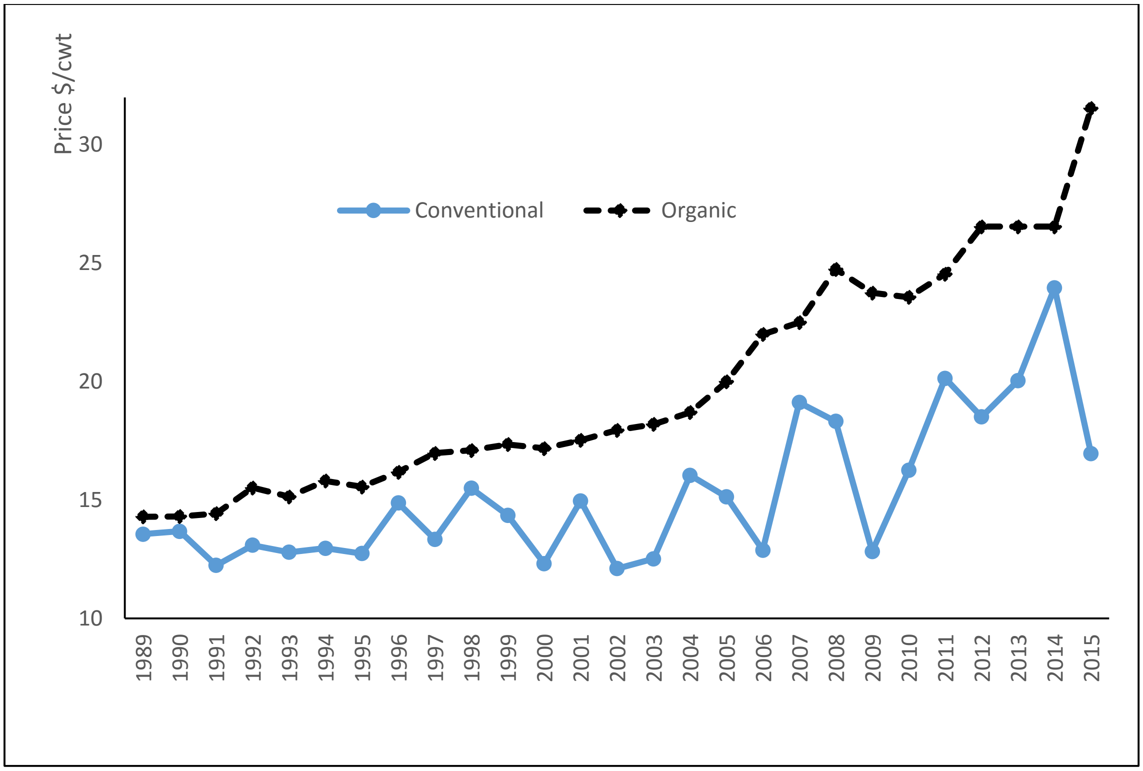

Figure 5. Annual Organic and Conventional Milk Farm Prices 1989-2013

Sources: The organic milk price was provided by Organic Valley Cooperative; http://www.farmers.coop/producer-pools/dairy-pool/pay-price/dairy-pay-price-comparison-chart/

Conventional milk prices were downloaded from the University of Wisconsin Dairy Marketing and Risk Management Program.

http://future.aae.wisc.edu/data/monthly_values/by_area/10?tab=prices

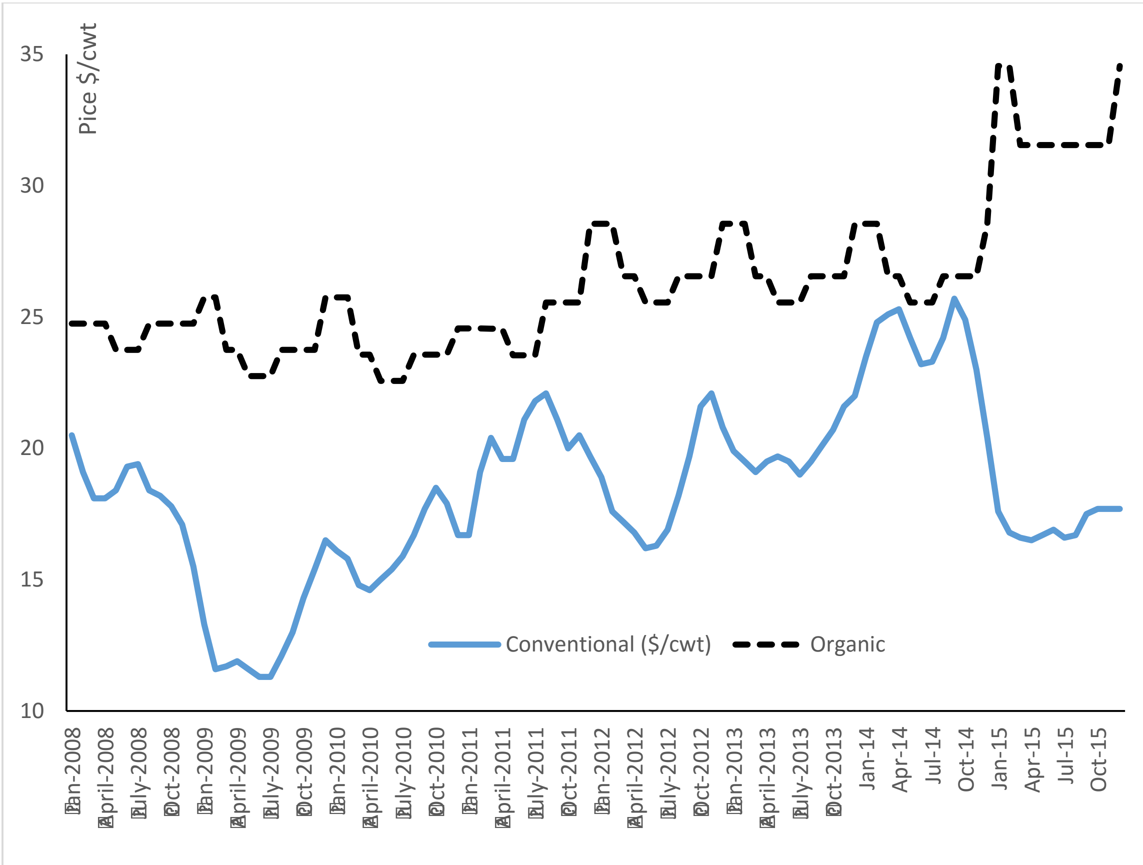

Figure 6. Monthly Organic and Conventional Milk Farm Prices 2008-2013

Sources: The organic milk price was provided by Organic Valley Cooperative; http://www.farmers.coop/producer-pools/dairy-pool/pay-price/dairy-pay-price-comparison-chart/

Conventional milk prices are national average all milk prices, downloaded from the University of Wisconsin Dairy Marketing and Risk Management Program.

http://future.aae.wisc.edu/data/monthly_values/by_area/10?tab=prices

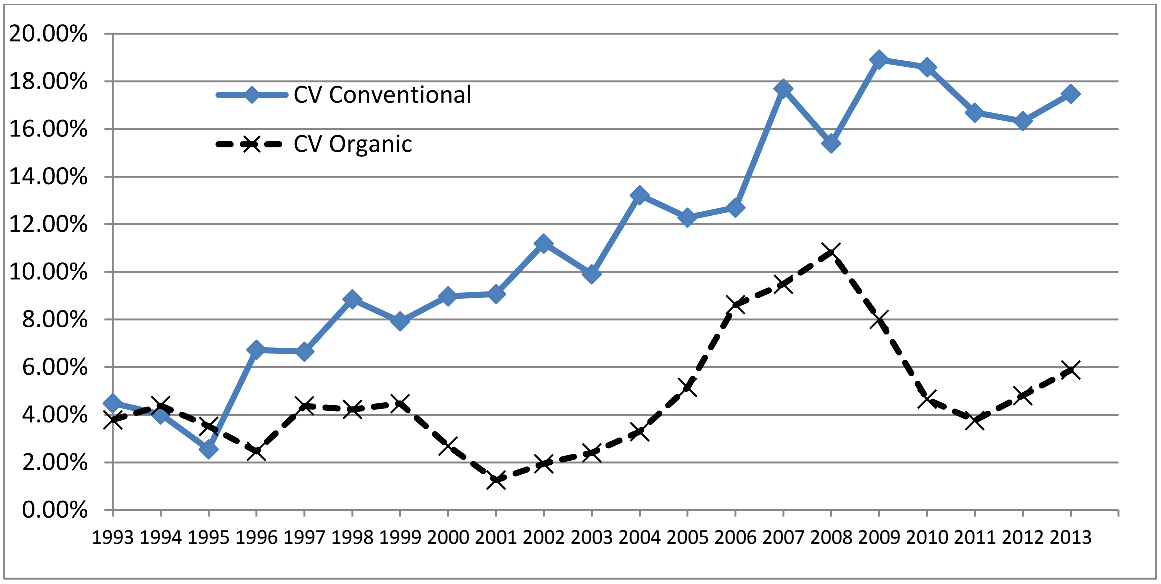

Figure 7. Coefficients of Variation (CV) for 5-year Moving Average for Conventional and Organic Milk Farm Prices 1989-2013

Note: The coefficient of variation (CV) is defined as the ratio of the standard deviation to the mean and informs the comparison of variations between different samples. The higher the CV, the larger the variation. The first 5-year moving average starts from 1993.

2 Dairy Farmer Decision Making

Farm managers have three basic decisions to make: what to produce, how to produce it, and how much to produce. Three major cost factors affect dairy farmers' decision making: operating costs, unpaid family labor costs and capital costs (MacDonald et al. 2007). For an established dairy farmer, the first question, i.e., what to produce, is changed to: Should she/he stay in business or exit the business. Additionally, capital costs are usually considered sunk costs and are not relevant to continuing operation of the farm.

Decision making for established dairy farmers is based on the other two costs (MacDonald et al. 2007).

2.1 How to Produce (Organically or Conventionally)

Personal values play a certain role in farm production decision making (Browne et al. 2000, Darnhofer, Schneeberger, and Freyer 2005). Some farmers may make decisions only based on economic return; others may make decisions based on both economic and social benefits. Dairy farmers have two choices regarding how to operate their farms: produce milk conventionally or organically.

Farming methods are influenced by technical aspects of agricultural production, farm structure, and personal characteristics of farmers. ARMS data show small farms (with less than $250,000 in sales) are more likely to adopt organic production. Education also plays a role in the adoption of organic production. Farmers who have at least a bachelor's degree are more likely to adopt organic operation (Bagi 2013).

The U.S. Department of Agriculture's National Agricultural Statistics Service (NASS) reported that the number of organic farms increased by 72% from 2008 to 2014. Organic milk is the number one organic commodity, with sales of $1.08 billion in 2014 (National Agricultural Statistics Service 2015b).

Broadly, there are two types of reasons that dairy farmers operate organically: economic and non-economic. Economically, farmers expect that organic operation will bring them higher profit and net return. Most organic dairy farmers converted from conventional farming, and only a small number of organic farmers started as an organic operation (Robison 2014). Non-economic reasons include environmental protection, animal welfare, health concerns, ethical concerns and/or lifestyle (Darnhofer, Schneeberger, and Freyer 2005). According to these authors, organic farmers are willing to adopt organic farming by sacrificing part of their economic return.

According to farmers' attitudes toward organic production, Darnhofer, Schneeberger, and Freyer (2005) segmented agricultural producers into four categories: committed conventional producers, pragmatic conventional producers, pragmatic organic producers and committed organic producers. They pointed out that economic considerations are the main motivation for pragmatic organic producers, whereas non-economic reasons play a more important role in committed organic producers' decision making. They noted that the other types are in between.

A primary question organic farmers and potential organic farmers consider is how long the organic price premium will last. The answer to this question helps many farmers determine how they will produce their milk. But the answer to this question depends on their assumption about consumer demand for organic milk as well as supply.

2.2 How Much to Produce (Expand, Reduce, or Status Quo)

How much to produce is actually an investment issue. Dairy farmers usually expand their herds when net return is positive. When they expect the future return to be positive, they are more likely to expand their operation and produce more. In the case of low net return, they will be cautious in expanding their herd size. In the case of negative return, they may consider exiting the industry. So information on future prices, net return and consumer demand is important for farmers' investment decision making.

Price is an instrument that provides an incentive to produce more. In the winter, U.S. cows produce less milk naturally, but demand is high due to the holiday effect. Organic milk buyers pay a premium for milk produced in December, January, and February. This incentive payment increases the milk supply in the short run. In the long run, if the margin for organic milk is continuously high, organic dairy farmers will increase their herd size and shift the supply curve to the right. The question is, can the margin stay high in the long run?

3 Background

3.1 Demand for Organic Food and Organic Milk

Organic food demand in the U.S. has been increasing for the past few decades. Total organic food sales were more than $35 billion in 2013 in the U.S., with double-digit annual growth most years. This growth is largely driven by consumer demand (Greene et al. 2009, Dimitri and Oberholtzer 2009). The Organic Trade Association (2012) reported that three-quarters of U.S. consumers purchase some organic food each year, and one-quarter of consumers purchase organic food monthly. In the 1990s, most organic food was sold in natural and specialty stores. By 2011, only 38% of organic food was sold in such stores, and 55% of organic food was sold through traditional food stores (Greene et al. 2009). With growing consumer demand, organic product producers and manufacturers demanded national uniform organic production standards. Due to this and other reasons, the U.S. Congress passed the Organic Food Production Act in 1990 to enforce a national standard. This law established the National Organic Program, which created uniform national organic food standards that were implemented beginning in October 2002 (National Organic Program 2014).

The Organic Trade Association performs an annual industry survey. Its 2015 report showed that organic dairy products represented 15% of total organic food sales, and increased from $500 million in 1997 to $5.5 billion in 2014 (Organic Trade Association 2015). Market research suggests that organic fluid milk is one of the first organic products that consumers purchase.

Figure 8 shows that annual sales of organic fluid milk have increased almost every year since 2006. Figure 9 shows that the compound annual growth rate of organic fluid milk decreased beginning in 2007, but seemed to rebound in 2014. As of July 15, 2015, monthly sales of organic milk were 4.8% of total milk consumption, increasing from 1.7% of total milk consumption in 2006.[2] Due to higher production costs for organic food and increasing consumer demand, organic food has commanded a significant premium over comparable conventional food products (Greene et al. 2009). For example, a half-gallon of organic fluid milk generated a 60-109% premium over conventional branded milk in 2006 (Smith, Huang, and Lin 2009).

[2] Calculated using monthly conventional and organic fluid milk sales data from the Economic Research Service.

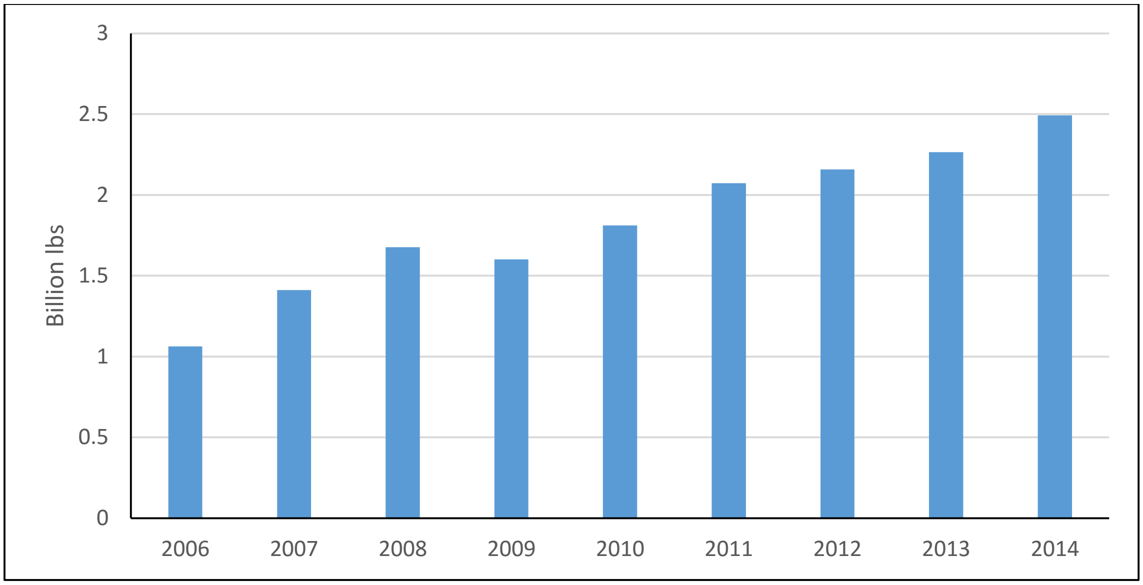

Figure 8. Organic Fluid Milk Sales in the U.S. 2006-2014 in billion lbs.

Source: Economic Research Service of the USDA, estimated U.S. sales of organic and total fluid milk products, http://www.ers.usda.gov/data-products/organic-prices.aspx

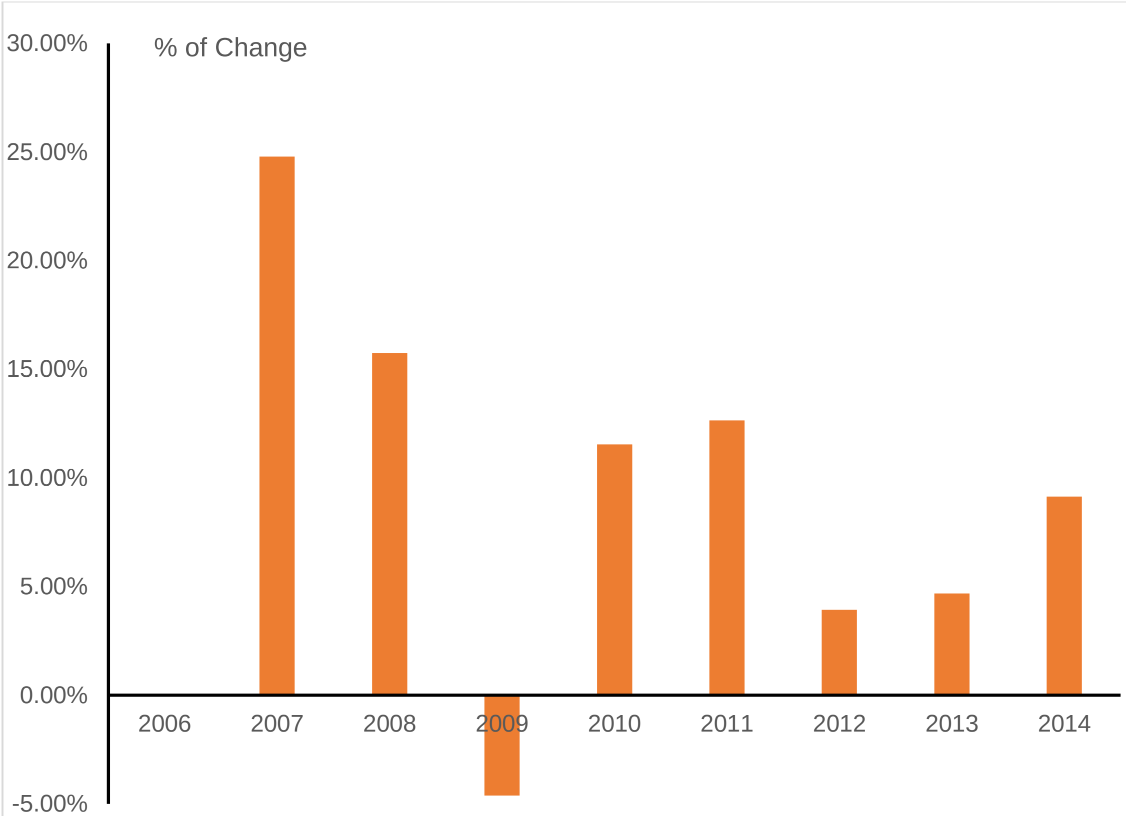

Figure 9. Organic Fluid Milk Annual Sales Growth Rate in the U.S., 2007-2014

Growth rate was calculated by (current year sales minus previous year sales) divided by previous year sales multiplied by100

Source: Calculated results using data from Figure 8

3.2 Profitability of Organic and Conventional Dairy Farms

Data from Minnesota for 2006-2013 show that organic dairy farms performed better financially than conventional dairy farms in seven of the eight years (Table 1). The most significant difference was in 2009, when organic farms had a net return of $366/cow, while conventional farms had a net loss of $402/cow. In Wisconsin, organic dairy farmers' revenue decreased by 10% on average, but conventional dairy farmers' revenue decreased by 40% in 2009 (Barham 2010). Barham found a major reason that organic dairy farmers had a higher return was the supply control program of Organic Valley, an organic farmer-owned cooperative.

The period from 2009 to 2013 was economically difficult for both conventional and organic dairy farmers. They had to deal with an economic recession in 2009, low net return in 2010, and drought and spiking feed prices in 2012. This was especially the case for small farmers because of their relative cost disadvantage. Nationally, organic and conventional dairy farms of all sizes saw a negative net return in 2010, except for farms with more than 1000cows (Table 2). In both the organic and conventional categories, large dairy farms have higher returns than smaller ones due to economies of scale, as shown in Table 2. However, among dairy farms with fewer than 100 cows, organic dairy farms outperformed conventional dairy farms, especially in terms of return on operating costs.

Using data for the entire U.S., organic farms have higher overhead costs within each size category, while the gross margin for organic milk is much higher than for conventional dairy farms in the same category (Table 2). Greene et al. (2009) found that some farmers make their production decision based on operating costs instead of total costs, because they care about the family farm lifestyle and are willing to sacrifice part of their labor opportunity cost for the lifestyle. Therefore, this type of farmer is more likely to choose organic farming, which can help these farmers keep relatively small family farms while earning enough to live.

Table 1. Organic and Conventional Dairy Farm Profitability Analysis for Minnesota 2006-2013

		2013	2012	2011	2010	2009	2008	2007	2006
Organic	Number of farms	19	25	27	38	31	30	23	22
	Average number of cows/farm	103.8	95.9	84.8	78.8	77.8	76.9	64.7	72.3
	Milk produced per cow(lbs)	13,715	12,720	12,133	12,819	12,129	12,629	13,372	12,323
	Avg. milk price per cwt. ($/cwt)	29.92	29.23	27.32	26.19	25.77	25.39	24.44	22.15
	Net return over operating expense ($/cow)	545.17	577.49	421.37	756.2	651.63	674.65	814.91	821.54
	Net return ($/cow)	302.68	303.33	124.62	487.68	366.47	411.7	541.49	568.28
Conventional	Number of farms	399	427	468	527	509	499	575	557
	Average number of cows/farm	178.4	166.7	158.1	137	136.4	140.7	128.5	124.3
	Milk produced per cow (lbs)	22,926	22,434	22,071	21,732	21,264	21,344	21,300	21,432
	Avg. milk price per cwt. ($/cwt)	20.34	19.63	19.96	16.26	13.57	19.46	18.64	13.34
	Net return over operating expense ($/cow)	289.93	293.33	535.24	211.85	-201.56	514.17	864.95	308.83
	Net return $/cow	92.24	90.62	331.08	11.61	-402.77	290.44	639.12	103.52

Source: Data were downloaded from the Farm Financial Database of Farm Business Management, University of Minnesota, www.finbin.umn.edu. This database provides detailed data on profitability of dairy, livestock, and crop businesses in the state.

Table 2. Conventional and Organic Milk Costs and Returns by Size Group in the U.S., 2010

Item	<50 cows		50-99		100-199		200-499		500-999	>1,000	All Sizes	
	Unit = dollars per cwt sold											
	Con*	Org	Con	Org	Con	Org	Con	Org>200	Con	Con	Con	Org
Milk sold	16.61	25.83	16.61	26.69	16.63	25.22	16.64	27.72	16.30	15.05	15.95	26.59
Total gross value	19.06	28.60	18.77	29.41	18.52	27.49	18.39	30.05	18.04	16.66	17.74	29.11
Operating costs:												
Total feed costs	12.54	15.65	11.50	14.96	11.04	14.79	10.94	15.51	9.69	8.85	10.01	15.24
Total operating cost	16.54	20.52	15.35	20.25	14.36	19.67	14.45	19.49	12.75	11.03	12.92	19.93
Allocated overhead:												
Hired labor	0.52	0.84	0.80	1.72	1.21	2.24	1.79	4.49	1.84	1.43	1.41	2.60
Opportunity cost of unpaid labor	13.22	15.52	6.79	8.99	3.42	4.59	1.40	1.01	0.49	0.16	2.09	6.65
Total overhead	22.55	27.46	14.88	20.56	9.88	15.43	7.55	10.99	5.33	3.85	7.40	17.60
Total costs listed	39.09	47.98	30.23	40.81	24.24	35.10	22.00	30.48	18.08	14.88	20.32	37.53
Value of production less total costs	-20.03	-19.38	-11.46	-11.40	-5.72	-7.61	-3.61	-0.43	-0.04	1.78	-2.58	-8.42
Value of production less operating costs	2.52	8.08	3.42	9.16	4.16	7.82	3.94	10.56	5.29	5.63	4.82	9.18
Supporting information												
Milk cows (head)	35	34	69	68	135	130	313	460	701	2,236	182	77
Output per cow (lbs.)	15,885	12,223	17,530	12,599	19,232	13,721	20,040	16,663	22,673	23,297	20,961	13,884

*Con=Conventional; Org=Organic. Data were downloaded from Milk Production Costs and Returns from the 2010 Agricultural Resource Management Survey (ARMS) data. The 2010 ARMS collected detailed information on production practices and costs of dairy farms in 26 States, representing more than 90% of national milk production. A subsample of organic dairy operations was included as part of the survey. The data are available from the following website:

http://www.ers.usda.gov/data-products/commodity-costs-and-returns/organic-costs-and-returns.aspx

4 Motivation

The above information shows that there are differences between organic milk and conventional milk farm prices, pricing methods and farm profitability. In the long run, the organic milk farm price has been increasing continuously since 1989, while the conventional milk price has fluctuated during the same period. Additionally, the organic milk farm price of Organic Valley cooperative is determined at the beginning of a calendar year and is stable throughout that year. Other organic milk buyers have adopted a pricing mechanism similar to Organic Valley's. As a result, the organic milk farm price is stable throughout the entire industry. However, the conventional milk price is announced monthly and changes from month to month. Intra-year and inter-year price volatility is a norm for most agricultural commodities. How is it that the organic milk farm price can be relatively stable over a given year and continue to grow? I want to shed light on this puzzle.

