# Essays on the fluid milk industry

by

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B.A., Handong Global University, 2012

M.A., Seoul National University, 2014

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AN ABSTRACT OF A DISSERTATION

submitted in partial fulfillment of the
requirements for the degree

DOCTOR OF PHILOSOPHY

Department of Agricultural Economics
College of Agriculture

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Manhattan, Kansas

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# Abstract

Industrial organization deals with how seller concentration, product differentiation, and conditions of entry affect firms' behavior and market perform. In particular, the U.S. fluid milk industry is characterized by concentration. As a result of mergers and acquisitions among fluid milk processors in the late 1990s, the national four-firm concentration ratio grew faster than any other food processing sector and it accounted for approximately 45% in the late 2000s. The U.S. fluid milk industry is also marked by co-operative associations. Marketing co-operatives might play a role in counterbalancing the processor's buyer power. In addition to concentration, an organic label is considered a key strategy for differentiating products in the fluid milk industry. As consumers are willing to pay a premium for the organic attribute, organic labels are commonly considered a profitable marketing strategy in the fluid milk industry. These two key features of the U.S. fluid milk industry, 1) concentration in milk processing and the existence of co-cooperatives and 2) a way of product differentiation, organic labeling, have led to using an empirical industrial organization approach to study these two issues in U.S. fluid milk industry.

The first essay examines the role of upstream and downstream market power in determining the effect of potential supply shocks on price transmission. To do this, I develop a conceptual framework, which extends Villas-Boas and Hellerstein (2006)'s model of successive oligopoly, to illustrate the effect of supply shocks on price accounting for 1) market power and 2) sequential vertical-pricing games. A structural econometric model is employed to estimate demand, downstream and upstream firms supply and market power parameters which are derived from the conceptual model. Using the estimated parameters, I simulate how market power impacts the effect of supply shocks on prices. The conceptual framework shows the following propositions. First, the effect of a negative supply shock on the

change in output price is diminished by the degree of its' market power. The effect of upstream firms' market power on the change in upstream firms' output price is larger than that of downstream firms' market power on the change in downstream firms' output price. Second, the effect of a negative supply shock on the change in downstream firms' output price is diminished by the degree of upstream firms' market power. Third, the impact of downstream firms' market power on the change in upstream firms' output price caused by a negative supply shock is ambiguous. Fourth, the effect of a negative supply shock on the change in upstream firms' output is larger than on the downstream firms' output price. The empirical framework suggests that the assumption of perfect competition for upstream and downstream firms in the U.S. fluid milk industry is rejected. The simulation analysis indicates that perfect competition assumption overestimates the effect of supply shocks on both upstream and downstream firms' output prices. Thus, it is important to account for the presence of market power when considering the impacts of supply shocks.

In the second essay, I investigate new econometric evidence on the economic value of organic labels in the fluid milk market from a producer's standpoint. To do this, a structural econometric model is used to estimate organic and conventional milk demand. Given the demand estimates, I simulate two counterfactual analyses in which 1) organic milk products are replaced by conventional milk products and 2) organic milk producers go out of business by 1) removing organic attributes from both consumer utility and marginal costs and 2) removing organic brands from the choice set. The demand estimates show that consumers are willing to pay a significant premium for organic milk products. Consumers' willingness to pay for the organic label is $2.47 per half gallon of milk. The counterfactual analyses suggest that the presence of organic label increases market share and producer surplus for organic milk brands by approximately 33 (when removing organic attributes) to 100% (when removing organic brands) while it decreases market share and producer surplus for conventional brands. Also, the impact on price, share, and producer surplus for conventional brands are greater when removing organic products from the choice set compared to removing organic attributes.

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In the second essay, I investigate new econometric evidence on the economic value of organic labels in the fluid milk market from a producer's standpoint. To do this, a structural econometric model is used to estimate organic and conventional milk demand. Given the demand estimates, I simulate two counterfactual analyses in which 1) organic milk products are replaced by conventional milk products and 2) organic milk producers go out of business by 1) removing organic attributes from both consumer utility and marginal costs and 2) removing organic brands from the choice set. The demand estimates show that consumers are willing to pay a significant premium for organic milk products. Consumers' willingness to pay for the organic label is $2.47 per half gallon of milk. The counterfactual analyses suggest that the presence of organic label increases market share and producer surplus for organic milk brands by approximately 33 (when removing organic attributes) to 100% (when removing organic brands) while it decreases market share and producer surplus for conventional brands. Also, the impact on price, share, and producer surplus for conventional brands are greater when removing organic products from the choice set compared to removing organic attributes.

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Above all, I give my thanks to you my Heavenly Father. *Soli Deo Gloria.*

# Dedication

To my parents and beautiful wife Soomin

# Chapter 1

# Introduction

Market structure and competition have long been the main topics in the field of industrial organization as they affect both price and output determination. There is a general belief among economists that seller concentration, product differentiation, and conditions of entry may affect market structure and competition. Seller concentration refers to a measure of the number of firms and their shares of the total production in a market. Product differentiation is the process of distinguishing a product from others. The conditions of entry refer to the ease with which new firms can enter a market. Industrial organization deals with how seller concentration, product differentiation, and conditions of entry affect firms' behavior and market perform. In addition, industrial organization also attempts to identify factors that influence seller concentration, degree of product differentiation, and conditions of entry.

The U.S. fluid milk industry is characterized by concentration. Figure 1.1 presents numbers of milk processors and concentration ratios for the fluid milk industry between 1992-2007. The four-firm concentration ratio for fluid milk has been relatively low compared to other food processing industries up to the late 1990s. However, several merges and acquisitions that occurred in the early 2000s