Commodity prices are affected by supply and demand. Any factors affecting supply and demand can affect the price of a commodity. Prices that farmers receive are affected by the supply and demand of the given commodity and of substitute commodities. Demand for the commodity is ultimately affected by consumer demand through the value chain, which affects the prices farmers receive.

In the previous section it was shown that organic dairy farms perform better than counterpart conventional dairy farmers on average. It is costly for dairy farmers to convert from conventional production to organic production and conversion costs are sunk costs that cannot be recovered. Consumer demand is an important driving force for the organic dairy industry. As an organic dairy farmer or a potential organic dairy farmer, she/he has to ask how long the current market situation will continue and how long she/he can expect an increase in demand and a significant premium price over conventional milk. Can current consumer demand support a high enough price to maintain an adequate margin so that their farms can recover their capital investment? Farmers need to have an outlook about future demand for their output to inform their investment decision making and production management.

Knowing the condition of supply is equally important for the farm price of organic milk and for organic milk processors, who provide consumer demand and preference information to farmers. In the short run, organic milk supply is inelastic. It takes at least three years to convert from a traditional dairy to an organic production operation, two years for land and one year for dairy cows (National Organic Program 2014). Therefore, information on consumer demand and effective strategies to cope with increasing or decreasing demand is critical for organic dairy farmers, industry stakeholders, and decision makers. The integrated management of supply and demand is important for the profit maximization of a business.

5 Research Objectives

The general objective of this study is to examine the organic dairy industry supply-demand coordination challenge with a specific emphasis on the consumer demand side. The specific objectives are as follows:

The first objective is to examine consumer demand for organic and conventional milk in the U.S. and how consumers respond to price and income changes. Farm management and investment depend on farm return, which depends on price to a large degree. The farm price is closely related to consumer demand. When consumer demand increases, the demand for farm products increases, and so does the farm price. Therefore, farmers need consumer demand information for their farm management and investment decision making. This study provides information on market conditions of the organic dairy industry and how consumer demand for organic milk products affects the raw organic milk price.

The second objective is to describe organic milk industry participants from production to processing, to compare the price and profitability of organic and conventional dairy farmers, and to suggest decision making options for potential organic dairy farmers.

The third objective is to examine a supply chain coordinator – Organic Valley cooperative – and its internal decision making challenges. Organic Valley is the largest organic cooperative and functions as a supply-demand coordinator in the organic milk value chain. This study will analyze how Organic Valley balances organic milk supply and demand, how the cooperative copes with industry crises, and the roles a cooperative plays in the industry.

This study concludes by drawing implications for organic milk producers, producer organizations, the industry and public policy makers.

Chapter Two: Consumer Demand Theory and Empirical Demand Models

1 Consumer Preference and Representation

Consumer choice for a particular good or service is dependent on consumer preference for the good or service and the consumer's budget constraints. The quantity or bundle of goods and services that consumers buy affects the profit of manufacturers, producers, retailers and relevant stakeholders. Therefore, there is a practical reason for understanding the decision-making process related to purchasing goods and services.

Assuming that consumer preferences are complete, transitive, monotonic, nonsatiation, convex, and continuous and these preferences play an important role in consumer demand analysis, these assumptions can be represented by mathematical notation. Consumers' preference set or available consumption bundle is denoted by X, which belongs to a commodity space $\mathbb{R}_{+}$, a vector of all possible alternatives. The elements in X can be ordered according to consumer preference, such as: for all $x, y \in X,\ x \succsim y, or\ y \succsim x$ or both. ($\succsim$ means at least as good as, and ~ means indifferent), and for all $x, y, z \in X,\ if\ x \succsim y\ and\ y \succsim z, then\ x \succsim z$. In addition, consumers are assumed to be price takers and price is exogenous for consumers.

Consumer preference is an important concept and tool in consumer demand theory. More preferred bundles in the choice set bring more satisfaction to consumers and consumers are more likely to consume the bundles. Consumer preference is represented by a utility function. The higher the preference, the more utility consumers receive from the goods or bundle.

2 Utility Function and its Derivatives

Under budget constraints, consumers maximize their satisfaction by allocating income to their preferred bundles of goods and services. Their satisfaction is defined as utility. The level of utility ranks the order of consumers' satisfaction related to different consumption bundles. Each utility function represents an underlying consumer preference. For all $x, y \in X,\ x \gtrsim y, if\ and\ only\ if\ u(x) \geq u(y), x\ and\ y$ are bundles and belong to all available options of X. The utility function connects satisfaction to particular consumption bundles and serves as a foundation for consumer demand theory, because rational consumers maximize their satisfaction or utility. This can be expressed as:

$$\boldsymbol{max\, u(x)\ such\ that\ px = m} \tag{1}$$

Where $u\ (x)$ is the utility function, p is the price vector with n x 1 dimensions, x is the bundle and choice variable $\epsilon\ X$ with n goods, and m is the total budget. In this model, price and expenditure are assumed to be exogenous. Rational consumers are assumed to maximize their utility with constrained budgets. The utility maximization is obtained by:

$$\mathcal{L} = u\ (x) - \lambda\ (px - m) \tag{2}$$

Where λ is the Lagrange multiplier, and also is the marginal utility of income change. To solve the maximization problem, the first order condition regarding the choice variable x is:

$$\frac{\partial \mathcal{L}}{\partial x} = \frac{\partial u(x)}{\partial x} - \lambda\, p = 0$$

(3)

Some popular utility functional forms are Cobb-Douglas, Leontief, and logarithmic linear utility functions. In a two-goods system, a Cobb-Douglas utility function has the form of

$$u\ (x_1, x_2) = k x_1^{\alpha} x_2^{1-\alpha}, \alpha \in (0,1)\ and\ k > 0$$

(4)

Utility functions represent consumers' preference for the bundles of goods or service orderly. If two bundles bring the same level of utility to a consumer, the consumer is indifferent between the two bundles. Any monotonic transformation of a utility function represents the same preference order. Since the utility function represents consumer preference, it has the same properties as consumer preference. Therefore, the utility function is continuous, differentiable, concave, and monotonic.

2.1 Indirect Utility Function

The utility function is related to the quantity or bundle of goods. However, utility is unobservable and difficult to measure. Another way to represent utility is to employ the concept of an indirect utility function, which is defined by price and income and is observable:

$$v\ (p, m) = \max u\ (x)\ such\ that\ px = m$$

(5)

Utility functions represent underlying preferences and have certain properties. This is also true for indirect utility functions. Indirect utility functions have four properties: nonincreasing in p and nondecreasing in m, homogenous at degree zero in (p, m), quasi-convex in p, and continuous.

2.2 Expenditure Function

Another way to describe consumers' preferences is utilizing the expenditure function, which can be derived by inverting the indirect utility function with constraint to achieve desired utility. The expenditure function is represented by e (p,u) and has properties similar to a cost function: nondecreasing and homogenous of degree one in p, concave in p, and continuous. Duality of consumer theory indicates that utility maximization with limited income is the dual of expenditure minimization with constraint to achieve desired utility. We can formulate the expenditure function as:

$$e(p,u) = \min px \;\; st \; u(x) = u \tag{6}$$

By introducing the Lagrange multiplier and setting the first order condition, we can solve the expenditure minimization problem and derive a demand function. In addition, by inverting the expenditure function, we can obtain an indirect utility function. These functions are interrelated and one can be derived from the other.

3 Demand Functions

3.1 Marshallian Demand Function

A regular observable demand function assigns a relationship between the quantity demanded and the prices of available choice bundles and income. This is also called the Marshallian demand function, or uncompensated demand function. It can be represented by $x(p,m)$. This equation can be derived from the first order conditions of maximization of the utility function. It also can be derived from the indirect utility function by Roy's identity.

$$x(p,m) = -\frac{\partial v(p,m)/\partial p}{\partial v(p,m)/\partial m} \tag{7}$$

To ensure we have a well-defined demand function, consumer theory imposes a set of constraints on demand functions. The first property is that a demand function is homogenous at degree zero on price and income. This is also called the absence of money illusion, because if price and income increase or decrease the same degree, the quantity demanded is constant. The other property is adding up, i.e., $px = m$, with all costs for the choice set equal to the total income. The other two assumptions are: The Slutsky matrix is symmetric and negative semidefinite. Any function meeting all properties of the demand function can be deemed a demand function. The property of homogeneity is defined as:

$$\sum_{k=1}^{L} \frac{\partial x(p,m)}{\partial p_k} p_k + \frac{\partial x(p,m)}{\partial m} m = 0$$

(8)

This can also be expressed as elasticity of price and income:

$$\sum_{k=1}^{L} \varepsilon_p\,(p,m) + \varepsilon_w(p,m) = 0$$

(9)

If we have a well-defined demand function, we can integrate the demand function and get the underlying utility function. By substituting the quantity in the Marshallian demand function into the underlying utility function, we can derive the indirect utility function. The Marshallian demand function is considered the ordinary market demand function and is the focus of empirical study.

3.2 Hicksian Demand Function

By differentiating the expenditure function and minimizing consumers' expenditure to achieve a desired level of utility, a Hicksian demand function can be derived. The Hicksian demand function is also called the compensated demand function, because income changes to compensate for the change in price to keep utility constant. The Hicksian demand function can be achieved through the following equation:

$$\boldsymbol{h} = \frac{\boldsymbol{\partial e(p,u)}}{\boldsymbol{\partial p}}$$

(10)

The Hicksian demand function is unobservable. It has the following properties: homogenous at degree zero in p, where the matrix of substitution terms is negative semi-definite and symmetric.

3.3 Slutsky Equation

The Slutsky equation connects the Marshallian and Hicksian demand equations:

$$\frac{\partial x_i(p,m)}{\partial p_i} = \frac{\partial h_i(p,u)}{\partial p_i} - \frac{\partial x_i(p,m)}{\partial m} x_i(p,m) \tag{11}$$

The Slutsky equation decomposes the effects of price change into two parts. One is the substitution effect (the first term on the right side), and the other is the income effect (the second term on the right side). The Marshallian demand function includes both effects, and the Hicksian demand function only describes the substitution effect. Although the two demand equations are not identical, in certain circumstances they are equal. For a certain level of utility, these two equations are identical. Two important identities emerge:

$$x_i(p,m) \equiv h_i(p, v(p,m))$$

$$h_i(p,u) \equiv x_i(p, e(p,u)) \tag{12}$$

The first identity means that Marshallian demand at income *m* is the same as Hicksian demand with utility from income *m*. The second identity shows that Hicksian demand at utility *u* is the same as Marshallian demand at the minimal expenditure for utility *u*. In addition, the Slutsky equation reflects the substitution effect of goods. Consumer demand is not only affected by the price of preferred goods and services, but also by the prices of alternatives in the choice set.

4 Relationship of the Functions

Consumer choice theory starts with consumer preference, represented by a utility function. As in production theory, duality exists in consumer theory. All functions related to consumer choice are associated and one can be derived from the other(s). If we have an underlying preference and a utility function to represent the preference, by maximizing the utility function under a budget constraint, we can derive the indirect utility function representing the underlying preference. From the indirect utility, we can obtain a Marshallian demand function through Roy's identity. In addition, by inverting the indirect utility function, we can obtain the expenditure function under the constraint of desired utility. Then the utility function can be derived by minimizing the indirect utility function, or by integrating the demand function. By differentiating the expenditure function, we can obtain the Hicksian demand function. The expenditure function also can be derived by integrating the Hicksian demand function. We can get the Marshallian demand function from the Hicksian demand function or vice versa with the identities at the desired utility and income. These relationships are shown in Figure 10. Therefore, we have different approaches for deriving the regular consumer demand functions.

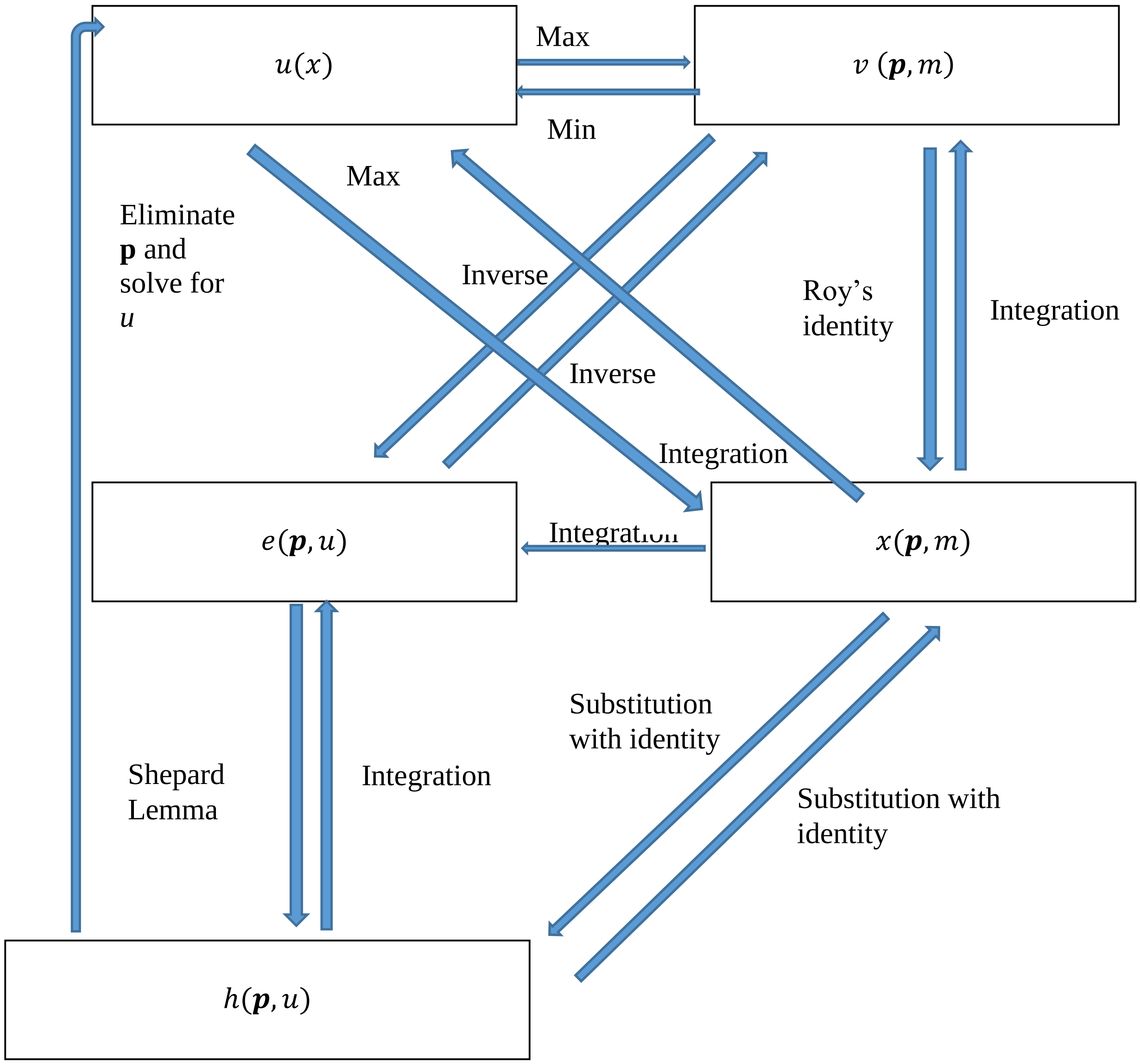

Figure 10. Relationship of Functions in Demand Theory

Note: Through maximization, the indirect utility function can be derived from the utility function. The Marshallian demand function can be derived from an indirect utility function through Roy's identity. Through substitution, the Hicksian demand function can be derived from the Marshallian demand function. The cost function can be derived from the Hicksian demand function through integration. The indirect utility function has an inverse relationship with the cost function. The Marshallian demand function also can be derived through solving the maximization problem of the utility function. The reverse relationships of all the aforementioned can also be derived.

5 From Consumer Theory to Empirical Consumer Demand Model

5.1 Generalized Axiom of Revealed Preference

Consumer theory is abstracted from consumer choice behavior based on the assumption that consumers are rational and maximize their utility under budget constraints. In reality, what we can observe is a consumer's choice set and actual choice. In the setting with two choices, $p^t x^t$ and $p^t x$, if the consumer selects $p^t x^t$, then we know x^t is preferred to x and $u\ (p^t x^t) \geq u\ (p^t x)$. This says that x^t is directly revealed preferred to x. Therefore, we can derive consumer preference from a consumer's revealed choice behaviors. The generalized axiom of revealed preference (GARP) is a necessary and sufficient condition for the existence of utility maximization behavior. GARP says if x^t is revealed preferred to x^s, then x^s cannot be strictly directly revealed preferred to x^t. Therefore, we can use a utility function to describe consumer preference in relation to the consumer's choice set and model possible choice, then use the model for policy analysis, welfare analysis, and forecasting consumer demand for certain products.

5.2 Aggregate Consumers and Aggregate Products

Consumer theory explains individual consumer behavior. What we are interested when doing an empirical study is the aggregation of consumers, or a group of consumers. The most popular aggregation is aggregated household data. Aggregated household demand is generated by a representative household. The Gorman form utility function is a necessary and sufficient condition for demand aggregation through representative consumers. The representative Gorman consumer demand function is given by:

$$X(p,m) = A(p) + B(p)m$$

(13)

Where A(p) can be different for consumers, but B(p) is the same for all consumers.

Consumers have a large number of choices of goods and services. It is impractical to estimate demand for every good and service. By generating price and quantity indices, we can aggregate across goods in the same category and reduce the number of parameters that need to be estimated. The assumption of separability is important for this aggregation. Under this assumption, preference for a particular good in one consumption subgroup is independent of preference for goods in another subgroup. Hicksian separability and functional separability are two popular methods of aggregating across commodities. In the Hicksian separability approach, the relative price of goods in the same group should remain constant. Functional separability requires that the utility from one good be independent of the utility of other goods, and the demand for goods in one group be independent of the prices of other goods, and only determined by the price of each good in the group and total expenditure on the group. This approach is the foundation for the two-stage budgeting process. In the first stage, expenditure on a particular group is allocated. In the second stage, the expenditure on a particular good is dependent on the price of the goods and the total budget for this group. This is called weak separability of preference. First-level budgeting can be defined by the following equation:

$$\ln(Q) = \beta_0 + \beta_1 \ln(I) + \beta_2 \ln(P) + \beta_3 Z + \varepsilon \tag{14}$$

Where Q is the overall consumption for the specified group, I is real income, P is the price index of the group and Z are variables that can shift demand. The more prices are correlated and the better substitutes the products are, the easier it is to compute the price index. Price and supply are considered exogenous.

6 Empirical Demand Models for Consumer Analysis

Demand analysis examines factors affecting consumer demand and how these factors affect demand, what functional forms the consumer demand equation might take, how to measure elasticity, and how demand analysis relates to demand theory. Demand theory is a guideline for empirical demand analysis. The other question consumer demand analysis focuses on is aggregation across consumers. Demand theory is abstracted from one specific individual, but empirical study deals with consumers as a whole. In reality, consumers choose large quantities of goods and services. However, in empirical studies, we are interested in a few goods or services in one specific category.

Theoretically, for a function to be an empirical demand function, it needs to meet all the properties of a demand function. In a demand function, utility is assumed separable and consumption goods can be split into groups. A flexible demand system can be estimated within a group and among groups. A two-stage budgeting process is assumed. In the first stage, expenditure is distributed among different consumption groups. In the second stage, expenditure is distributed among different goods within the group.

In an empirical study, we only observe the consumer choice set, price vector p and consumers' total expenditure m on goods and services of interest. Prices and expenditure are considered exogenous in a system with budget constraint. So, the consumer demand function is represented by the general form:

$$Q = Q(p, m) \tag{15}$$

Three different approaches were attempted in arriving at a demand function in empirical analysis: from a utility function, an indirect utility function, or a direct demand function. Each of them has some advantages and disadvantages. Some of them may not conform to consumer demand theory in certain aspects. The following section will discuss some of the most popular consumer demand functional forms employed by scholars so far.

6.1 Linear Expenditure Model

The linear expenditure system was first proposed by Stone (Stone 1954). The demand function is derived through maximization of a Klein-Rubin utility function, which is also known as the Stone-Geary utility function under budget constraint. The underlying utility function is defined as:

$$U(q) = \Sigma_{i=1}^{n} \beta_i log(q_i - \gamma_i) \tag{16}$$

Where q is the quantity demanded, β and γ are coefficients, $(q_i - \gamma_i) > 0$, $\gamma > 0$ for all I, $0 < \beta < 1$ for all i, and $\sum_{i=1}^{n} \beta_i = 1$. The γ is the minimum required quantity for subsistence. β_i is the proportion of expenditures on goods and services. By maximizing the utility function (16), we can get the general demand function:

$$q_i = \gamma_i + \frac{\beta_i}{p_i}(x - \sum_{j=1}^{n} p_j \gamma_j) \tag{17}$$

By multiplying q by both sides of (17), the following equation in expenditure form is obtained:

$$p_i q_i = p_i \gamma_i + \beta_i \left(x - \sum_{j=1}^{n} p_j \gamma_j \right) \tag{18}$$

In this system, $\sum_{j=1}^{n} p_j \gamma_j$ is the expenditure on necessities for survival, and $\left(x - \sum_{j=1}^{n} p_j \gamma_j\right)$ is the expenditure left after spending on necessary goods. The term $p_i q_i$ is the expenditure on individual commodity *i*. This demand equation was called the Linear Expenditure System by Stone (1954), because the expenditure on a particular good piq_i is a linear function of total expenditure *x* and the prices of all goods and services in the choice set. The linear expenditure system is homogenous at degree zero in price and income. It also meets the additive and symmetric constraints. The system can take a special and a general form. In the special form, the expenditure on any commodity represents a fixed proportion of total expenditure. In the general form, this restriction is relaxed and gives better results. In addition, a mixed model with both special and general forms is introduced.

The mixed model describes some commodities according to the special form, and the rest according to the general form. Stone (1954) estimated the demand for six groups of goods in the United Kingdom using data from 1920 to 1938 with the three aforementioned systems. He concluded that these systems can be a basis and framework for analysis of free market system. After that, linear expenditure system quickly became a benchmark model for empirical analysis. Special contributions were made by Pollak and Wales, Park, and Phlips (Pollak and Wales 1969, Parks 1971, Phlips 1972).

The linear expenditure system greatly reduces the number of parameters, totally

2n-1 by imposing theoretic constraints (n γ s and (n-1) βs). However, Deaton and Muellbauer (1980) pointed out that the system does not hold for inferior goods or complements. These problems limit the application of linear expenditure system.

6.2 Rotterdam Model

The Rotterdam model was developed by Barten (Barten 1969, 1964) and Theil (Theil 1965). The name of the model is based on the location where both of them worked at the time. This demand model is not derived from an explicit utility function, but from differentiation of a general demand function $q = q\ (m, p)$. The demand equation is expressed as:

$$\overline{w_{it}}\Delta(logq_{it}) = \alpha_{it} + \beta_i \sum_j \overline{w_{jt}}\,\Delta\big(logq_{jt}\big) + \sum_j \gamma_{ij}\big(logp_{jt}\big) + \varepsilon_{it}$$

$$\overline{w_{it}} = \frac{w_{it} + w_{it-1}}{2}$$

$$\beta_i = w_i e_i = p_i(\partial q_i/\partial x)$$

$$\gamma_{ij} = w_i e_{ij}{}^* = p_i p_j s_{ij}/m$$

(*sij* is the *ijth* term from the Slutsky substitution matrix)

$$\sum_{i=1}^{n} \beta_i = 1, for\ aggregation\ \ \gamma_{ij} = \gamma_{ji}, for\ symmetry$$

$$\sum_{i}^{n} \gamma_{ij} = 0, for\ all\ j, for\ homogeneity$$

(19)

Where w_{it} is the budget share of the *i*th commodity at time *t*, q_{it} is the quantity of demand, and p_{jt} is the deflated price of the *j*th commodity. $\alpha_{it}, \beta_i, and\ \gamma_{ij}$ are parameters. Negative semidefiniteness of the Slutsky matrix implies that the matrix γ with elements γ_{ij} is negative semidefinite.

This is the first model to test the constraints of consumer theory. In addition, the model is linear in parameters. Nonetheless, this demand model is consistent with utility maximization theory only if the utility function is logarithmic linear, which is additive and homothetic (Christensen, Jorgenson, and Lau 1975). Many empirical studies have been done with this model. However, the demand analysis using the Rotterdam model with macroeconomic data by Barten (Barten 1969) and Deaton rejected the homogeneity restriction, which implies that the Rotterdam model is too restrictive. This led to a search for more flexible functional forms.

6.3 Translog Demand System

More flexible demand functional forms were developed in the 1970s from direct or indirect utility functions, or cost functions. One of them is the transcendental logarithmic model developed by Christensen, Jorgenson, and Lau (Christensen, Jorgenson, and Lau 1975). This model is derived from quadratic logarithmic indirect utility functions and meets the homogeneity constraint of consumer theory. The indirect utility function and demand function are defined as:

$$logV = \alpha_0 + \sum_i \alpha_i \log\left(\frac{p_{it}}{m_t}\right) + \frac{1}{2}\sum_i \sum_j \beta_{ij} \log\left(\frac{p_{it}}{m_t}\right) \log\left(\frac{p_{jt}}{m_t}\right)$$

$$w_i = \frac{\alpha_i + \sum_j \gamma_{ij} \ln(\frac{p_j}{m})}{\alpha_M + \sum_j \gamma_{Mj} \ln(\frac{p_j}{m})}$$

$\alpha_M = \sum \alpha_i = -1$ to normalize the data to ensure homogeneity

$$\gamma_{Mj} = \sum_{i=1}^{M} \gamma_{ij} \;\; M = n$$

$$\gamma_{ij} = \gamma_{ji} \; for \; symmetry$$

(20)

Compared with the Rotterdam model, this demand model is more flexible and has fewer constraints on the utility function form. However, Christensen, Jorgenson, and Lau's empirical test with U.S. time series personal consumption data from 1929 to 1972 suggests that the model does not conform to demand theory. None of the aforementioned models are completely consistent with consumer theory.

6.4 Almost Ideal Demand System

By 1980, Deaton and Muellbauer developed a better demand model than the aforementioned models and one that is consistent with consumer theory (Deaton and Muellbauer 1980). Therefore, they named their model the Almost Ideal Demand System (AIDS). Since then, this model has become a benchmark and has been widely used and modified by empirical econometricians.

AIDS starts from a first-order approximation of a price-independent generalized logarithmic (PIGLOG) (expenditure shares that are linear in log total expenditure) cost function:

$$\log[c(u,p)] = (1-u)\log[(a(p)] + u log[(b(p)] \tag{21}$$

Where u is utility and greater than zero, but less than one. The functional forms for $\log[(a(p)], log[(b(p)]$ are defined as:

$$\log[(a(p)] = \alpha_0 + \sum_{i=1}^{n} \alpha_i \log(p_i) + 0.5 \sum_i \sum_j r_{ij} \log P_i log P_j$$

$$log[(b(p)] = log[(a(p)] + \beta_0 \prod_{i=1} p_i{}^{\beta_i}$$

(22)

The cost function is globally flexible to reproduce any first and secondary derivatives. By putting (22) into the cost function and after some derivations, we can get a new cost function:

$$\log[c(u,p)] = \alpha_0 + \sum_k \alpha_k logp_k + \frac{1}{2}\sum_k \sum_j \gamma_{kj}^* logp_k \, logp_j + u\beta_0 \prod_k p_k^{\beta^k}$$

A demand function as the budget share format can be derived from the cost function after a few derivations:

$$w_i = \frac{\partial \log c(u,p)}{\partial logp_i} = \frac{p_i q_i}{c(u,p)}$$

$$w_{it} = a_i + \sum_{j=1}^{n} r_{ij} logp_{jt} + \beta_i \log\left(\frac{x_t}{P_t}\right) + \varepsilon_{it}$$

(23)

where w_{it} is the share of subcategory *i* of total expenditure at time *t*, a_i is the intercept, and p_{jt} is the price of *j* subcategory at time *t*. x_t is total expenditure on the interested goods, P_t is the translog price index, and $\frac{x_t}{P_t}$ is considered to be the real expenditure. β_i reflects the effect of real expenditure on the budget share, holding price constant. A positive β_i denotes a luxury good and negative denotes a necessary good. The price index P_t is defined by:

$$logP_t = \sum_{i=1}^{n} logP_{it} + 0.5 \sum_{i} \sum_{j} r_{ij} \log P_{it} logP_{jt}$$

(24)

In order to satisfy choice theory, a few constraints need to be met. The adding up condition is automatically satisfied if:

$$\sum_i a_i = 1,\ \sum_i r_{ij} = \sum_i \beta_i = 0$$

Homogeneity and symmetry conditions are imposed by satisfying the following constraints:

$$\sum_{j} r_{ij} = 0\ and\ r_{ij} = r_{ji}\ , \forall i, j\ i \neq j$$

In practice, one of the equations is dropped in estimation to satisfy the homogeneity and adding up constraints.

AIDS has two advantages over other flexible functional forms. First, it aggregates well over individuals, and second, it is easy to impose the consumer demand theory. Two methods are available for estimating demand equations jointly to increase the efficiency of estimators, maximum likelihood and generalized least square. A few assumptions are made in the model, such as that prices and income are exogenous, and the interested goods are weakly separable from other goods. A two-stage budget process is also assumed. In the first stage, the expenditure is assigned to different groups of goods. In the second stage, the expenditure is assigned within the group. The primary concern focuses on the second stage.

6.5 Linear Approximation of Almost Ideal Demand System (LAIDS)

At the time AIDS was developed, computation capacity was limited. As a result, Deaton and Muellbauer suggested using the Stone price index to make the model linear and easy to estimate empirically. The Stone price index is calculated by:

$$logP_t = \sum_{i=1}^{n} w_{it} logP_{it} \tag{25}$$

Under certain conditions, the Stone Price index is proportional to the real price index, especially when prices are highly collinear. Therefore, LAIDS has been widely adopted since it was developed for its simplicity. However, the Stone index typically is not invariant to changes in units of measurement, which may seriously affect the approximation properties of the model. In addition, the budget share exists on both sides of the equation, which leads to a simultaneity problem. The most popular method is to use lagged budget share as an instrumental variable for budget share on the right side. This model will be used in the later empirical study. From the demand equation, elasticities can be calculated. Uncompensated price elasticity for LAIDS is calculated by the formula (Green and Alston 1990) :

$$\varepsilon_{ij}^{M} = -\delta_{ij} + \frac{r_{ij}}{w_i} - \beta_i \frac{w_j}{w_i}, \tag{26}$$

δ_{ij} is the Kronecker delta = 1 for = j and = 0 otherwise. w_i is the mean expenditure share across the sample for good *i*. The compensated price elasticity formula is:

$$\varepsilon_{ij}^{H} = \varepsilon_{ij}^{M} + \beta_i w_j = -\delta_{ij} + \frac{r_{ij}}{w_i} + w_j \tag{27}$$

The expenditure elasticity formula is:

$$\eta_i = 1 + \left(\frac{\beta_i}{w_i}\right) \tag{28}$$

The positive expenditure coefficient gives an expenditure elasticity greater than one, and a negative expenditure coefficient produces an expenditure elasticity less than one.

6.6 Quadratic Almost Ideal Demand System (QAIDS)

Bank, Blundell, and Lewbel (1997) developed the more flexible demand model QAIDS for income effect and welfare analysis of tax reform in the U.K. This model nests AIDS and makes it a special case. This model has all the properties of the AIDS model and adds more flexibility. As with AIDS, QAIDS is also derived from a PIGLOG indirect utility function. The demand model is defined as:

$$w_i = \alpha_i + \sum_j r_{ij} ln p_j + \beta_i \ln\left[\frac{m}{a(p)}\right] + \frac{\lambda_i}{b(p)}\left[ln\left(\frac{m}{a(p)}\right)\right]^2 \tag{29}$$

$a(p)$ and $b(p)$ are the same as in AIDS, $\sum_i \lambda_i = 0$ in addition to all constraints for AIDS. Demographic variables can be added in the intercepts. The elasticities can be derived through differentiation of the demand equation with log price and log income. Currently, this model is widely used for empirical analysis.

6.7 Challenges for Empirical Estimation

6.7.1 Large Number of Parameters

In a general demand model $q = D(p, m)$ with n commodities or goods. The parameters for price vector p will be n x n, and the parameter for m will be n. The larger the number of commodities in the model, the larger the number of parameters. It is difficult to estimate when n is large. When constraints are imposed, the number of parameters is reduced, but is still large. So, selecting the right functional form for the demand function, and the number of commodities in the model, is critical for empirical analysis.

6.7.2 Aggregation of Consumers

Consumer theory informs individual consumer behavior. In many circumstances, we have data at the aggregate consumer level, household level and market level. These are actually what we are interested in and want to estimate. Therefore, we need to have the right theory and model to estimate aggregate consumer demand using the theory for individual consumer behavior.

6.7.3 Endogeneity

In the general demand model, price and expenditure are considered exogenous. However, price and expenditure can be correlated with the error term and affected by consumer demand, especially for aggregate macro-level data. Therefore, there is a simultaneity problem in the demand model. An effective approach to fixing this problem is finding an instrumental variable for both.

7 Summary

Consumer theory is widely used for studies of industry organization, market power, and empirical consumer demand analysis. This chapter serves as the background and framework for the following chapters. The AIDS is adopted for the empirical study discussed below. In addition, price and expenditure endogeneity will be tested and analyzed. In the next chapter, a thorough literature review of current available studies of consumer demand for organic milk in the U.S. is reported.

Chapter Three: Literature Review for Organic Milk Demand in the U.S.

1 Introduction

A few studies on consumer demand for organic milk in the U.S. have been published. This chapter gives a comprehensive review of models, demographic factors, and elasticities used and estimated in these studies.

2 Econometric Models

Three econometric models are most common in previous studies: the almost ideal demand system (AIDS) model and its derivatives (Chang et al. 2011, Li, Peterson, and Tian 2012, Dhar and Foltz 2005, Glaser and Thompson 2000), the two-step model (Alviola and Capps 2010), and the mixed logit demand model (Chikasada 2008, Choi, Wohlgenant, and Zheng 2013).

3 Data Sources

Two types of data have been analyzed in organic milk demand model studies. One is Neilsen homescan data (Alviola and Capps 2010, Chikasada 2008, Choi, Wohlgenant, and Zheng 2013), and the other is time series data. Two types of time series data have been used. One is Nielsen national supermarket retail scan data (Glaser and Thompson 2000, Li, Peterson, and Tian 2012), and the other is regional supermarket retail scan data (Chang et al. 2011, Dhar and Foltz 2005). Different fat content (e.g., whole, 2% fat, 1% fat and skim/nonfat) organic fluid milk and their conventional milk counterparts are the subjects of these studies. To date and to my knowledge, no demand studies on other organic dairy products (e.g., cheese, butter, yogurt, etc.) have been published. Below is a summary of the methods and results of these empirical studies of organic milk demand.

4 Demographic Variables

4.1 Income

Income has a positive effect or no effect on organic fluid milk purchases according to several studies. Dimitri and Venezia (2007) found that income has a positive effect on organic fluid milk consumption. Alviola and Capps (2010) contended that organic fluid milk is income elastic and conventional milk consumption is income inelastic using the same Nielsen 2004 data. They also showed that families with higher incomes are more likely to buy organic milk than families with lower incomes. Chikasada (2008) found that the income effect on organic milk consumption is insignificant; however, the higher the income, the less organic and conventional milk are consumed (-0.040 for organic elasticity, and -0.054 for conventional). Chikasada also found that both low- and high-income families purchase organic fluid milk. The low-income families were reported to spend a higher percentage of their incomes on organic milk than high-income households. However, Choi et al. (2013) stated that there is no clear pattern between income and organic milk purchase behavior. In summary, one can conclude there is no uniform income effect on organic milk consumption.

4.2 Education

Education is positively related to organic fluid milk purchases. The higher the educational level of household heads, the more likely the household will purchase organic fluid milk (Alviola and Capps 2010, Choi, Wohlgenant, and Zheng 2013, Dimitri and Venezia 2007b).

4.3 Children and Household Size

Choi et al. (2013) found that households with children purchased more organic fluid milk compared to households with no children. Alviola and Capps (2010) reported similar results. The effect of household size on the quantity of organic milk purchased is less conclusive. Choi et al. (2013) found that households with fewer people purchase more organic milk. This contradicts Alviola and Capps's (2010) study, which showed that the larger the size of the household, the more the household buys organic milk, except for households with five or more people.

4.4 Age of Household Head

Choi et al. (2013) found that there is no clear relationship between the age of household heads and their organic milk purchasing behavior. However, Dimitri and Venezia suggested that younger household heads (<54) are more likely to purchase organic milk (Dimitri and Venezia 2007b).

4.5 Race and Ethnicity

Overall, whites buy more organic milk than others. Dimitri and Venezia (2007) reported that relative to other races, whites are more likely to consume organic milk. Alviola and Capps (2010) showed that white and oriental households purchase more organic milk than other races, and hispanic households buy more organic milk than non-hispanic families. Chikasada (2008) found that white households are 40-61% more likely to purchase organic milk than nonwhites.

4.6 Regions

Alviola and Capps (2010) found that consumers in the U.S. West are more likely to purchase organic milk than people in the East and Midwest, and consumers in the South buy the least. Dimitri and Venezia (2007) found consumers on the two coasts are more likely to purchase organic milk than consumers in the Central and Southern U.S. They said this might be a result of organic milk first being offered in coastal areas and later penetrating into the Central and Southern regions.

5 Elasticity

5.1 Own Price Elasticity

Most previous studies found that organic milk is more price sensitive than conventional milk (Alviola and Capps 2010, Glaser and Thompson 2000, Dhar and Foltz 2005, Li, Peterson, and Tian 2012, Dong and Stewart 2013a). Chikasda (2008) analyzed Nielsen homescan 2004 and 2005 data and found that the uncompensated price elasticity of organic milk is lower than for conventional milk (-1.033 vs -1.184), but the compensated price elasticity is higher for conventional milk in absolute value.

Li et al. (2012) showed that skim, 1%, 2%, and whole organic milk are significantly elastic to their own prices, while counterpart conventional milk is less own-price elastic based on Neilsen national retail weekly scan data from April 2008 to April 2010.

5.2 Cross -price Elasticity

All available studies showed asymmetric cross-price elasticity between organic milk and conventional milk. The organic milk purchase response to a conventional milk price increase was higher than the conventional milk purchase response to an organic milk price increase (Dhar and Foltz 2005, Choi, Wohlgenant, and Zheng 2013, Chikasada 2008, Li, Peterson, and Tian 2012). One of the explanations for the asymmetry was the large share of expenditure on conventional milk (Chikasada 2008), and the other was the structure of cross-price elasticities in the AIDS model (Glaser and Thompson 2000).

Li et al. (2012) showed that skim milk and 2% milk are substitutes for organic and conventional whole milk. Conventional 2% milk is also a substitute for four (skim, 1%, 2%, and whole) types of organic milk. Conventional 1% milk is a substitute for organic skim and 1% milk. Conventional whole milk is a substitute for organic whole and 2% milk. However, Choi et al. (2013) did not find any clear substitution patterns among products with different fat contents, either organic or conventional milk.

5.3 Expenditure Elasticity

Chikasada (2008) found that conventional and organic milk expenditure elasticities were 1.191 and -0.693. The negative expenditure elasticity for organic milk contradicts intuition. Glaser and Thompson (2000) showed negative expenditure elasticity for organic milk, too. The authors of both studies suggested this might be due to the small expenditure share for organic milk and the equation used to calculate the elasticity.

Li et al. (2012) found that expenditure elasticities for four types of organic milk (skim, 1%, 2%, and whole) were lower than the elasticities for their conventional milk counterparts. The elasticities for both organic and conventional milk were lower than one statistically, and they concluded that organic milk is a necessary good. Uncompensated and compensated price elasticities for organic milk with different fat content show little difference. This indicates that the income effect on organic milk consumption/expenditure is not significant. However, they found the income effect on conventional milk demand is more significant than for organic milk.

6 Summary

This chapter reviewed current available studies on organic milk demand in the U.S., describing econometric models, data sources, demographic variables, and price and expenditure elasticities. The results will be compared and contrasted in next chapter of this study.

Table 3. Summary of Previous Studies on Organic Milk Demand in the U.S.

Author(s)	Data	Model	Products	Own elasticity	Cross-elasticity	Expenditure elasticity	Demographic variables
Glaser and Thompson (2000)	Nielsen 1988-1996, IRI 1993-1999; National retail scanner data	Nonlinear AIDS	Branded and private, Org, Con, whole, 2%, 1%, nonfat/skim	Uncompensated for organic whole is -3.637, Org 2% -7.374, Org 1% -9.733, org nonfat -3.668	Branded whole to organic whole is 8.152; organic whole to branded whole is 0.162	Org whole, 2%, 1%, skim are -5.730, -2.836, -8.678, -2.807, respectively	No
Dhar and Foltz (2005)	1997-2002 IRI retail scanner data in 12 cities	QAID*	rBST-free and organic, conven-tional milk	Compensated organic -1.37, con -1.08, rBST free -4.40	Organic to con 3.15, con to org 0.02	Organic 0.50, rBST free 4.39, conventional 0.97	No
Chikasada (2008)	Nielsen homescan 2004, 2005	QML*, translog	Org* milk, Con* milk, Con cheese, Con yogurt/butter	Uncompensated -1.033 (org) -1.184 (con)	0.411, 0.399 (org, con) -0.054, -0.065 (con, org)	Con 1.191, Organic - 0.693	Income, size, college, female head, white
Alviola and Capps (2010)	Nielsen homescan 2004	Two-step Beckman model	Organic and conventional milk	Org -2.0046, Con -0.8729	Organic to conventional 0.7027, conventional to organic 0.1797	Income elasticity organic 0.2672, conventional -0.0135	Income, education, employment, number of children younger than 18, race and ethnicity, region
Chang (2011)	Retail scanner data from six stores of a national supermarket chain in Columbus OH 2006-2008	Nonlinear AIDS	Organic high fat (whole and 2%), organic low fat (1% and skim) and four kinds of Con milk	Organic high -0.941, organic low -0.802 in suburban	Organic high to organic low 0.406, organic high to conventional whole, 2% are 0.178 and 0.441.	Organic high 0.42, organic low 0.511 in suburban	Income, education, and race
Li, Peterson, and Xia (2012)	Nielsen April 2008 to April 2010 weekly retail scan data	LA/AIDS	Whole, 2%, 1%, skim Org and Con	Organic -1.598, -1.320, -1.149, -1.046 for organic skim , 1%, 2%, and whole milk;-0.585, -1.319, -1.022, -0.861 for conventional milk (compensated)	Conventional to organic is higher than organic to conventional	Organic: 0.871, 0.854, 0.726, 0.706 for skim, 1%, 2%, and whole, respectively; Conventional: 0.998, 1.069, 1.044, 1.061 for skim, 1%, 2%, and whole, respectively	No
Choi (2013)	Nielsen homescan data in RDU* of 2005	Hausman's three-stage demand system	20 groups by fat, flavor and organic, soy milk is also included	Organic reduced fat −2.052	Organic RF* to private conventional RF 0.064 [a]	No report	No

QML: Quadratic maximum likelihood; Org: Organic; Con: conventional; OB: organic branded: OPL: organic private label; CB: conventional branded; CPL: conventional private; RDU: Raleigh Durham Chapel; RF: reduced fat; QAID: Quadratic Almost Ideal Demand. a: multiple cross-elasticities were reported, but only one is reported here.

Chapter Four: A Vector Error Correction Almost Ideal Demand Model for Organic Milk in the USA

1 Introduction

All participants in a supply chain are associated with final consumer demand, which is the ultimate driving force for the entire industry. Factors shifting consumer demand at the retail level affect derived demand at all levels of the supply chain. Total organic dairy sales were about 14% of organic food sales in 2014, only second to organic fruit and vegetables (Organic Trade Association 2015). Compared with conventional fluid milk, organic fluid milk sales have grown at a rate of more than 10% per year since 2006 vs. flat or declining conventional milk sales growth.[3] There is little published work on organic milk demand and factors affecting demand in the U.S.

The majority of studies in the U.S. about organic milk demand models use Neilsen homescan data. Two of them use 2004 data (Alviola and Capps 2010, Chikasada 2008). The USDA National Organic Program was promulgated in October 2002. As of 2004, organic milk consumers were still unfamiliar with new labeling and regulations. Two national organic fluid milk brands totaled 80% of the market share in 2004 (Dimitri and Venezia 2007b). Since then, private label organic milk sales have increased dramatically.[4]

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[3] Calculated using AMS-USDA, Federal Milk Market Order statistics, www.ams.usda.gov.

[4] http://www.nodpa.com/payprice_update_02062013.shtml

More than 100 local, regional, and store brands of organic milk have emerged[5]. Organic food is now sold in almost all traditional venues. The variety of organic milk also has increased. Flavored organic milk and DHA-fortified organic milk are two examples. The market for organic milk is maturing. Consumer preference and taste may also change with time. These factors can have a profound effect on consumer purchasing behavior. The most recent data among these studies are from 2010 (Li, Peterson, and Tian 2012). Therefore, it is necessary to provide an update on the status of consumer demand for organic milk.

Three studies (Chang et al. 2011, Glaser and Thompson 2000, Li, Peterson, and Tian 2012) have used time series data to consider habit formation, but they do not consider the time series properties of the data. Although the ordinary least square (OLS) estimator of time series data is consistent, the inference of the estimators will be invalid if the data are not cointegrated. This is because the OLS technique requires that the error term is variance-covariance stationary, autocovariance is finite and do not change over time. Cointegration provides a framework for nonstationary time series data.

There are two problems with the datasets used in previous studies. The first is that household survey data exclude consumption outside the home and consumption at school. The second is most of these studies use data from one specific year. The homescan data representing one year cannot provide time varying variables such as income and changes in consumer preferences and taste. A few studies used retail scanner time series data, but

[5] Organic Dairy Report - Cornucopia Institute, http://www.cornucopia.org/dairysurvey/Ratings_Alphabetical.html

these data are either regional or lack demographic variables (Chang et al. 2011, Li, Peterson, and Tian 2012).

The objective of this study is to consider the long-run relationship of organic milk price and consumption and provide both short-run and long-run information for organic milk demand in the U.S. The study uses aggregate national data to include all possible consumption. In addition, this study also includes time series techniques to analyze the data. It contributes to the literature by providing a new econometric model for organic milk analysis. In addition, it adds price and expenditure endogeneity analysis and the effects of consumption patterns to the literature.

2 Vector Error Correction Model (VECM) Almost Ideal Demand System (AIDS)

Among all the empirical models for demand analysis, AIDS has been the most popular one since it was developed (Karagiannis, Katranidis, and Velentzas 2000). In the following study, two-stage budget and separability are assumed instead of a formal test. When Deaton and Muellbauer and other scholars estimated consumer demand with the AIDS model, they assumed that the error terms were uncorrelated and normally distributed. This assumption can be a problem in time series data because of the nonstationarity of the series, i.e., the covariance of a series changes over time. In fact, many time series data are first-difference covariance stationary instead of level stationary. The first-difference covariance stationary series is said to be integrated at order one, I(1) process. One popular method for regressing nonstationary data is to use the first difference. However, if the time series are cointegrated, the simple first difference will misspecify the model. Two variables are cointegrated if each is an I(1) process, but a linear combination of them is an I(0) process. For example:

$$y_t = a + x_t + \mu_t, \qquad y_t \; and \;\; x_t \; are \; \text{I(1) processes}$$

$$\mu_t = y_t - a - x_t, \mu_t \text{ is a I(0) process. } y_t \; and \; x_t \text{ are cointegrated.}$$

In addition, the regular AIDS model only considers the static aspect or long-run relationship of the demand system. In order to address the time series properties of the data and add dynamic aspects of demand, Vector Error Correction Model was applied to empirical demand analysis inside and outside the U.S. by many scholars (Karagiannis, Katranidis, and Velentzas 2000, Wang and Bessler 2003, Eakins and Gallagher 2003, Balcombe and Davis 1996, Fanelli and Mazzocchi 2002).

The Vector Error Correction Model (VECM) adds a short-run dynamic aspect to the long-run equilibrium relationship. By including an error correction term in the model, VECM incorporates the mechanism of short-run adjustment of consumption to move short-run disequilibrium back to long-run equilibrium. This model includes a unit root test, cointegration test and then VECM modeling. The Augmented Dickey Fuller test (ADF) is used in this study to test the unit root. The estimated regression of ADF is specified as:

$$\Delta Y_t = \alpha + \delta t + \rho Y_{t-1} + \sum_{i=1}^{p} \varphi_i \Delta Y_{t-i} + u_i$$

Where Y_t is a random variable with no zero mean, ΔY_t is the first difference of Y_t, α is the constant, t is a time trend, μ is the error term with iid (0, σ^2) distribution. The null hypothesis is that the time series is nonstationary and $\rho = 1$. The alternative hypothesis is the time series is stationary. Under the null hypothesis, the test statistic has a Dickey Fuller distribution. Nonstationary time series is differenced until they are stationary and the degree of integration is determined by the times of difference.

If the three time series - budget share, prices, and expenditure are integrated at the same degree(s), Johansens' maximum likelihood cointegration test is used to test the cointegration of the series. The cointegration represents the long-term relationship between price, expenditure and budget share in the demand model. The null hypothesis is that the series are not cointegrated.

The traditional almost ideal demand system uses simultaneous price and expenditure data with budget share. This is considered as long-term effect. In the long run, there is an equilibrium between price, expenditure and budget share. In the short run, due to asymmetric information, transaction costs and persistence of consumption patterns, adjustment of consumption to price and income changes requires a period of time, which makes consumption deviate from the long-run equilibrium. This is called short-run disequilibrium. The static model does not include dynamic short-run adjustment in the model specification. The dynamic model solves this problem by including short-run adjustment in the model using the VECM. A vector error correction model is specified as:

$$\Delta Y_t = c + \alpha' \beta (Y_{t-1}) + \sum_j \emptyset_j \, \Delta Y_{t-j} + \varepsilon_t$$

Where β is the cointegrating vector, c is constant, α and ∅ are coefficients. ε_t is the error term with identical and independent distribution. $\beta(Y_{t-1})$ is the error term and is estimated by the lagged residual of the OLS regression of the static demand equations. Due to the nonlinear property of AIDS, LAIDS is used in the VECM. The VECM LAIDS is defined as:

$$\Delta w_i = \delta'_i \vartheta(w_{it-1}) + \sum_j r_{ij}\,\Delta lnp_j + \beta_i \Delta \ln\left(\frac{M}{P^*}\right) + \varepsilon_i$$

Or

$$\Delta w_i = \theta_i \Delta w_{it-k} + \delta'(\mu_{it-1}) + \sum_j r_{ij}\,\Delta lnp_j + \beta_i \Delta \ln\left(\frac{M}{P^*}\right) + \varepsilon_i$$

The same economic constraints as in AIDS are applicable to the VECM AIDS.

$$\sum_i r_{ij} = \sum_i \beta_i = 0 = \sum_i \theta_i = 0 = \sum_i \delta_i = 0$$

$$\sum_j r_{ij} = 0 \; and \; r_{ij} = r_{ji}\,, \forall i, j \; i \neq j$$

The uncompensated and compensated price elasticities and expenditure elasticities are calculated by the following formula:

$$\varepsilon_{ij}^{M} = -\delta_{ij} + \frac{r_{ij}}{w_i} - \beta_i \frac{w_j}{w_i},$$

$$\varepsilon_{ij}^{H} = \varepsilon_{ij}^{M} + \beta_i w_j = -\delta_{ij} + \frac{r_{ij}}{w_i} + w_j$$

$$\eta_i = 1 + (\frac{\beta_i}{w_i})$$

The consumption of milk is heavily affected by habit. Lagged budget shares in the dynamic equation reflect the dynamic behavior of consumption and the short-term effect. The error term μ_{it-1} is a disequilibrium error from the long-run equilibrium. The coefficient of the error term is expected to be negative and indicates that the short-term adjustment of consumption will return to the long-run relationship. The lower the coefficient, the slower the correction returns to the long-run equilibrium and the stronger the habit effect. θ and δ represent the short-run dynamic of the demand system. The model is estimated using an iterated seemingly unrelated regression procedure in Stata version 13.

3 Hypotheses and Expected Signs of Coefficients

Based on previous studies and my literature review, I expected the following results for the empirical study:

Proposal 1: Demand for conventional whole and reduced fat fluid milk is price inelastic; Demand for organic fluid milk is price elastic.

Proposal 2: Demand for conventional whole and reduced fat fluid milk is expenditure inelastic and their elasticities are less than one; demand for organic fluid milk is expenditure elastic and its elasticity is greater than one.

Proposal 3: In the short run, consumers adjust their consumption patterns to converge upon their long-run equilibrium. The coefficients of the vector error correction term are negative for all types of milk.

Proposal 4: Consumption pattern or habit has a positive effect on milk consumption. The lagged budget shares represent the consumption pattern and their expected signs are positive.

Table 4. Expected Signs of Coefficients and Elasticities of Fluid Demand Models

	Total Expenditure	Vector Error Correction	Habit
w1	-	-	+
w2	-	-	+
w3	+	-	+

Elasticity

	ConWhole Price	ConRed Price	Organic Price	Expenditure
ConWhole	-, >-1	+	+	+, <1
ConRed	+	-, >-1	+	+, <1
Organic	+	+	-, <-1	+, >1

w1: Budget share of conventional whole fluid milk; w2: Budget share of conventional reduced fat fluid milk; w3: Budget share of organic fluid milk

ConWhole: Conventional whole fluid milk

ConRed: Conventional reduced fat fluid milk

4 Data

This study focuses on organic and conventional fluid milk consumption in the U.S., because the majority of organic milk is consumed as fluid milk (about 70%). The data used in this study are aggregate monthly sales and prices for organic fluid milk as a whole and conventional whole and reduced fat fluid milk (2%, 1%, and skim) over the period 2006-2013. The reason for combining organic fluid milk as a whole is that the prices of organic whole and organic reduced fat milk were almost the same in the study period. The data are available from the Agricultural Marketing Service (AMS) of the USDA. Monthly U.S. population data were downloaded from the U.S. Census Bureau. Per capita consumption data were calculated by dividing total sales by population. The real prices were average prices across the U.S. The expenditure on each type of milk was calculated by multiplying the real retail price by quantity consumed. Two-step budgets were assumed in the model, and separability was also assumed in the model. The budget share was calculated by dividing the real expenditure on each good by the total expenditure on three types of fluid milk. The descriptive statistics for the data are provided in Table 5.

Table 5. Descriptive Monthly Statistics of Conventional and Organic Fluid Milk Consumption in the U.S.

Variable	Description	Mean	Standard Deviation	Min	Max
p1	Retail price of conventional whole milk (dollar/half gallon)	1.705	0.137	1.489	1.980
p2	Retail price of conventional reduced fat milk (dollar/half gallon)	1.693	0.126	1.445	1.92
p3	Retail price of organic milk (dollar/half gallon)	3.877	0.300	3.41	4.7
v1	Conventional whole milk consumption (lbs./person	4.126	0.417	3.410	5.026
v2	Conventional reduced fat milk consumption (lbs./person)	9.890	0.592	8.090	10.924
v3	Organic milk consumption (lbs./person)	0.474	0.099	0.222	0.627
x1	Expenditure for conventional whole milk (dollar)	1.632	0.183	1.379	2.053
x2	Expenditure for conventional reduced fat milk (dollar)	3.890	0.347	3.222	4.699
x3	Expenditure for organic milk (dollar)	0.422	0.022	0.054	0.153
X	Expenditure for all milk (dollar)	5.945	0.500	5.105	7.178
w1	Budget share for conventional whole milk	0.274	0.019	0.243	0.327
w2	Budget share for conventional reduced fat milk	0.654	0.012	0.619	0.675
w3	Budget share for organic milk	0.071	0.012	0.041	0.092

The descriptive statistics (Table 5) indicate that the average retail price of organic fluid milk is more than two times that of conventional fluid milk during the study period. The prices of conventional whole and reduced fat fluid milk are very close to each other and the difference of their averages is less than two cents. The consumption of organic milk is very low, only 3.3% of total fluid milk. These data support the study with household scan data, 3% in 2007-2008 (Dong and Stewart 2013b). The consumption of reduced fat conventional fluid milk is the highest and reaches 68% of total fluid milk consumption. Regarding budget share, expenditure on organic fluid milk is 7% of total expenditure, while conventional fluid milk accounts for 93%. Average total monthly fluid milk consumption is 14 pounds (1.68 gallon; one gallon of milk equals 8.6 pounds) per capita, which costs about six dollars on average.

The retail prices of organic fluid milk show an overall decreasing trend in the study period, but the retail prices of conventional milk show slight overall increasing trends (Figure 11). The log retail prices of conventional and organic fluid milk appear nonstationary, but the first differences of the log prices look stationary. Figure 12 shows that the budget share of conventional whole milk decreased, but the budget shares of conventional reduced fat and organic milk increased from 2006 to 2013. According to Engel’s law, goods with an expenditure elasticity between zero and one will have decreasing budget share if income rises, and are known as necessary goods. Luxury goods have an expenditure elasticity greater than one and an increasing budget share as income rises. The level data of budget shares looks nonstationary, but the first differences in Figure 12 appear to be stationary. This is the same case for the log real expenditure on milk, nonstationary at the level, but stationary at the first difference (Figure 13). The real expenditure on milk has an overall decreasing trend.

Figure 11. Level and First Difference of Log Retail Prices of Organic and Conventional Fluid Milk

Monthly Data 2006-2013

Lnp1is log of retail price of conventional whole fluid milk

lnp2 is log of retail price of conventional reduced fat fluid milk

lnp3 is log of retail price of organic fluid milk

The left side of the figure is the level data of the log price, and the right side is the first difference of the log price.

Data were downloaded from AMS of USDA.

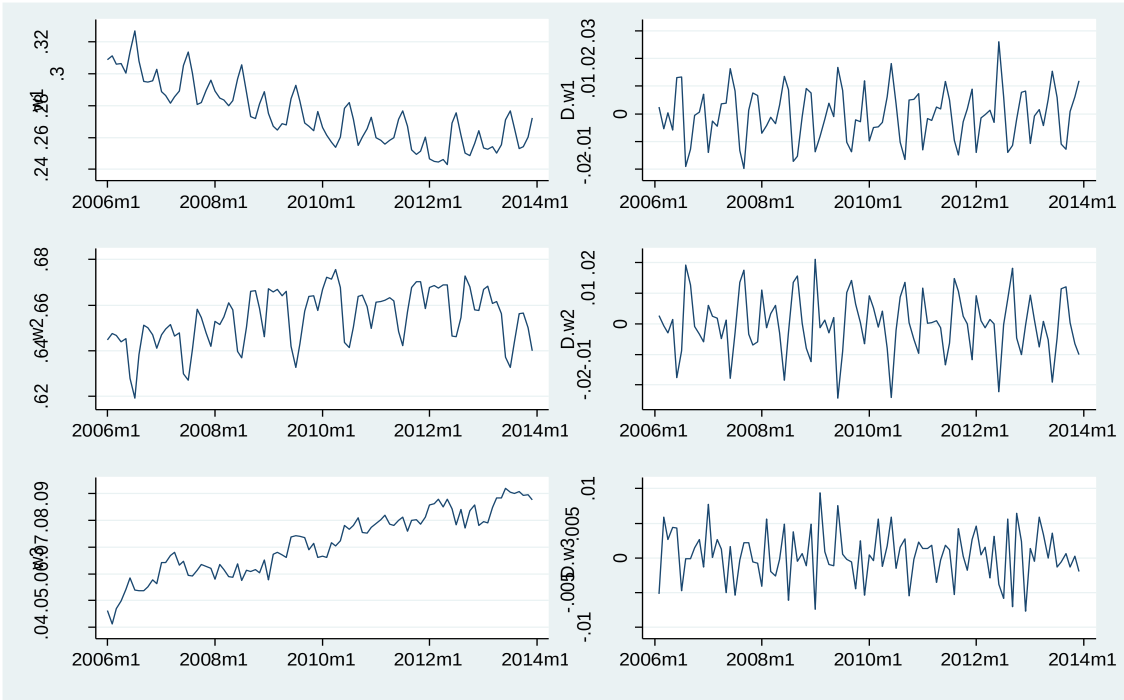

Figure 12. Level and First Difference of Budget Shares of Conventional and Organic Fluid Milk Monthly Data 2006-2013

w1 is the budget share for conventional whole milk

w2 is the budget share for conventional reduced fat milk

w3 is the budget share for organic milk

Left side is the level data and right side is the first difference of budget share.

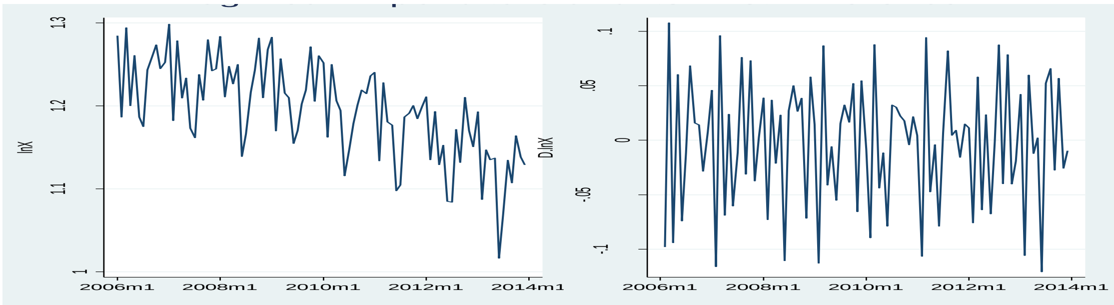

Figure 13. Level and First Difference of Log Real Expenditure on Conventional and Organic Fluid Milk Monthly Data 2006-2013

Left is the log of real expenditure and the right is the first difference of real expenditure for all three types of milk.

Price and budget share show clear seasonality. Since the data used in the study are monthly, 11 monthly dummies are included in the model. In addition, the economic recession in 2008-2009 was marked by a decrease in the consumption of organic milk. A year dummy 2009 also is included in the model to represent the macroeconomic shock. However, there were no significant effects from the monthly dummies and the year shock. So these dummy variables were removed in the final models.

5 Endogeneity of Prices and Expenditure

5.1 Endogenous Prices

In the original AIDS model, prices and expenditure are assumed to be exogenous. However, due to aggregation of the data in this study, the price of each type of fluid milk can be correlated with the error term in the demand equation. Under certain cases, prices can be treated as exogenous if the prices of the products are relatively rigid or stable and unresponsive to shocks (Duffy 2003). Previous studies show that price in an oligopolistic market can be exogenous (Azzam 1999, Nakamura and Steinsson 2013). Stable prices are a characteristic of an oligopolistic market or imperfect market structure (Nakamura and Steinsson 2013). In the case of the organic dairy market, there are only two national organic fluid milk producers. So the market structure is a duopoly. Therefore, the retail price of organic milk could be exogenous. Although conventional milk has a relatively competitive market structure, the retail price of conventional milk is not competitive due to the oligopolistic power of retailers (Chidmi, Lopez, and Cotterill 2005, Carman and Sexton 2005). The retail price of conventional milk is relatively stable and has a delayed response to the farm price (Lass 2005). Therefore, the prices of the three types of fluid milk in the model could be exogenous due to the market structure and retailers' market power.

One way to address endogeneity is to use an instrumental variable properly. This requires the instrumental variable to closely correlate with the endogenous variable, but be uncorrelated with the dependent variable and the error term. One of the popular instrumental variables for time series data is the lagged independent variable, which can be uncorrelated with the error term. Endogeneity can be tested with the Hausmen specification test. The Hausman test statistic is defined as:

$$H = (\theta^* - \theta)'(var(\theta^*) - var(\theta))(\theta^* - \theta)$$

The test statistic has a Chi square distribution with the degrees of freedom equal to the number of unknown parameters in θ. However, it is difficult to find a correct instrumental variable correlating highly to an endogenous variable but not to the dependent variable.

Another problem related to the instrumental variable is weak instrument, where the instrumental variable is weakly correlated to the endogenous variable. One way to measure the weak instrument is the F-statistic in first-stage regression. If the F-statistic is over 10, the instrumental variable is not considered to be a weak instrument (Wooldridge 2012).

5.2 Endogeneity of Group Expenditure

In the original AIDS model, expenditure is assumed to be exogenous. In this case, the expenditure in the system is unrelated to or unresponsive to prices of the interested goods. This could be a problem when the expenditure on group products is affected by demand behavior, or some unobservable factors affecting both expenditure and consumer demand. The endogeneity of expenditure can lead to an inconsistent and biased estimator (Thompson 2004, Dhar, Chavas, and Gould 2003, LaFrance 1991). To account for the endogeneity of the expenditure, a few strategies have been attempted by researchers. The first one is to apply an instrumental variable, and the other is to include an explicit expenditure function. In this study, the first strategy is adopted.

6 Unit Root and Cointegration Test

6.1 Unit Root Test Results

The Augmented Dickey Fuller (ADF) test is used for the unit root test. Constant and trend are included. The results show that all the series are nonstationary at level and stationary at the first difference (Table 6 and Table 7). So the next step is to test the cointegration of the series with Johansen tests.

Table 6. Augmented Dickey Fuller Unit Root Test Results for Time Series

Variables	Label	Test statistics	Lag	p value	Unit root
Dependent variables					
w1	Budget share for conventional whole milk	-2.8	3	0.188	Yes
w2	Budget share for conventional reduced fat milk	-3.1	3	0.103	Yes
w3	Budget share for organic milk	-3.05	2	0.117	Yes
Independent variables					
Lnp1	Log price of conventional whole milk	-2.23	2	0.471	Yes
Lnp2	Log price of conventional reduced fat milk	-2.36	2	0.398	Yes
Lnp3	Log price of organic whole milk	-2.75	1	0.214	Yes
LnX	Log real expenditure of all milk	-2.33	2	0.417	Yes

The critical values are -4.055, -3.457, and -3.154 for significance levels of 1%, 5%, and 10%, respectively, with trend and constant. The null hypothesis of the ADF test is that the series have a unit root. The results show that all series fail to reject the null hypothesis and the appropriate conclusion is that there is a unit root in each of the series.

Table 7. Augmented Dickey Fuller Unit Root Test Results for First Difference of Time Series

Variables	Label	Test statistics	Lag	p value	Unit root
Dependent variables					
Dw1	First difference of budget share for conventional whole milk	-7.70	4	0.0000	No
Dw2	First difference of budget share for conventional reduced fat milk	-9.33	2	0.0000	No
Dw3	First difference of budget share for organic milk	-8.29	1	0.0000	No
Independent variable					
DLnp1	First difference of log price of conventional whole milk	-5.14	1	0.0001	No
DLnp2	First difference of log price of conventional reduced fat milk	-4.31	1	0.0030	No
DLnp3	First difference of log price of organic milk	-5.63	1	0.0000	No
DLnX	First difference of log real expenditure on all milk	-8.306	1	0.0000	No

The critical values are -4.055, -3.457, and -3.154 for significance level of 1%, 5%, and 10%, respectively, with trend and constant. The null hypothesis of the ADF test is that the series have unit root. The results show that all series reject the null hypothesis and the appropriate conclusion is that there is no unit root in any of the series.

6.2 Cointegration Test Results

The lag selection procedure for the cointegration test is done using information criteria provided in Stata software. Three lags are selected for conventional milk budget share (w1), two lags are selected for conventional reduced milk budget share (w2) and organic milk budget share (w3). The results are shown in Table 8. The results show that all three budget shares are cointegrated with log prices and log real expenditure, with ranks one and two.

Table 8. Johansen Tests for Cointegration of the Time Series

	Lags	Rank	Eigen Value	Trace statistics	5% critical value
Without trend					
w1	3	1	0.42	67.76*	68.52
w2	2	1	0.43	25.86*	47.21
w3	2	2	0.33	31.45*	47.21
With trend					
w1	3	1	0.42	71.10*	77.74
w2	2	1	0.46	58.38*	68.52
w3	2	2	0.33	31.45*	47.21

* Significant at the 5% level. The null hypothesis of the Johansen test is that the series are not conintegrated.

Notes: The conintegration test among the variables budget share, prices of conventional and organic milk, and real expenditure are performed in Stata. When rank = 1, the null hypothesis is that the variables are cointegrated with one linear relationship. When we fail to reject the null hypothesis, we say that the variables are conintegrated and there is one linear relationship among them. The variables have a long-run relationship and we can run a cointegrated vector error correction model.

7 Empirical Results for Demand Models and Discussion

7.1 Static Estimation

First, the linear AIDS model without constraints is estimated and the homogeneity and symmetry constraints are tested. The results are shown in Table 9. In this estimation, the conventional whole milk equation is dropped to meet the adding up constraint. The coefficients for conventional reduced fat milk are all significant at 5%, but none of the coefficients for organic milk are significant at the 5% level. The coefficient of expenditure on conventional reduced fat milk is positive and significant. A positive expenditure coefficient means conventional reduced fat milk is a luxury good, while the expenditure coefficients of conventional whole milk and organic milk are negative.

Table 9. Estimated Parameters of Static LAIDS for Fluid Milk Demand in the U.S.

	lnp1	lnp2	lnp3	lnX	Constant	Trend
w1	-0.331	-0.608	-1.099	-0.130	0.642	-0.069
w2	0.286*	0.541**	0.924*	0.142**	0.336**	0.026**
t value	2.10	3.16	2.74	6.91	5.90	4.84
w3	0.045	0.067	0.175	-0.012	0.022	0.043**
t value	0.80	0.94	1.25	-1.40	0.94	18.91

The model is estimated without homogeneity and symmetry restriction. Equation one conventional milk demand is dropped in estimation to meet the adding up constraint.
w1: Budget share for conventional whole milk; w2: Budget share for conventional reduced fat milk; w3: Budget share for organic milk
Lnp1 is the log retail price of conventional milk; lnp2 is the log retail price of conventional reduced fat milk and lnp3 is the log retail price of organic milk; lnX is the real expenditure
** Significant at the 1% level; * Significant at the 5% level

The homogeneity and symmetry of each demand equation are tested with the Wald test adopted from the previous study (Karagiannis, Katranidis, and Velentzas 2000). Homogeneity requires the sum of coefficients of all prices to be equal to zero, i.e., $\sum_j r_{ij} = 0$ $(i = 1\ to\ 3, j = 1,2,3)$. The Wald statistic has a Chi square distribution with degrees of freedom equal to the number of restrictions. The homogeneity condition represents the absence of money illusion. The null hypothesis is that the equation is homogenous and symmetric. The results (Table 10) show that only the organic milk demand equation meets the homogeneity constraint (with a *p* value greater than 0.05). The other two equations are rejected for homogeneity in the static model. The symmetry is required by the Slutsky equation. However, the symmetry condition is rejected in all three equations.

Table 10. Homogeneity and Symmetry Test of Static LAIDS Model

	Homogeneity test	Symmetry test
w1 equation (*p*)	0.001	0.0016 (w1 w2)
Chi(2)	10.75	9.91
w2 equation (*p*)	0.005	0.017 (w2 w3)
Chi(2)	7.77	5.68
w3 equation (*p*)	0.27	0.001 (w1 w3)**
Chi(2)	1.22	10.8

The null hypothesis is that the equation is homogenous and symmetric. The test was done with the Wald test.

Chi(2) means the value of the Wald test with two degrees of freedom, because this is a system with three equations; (w1, w2) means the symmetry of equations of conventional whole and reduced fat milk; (w2, w3) is conventional reduced fat with organic milk; (w1, w3) is conventional whole and organic milk;
(*p*) is the p value of the test.

The linear AIDS model with constraints is also estimated. The results are shown in Table 11. Compared to the unrestricted model, the values of all coefficients decrease. Only two parameters, organic milk price in the organic milk demand equation and real expenditure in the reduced fat milk equation, are significant at the 5% level.

Deaton and Muellbauer (1980) and Duffy (2003) pointed out that one of the reasons that theoretic constraints are rejected is due to the misspecification of a dynamic model in a static one. So, the next step is to build a dynamic model to incorporate long- and short-run effects.

Table 11 Estimated Parameters of Constrained Static LAIDS for Milk in the U.S.

	lnp1	lnp2	lnp3	lnX	Constant	Trend
w1	0.077	-0069	-0.007	-0.139	0.484	-0.075
w2	-0.069	0.084	-0.014	0.150**	0.472**	0.032**
t value	-1.43	1.54	-0.36	7.07	5.80	6.18
w3	-0.007	-0.014	0.022**	-0.011	0.045**	0.044**
t value	-0.68	-0.36	4.24	-1.26	3.80	20.27

With homogeneity and symmetry restricted.
Equation one, conventional milk demand, is dropped for estimation.
w1: budget share for conventional whole milk; w2: budget share for conventional reduced fat milk; w3: budget share for organic milk;
Lnp1 is the log price of conventional milk; lnp2 is the log price of conventional reduced fat milk and lnp3 is the log price of organic milk; lnX is the real expenditure
** Significant at the 1% level

7.2 Dynamic Estimation with Vector Error Correction Model

Time plays an important factor in demand analysis since consumer preference, price and income (expenditure on milk) are subject to change with time. In the dynamic model, two lagged budget shares are included to represent habit persistence (the number of lags is determined by the information criteria in Stata). The error correction term is estimated from the lagged residual of Ordinary Least Square (OLS) regression of the static demand system, because the coefficients of OLS are consistent.

Initially, the unrestricted dynamic model is estimated and the results are shown in Table 12. The coefficients of lags of budget share, total real expenditure, and the error correction term in the conventional reduced fat milk model are all significant at the 5% level. The expenditure has the same positive sign as in the static model without constraints, but smaller, 0.08 vs. 0.148. The lagged budget share has a large coefficient and is positive. In the organic milk equation, only the error correction term is significant. The error correction terms in both organic milk and conventional reduced fat milk have the expected negative sign. The error correction term represents the short-run consumption adjustment of consumer demand to the long-term equilibrium. The larger the coefficient, the faster short-term disequilibrium converts to long-term equilibrium.

Table 12. Estimated Parameters of Unrestricted VECM LAIDS for Fluid Milk in the U.S.

	dlnp1	dlnp2	dlnp3	dlnX	L1dw	L2dw	EC
dw1	0.153	-0.246	-0.165	-0.073	-0.245	0.179	0.927
dw2	-0.217	0.175	-0.081	0.080**	0.402**	-0.182*	-0.578**
SE	0.161	0.163	0.355	0.012	0.067	0.072	0.089
t value	-1.34	1.07	-0.23	6.92	6.03	-2.51	-6.48
dw3	0.064	0.072	0.247	-0.007	-0.157	0.003	-0.348**
SE	0.070	0.071	0.152	0.005	0.088	0.078	0.090
t value	0.91	1.01	1.62	-1.46	-1.8	0.04	-3.88

d = first difference; L1 = one lag; L2 = two lags; EC = error correction term
* Significant at 5% level; ** Significant at 1% level
Equation one, conventional whole milk, is dropped for estimation
w1: budget share for conventional whole milk; w2: budget share for conventional reduced fat milk; w3: budget share for organic milk;
Lnp1 is the log price of conventional milk; lnp2 is the log price of conventional reduced fat milk and lnp3 is the log price of organic milk; lnX is the real expenditure
The intercept was omitted due to space limitations.

Homogeneity and symmetry are tested with the Wald test. All three budget share equations are homogenous and the cross-coefficients are symmetric in the system (Table 13). The results are very different from the results from the static model. Adding the dynamic component changes the property of the equation.

Table 13. Homogeneity and Symmetry Test of VECM-LAIDS for Fluid Milk in the U.S.

	Homogeneity test	Symmetry test
w1 equation (*p*)	0.2442	0.5023 (w1 w3)
Chi(2)	1.36	0.45
w2 equation (*p*)	0.6255	0.333 (w1 w2)
Chi(2)	0.24	0.94
w3 equation (*p*)	0.6746	0.6910 (w2 w3)
Chi(2)	0.18	0.16

The null hypothesis is the equation is homogenous and symmetric. The test was done with the Wald test. Chi(2) means the value of the Wald test with two degrees of freedom, because this is a system with three equations; (w1, w2) means the symmetry of equations of conventional whole and reduced fat milk; (w2, w3) is conventional reduced fat with organic milk; (w1, w3) is conventional whole and organic milk;
(*p*) is the p value of the test.

The next step is to estimate a restricted model. In the restricted dynamic model (Table 14), most coefficients are significant at the 5% level. This is a significant improvement over the unrestricted model. The own price for conventional reduced fat and organic milk are significant at the 5% level, but only the expenditure coefficient of conventional reduced fat milk is significant at the 1% level. The first lags of budget shares are significant. The error correction terms in the organic milk and conventional reduced fat milk demand equations have the expected negative sign and are significant. Conventional whole milk has a positive sign for the error correction term. This is due to the adding up constraint. The signs of the own prices in all three equations are positive, as expected. Compared with the static model, the own prices have the same sign, but the coefficients in the dynamic model are larger than those in the static model.

From the perspective of demand function properties – homogeneity, symmetry, and the significance of coefficients – the dynamic model is better than the static model. The dynamic model without constraints is homogenous and symmetric. In terms of the significance of the coefficients, the constrained model is better than the unconstrained model. The next step is to consider the endogeneity of price and expenditure.

7.3 Dynamic Model with Instrument Variables

The lagged prices are first adopted as an instrument for endogenous prices. However, the Hausmen-Wu test fails to reject the null hypothesis that the three prices are exogenous. The partial R^2 of the lagged endogenous variables in the first-stage regression is around 50%, and the partial F-statistic is about 25 (the F-statistic is > 10 for the standard). So this is not a weak instrument.

The second possible instrumental variable for the organic milk retail price is the price of organic feed, which is closely related to the retail price, but not to consumer demand. However, the data are not available. Therefore, the organic egg price is adopted as the instrument of organic milk price. The Hausmen-Wu test shows that the hypothesis that the organic milk price is exogenous is rejected at the 1% level. The F-statistic for the first stage is 15 and the first stage partial R^2 is 14%, which is relatively small. The instrumental variable only weakly correlates with the endogenous variable. The instrumental variables used for conventional milk are the U.S. monthly feed corn price and sorghum price. However, these two instrumental variables have very low correlation with the endogenous variables and are weak instruments. Weak instrumental variables also can lead to inconsistent and biased estimators. Based on the last two tests and the market structure and pricing strategy of the industry, exogenous prices are assumed in the study.

In the test of endogeneity of group expenditure, real disposable income is selected as an instrumental variable. The results show that the null hypothesis, i.e., expenditure is exogenous, is rejected, and the null hypothesis that instruments are weak is also rejected. The partial F-statistic is 22 and significant at the 5% level. Therefore, income deflated with the price index is used as an instrument for group expenditure.

The right side of Table 14 shows the regression results for the dynamic model with income as an instrumental variable for expenditure. In the model, almost all coefficients decreased compared with the model without the instrumental variable. An important difference is that the signs for expenditure change to their opposite signs. In the conventional reduced fat milk equation, the coefficient of expenditure changes from significant positive to insignificant negative. In the organic milk equation, the coefficient of expenditure changes from insignificant negative to significant positive. Based on this model, organic milk is a luxury good and conventional reduced fat is a necessary good. However, the previous month's consumption difference has a negative effect on the budget share of organic milk, but is positive for conventional reduced fat milk. The negative sign of lagged budget share does not make sense for organic milk consumption, because our consumption habit persists and pervious-period consumption affects the next period positively. The coefficients of the error terms for organic and conventional reduced fat milk have the expected negative sign, and show little change (-0.329 to -0.340) in the organic milk equation from the model without the instrumental variable. In the conventional reduced milk equation, prices of conventional whole and reduced fat milk are significant, but the price of organic milk is not significant. This makes sense if consumers only purchase conventional milk, because organic milk is not in the purchase basket. In the organic milk equation, prices of conventional milk are not significant. This is reasonable if consumers only purchase organic milk. For consumers who only purchase organic milk occasionally, the price difference between organic milk and conventional milk affects their purchase decision. The larger this price difference, the less likely that consumers will purchase organic milk.

Table 14 Estimated Parameters of Restricted VECM LAIDS for Fluid Milk Demand in the U.S.

	VECM-AIDS							VECM-AIDS with instrument						
	dlnp1	dlnp2	dlnp3	dlnX	L1dw	L2dw	EC	dlnp1	dlnp2	dlnp3	dlnX	L1dw	L2dw	EC
dw1	0.213	-0.186	-0.027	-0.072	-0.223	0.194	0.901	0.254	-0.215	-0.039	-0.017	-0.150	0.253	0.778
dw2	-0.186*	0.203**	-0.017	0.080**	0.404**	-0.183*	-0.572*	-0.215*	0.202*	0.014	-0.055	0.315**	-0.244*	-0.439**
SE	0.046	0.053	0.016	0.012	0.065	0.072	0.088	0.074	0.093	0.029	0.102	0.078	0.088	0.106
t value	-4.04	3.87	-1.03	6.92	6.22	-2.54	-6.52	-2.92	2.18	0.47	-0.54	4.05	-2.78	-4.16
dw3	-0.027*	-0.017	0.044**	-0.007	-0.181*	-0.011	-0.329*	-0.039	0.014	0.026*	0.073*	-0.165*	-0.009	-0.340**
SE	0.014	0.016	0.008	0.005	0.086	0.078	0.089	0.021	0.029	0.013	0.037	0.085	0.075	0.087
t value	-1.96	-1.03	5.13	-1.5	-2.12	-0.14	-3.68	-1.86	0.47	2.02	1.93	-1.94	-0.13	-3.89

d = first difference; L1 = one lag; L2 = two lags; EC = error correction term

* Significant at the 5% level; ** Significant at the 1% level

Equation one, conventional whole milk, is dropped for estimation

w1: budget share for conventional whole milk; w2: budget share for conventional reduced fat milk; w3: budget share for organic milk;

Lnp1 is the log price of conventional milk; lnp2 is the log price of conventional reduced fat milk and lnp3 is the log price of organic milk; lnX is the real expenditure.

8 Elasticity

8.1 Price Elasticity from Static Model

Price elasticities calculated using the unconstrained static model do not have expected signs (not shown here). Therefore, the price and expenditure elasticities are calculated with coefficients from restricted models. The uncompensated elasticities on the left of Table 15 for all three types of milk have expected negative signs. However, the elasticity of conventional reduced fat milk is even higher than that of organic milk, which is not as expected. Both organic and conventional whole milk have elasticities less than one (-0.582 and -0.682), but conventional reduced fat milk has an elasticity slightly greater than one (-1.022). The cross-price elasticity of conventional whole milk and conventional reduced milk is negative. This means that conventional whole and reduced fat milk are complements conditional on fixed expenditure on milk. However, when the price of conventional reduced fat milk increases, the consumption of conventional whole milk increases, but this is not statistically significant. These results show the cross-price effects between conventional whole and reduced fat fluid milk are not symmetric.

The average prices of conventional whole and reduced fat fluid milk across the country are also very close ($1.705 for whole vs. $1.693 for reduced fat). As a result, the price may not be the most important factor in the purchase decision. Other factors, such as health concerns and personal preference may play a more important role in the decision-making process. Consequently, health-conscious consumers may only buy reduced fat milk, and flavor-conscious consumers may only purchase whole fat fluid milk. The overall trend is that the consumption of reduced fat milk increases, the consumption of whole fluid milk the total consumption of milk decrease (Stewart, Dong, and Carlson 2013). Some consumers may stop buying fluid milk and switch to other alternatives, such as soymilk, rice milk or almond milk.

The cross-price elasticity between organic milk and reduced fat fluid milk is negative. This means that organic and reduced fat fluid milk are complements. All other cross-elasticities are not statistically significant at the 5% level.

Compared to uncompensated price elasticity, the compensated price elasticity (Table 16) of conventional reduced fat milk decreases significantly from -1.022 to -0.218, smaller than the elasticities of conventional whole milk and organic milk. This is because of the large budget share of conventional reduced fat milk (the budget share in the formula for compensated price elasticity). The changes in compensated price elasticities from the uncompensated price elasticities of conventional whole and organic milk are small relative to conventional reduced fat milk. Conventional whole milk changes from -0.582 to -0.446, and organic milk changes from -0.682 to -0.622. Organic milk has the largest compensated price elasticity (-0.662), but is still inelastic.

8.2 Price Elasticity from Dynamic Models

The uncompensated elasticities of all three milk products calculated from the dynamic VECM and VECM instrument are shown on the right of Table 15. All three uncompensated price elasticities in the dynamic model without instrument (VECM) are smaller (in absolute value) than the values in the static model. Comparing the VECM with the VECM with instrument, the absolute own price elasticities of conventional whole and reduced fat milk decrease further, but the absolute elasticity of organic milk increases in the VECM with instrument . The VECM with instrument has the largest absolute own price elasticity for organic milk, -0.714, -0.382 and -0.628, respectively, based on the VECM with instrument, VECM and static models. In the VECM with instrument, the own price elasticity of conventional whole milk is very small and statistically insignificant. The own price elasticities for conventional reduced fat milk and organic milk are close, but organic milk is more elastic than conventional reduced fat milk. The change in the elasticity of different models is due to the changes of coefficients in different models and the structural changes of the three different models. The elasticities calculated from this model will be used in the following discussion.

The elasticities for conventional milk become less elastic and statistically insignificant when compensated price elasticities are compared between static and dynamic models (Table 16). The own price elasticity for conventional milk is -0.037, and 0.201 for conventional whole milk. Both of them are statistically insignificant at the 5% level. The positive own price elasticity of conventional whole fluid milk looks odd and is not expected. This is hard to explain in theory. Only Giffen goods have positive own price elasticity of demand. One possible reason is because this demand equation was dropped during the estimation and all coefficients were calculated using economic constraints. The organic milk elasticity becomes smaller (in absolute terms) in the VECM, then larger in the VECM with instrument , but is still smaller than the one in the static model. Only four elasticities are statistically significant at the 5% level in the VECM with instrument. Cross-price elasticities between conventional reduced fat and organic milk are positive and statistically significant, suggesting they are substitutes. This is different from the uncompensated elasticities. The uncompensated cross-elasticity for organic milk to conventional reduced milk is negative, but statistically insignificant.

The own price elasticities of conventional whole and reduced fat milk in this study are much lower than the elasticities estimated by other studies. Huang and Raunikar reported that the uncompensated own price elasticity for conventional milk was -0.259 (Huang and Raunikar 1983). Gould, Cox and Perali (Gould, Cox, and Perali 1990) reported compensated own price elasticities of -0.324 for whole and -0.437 for lowfat conventional milk; they also found that whole and fat reduced milk were substitutes. Andreyeva, Long and Brownell (Andreyeva, Long, and Brownell 2010) surveyed 24 studies from 1938 to 2007 and reported that uncompensated conventional milk elasticities range from -0.40 to -0.79. Recent studies reported that own price elasticities are between -0.861 and -1.319 for conventional milk, and between -0.80 and -2.05 for organic milk (Table 3). The most likely reason for the difference in elasticities between these studies and the present study is the different dataset used in this study in comparison with other studies. Most other studies use one-year Nielsen homescan data, which excludes consumption away from home. Some other studies use supermarket scanner data, which has the same problem as the homescan data. This study uses aggregate national data from 2006 to 2013.

As time passes, consumer incomes and preferences may change, which affect consumer price sensitivity. Glaser and Thompson (2000) found that the price elasticity of organic fluid milk demand changes with time. Figure 14 and Figure 15 show the changes in uncompensated and compensated elasticities of conventional whole, conventional reduced fat, and organic fluid milk from 2006 to 2013. Conventional whole milk is the least elastic among the three for uncompensated elasticity. Overall, conventional whole milk becomes less elastic from 2006 to 2013. The elasticity of conventional reduced fat milk is stable and flat. Organic milk becomes more elastic in this period. The elasticities of reduced fat milk and organic milk are close, but conventional whole milk is much less elastic than the other two. Consumers are becoming more price sensitive to organic milk during this time period. This may partially explain why the retail price of organic milk decreased during the studied period.

For the compensated price elasticity (Figure 15), the results demonstrate a pattern similar to uncompensated price elasticity. Conventional whole milk is least price elastic and positive. Organic is the most price elastic. The elasticity of conventional reduced fat milk remains flat and close to zero, nonresponsive to price changes. Organic milk becomes more price elastic. The irresponsiveness of reduced fat milk to price change may be due to the increased health consciousness of consumers, which is manifested in the increased consumption of reduced fat milk and decreased consumption of whole milk. The other reason for the relatively low price responsiveness of all three milk products is the aggregation of the data. The aggregate consumption changes lower than the changes in individual consumers.

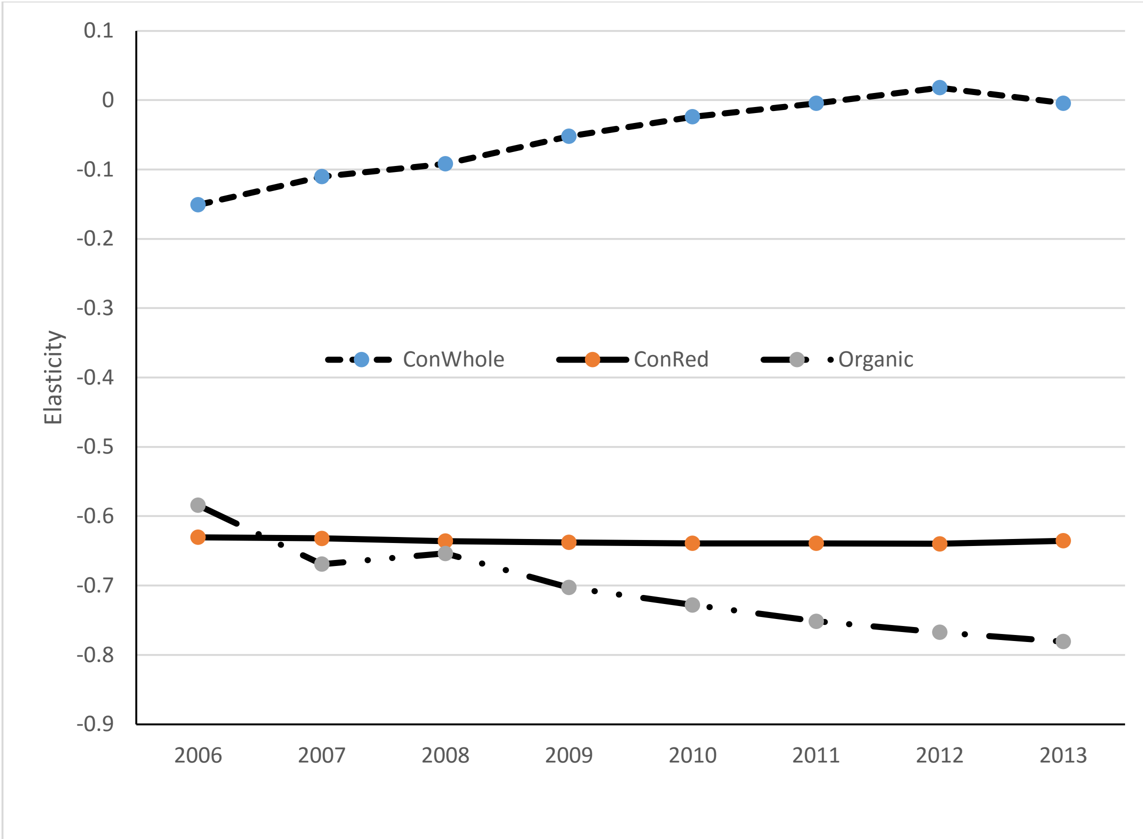

Figure 14. Uncompensated Price Elasticity of Organic and Conventional Fluid Milk 2006-2013

The results are calculated from the VECM with instrument. Elasticity is calculated using this formula: $\varepsilon_{ij}^{M} = -\delta_{ij} + \frac{r_{ij}}{w_i} - \beta_i \frac{w_j}{w_i}$.

ConWhole: Conventional whole fluid milk; ConRed: Conventional reduced fat fluid milk

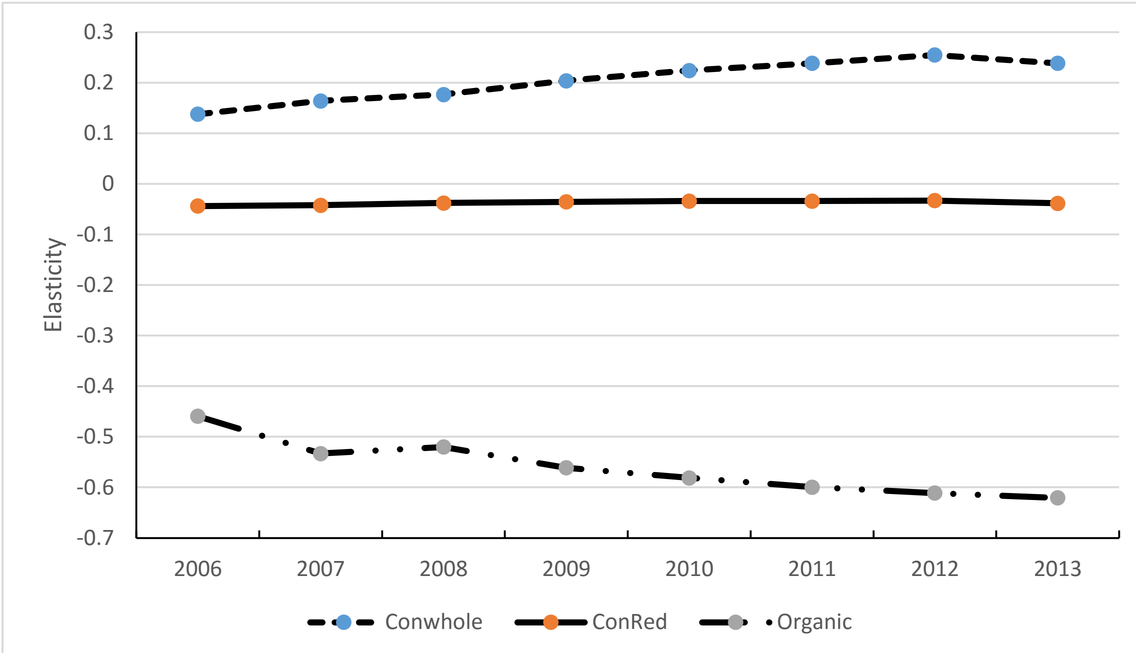

Figure 15. Compensated Price Elasticity of Conventional and Organic Fluid Milk 2006-2013
Results are calculated from the VECM with instrument. The compensated elasticity is calculated using the formula: $\varepsilon_{ij}^{H} = \varepsilon_{ij}^{M} + \beta_i w_j = -\delta_{ij} + \frac{r_{ij}}{w_i} + w_j$
Conwhole: Conventional whole fluid milk; ConRed: Conventional reduced fat fluid milk

The other possible reason for the low price sensitivity toward all milk products may be the consistency of consumption. Milk is a staple food for U.S. consumers, especially for children. Milk is widely consumed at home and in institutions by children, partially due to recommendations in the Dietary Guidelines for Americans. (Dimitri and Venezia 2007b, Alviola and Capps 2010). Previous scholars found that parents with young children represent a large portion of organic milk consumers. These consumers are considered to be loyal consumers of organic milk and are less price sensitive than households without children.

Table 15 Marshallian Uncompensated Elasticity of Fluid Milk for Three Models

	Static Model			VECM			VECM with instrument		
Demand	p1	p2	p3	p1	p2	p3	p1	p2	p3
Conventional whole	-0.582*	0.078	0.009	-0.150	-0.507*	-0.079	-0.056	-0.744*	-0.138
	(-3.48)	(0.43)	(0.24)	(-0.94)	(-2.93)	(-1.58)	(-0.2)	(-3.52)	(-1.52)
Conventional reduced fat	-0.169*	-1.022**	-0.038*	-0.318**	-0.770**	-0.034	-0.306*	-0.636**	0.027
	(-2.24)	(-12.14)	(-2.19)	(-4.53)	(-9.36)	(-1.38)	(-2.13)	(-6.42)	(0.51)
Organic	-0.063	-0.103	-0.682**	-0.349	-0.164	-0.382*	-0.828*	-0.475	-0.714*
	(-0.43)	(-0.59)	(-10.8)	(-1.81)	(-0.7)	(-3.2)	(-2.11)	(-1.65)	(-3.45)

All elasticities are calculated from restricted models with homogeneity and symmetry imposed at the means of budget share. p1 is the price of conventional whole milk; p2 is the price of conventional reduced fat milk; and p3 is the price of organic milk; t-value is in parentheses.

Elasticity is calculated using the formula: $\varepsilon_{ij}^{M} = -\delta_{ij} + \frac{r_{ij}}{w_i} - \beta_i \frac{w_j}{w_i}$

Table 16 Hickman Compensated Elasticity for Fluid Milk for Three Models

	Static model			VECM-AIDS			VECM with instrument		
Demand	p1	p2	p3	p1	p2	p3	p1	p2	p3
Conventional whole	-0.446*	0.402*	0.044	0.052	-0.025	-0.027	0.201	-0.130	-0.071
	(-2.72)	(2.28)	(1.2)	(0.32)	(-0.15)	(-0.54)	(0.87)	(-0.49)	(-0.93)
Conventional reduced	0.169*	-0.218*	0.049*	-0.010	-0.036	0.046	-0.055	-0.037	0.092*
	(2.28)	(-2.63)	(2.85)	(-0.15)	(-0.44)	(1.87)	(-0.49)	(-0.26)	(2.08)
Organic milk	0.170	0.452*	-0.622**	-0.104	0.422	-0.318*	-0.274	0.844*	-0.571*
	(1.2)	(2.85)	(-9.9)	(-0.54)	(1.87)	(-2.67)	(-0.93)	(2.08)	(-3.22)

All elasticities are calculated from restricted models with homogeneity and symmetry imposed at the means of budget share.
p1 is the price of conventional whole milk; p2 is the price of conventional reduced fat milk; and p3 is the price of organic milk; t-value is in parentheses.

The compensated elasticity is calculated using the formula: s$\varepsilon_{ij}^{H} = \varepsilon_{ij}^{M} + \beta_i w_j = -\delta_{ij} + \frac{r_{ij}}{w_i} + w_j$

8.3 Expenditure Elasticity

The expenditure elasticities for all milk are statistically significant at the 1% level in all three models (Table 17). Conventional reduced fat milk has the highest expenditure elasticity and is greater than one in the static model and the dynamic model without instrument. In the instrumental variable dynamic model, organic milk is expenditure elastic and conventional milk has almost unit expenditure elasticity. For organic milk, a 1% increase in total milk expenditure will increase organic milk consumption by 2%. This supports the hypothesis that organic milk is a luxury good.

Table 17 Estimated Expenditure Elasticities for Three Models

	Static model			VECM			Instrument VECM		
	ConWhole	ConRed	Org	ConWhole	ConRed	Org	ConWhole	ConRed	Org
Elasticity	0.495	1.229	0.848	0.737	1.122	0.895	0.937	0.915	2.017
SE	0.077	0.032	0.119	0.039	0.018	0.070	0.303	0.157	0.526
t value	6.4	38.01	7.15	18.88	63.69	12.77	3.1	5.84	3.84

ConWhole: Conventional whole milk; ConRed: Conventional reduced fat milk; Org: Organic milk

The elasticity is calculated using the formula: $\eta_i = 1 + (\frac{\beta_i}{w_i})$

Income has a profound impact on consumer expenditure on food. When disposable income decreases or consumers perceive a possible decrease in future income, they reduce their expenditure on food purchases and save more. During the economic recession of 2008-2009, consumers' real per capita disposable income decreased 1.34% in 2009 from

2008.[6] Total organic milk sales decreased by more than 4%[7] in 2009. Consumers substituted less expensive items for expensive ones (Dong and Stewart 2013b).

Andreyeva, Long, and Brownell collected income elasticities from 24 studies and found low-income consumers are more price elastic regarding conventional milk than higher income consumers (Andreyeva, Long, and Brownell 2010). For organic milk, Dimitri and Venezia found higher income consumers are more likely to purchase organic milk than lower income consumers (Dimitri and Venezia 2007b). Income change affects the portion of expenditure on food. High-income families spend a lower percentage of income on food than lower income families. So they are less price responsive.

The expenditure elasticity of organic milk decreased with time, from 2.38 in 2006 to 1.82 in 2013, while the elasticities for conventional milk did not change significantly from 2006 to 2013 (Figure 16). They remained flat and close to one. This might be explained by consumption patterns. Milk is a necessary good and consumed almost every day. A 1% increase in expenditure raises consumption by 1%. As a luxury good, a 1% expenditure increase changes the consumption of organic more than 1%, but with a diminishing rate of increase.

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[6] Calculated based on data provided by the U.S. Census Bureau.

[7] Calculated based on data provided by ERS.

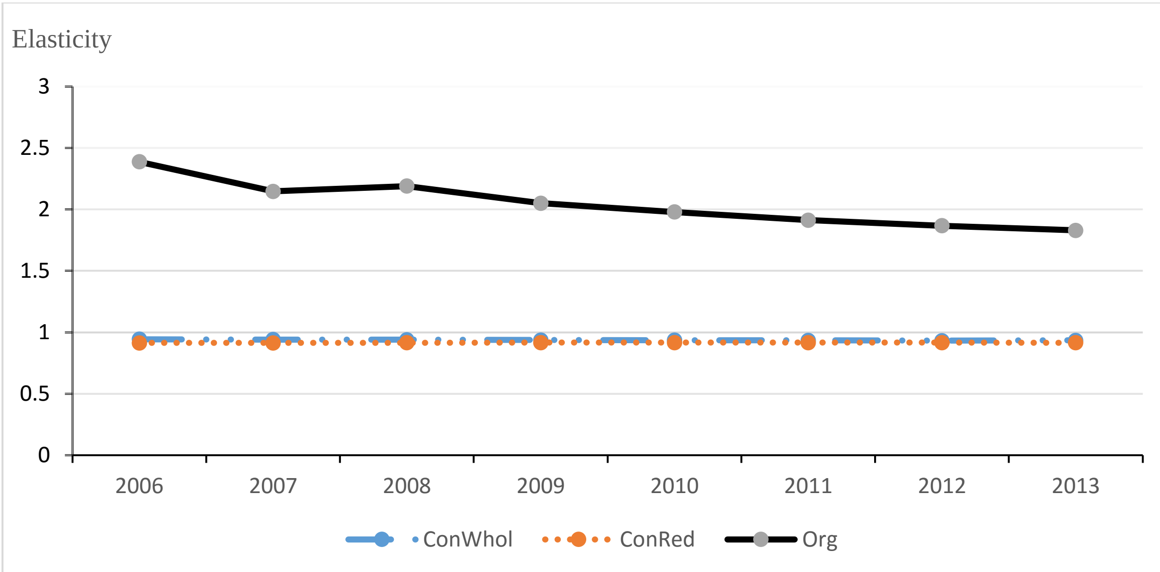

Figure 16. Change in Expenditure Elasticity of Conventional and Organic Fluid Milk 2006-2013

Results are calculated using the VECM with instrument using the following formula:

$$\eta_i = 1 + (\frac{\beta_i}{w_i})$$

9 Impact of Price Change on Consumption

The real price change of the three milk products studied from 2006-2013 is shown in Figure 17. Year 2009 is a special case due to the economic recession. The real price of organic milk increased 10% from 2008, while the real price of conventional milk decreased 10% from 2008. The real organic milk price showed a negative change in most years with an overall decreasing trend. A decreased real organic milk price might also have contributed to increased sales of organic milk in recent years. Organic fluid milk demand has increased at a double-digit rate every year since the late 1990s. Uncompensated cross-elasticity between organic milk and conventional reduced milk is positive and suggests they are substitutes. The increased gap between organic milk and conventional milk during the 2009 recession was one of the reasons sales of organic milk plummeted (Siemon 2010). The increased real price of conventional milk and the gap between the real price of organic and conventional also might have contributed to the substitution of organic milk by conventional milk in the study period.

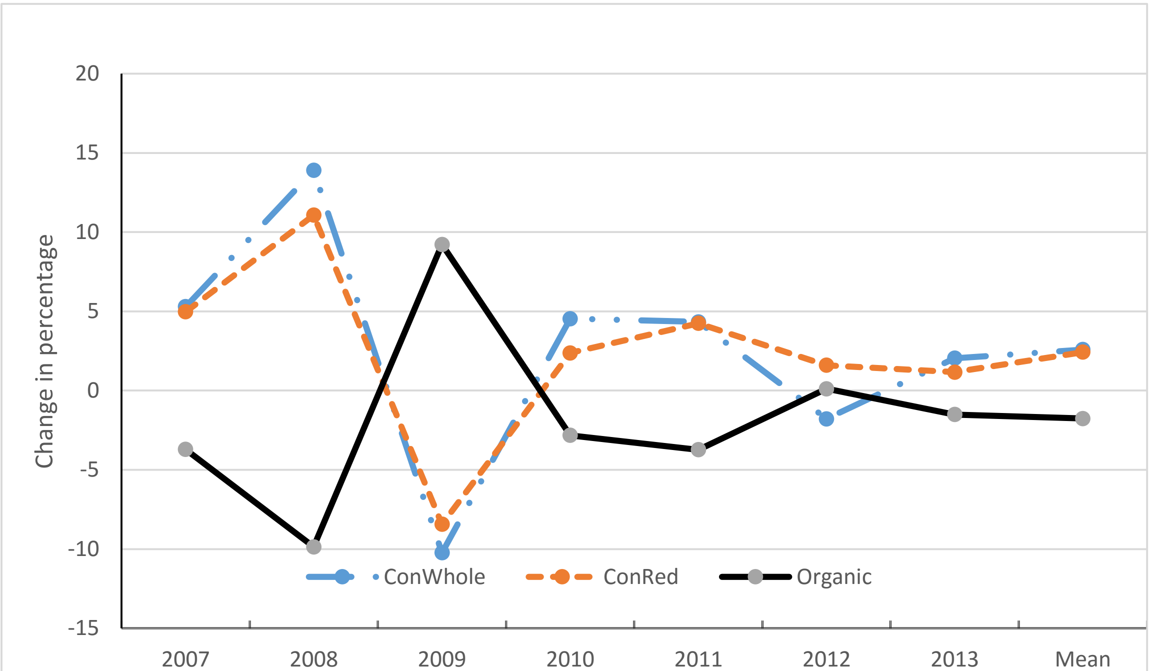

Figure 17. Real Annual Average Price Changes from the Previous year for Conventional and Organic Milk in the U.S. 2006-2013

The price is deflated using the CPI for food. The price change is calculated using the following formula = (current year price – previous year price)/previous year price x 100

10 Habit Formation

There are different ways to model the habit persistence effect in the model. One of the methods is to use lagged consumption quantities in the model, and the other is to use the lagged dependent variable, budget share. The dependent budget share is used in this study adopted from Li, Peterson and Tian (2012). In the dynamic model, the coefficients of lagged budget shares of conventional reduced fat milk and organic milk are statistically significant at the 5% level. In the conventional reduced fat demand model, the previous two consumption periods have different effects on current consumption. Immediate past consumption has a positive effect, but consumption from two months ago has a negative effect. We would expect both past consumptions to have positive effects on current consumption. One possible reason for the negative effect of the past two months is the seasonality of the data used in this study. A possible solution for this problem is to include monthly or quarterly dummy variables to represent seasonality in future studies.

For organic milk, consumption in the previous two months has a negative effect on current consumption. Intuitively, we expect that past consumption would have a positive effect on the future because consumers are reluctant to change their consumption pattern and it takes time for them to adjust to new information about price and income changes. Negative lagged consumption of organic milk is possible. Some consumers may just start to try organic milk and gradually increase their consumption.

11 Summary, Limitation, and Future Research

11.1 Summary

The objective of this study is to incorporate the time series property of fluid milk data and develop a VECM-LAIDS model for conventional whole, reduced fat milk and organic milk. This is the first paper to apply time series techniques to the demand analysis of organic milk. In addition, the study updates organic milk consumption data to 2013, while the most recent previous study was done with data from 2010.

Organic milk consumption is still a small portion of entire fluid milk consumption, 3% of volume and 7% of expenditure. The retail price of organic milk is two times that of conventional milk. The consumption of organic milk and reduced fat conventional milk increased during the period, but the consumption of conventional whole milk decreased.

The time series data are nonstationary and integrated at degree one. The budget shares are cointegrated with log prices and log expenditure. The estimated coefficients from the static and dynamic models have large differences, especially for price elasticity. The results in both models show that conventional and organic milk are price inelastic, and the expenditure elasticities of conventional milk are close to unit, but the expenditure elasticity of organic milk could be up to 2.0 in the VECM with instrument. In the VECM, the demand for conventional milk is almost unresponsive to price change. The dynamic model shows that the consumption pattern does affect the demand for milk or the persistence of consumption. Compared with the static model, the dynamic model meets both homogeneity and symmetry constraints, while the static model does not meet these constraints.

In both the static and dynamic models, compensated price elasticity has large differences compared with uncompensated elasticity. The results show organic milk has larger own price elasticity than conventional milk, but is still inelastic, -0.714. This could be true for committed organic milk consumers, or consumers who only consume organic milk. This elasticity is the lowest among all current studies of organic milk demand

(Alviola and Capps 2010, Chang et al. 2011, Choi, Wohlgenant, and Zheng 2013, Glaser and Thompson 2000, Li, Peterson, and Tian 2012, Chikasada 2008, Dhar and Foltz 2005). The closest elasticity is -0.802 in Chang (2011). The highest elasticity is -9.7 in Glaser and Thompson (2000), who found that price elasticity decreased with time. The most recent dataset is Li, Peterson and Tian (2012), in which supermarket weekly scanner data from 2008-2010 were used. In this study, the elasticities for organic milk with different fat content are from -1.046 to -1.598, and organic whole milk has the lowest own price elasticity among all organic milk. However, the time series property is not considered in this study.

The compensated own price elasticities of conventional milk (0.201 for conventional whole, and -0.037 for conventional reduced fat in the VECM with instrument are statically insignificant from zero and lower than the elasticities in all current studies. The positive price elasticity of conventional whole fluid milk does not conform with consumer theory and needs more exploration. The low compensated elasticity means that with income compensated, the price has little effect on consumer demand for conventional milk.

In the VECM , the expenditure elasticities of organic milk and conventional whole milk show they are inelastic, and the expenditure elasticity of conventional reduced fat is 1.122. The expenditure elasticity of organic milk (0.895) is in the range of elasticities from current studies (from -8.6 to 0.871). This elasticity is close to the study of Li, Peterson and Tian (2012), 0.871, while the elasticity of organic milk in the VECM with instrument is 2.0, making it elastic. This is also in the range of current studies.

Demand analysis, especially price elasticity, is important for marketing strategy. Conventional and organic milk manufacturers and retailers can use price elasticity information to direct their production, sales and marketing. Milk retailers also can use price elasticity to set their pricing strategy to increase sales and revenue. The properties of aggregate data also provides information for milk producers. The study shows that organic fluid milk demand is inelastic, and the real retail price of organic fluid milk decreased during the study period. Consumer demand for organic milk increased due to changes in consumer preference, and could increase even more with decreasing retail price. Increased demand at the consumer level also could increase farm level demand. This is promising for organic milk producers. They should expect increasing derived demand for their raw milk in the future, ceteris paribus.

11.2 Limitations and Future Research

The major interest for this study is the demand for organic milk. The substitutes for organic milk are growing, but we only include milk in this model. For loyal organic food consumers, organic beverages are also available as a counterpart. In fact, Organic Valley and Horizon Organic, the two largest organic milk processors, also market organic soy milk. Organic soy milk has entered large box stores and club stores like Sam’s Club and other low-cost grocery stores like Aldi. Price elasticity is affected by the availability of substitutes. Few substitutes are included in the model. However, I expect the elasticities estimated in this study are less responsive than in the real life.

This study does not include demographic factors, which play an important role in consumption patterns. I will explore important demographic factors in the future with micro-level household data. These factors are more relevant to individual household or consumer purchase decisions.

Price is assumed to be exogenous in this study because no appropriate instrumental variable could be found. In the future, I will include a function for retail price, which is dependent on raw milk and other input costs. In this case, we can simulate how future raw milk price changes will affect the retail price, which affects consumer demand. In addition, we can simulate how consumer demand affects retail price and then the raw milk price, and analyze how consumer demand affects organic dairy farm profitability.

Chapter Five: Organic Milk Supply and Processors

1 Organic Milk Processors

There are two national organic milk processors in the U.S.: Horizon Organic, a subsidiary of WhiteWave Foods, and Organic Valley, a cooperative. There are also a number of regional and local processors. These two national rivals compete in organic milk procurement, and in the organic dairy wholesale and retail markets. Both Organic Valley and Horizon Organic invest heavily in brand building, customer loyalty, quality, new products, new package development, and market analysis. In 2004, the organic fluid milk market share at the consumer level was 42% for Horizon Organic and 36% for Organic Valley; in 2007, their shares were 33% and 19%, respectively (Dimitri and Venezia 2007a). Total market shares for these two were 75% and 54% in 2004 and 2007 respectively, higher than 50%. These figures show that the fluid milk retail market is highly concentrated. A brief introduction to the major processors follows.

Horizon Organic, founded in 1990, was the first company to market fluid organic milk nationally. It was acquired by Dean Foods in 2004 and operated as the WhiteWave Foods Division until 2012, when Dean Foods spun off WhiteWave Foods as an independent company. WhiteWave Foods is a natural and premium food-processing company owning well-known brands such as Silk, International Delight, Earthbound Farm Organic, Horizon Organic, and the European brand Alpro. Net sales of WhiteWave Foods in 2014 were $3.4 billon (WhiteWave Foods 2015). In 2013, total sales of Horizon Organic branded products were $644 million, making it the number one brand in organic dairy products, with 43% of the U.S. market in organic fluid milk.

Organic Valley, a marketing cooperative for organic products is located in southwestern Wisconsin in the U.S. It represents mainly small family farms and is the second largest organic milk processor in the U.S. Its brand, Organic Valley®, is the number three brand in the organic dairy market. It has a unique mission statement and significant market power in both the organic milk supply and retail markets.

The third largest organic milk processor is Aurora Organic Dairy, a private company located in Boulder, Colorado. It is a vertically integrated firm, having large dairy farms and a processing facility. The main products of the company are privately labeled organic milk and butter (Aurora Organic Dairy 2014).

Stonyfield is an organic dairy processor located in New Hampshire, which offers premium organic yogurt products among other dairy products. Stonyfield sources its raw milk from Organic Valley and independent producers. It also licenses its Stonyfield® organic fluid milk brand to Organic Valley.

Other processors with brand recognition include Trickling Springs and Natural by Nature in Pennsylvania. Besides these prominent organic milk companies, about 50 smaller organic milk buyers or processors operate in the U.S. Some of them are family-owned-and-operated facilities, and others are local or regional factories or cooperatives that handle both organic and conventional milk.

2 Organic Milk Supply

Organic milk production certification is regulated by the National Organic Program. In order to convert from conventional to organic production, this program mandates a three-year transition period for land and a one-year transition period for dairy cows.

Approximately 2,262 organic dairy farms were operating in the U.S. in 2014 (National Agricultural Statistics Service 2015a), an increase from 2,000 in 2008 (National Agricultural Statistics Service 2012). Wisconsin has the largest number of organic dairy farms, but California produces the largest volume of organic milk. Of the 424 organic dairy farms in Wisconsin in 2014, 292 were members of Organic Valley.

The average herd size is 80 cows for Organic Valley (Organic Valley 2014b), and 90 for Horizon Organic producers (Horizon Organic 2014). At the beginning of 2011, Organic Valley's membership included 1,144 dairy farmers, and Horizon had 531 contracted farmers and two company-owned farms (Table 18). In December 2013, Horizon Organic sold its 4,000-cow farm, but contracted with the buyer to purchase milk (Cornucopia Institute 2014). As of 2014, 1,498 dairy farmer members were affiliated with Organic Valley, representing 50% of U.S. certified organic dairy cows; Horizon Organic contracted with 600 dairy farms, representing 24% of U.S. certified organic dairy cows. These two large organizations control 74% of raw organic milk in the U.S. The market is also highly concentrated.

Table 18. Certified Organic Dairy Cows Supplying Organic Valley and Horizon Organic 2007-2013

	2007	2008	2009	2010	2011	2012	2013
Total certified cows in U.S.	166,178	249,766	n/a	254,579	254,771	n/a	235,620**
HO farms	400	500	n/a	533	n/a	n/a	600
HO cows	40,000	49,000	n/a	51,790	n/a	n/a	57,400
HO percentage of total	24%	20%	n/a	20%	n/a	n/a	24%
OV dairy farms	N/A	1037	1098	1144	1366	1507	1498
OV cows	69,300	79,849	84,546	88,088	105,182	116,039	119,840
OV percentage of total	42%	32%	n/a	35%	41%	n/a	50%*

HO: Horizon Organic; OV: Organic Valley;

Organic Valley, 2013. “CROPP Cooperative Roots - the First 25 Years,” p. 176; ** Calculated based on Organic Valley data

Source: Horizon and Organic Valley data are from their websites. U.S. data were downloaded from the Economic Research Service (ERS) of the USDA, certified organic farmland acreage, livestock numbers, and farm operations, http://www.ers.usda.gov/data-products/organic-production.aspx.

3 Organic Milk Farm Price

The U.S. conventional milk price is primarily market driven but is regulated by the Federal Milk Market Order (FMMO) system. FMMO announces a blended minimal milk price each month for non-organic milk (Agricultural Marketing Service 2010). The organic milk price is largely determined by market conditions. The two major organic milk processors, Organic Valley and Horizon Organic, forward contract with their milk producers. Their pricing protocols include four basic elements: a base price, seasonal premium, seasonal deduction (Organic Valley only), and market-adjusted premium.

Horizon Organic contracts with farmers for one to three years by setting prices with individual farmers confidentially (Horizon Organic 2007). Large farmers have more bargaining power than small ones. Horizon Organic changes its market-adjusted premium (MAP) to reflect market conditions and cost of production. It has the sole right to reduce the pay price based on market conditions with 30 days' written notice to its producers if the proposed price change is less than 25%; when the price change is higher than 25%, it needs to negotiate with its farmers (Northeast Organic Dairy Producers Alliance 2011).

Organic Valley's farmer members collectively determine their pay price for the upcoming year based on current costs of production and a "fair return" (Organic Valley 2014a). This pay price is announced early in the calendar year and is fixed for one year. Members in the same region receive the same price regardless of herd size. If market conditions or cooperative performance changes within a given year, the board of directors has the right and responsibility to adjust the pay price.

The historical base prices of Organic Valley have been consistently set higher than the base prices of Horizon Organic. Nevertheless, with added premiums, the final annual pay prices of the two rivals generally converge. Final average differences ranged between 25 cents to $1.16/cwt (cwt = hundred lbs.) from 2007 to 2013as shown in Table 19.

Table 19. Organic Milk Pay Price of Organic Valley and Horizon 2007-2013

	Organic Valley ($/cwt)*							Horizon Organic ($/cwt)*						
Year	2007	2008	2009	2010	2011	2012	2013	2007	2008	2009	2010	2011	2012	2013
Base price	26	28.75	27.3	27.3	27.3	28.8	28.8	24	25	25	25	25	25	25
MAP					1	1	1	2	2.5	2	1	2.5	3.5	3.5
Seasonal MAP			2	2	3	3	3	1.5	3	4	3	3	3	3
Summer deduction		-1	-1	-1	-1	-1	-1							
Average	26	28.25	27.17	27.5	28.8	30.55	30.55	26.5	28.5	28.33	27	28.5	29.5	31.5

*This is the Northeast regional price; Organic Valley charges a flat hauling fee for each member, and pays all members in the same region the same price, with no volume premium. MAP: market adjustment premium

Note: Organic Valley also has regional premiums based on the cost of production. In the Northeast region, the premium was $3.25 in 2013. It has 11 regional premiums. Both firms offer component prices and quality premiums.

Source: Northeast Organic Dairy Producer Alliance (NODPA), 2014, http://www.nodpa.com/payprice_update_01192012.shtml

Chapter Six: Organic Milk Supply and Demand Coordination: The Case of Organic Valley Cooperative

1 Introduction

One of the trends in the agri-food value chain is increased vertical coordination through marketing agreements and production agreements. Vertical coordination ensures stable supply, and reduces excess supply. In addition, vertical coordination increases the efficiency of the marketing system and provides more value to consumers. Manufacturers contract with farmers to control the quality and quantity of their inputs according to consumers' demand. Farmers secure a more predictable and stable price through such coordination. Milk is a perishable product and needs to move along the value chain quickly to ensure safety and quality. More than 70% of milk is marketed under marketing agreements (Wissman 1997). Farmers, manufacturers, and consumers all benefit from vertical coordination, which is part of economic coordination and reduces price uncertainty by matching supply and demand.

Cooperatives provide economic coordination between individual farms and cooperatives, which is micro-coordination; another type of economic coordination provided by cooperatives is coordination of total supply with total demand during the production-distribution process, which is macro-coordination (Staatz 1989). Organic Valley is a cooperative that provides economic coordination between farmers and their cooperative, and between supply and demand for organic milk. In this chapter, Organic Valley cooperative's policies, organization, supply and demand management for organic milk, and economic coordination role will be examined. The challenges and crises the cooperative has faced and the solutions it has implemented also will be analyzed.

2 Theoretic Framework: Supply and Demand Integrated Management

The purpose of supply chain management is to meet consumer demand profitably and increase the competitive advantage of a firm. Supply chain management is a complex task and involves participants at many levels and stages of the supply chain. Integrating supply and demand management is a new trend in management theory and practice and has proved to be more effective in improving the financial performance of a business (Tate et al. 2015).

Supply and demand integrated management focuses on resource allocation within a firm to better meet consumer demand and realize high margins. The key is the coordination of marketing and production personnel inside a firm by its top leaders. Tate et al. proposed five aspects of supply and demand integrated management: value creation for the organization and consumers; knowledge sharing across the firm; resource allocation to the most important customers; experience accumulation; and balancing capacity and demand. It is an inclusive procedure and involves change in organizational culture and politics. It is important for a business to share information with its suppliers about consumer values and needs and collaborate with suppliers to satisfy those needs.

In applying supply and demand integrated management to marketing cooperatives, it is critical to share the information about consumer demand and value, and risk with farmer members, who are both the suppliers and owners of the firm. It is important to share information about the quantity and quality of consumer demand, trends in consumer demand, how the cooperative can meet consumer demand, and information about the importance of coordination between farmers and the cooperative in order to meet consumer demand profitably.

Many cooperatives, especially new-generation cooperatives, sign marketing agreements with their farmer members to ensure stable supply and products that meet required quality standards. These marketing agreements play an important role in cooperatives' effort to balance supply and demand and ensure enough inventory to meet marketing objectives and financial goals. Additionally, many cooperatives have specified quality requirements for their members' products in order to produce high quality products that meet consumer needs. Some marketing cooperatives have established well-known brands and have their own marketing research teams to understand consumer needs and align their resources with consumer demand.

In this chapter, a particular cooperative, Organic Valley, an economic coordinator and its strategy of integrated supply and demand management is examined.

3 The Objective of Organic Valley

Organic Valley was founded in March 1988 by a small group of farmers in LaFarge, Wisconsin. At that time, farmers were experiencing economic hardship. Many small farmers stopped farming due to low prices and negative returns on agricultural products. Organic food commanded a significant premium over conventional food and a market for these products was emerging in southwestern Wisconsin. Some organic production practitioners saw the promise of the market and many others were attracted by higher prices. Organic Valley was formed as a way to protect family farms financially by using collective bargaining power.

Cooperative theorists postulate that the objective functions of cooperatives include maximizing member returns, increasing cooperative profits, and increasing the joint return of the cooperative and its members. The mission statement of Organic Valley is “to create and operate a marketing cooperative that promotes regional farm diversity and economic stability by means of organic agricultural methods and the sale of certified organic products.” Therefore, the objective function of Organic Valley is to maximize members’ value (Organic Valley 2013a) (page 173). This value is the combination of economic profit and social value. Additionally, Organic Valley was founded to maintain economic sustainability for farmer members through a stable pay pricing strategy. Another objective of Organic Valley is to operate as a social entity to protect family farms and maintain the integrity of rural areas. Since its founding, Organic Valley has extended its territory to serve family farmers all over the country and provides young farmers more opportunity to stay in farming.

Organic Valley claims that it is a mission-driven business. The policy Organic Valley has adopted to achieve its mission is to announce the farm price by farmer members based on their costs of production plus a reasonable return. The farm price is set at the beginning of the calendar year and fixed for a year. This is known as its stable pay pricing policy. This pricing strategy demonstrates transparency and provides information members can use in their budgeting process. The stable pay price helps farmers pay their bills on time and is critical for their farm operations.

Organic Valley is a netchain based on pooled, sequential and regional interdependencies, with stakeholders including farmer members, employees, co-packing plants, customers, local communities, and other partner organizations. As a social entity, Organic Valley promotes organic production, environmental and animal protection, contributes to local communities, and provides training and assistance for next-generation young farmers. Organic Valley CEO George Siemon described the cooperative as a "social experiment disguised as a business." Most importantly, as a farmer-owned and farmer-run cooperative, Organic Valley provides its farmer members a sense of belonging, an identity, and decision-making rights that help determine their own destiny.

4 Commodity Pools, Membership Policy and Dairy Pool

Organic Valley, founded in Wisconsin, expanded to Minnesota and Iowa in 1994, and now has membership in 35 states. Organic Valley has eight different commodity pools. Organic dairy is the largest pool and represents 85% of sales. The number of total members of Organic Valley has increased since its founding (Figure 18). The average herd size of its dairy members is 80 cows per farm. Among its 1,498 dairy farmer members, 761 have 50 or fewer cows, and 487 have from 50-100 cows. These two size categories account for 83.3% of the cooperative's total farms. The remaining 250 farms have from 100 to more than 1,500 cows (Figure 19). Organic Valley requires that all producer members be third party-certified organic producers. Besides meeting USDA organic standards, Organic

Valley members must meet other quality standards required by the cooperative to ensure high quality products.

Upon joining the cooperative, members sign membership agreements with Organic Valley. Under the agreement, members agree to deliver all their milk to the cooperative and the cooperative agrees to purchase raw materials only from members except under special circumstances. Membership will be terminated if a farmer does not patronize the cooperative for a year. Currently, Organic Valley's non-member business accounts represent less than 1% of total volume. Membership for dairy members is continuous. However, either party can end the agreement with a 180-day notice (Organic Valley 2013b).

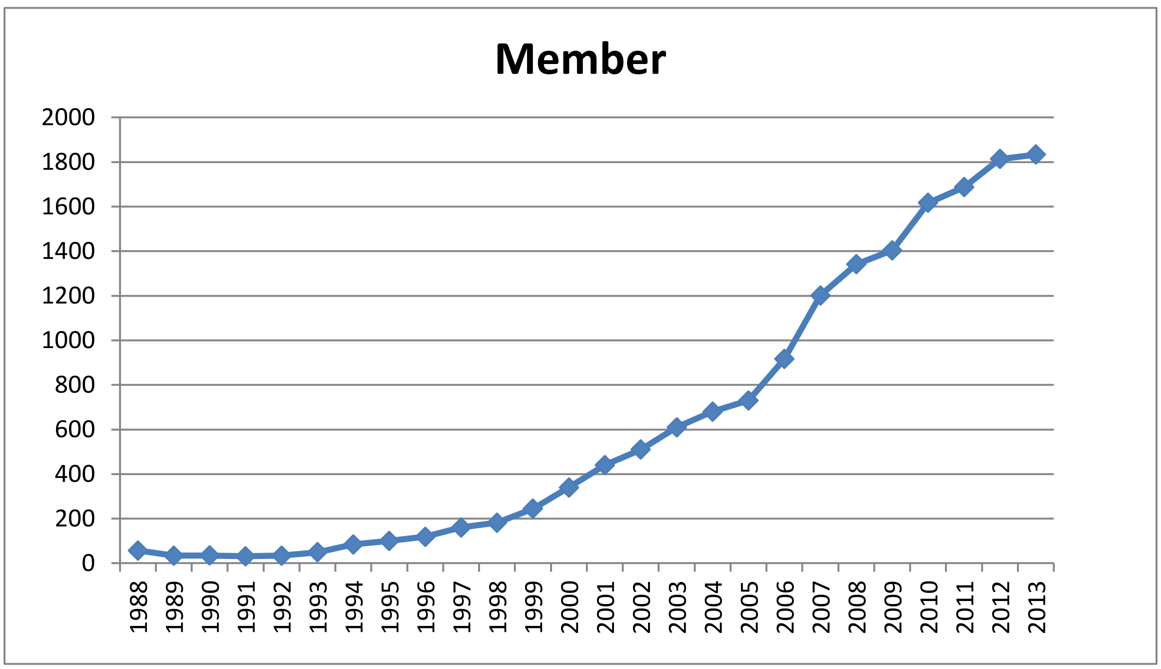

Figure 18. Organic Valley Members 1988-2013

Data source: Organic Valley website http://www.organicvalley.coop/

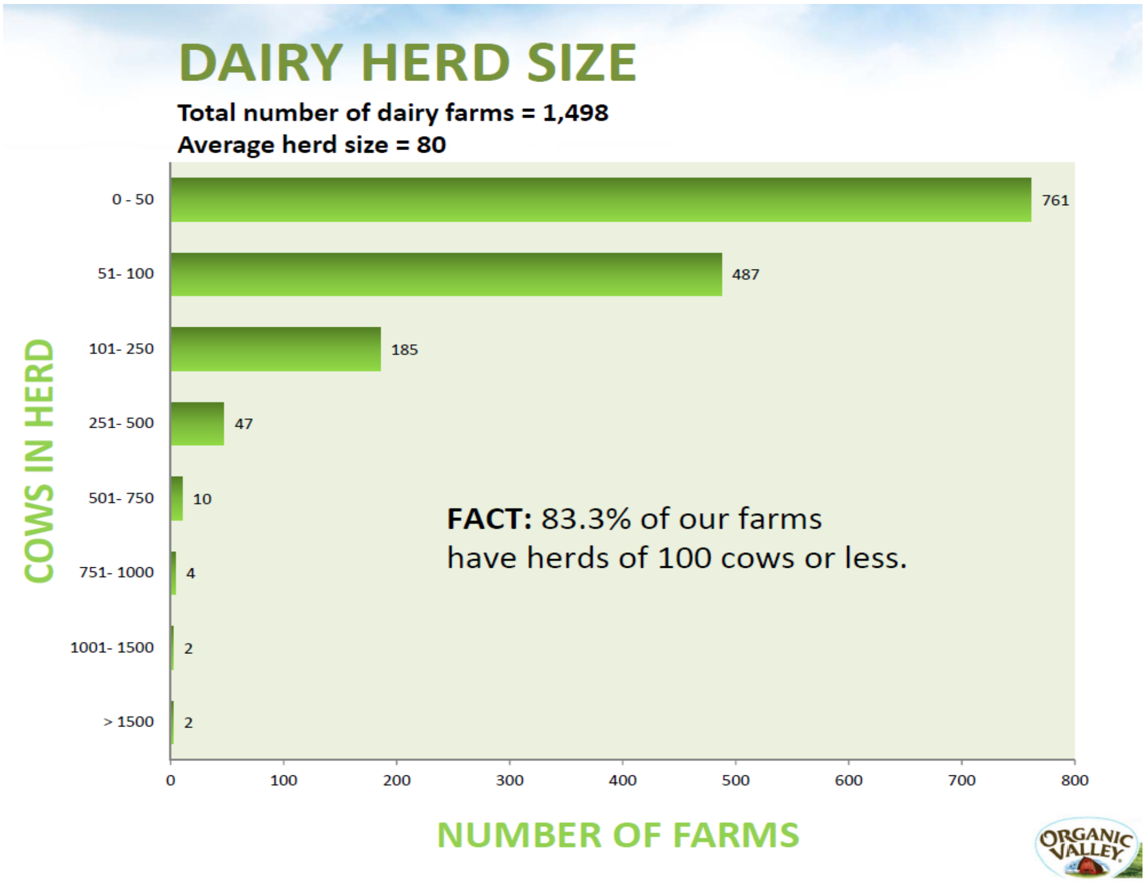

Figure 19. Dairy Herd Size of Organic Valley in 2013

Source: Organic Valley Website
http://www.organicvalley.coop/fileadmin/pdf/pools/EOY_2013_Herd_Size_Chart.pdf

5 Organic Valley Ownership Structure

Organic Valley is a new-generation cooperative. Members are required to invest 5.5% of their estimated annual gross income in the cooperative. This capital earns 8% interest annually (Organic Valley 2014b). Currently, the equity capital of Organic Valley includes four different types of stock. Class A stock is voting stock and is not transferable. Each farmer member holds one and only one share of Class A stock, which grants one vote to each member. In 1993, Organic Valley started a base capital plan, Class B stock, which is transferable to eligible producers. Class C stock was issued in 2004, and Class E stock was issued in 2009 and 2013 to members, employees, and outside investors with various dividend rates depending on the cooperative's performance.

Organic Valley formed Organic Meat Company, a wholly owned corporation in 2003, and Organic Logistics LLC, a wholly owned subsidiary in 2004. In 2011, Organic Meat Company purchased a 66% share of a meat-processing plant (Organic Valley 2013b).

6 Organic Valley Consumer Demand Management

The key to consumer demand management is to know the values and preferences of consumers and allocate necessary resources to meet consumer demand, especially the most important consumers' demand, in order to realize a relatively higher margin and the financial goals of the company. Branded products are the key to meeting consumer demand for Organic Valley, because they satisfy consumers' high-quality preference and support farmer-owners' values. Organic Valley allocates major resources to its branded product development, marketing and sales.

6.1 Product Development

Organic Valley established Organic Valley® brand in 1990. This brand is used for organic dairy, egg and vegetable products. The cooperative established another brand, Organic Prairie®, for its meat products. In addition, Organic Valley offers private label products to balance its extra supply. In total, Organic Valley has 1,470 individual SKU products, including branded, private label, ingredients, food service, and exports.

Organic Valley is committed to new product development in order to meet changing consumer preference. It has launched many firsts in the organic dairy industry. In 2011, Organic Valley finished construction of its quality research and development center. The cooperative develops or improves 20-30 products every year (Organic Valley 2012). New product development is teamed with sales, marketing, operations, and procurement to meet consumer needs and the company's goals.

6.2 Consumer Education

The purpose of consumer education is to increase consumer awareness of products and influence consumer demand. When Organic Valley was founded, very few organic products were available in the market. Consumers could not understand why organic products were more expensive than conventional products. Organic Valley educated consumers on how organic food was produced and why it commanded a premium. Up to the present, Organic Valley has continued to invest in consumer education about sustainable agriculture and how organic is different, now using its website and social media to connect with consumers. In addition, Organic Valley provides a system for consumers to track the farms that supply their milk. It provides virtual tours of farms and gives consumers a chance to understand the production system. The effect of Organic Valley's consumer education has been to increase branded sales and profits.

6.3 Farmers-in- the-Market Activities (Advertisement)

Organic Valley promotes its farmer-owner identity and meets the needs of consumers who support family farms and the local economy. The cooperative designs programs to involve farmer members in marketing. These programs include adopt-a-store, generation organic, farmer speaking engagements, retail events, and marketing ambassadors.[8] By involving farmers in marketing activities, the cooperative increases its public exposure and consumer awareness. These programs also increase farmer members' sense of ownership and strengthen their dedication and commitment to the cooperative.

7 Organic Valley Supply Management

7.1 Contract Production

Since its founding, Organic Valley has emphasized contract production to balance supply and demand and maintain its pre-announced stable price, as well as to maintain minimum efficient scale. Members sign marketing and membership agreements with the cooperative before they join it. Members need to deliver 100% of their milk to the

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[8] http://www.organicvalley.coop/fileadmin/pdf/CROPP_Annual_Report_11.pdf, Organic Valley 2011 Annual Report.

cooperative. Marketing contracts give Organic Valley a clear idea of how much it will handle in a year so it can find an outlet for the milk and improve returns for its members.

7.2 Add Members When Demand Increases

Organic Valley does not add new members unless there is an outlet for its milk. In the early years of the cooperative, Organic Valley put potential members on a waiting list. When marketing and sales persons found more demand for the cooperative's organic milk, they would move people from the waiting list to full membership. This policy still holds today. In recent years, organic milk demand has been increasing. Organic Valley has staff focus on recruiting new members to satisfying the increasing demand and improve its financial performance.

8 Crises, Solutions, and Outcomes of Organic Valley and Organic Dairy Industry

From the 1990s through 2004, the organic milk industry's supply and demand growth was mostly balanced. However, from 2004 through 2007, organic milk demand exceeded supply. The change can be attributed to implementation of the Organic Standards Regulations, which resulted in fewer cows being certified under the new regulations. This net margin opportunity became attractive to rivals. As a result, Dean Foods acquired Horizon Organic, and HP Hood licensed the Stonyfield brand for fluid organic milk. These transactions resulted in increased rivalry in the organic milk market, especially in milk procurement. Some milk buyers provided bonuses for transitioning farmers in order to increase future supply. As a result, total organic milk supply increased 50-60% in 2006-2007 (Dyck and Mendenhall 2009). However, the economic recession of 2008-2009 brought an end to excess demand for organic milk. During 2008-2009, real per capita disposable income in the U.S. decreased by 1.3% and real consumption of food and beverages decreased by 1.5%.[9] In addition, the price of conventional milk decreased to about one-third the price of organic milk (Siemon 2010). The decrease in real income and the price gap between organic and conventional milk caused total sales of organic fluid milk to drop by 4% in 2009 (Figure 9). Organic milk buyers had to reduce their prices or cut milk supply to balance decreased demand.

8.1 Rivals' Practices and Outcomes

In dealing with this unforeseen crisis, HP Hood changed its contract with farmers in July 2009. With the new contract, the organic milk price was calculated monthly based on utilization, like the conventional milk price. This situation lasted until 2010. In addition, HP Hood also cancelled contracts with farmers and forced more than 80 farmers to stop organic production. In January 2010, HP Hood transferred its 275 organic dairy farmers to Organic Valley, and also licensed Stonyfield brand fluid milk to Organic Valley, thus exiting the organic dairy market.

Horizon Organic cut its market adjustment premium and decreased its average pay price from \$28.5/cwt in 2008 to \$28.33/cwt in 2009 and \$27.0/cwt in 2010, and increased the price to the level of 2008 in 2011 (Table 19). Due to contract specifications, Horizon

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[9] These values were calculated using the data Personal Income and Its Disposition from the Bureau of Economic Analysis.
http://www.bea.gov/iTable/iTable.cfm?reqid=9&step=1&acrdn=2#reqid=9&step=3&isuri=1&903=58

Organic cannot enforce a supply management program. Instead, it commanded farmers to reduce their delivery 7% voluntarily. To cope with decreasing consumer demand, Horizon Organic and other local organic brands decreased their retail prices to maintain market share. In addition, Horizon Organic did not renew some expired contracts, thus resulting in reduced milk supply.

8.2 Organic Valley's Solutions

In contrast with decreasing consumer demand, Organic Valley's supply of organic milk continued increasing for the first eight months of 2009, at a rate higher than projected, thus increasing inventories and related costs. A potential crisis at Organic Valley and in the organic milk industry loomed. In addressing this excess supply situation, Organic Valley's leadership considered three options: 1) recalculate the pay price based on actual monthly organic milk utilization; 2) terminate the membership of recently accepted members; or 3) collectively reduce production.

"The farmer-owners stepped up by providing leadership and sacrificing income to safeguard their long-term strategy" (Organic Valley 2010). The board acted quickly and decisively. After discussion and communication with members, the board of directors adopted the third option and recommended a quota system. The quota program required that each farmer reduce delivery 7%, using the farmer's average milk production for the previous three years as the basis. Farmers were allowed to deliver more milk, but over-quota milk was priced at $15/cwt, considerably less than the annual pre-announced base price. In addition, Organic Valley also decreased its pay price, but still kept the pay price stable. The national average annual pay price decreased from $28.25 to $27.17/cwt from 2008 to 2009, the first decrease since 2000 (Organic Valley 2010). The average pay price rebounded in 2010 to $27.50/cwt, and increased to 28.80 in 2011, higher than the price before the recession.

Unlike the other two buyers, all of Organic Valley's farmer members survived the crisis and no one left the cooperative. Under the supply management program, the organic milk supply of Organic Valley decreased in September, and was significantly lower than projected for the following three months, making projected and actual supply growth converge. Organic utilization increased to 94%, current inventory was reduced by 25% from 12.2 to 9.2 million pounds, and the quality of milk delivered by farmers increased. Total milk delivered in 2009 increased by 1% from 2008, instead of a projected 3.7%, and customer complaints decreased due to higher milk quality (Organic Valley 2010). In January 2010, Organic Valley decided to take over all of HP Hood's farmers and licensed Stonyfield brand fluid milk.

Organic Valley's total revenue in 2009 decreased by 1.5% (Figure 20). Since it had a pre-announced pay price, Organic Valley did not decrease its wholesale price in 2009 as Horizon Organic and other processors did. In an attempt to maintain market share, the cooperative spent an additional $3 million on product promotion. Market share for Organic Valley's half-gallon fluid milk decreased by 10%, but private label and bulk sales increased due to the substitution effect (Organic Valley 2011). Overall, 2010 was a successful year for Organic Valley. Sales increased by 19% over 2009, and the number of members increased 14%, from 1,404 to 1,607. Although the quota was enforced for the first half of the year, the cooperative met its expected profit goal, which enabled the cooperative to renew its profit sharing program (Organic Valley 2011). The quota was enforced from July 2009 to July 2010 for most farmers, until September 2010 for new members from HP Hood, and until December 2010 for West Coast farmers (Organic Valley 2011). Afterward, all members were allowed to deliver 100% of their production to the cooperative.

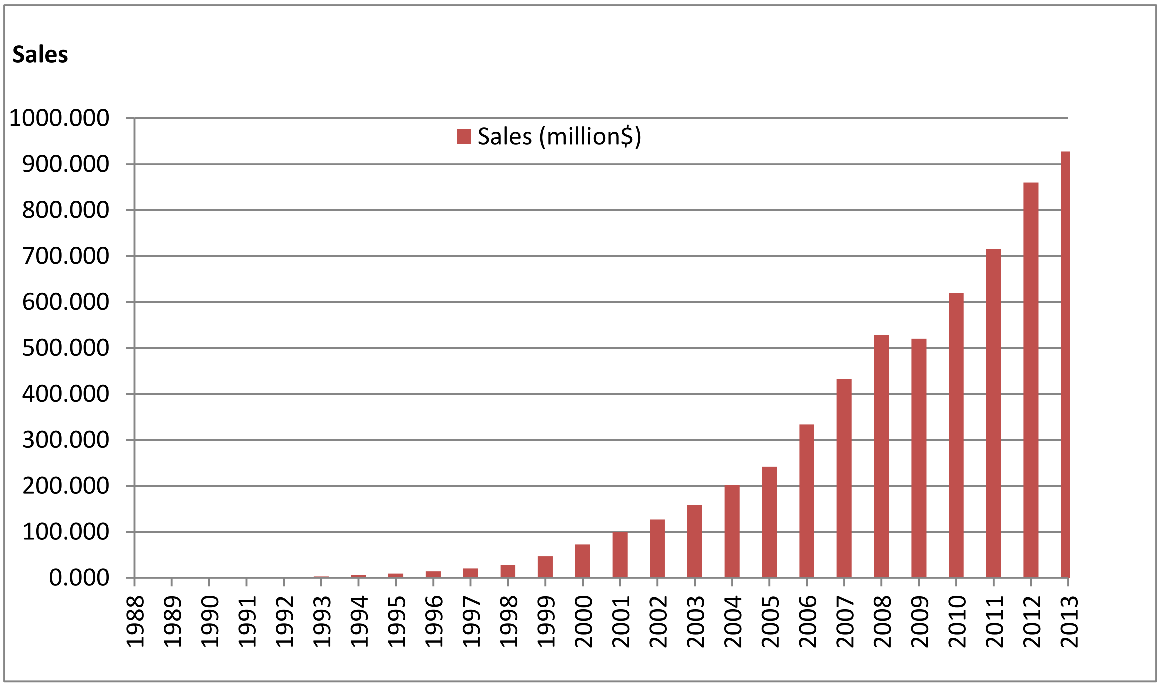

Figure 20. Organic Valley Nominal Sales 1988-2013

Data source: Organic Valley website http://www.organicvalley.coop/

9 Competitive Yardstick Effect of Organic Valley Cooperative on Organic Milk Farm Price

9.1 Organic Milk Market Structure

One of the key characteristics of a competitive market is the presence of many sellers and buyers (Robert Pindyck 2012). In the U.S. organic raw milk industry, there are only two national organic milk buyers, one private label processor, and about 50 small regional and local processors, as mentioned earlier. In some areas, only a single buyer is available; farmers have no choice in selecting a buyer and the buyer is a spatial monopoly.

The two national buyers Organic Valley and Horizon Organic together control 74% of organic milk supply and more than 50% of the fluid milk retail market. This is a duopsony/duopoly market structure. That is, the pricing behaviors of the two firms – in both organic raw milk purchases and organic fluid milk retail – are interdependent. Bolotova and Novakovi (Bolotova and Novakovic 2012) found that the profit margin in more concentrated markets is higher. This is true for the organic milk industry compared with the conventional milk industry. The average retail price of national brands of organic fluid milk was 46 cents higher than the average price of private labels in 2012.[10]

Price-cost margin is one of the measures of market power (Rogers and Petraglia 1994). The retail to farm price spread is used as a proxy for the margin. Table 20 shows

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[10] Calculation based on data from the AMS Biweekly National Dairy Retail Report, http://www.ams.usda.gov/AMSv1.0/ams.fetchTemplateData.do?startIndex=1&template=TemplateW&navID=MarketNewsAndTransportationData&leftNav=MarketNewsAndTransportationData&page=DairyRetailPrintedReports

the profit margin (difference between the retail price and farm price) of organic and conventional fluid milk and Table 21 shows the ratio of farm price to retail price. The margin for conventional milk was$ 1.0 to $1.5 in 2004-2012, while the margin for organic milk was 2.5 to 3.5 dollars. Smith and Huang et al. (Smith, Huang, and Lin 2009) found that the organic milk retail price premium was about 60-109% over conventional milk, using 2006 Nielsen Homescan data. We find the retail price premium for organic fluid milk was 46-136% in 2004-2012, using USDA Agricultural Market Service (AMS) data. Overall, both organic and conventional fluid milk retail margins were stable in this period. Conventional dairy farmers receive 30-40% of consumer dollars, and organic dairy farmers receive 20-30% of consumer dollars.

Table 20. Average Annual Profit Margin of Organic and Conventional Fluid Milk in the U.S.

Year	2004	2005	2006	2007	2008	2009	2010	2011	2012
Conventional	1.28	1.34	1.36	1.33	1.47	1.34	1.24	1.27	1.30
SD of Con	0.13	0.01	0.04	0.05	0.04	0.16	0.04	0.06	0.07
Organic	2.43	3.32	3.31	3.47	2.75	2.75	2.67	2.67	2.64
SD of Org	0.03	0.19	0.07	0.15	0.03	0.07	0.06	0.09	0.17

SD: standard deviation; Con: conventional milk; Org: Organic milk

Table 21. Farm Price to Retail Price Ratio of Organic and Conventional Fluid Milk (%) in the U.S.

Year	2004	2005	2006	2007	2008	2009	2010	2011	2012
Conventional	35.21	32.73	28.94	38.03	34.87	29.36	36.07	40.49	38.07
SD Of Con	3.75	0.81	2.05	3.55	2.08	4.70	2.52	1.99	3.85
Organic	24.97	20.62	22.48	21.69	27.73	27.36	27.81	28.83	30.68
SD Of Org	0.69	0.60	0.59	0.77	0.40	1.33	1.38	1.94	1.83

SD: standard deviation; Con: conventional milk; Org: Organic milk

Sexton and Iskow (Sexton and Iskow 1988) argue that only cooperatives that control significant market share can extract abnormal margins. Organic Valley has a large enough market share (50%) in the raw milk and fluid milk markets to affect the farm and retail prices of organic milk. It appears that large market share allows Organic Valley to affect farm gate and wholesale prices. It maintained its retail price during the economic recession of 2008-2009 while other organic milk processors decreased their retail prices. It increased its retail price in 2015 to increase its farm gate price.

9.2 Competitive Yardstick Effect of Organic Valley Cooperative

According to Edwin Nourse, cooperatives serve as a competitive yardstick of the performance of a concentrated market (Nourse 1942). The existence of cooperatives makes an imperfect market competitive. A cooperative controlling a modest market share can keep the market competitive (Schomisch 1979).

However, Helmberger (1964) contended that only cooperatives with an open membership policy can create the yardstick effect. Cotterill (1997) also agreed with Helmberger's view that closed membership cooperatives can perform as a monopoly and generate profits for its members, but are not good for consumers because of their higher monopoly price. Organic Valley is a closed membership cooperative, but not a monopoly. The quantity delivered by farmer members is restricted. In addition, because of its large number of farmer members, Organic Valley has market power in the organic milk supply market. So, based on the conclusion of Helmberger, Organic Valley cannot create the yardstick effect.

Organic Valley has a stable pay price policy. It advocates a fair and reasonable profit for its farmer members in order to maintain economic sustainability. In 2004, when organic milk supply was in shortage, some organic milk buyers increased their pay price. However, Organic Valley wanted to maintain a stable pay price at the time and in the future in case of adverse economic conditions (Organic Valley 2013a) (p. 149). In 2009, Organic Valley had an oversupply. Instead of reducing its pay price, Organic Valley introduced an internal supply management program. In 2014, when the supply of organic milk experienced a shortage again, Organic Valley did increase its pay price but not as much as other competitors. Consequently, some members left the cooperative for higher prices (Organic Valley 2015). In 2015, Organic Valley increased its retail price and further increased its pay price, which will have profound effects on the pay price of the organic dairy industry.

Organic Valley publicly announces its pay price at the beginning of each calendar year, while Horizon Organic signs confidential contracts with its farmers. Organic Valley's public pay price information serves as a standard for other organic dairy farmers when they sign contracts with Horizon Organic or other buyers. Therefore, the existence of Organic Valley benefits all organic dairy farmers.

Sexton (Sexton 1990) examined the role of cooperatives in oligopsonistic agricultural markets with a spatial model. He found that cooperatives with an open membership policy have a positive effect on the behavior of private firms, and therefore benefit farmers. The presence of cooperatives forces private firms to pay higher prices than otherwise. In a duopsony market with one cooperative and one investor-owned firm (IOF), the IOF has to pay the same price as the cooperative. Otherwise, farmers will join the cooperative for a better price (Nourse 1942).

Organic Valley has added new members almost every year since it was founded in order to exploit economies of scale and meet growing market demand. As long as farmers meet the quality requirements of Organic Valley, they can easily switch from Horizon Organic to Organic Valley. As seen in the average pay prices of Organic Valley and Horizon in Table 19, Horizon Organic has paid slightly higher prices than Organic Valley to secure its milk supply; this is the competitive yardstick effect of Organic Valley.

An organic dairy farm requires extra paper work, third-party certification, specific pasture and animal management, and extra fees to maintain the certification. Physical asset specificity, human capital asset specificity, and the temporal specificity of the operation make dairy farmers vulnerable to opportunistic behavior, especially in a monopsonist or oliopsonist market. Consequently, milk producers have an incentive to vertically integrate. A cooperative, as a farmer-owned organization, provides necessary protection for its farmer members. Being a member of a cooperative helps to avoid extremely high transaction costs and ameliorates the holdup problem. Therefore, Horizon Organic has to match the price of Organic Valley or even exceed it to acquire its milk supply. As a result, the existence of Organic Valley benefits the farmers of both Organic Valley and Horizon Organic.

Tennbakk (1992) compared three duopsony models: one public firm and one private firm; one cooperative and one private firm; and two private firms. He found that mixed ownership structures were preferred over a private ownership structure, in terms of producers' welfare. The mixed model with one cooperative and one private firm is closest to the structure of the organic milk market. Under the assumption that two firms have the same number of producers and the same cost function, Tennbakk concluded that the cooperative bought a greater quantity than the private firm under Cournot competition. This is true for the two large organic milk buyers, Organic Valley and Horizon Organic. Organic Valley handles almost two times the milk of Horizon Organic. One assumption, the same cost function, does not hold here. In fact, the average herd size of Organic Valley is smaller than the average herd size of Horizon Organic (80 vs. 90 cows) and more than 80% of Organic Valley farmers have 100 cows or fewer. Hence, the average cost for farmer members of Organic Valley is higher than for the contracted farmers of Horizon Organic. It is more costly to transact with a large number of small farmers for the same quantity of milk than to transact with a smaller number of large farms. This is why large farmers get volume premiums relative to small farms. Thus, the existence of Organic Valley benefits small organic dairy farmers more.

Rogers and Sexton (1994) modeled the effect of a cooperative on an oligopsony market with three buyers, i.e., one cooperative and two investor-owned firms. They found that the existence of a cooperative significantly improved market efficiency, especially in markets with low transportation costs. Organic Valley contracts with local dairy plants to process its milk and sources raw milk locally. This practice reduces transportation costs.

Azzam and Andersson (2008) tested the market power and efficiency effects of market concentration with mixed organization forms, i.e., cooperative and private firm (IOF) in the Swedish beef slaughter market. They found a market power effect with both IOFs and cooperatives. Their results showed that a 10% increase in cooperative concentration contributed to a 9.5% increase in the wholesale beef price, whereas a 10% rise in market concentration from IOFs and cooperatives together was associated with only a 8.6% increase in the wholesale price of beef. They also found that the cooperative market share was 79-81% in Sweden, and that cooperatives were price leaders and IOFs were price-takers in the industry. This implies that the high market share of Organic Valley in the U.S. organic dairy industry may contribute to higher prices, and Organic Valley could be a price leader and Horizon Organic a price follower in terms of the organic milk raw milk price.

Hanisch et al. (2012) studied farm milk prices in Europe and found that the higher the market share of cooperatives, the higher the milk farm price. Their results showed that a dairy industry controlled entirely by cooperatives could pay 3.60 euro per 100 kg milk more than a market with only 10% controlled by cooperatives. They concluded that farmers prefer cooperatives and maintain loyalty to their cooperatives because cooperatives provide incentive programs such as extra services provided to farmers, patronage refunds and industry information, and ameliorate the holdup problem created by opportunistic buyers due to the temporal and site asset specificities of milk.

To summarize, based on previous theories and evidence, Organic Valley has enough farmer members to affect the market and set farm price. In order to compete for organic milk supply with Organic Valley, Horizon Organic has to offer a similar or better price. Otherwise, farmers have the potential of joining Organic Valley instead of contracting with Horizon Organic. Organic Valley provides a stable pay price, and the price is considered fair.[11] Organic Valley (founded in 1988) has a longer history than Horizon Organic (founded in 1990), which sourced its milk from the former when it started to market fluid milk. Later, Horizon Organic developed its own farms and started to source milk from independent producers. Currently, Horizon Organic uses a similar pricing method as Organic Valley, which sets the standard for the industry. Based on the actual prices paid to farmers by the two competitors, we conclude that Organic Valley serves as

[11] Price is set by a committee of producers and staff.

a price leader and Horizon Organic is a price follower. Consequently, Organic Valley cooperative creates a competitive yardstick effect in the organic dairy industry.

10 The Theory Behind the Success of Organic Valley's Supply Control

Neoclassical economists assume that people are rational and self-interested. Mancur Olson (1971) pointed out that in large groups, self-interested members have an incentive to be free riders; that is, unless coercion or selective incentives are used, collective action is impossible. This is the classical collective action social dilemma. However, Organic Valley's 1,400 dairy farmers worked collectively in the past and successfully coped with the industry crisis of 2009. How does collective action function at Organic Valley with self-interested farmers?

10.1 Informal Institutions and Social Norms Play Important Roles in the Behavior of Farmers

Ostrom has presented empirical and theoretical evidence that self-interested individuals can behave collectively informed by a group of organizational design principles (Ostrom 1990, 2000). She pointed that there are different types of people. Some are more likely to act collectively than others. Social norms and informal institutions influence individual behavior. Farmers with the same social values or philosophy are more likely to join a group that represents their philosophy.

As mentioned above, the objective of Organic Valley is to maximize the values of members including economic and social values. Organic farmers feel a sense of social responsibility about protecting the environment and small family farms. Protecting their organic dairy farmer neighbors conforms to their social values, and is an integral part of their organizational and social culture. The farmer members of Organic Valley share similar social norms and a culture of mutual help and sharing. These social norms are embedded in the mission of Organic Valley cooperative, and the culture of Organic Valley's founding members, its current members, and the local community. The members recognize the interdependency of farmer members, their cooperative, cooperative employees and the local community. These informal institutions play an important role in understanding Organic Valley's decision making.

10.2 Farmer Coordination Boosts Farm Gate Price in a Cooperative

In a coordinated cooperative, members recognize their interdependence and behave accordingly to maximize joint profit. The quantity each member delivers is determined by their joint profit, not only at the moment, but also in the long term. In a coordinated cooperative, the quantity of milk a member delivers to her/his cooperative is determined by the point where the marginal cost of production equals the marginal revenue product of the cooperative. This is less than the quantity delivered to a cooperative without coordination, since members of the latter organization determine how much to deliver by maximizing individual profit, not joint profit. Within a coordinated cooperative, the price is higher, but the quantity delivered is lower. Farmer members' joint profit also is higher than profit without coordination.

Cooperatives use three approaches to promote coordination in order to maximize members' joint benefits: supply control, education and pricing strategies (Lopez and

Spreen 1985). The relationship among price, quantity delivered, and coordination can be expressed by the following formula (Lopez and Spreen 1985):

$$\eta_{P,y} = \eta_{cs,y} - 1 = \frac{\partial cs}{\partial y}\frac{y}{cs} - 1$$

Where $\eta_{P,y}$ is the elasticity of price to total delivery, and $\eta_{cs,y}$ is the elasticity of total profit of the cooperative to total delivery, which is proportional to the total quantity of delivery. y is the quantity delivered. $(\eta_{cs,y} - 1)$ represents the cooperation of farmer members in a cooperative. The larger the value of $(\eta_{cs,y} - 1)$ (i.e., the more coordination of farmer members), the higher the farm gate price.

Organic Valley has a contract production policy to coordinate members' delivery and balance supply and demand. They enroll new members when there is an outlet for the milk. The founders of Organic Valley learned from a local tobacco cooperative that supply control can bring them high prices and high margins. So, supply management has been enforced since the cooperative was formed. That is why Organic Valley was able to quickly institute a supply control program during the 2008 recession. The objective of supply control policy and practice at Organic Valley is to balance supply and demand while keeping the pay price stable and high.

The second strategy used by Organic Valley is to educate their members as to the benefits of coordinated production. Organic Valley's founders set a target price upon which farmers could maintain a sustainable life through their farming business. In order to maintain the price of organic milk, Organic Valley has sold extra milk to the conventional market at a lower price from time to time, which jeopardized the profit of the cooperative and its members. Therefore, the staff of Organic Valley teach its members the importance of maintaining the contracted quantity in order to ensure a desired profit level. Historic events have also taught Organic Valley's staff and members the necessity of fulfilling their delivery quota.

The pricing strategies approach suggested by Lopez and Spreen (1985) aims to differentiate price based on quantity. The price for under-quota products is higher than the over-quota price. Using this approach, farmers have no incentive to overproduce. During the economic recession in 2009, Organic Valley adopted this approach with its supply control program. Organic Valley enforced a quota program based on members' past three years of production. Each member was required to reduce production by 7%. Farmers were allowed to deliver extra milk, but over-quota organic milk was priced at $15/cwt, much lower than the regular price of $27/cwt. The quota system and pricing strategy helped Organic Valley manage the oversupply problem during the 2009 crisis.

10.3 Market Power Allows a Supply Control

Cakir and Balagtas (2012) found that U.S. dairy cooperatives have significant market power in the fluid milk market. This is because dairy cooperatives control a large amount of raw milk and processed dairy products in the U.S. Their market power increased the farm milk price by 9% above the marginal costs, leading to more than $600 million in income being transferred from milk processors to cooperatives every year.

Restricted membership is necessary for market power. A restricted membership cooperative is one where expansion of membership will increase or maintain the net return for members and their cooperative (Youde and Helmberger 1966). Cooperatives manufacturing consumer packaged products and branded products can more easily achieve market power. This is because consumer packaged goods are more likely to be differentiated, and branded products can generate consumer loyalty and extract a higher margin.

Organic Valley is a closed membership cooperative and manufactures consumer packaged goods. The Organic Valley brand is the third most popular brand in the organic dairy industry. It controls 50% of the raw organic fluid milk market, and 30% of the branded fluid milk market. This gives Organic Valley market power in both organic raw milk procurement and the organic dairy retail price. This market power gives Organic Valley leverage in pricing, and the ability to enforce a supply control program (Organic Valley 2015) (p. 3). The producer-oriented stable and sustainable price policy is ensured by sales of branded products, which generate higher net margins for Organic Valley. Branded sales are the backbone of Organic Valley's net income.

10.4 Game Theory Explains the Cooperation of Members in a Cooperative

In infinite repeated prisoners' dilemma games, players realize that the payoff for cooperation is greater in the long run than the payoff for short-term defection. Therefore, they elect to cooperate instead of defect. Farmer members of Organic Valley are in the same situation as in a repeated game, because they interact with each other on a daily basis.

Their milk has to be hauled at least every other day. In such a game, farmers' return for cooperation in the long run is higher than the short-term return for defection. From previous experience and local culture, farmers know that their fellow farmer members cooperate in most cases. Ups and downs are norms of a business. So the board members decided to institute supply controls in 2009 to achieve a better return in the future.

Organic milk demand recovered in 2011. Organic Valley was able to increase its supply by removing the quota. However, the other competitor experienced short supply because it had dropped farmers during the recession and was unable to recruit new members in a short period.

Chapter Seven: Summary, Discussion and Implication

1 Summary and Conclusion

The organic food industry has generated increased consumer interest since the 1990s. The uniform USDA Organic Food Production Standards have propelled consumer demand even further. Dairy is the second largest organic sector of and has undergone ups and downs. The number of organic dairy farmers is less than conventional dairy farmers, but the former have received higher and more stable pay prices than their conventional counterparts. Their financial situation is also better than conventional dairy farmers on average.

The organic dairy industry experienced an oversupply crisis during the 2008-2009 economic recession. Some farmers were dropped by their processors and had to exit the business, and others had to process their own milk due to a lack of buyers. Organic Valley, as a farmer cooperative, was able to help farmer members deal with the crisis and maintain a stable pay price through its supply control program. Organic Valley's informal institutions and social norms, internal coordination, institutional objectives, and market power all might play a critical role in this successful collective action.

Balanced demand and supply is critical for a stable farm gate price and long-term development of the organic milk industry. Consumer demand analysis is critical for relevant stakeholders as they undertake long-term planning. Farmers make production decisions according to available information about future demand. Accurate demand information is important to the decision making of farmers and other participants in the organic dairy industry. Up to now, only very few consumer demand analyses for organic milk in the U.S. have been done. None of these studies have used national aggregate data. This study fills this gap.

The linear approximate almost ideal demand model was selected for this study. By incorporating time series properties, a vector error correction almost ideal model was developed for elasticity estimation. The demand model adds dynamic consumption patterns to represent consumer preference persistence. The study also explores the endogeneity of price and expenditure. The results show that price is exogenous but expenditure is endogenous. The erogeneity of price is due to the duopsony market structure of the organic milk industry. Organic milk manufacturers have the market power to affect retail prices. Real income was used as an instrumental variable for expenditure and a new model was developed. This model produces better results than the model without an instrumental variable in term of the significance of coefficients, conformation to consumer theory, and reasonableness of elasticities.

Using the instrumental VECM, price and expenditure elasticities were calculated and compared between organic and conventional milk. The results show that both organic milk and conventional milk are price inelastic, but organic milk is more elastic than conventional milk. Organic milk is expenditure elastic and is a luxury good, but both conventional whole and reduced fat milk are expenditure inelastic and are necessary goods. Based on these results, some implications for the industry stakeholders are developed in the following section.

2 Implications for Organic Milk Industry Stakeholders

2.1 Implications for Producers

After the economy recovered from 2008-2009 recession, consumer demand for organic dairy increases. Organic milk has been in short supply from late 2013 up until now. Two factors have caused the supply shortage. One is the decreasing number of dairy cows transitioning from conventional to organic, and the other is increased feed price, which has caused a decrease in current milk production. It takes three years for dairy cows to transition from conventional to organic production. The number of cows making this transition slowed down due to the 2008-2009 recession and the 2011-2012 drought. With more and more consumers purchasing organic milk and dairy products, the demand for organic dairy will likely increase in the future, even if there is a temporary drop as occurred in 2009. Overall, consumer demand is likely to increase over the next a few years as it has increased in the past.

Conventional farmers who can produce some of their feed or use intensive grazing may consider converting to organic operation. Farmers who do not want their operations to get too large may be especially interested. Organic milk commands a significant premium over conventional milk. The current conventional milk price is less than $17/cwt, while the organic milk price can go as high as $40/cwt in the northeastern region of the U.S., more than double the price of conventional milk. Past data showed that the costs of production per cwt of organic milk is $ 5 more than the cost of conventional milk (McBride and Greene 2009). So the premium of organic milk is enough to cover the extra cost of organic milk over conventional milk. Small organic farmers get much better returns than their peers in conventional dairy. So, organic operation may help small dairy farmers financially.

The economic crisis during the last recession tells us that farmers need to have a reliable buyer for their milk to ensure their continuing operation and return on their investment. Large buyers have more leverage in the market and can ensure payment in the case of an adverse situation, as happened in 2008-2009. Smaller buyers may pay a higher price in the short run since they have less overhead and fewer advertising costs, but they may have less ability to survive unexpected crises. Farmers select their buyers according to their needs and philosophies. Some buyers provide price incentives and bonuses during the last year of transition, but others do not. A few entities help conventional dairy farmers go through the transitioning process and secure reliable buyers. One of them is the Organic Agricultural Program of National Institution of Food and Agriculture (2016). Potential organic dairy farmers need to make a detailed transitioning plan and consult with all possible buyers and their neighbors before making a decision about which buyer to use. This is critical during periods of economic hardship. Small farmers have less ability to cope with economic recession than their larger peers. A large cooperative owned by farmer members can help farmers deal with economic hardship better than investor-owned firms and smaller cooperatives.

Organic feed is the largest variable cost in organic milk production. During the 2011-2012 drought, farmers who produced at least part of their feed performed much better than farmers who did not. Therefore, farmers need to make wise plans about their feed procurement to ensure a sufficient margin.

Other factors also affect the profitability of organic dairy farms. Any change in macro-level economic conditions may influence the cost of farm inputs. The current increasing cost of feed seems a duplication of the last few years. Parsons (2013) researched the sustainability and profitability of northeastern organic dairy farmers and found that farm management is critical for farm profitability. Hence, farmers should consult with local extensions or other professionals to examine their practices carefully and improve their management and operating efficiency. Only farmers who can outperform can survive in the long run.

2.2 Implications for Manufacturers

With increasing consumer demand, more buyers enter the market. This increases market competition significantly. Some of them pay a mailbox price as high as $40/cwt without charging for trucking. This puts pressure on existing buyers and forces them to increase their price. Under such pressure, Organic Valley increased its pay price by $2/cwt in 2015 by increasing its retail price. Large firms have higher overhead and advertising costs. The margin for branded products may be lower than the margin for private label products produced by local or regional buyers. In this situation, all organic milk buyers should communicate well and should not start a price war for the milk supply. Otherwise, the price war will affect all buyers' profits. These buyers may differentiate themselves from others by developing higher quality products, adding more value to their products and increasing margins to cover their high input costs.

Organic Valley, as a virtual cooperative contracting with local manufacturing plants for production, has higher costs of production than Horizon Organic. Also, being a cooperative, Organic Valley has capital constraints and higher capital costs than Horizon Organic. As a branch of an almost $3 billion business, Horizon Organic has more resources from its parent company than Organic Valley. Aurora Organic is a highly vertically integrated firm. It does not pay the FMMO. These factors give Aurora advantages over Organic Valley. Consequently, Organic Valley needs to differentiate itself from its two rivals to attract more farmer members and consumers in order to run a successful business. Relative to Horizon Organic, the gross margin of Organic Valley is much smaller.[12] Saving on production costs and increasing market share and margin can be some future targets for Organic Valley cooperative.

Small firms are hard to compete with large firms in retail outlets like Walmart and other big box chain stores. They need to find a niche market for their manufactured products in order to make a profit.

2.3 Implications for Retailers of Organic milk

A decade or two ago, the major marketing channel for organic milk and other organic food was natural food stores. However, as consumer demand has increased, more and more box stores, grocery stores, drug stores and convenience stores have entered the organic milk retail business. Now, conventional food retailers have become the major outlet for organic dairy food (Greene et al. 2009). This endangers the customer traffic of

[12] Calculated using financial data from the two firms' financial report.

natural food stores. So, natural food stores need to change their sales strategy to attract new customers as well as retain their committed organic food buyers.

The elasticity of a good is closely related to its sales strategy. Retailers adopt different pricing strategies according to the price elasticity of a good in order to maintain or increase their sales or revenues. If a good has elastic demand, lowering the price will increase sales. For a good with inelastic demand, increasing the price will increase sales with little decrease in sales volume. Both organic and conventional milk are price inelastic, based on the results of this study. So, retailers and manufacturers should be able to increase their prices and thus get higher revenue.

Demographic factors affect consumption patterns. Dimitri, and Venezia, using 2004 Neilsen homescan data, found that organic milk consumers tend to have high incomes. High-income consumers are less price sensitive and do not decrease their consumption much when prices increase. Organic milk is considered a luxury good, with an expenditure elasticity greater than 2. Therefore, retailers may want to target high-income consumers in order to increase their sales and revenue. Also, as the CEO of Organic Valley pointed out, sales of organic milk are dependent to some degree on the price gap between organic milk and conventional milk (Siemon 2010). When a decrease in consumer income is accompanied by an increased price gap between organic and conventional milk, sales of organic milk will decrease. Although neither organic nor conventional milk is price elastic, consumers' purchasing decisions may be affected by the price gap due to psychological reasons. Therefore, retailers may keep this factor in mind when setting prices.

2.4 Implications for the Organic Milk Industry

The organic dairy industry is experiencing continuing rising demand for its products in the last 20 years except the economic recession of 2008-2009. In the past, organic products were mainly sold in natural food stores. Now, more chain stores, including big merchandisers like Sam's Club and Costco, and grocery and drug stores like Aldi and Walgreen's, offer organic fluid milk. The sales of organic dairy products increased to $5.6 billion in 2014 (Organic Trade Association 2015). The industry has an opportunity for growth based on previous data if normal years coming in the future.

The imbalance between increasing consumer demand and slow supply growth in the last a few years represents a hurdle to further expansion of the organic dairy industry. Even though conventional dairy industry growth has been flat or even negative in some years, conventional dairy farmers are reluctant to convert to organic operation. Some organic dairy farms have even converted back to conventional operation due to high feed prices and low margins. Relevant stakeholders need to provide more useful industry information – including information on future consumer demand, pay price, and feed price – to farmers in order to secure a stable organic milk supply and meet rising consumer demand.

The biggest obstacle to increasing organic dairy consumption is the much higher price of organic products relative to conventional milk. The retail price of organic milk is almost two times that of conventional milk. But organic dairy producers still complain that the farm price is too low to cover their cost of production. The industry needs to work together to improve communication between farmers and consumers in order to promote mutual understanding and increase industry efficiency.

Another controversial issue in the industry is regulation over organic production. With large organic dairy farms emerging, the organic dairy industry is converging with the conventional dairy sector. Large organic dairy farms have a cost advantage and lower the pay price for the entire organic dairy industry. This hurts the profits of smaller farmers. So, small family farms are working together to propose more detailed industry regulations.

Even though a large number of consumers purchase organic food, organic dairy is still a very small part of the entire dairy section, i.e., only 6% of total dairy consumption. So, all organic dairy industry stakeholders need to work together to increase the market penetration for organic milk and other products in order to promote consumption. As consumer demand increases, the organic dairy industry will have more leverage in setting prices and can improve profits for all participants in the supply chain.

Consumer education and advertising have been widely used by the industry. Scientific evidence is a very powerful tool for increasing sales. Studies show that organic milk is more nutritious than conventional milk (Benbrook et al. 2013, Palupi et al. 2012). Scientific research and publications provide solid proof to health conscious consumers and make them become more loyal organic consumers. Such consumers will also be less price elastic and small price changes will not affect their purchase decision. The current supply shortage has been created by the low margin of organic milk. If consumers are willing to pay more for organic milk, the retail price can rise and farmers will be paid more, making the organic dairy industry more sustainable.

2.5 Implications for Organic Valley Cooperative

Organic Valley was formed to maintain economic sustainability for its farmer members. Since the economic recession of 2008, Organic Valley's mission has been challenged. Recent high feed prices and the cooperative's relatively low pay price have made some farmers leave Organic Valley for other buyers. The reputation of Organic Valley has been damaged. It is critical for the cooperative to adopt a strategy to improve its margin and keep its pay price competitive.

Organic Valley's large number of farmer members gives the cooperative some leverage in pricing both at the retail level and in the raw organic milk market. Although some farmers have left the cooperative for a higher pay price, Organic Valley may consider other selective incentives besides price to retain its farmer members and maintain its market power.

The other source of higher returns for the organic dairy industry is increasing exports, especially to markets in Asia. With recent economic development in Asia, particularly China, consumer demand for high quality milk has surged. Dairy powder exports have increased in past months and continuing growth is forecasted (Kenneth Mathews 2015). Organic Valley already has marketed its products in China. With growing demand, it can expand its export market to achieve higher margins.

3 Policy Implications

Organic milk production is more costly than conventional dairy operation. Dairy farmers depend on the premiums consumers are willing to pay to cover their costs. In the late 1990s and early 2000s, organic milk had a significant premium (72-88%) over conventional milk. Many conventional dairy farmers converted to organic productions for better economic returns. However, the unexpected economic recession in 2008-2009 and drought have put some organic dairy farmers in economic difficulty. Some of them have converted back to conventional production. Therefore, information about future demand and the price of organic milk is critical for organic and potential organic dairy farmers as they make long-term operating plans, and is critical to their economic returns and farm survivability.

The USDA provides outlooks for many commodities, but provides no information for organic dairy and other organic products. Although organic operation is still a small part of entire agricultural production, the number of organic producers is increasing and consumer demand is also increasing. It is necessary for the federal government to provide relevant policy, information and support to facilitate further growth of the organic industry.

Organic dairy farmers have less of a government-provided safety net. Dairy margin protection insurance is based on conventional milk and feed prices. However, organic feed prices are higher than conventional feed prices. The margin for organic milk will shrink or even be negative if it is sold in the conventional market. The USDA has a risk management agency that provides an organic to conventional crops ratio to mark up the higher cost of organic crops. However, organic dairy does not have such specific insurance. Up to now, there has been no safety net for organic dairy farmers. Therefore, the federal government may need to produce a specific income protection program for organic dairy farmers.

Current federal programs such as the Environmental Quality Incentives Program and the Conservation Stewardship Program have played important roles in helping organic dairy farmers maintain both environmental and economic sustainability. Because of the extra costs of producing organic milk, organic dairy farmers have more risk than conventional dairy farmers, especially in the period of transition from conventional to organic. In this period, milk production decreases and the cost of production increases, but milk is paid for at the conventional price. Currently, organic milk processors, such as Organic Valley and Horizon Organic, provide financial support and incentives for transitioning farmers. More support for organic dairy farmers, especially young organic dairy farmers, may be considered as a way of maintaining production diversity, and environmental and economic sustainability.

The National Organic Program is responsible for regulating and monitoring the compliance of organic food with national standards. In 2010, it changed organic dairy regulations and implemented a stronger pasture access policy for dairy herds. New organic dairy production rules can have a profound impact on industry structure and the cost of production. Farms of different sizes or in different regions may be affected by the same rules differently. Some analysts argue that the expansion of large-scale, low-cost organic farms can make organic food more affordable for low-income consumers (Johnson, 2013). The current situation shows that organic producers of different sizes are likely to persist in the organic dairy sector.

4 Limitations and Future Research

Organic Valley is a unique organization that plays an important role in the organic dairy industry. In this study, imperfect market structure is studied qualitatively. The duopsony structure and its strategic behaviors can be explored mathematically. I hypothesize that Organic Valley serves as a price leader and Horizon Organic is a price follower. In future studies, I will mathematically model the interactions of the two large firms, and the two large firms with other small firms. In addition, the effects of market structure on the organic milk price can be explored quantitatively, too.

Due to data availability, organic milk as a whole is included in study. In the future, disaggregated organic milk varieties will be considered. Other factors, such as demographic variables and simulation, need to be considered in the demand model in future research. A forecast model for derived demand at the farm level will be developed in the future.

Most previous studies have used micro-level household data. This study uses national aggregate data. I will compare and contrast the results using two types of data sets on the price and expenditure elasticities.

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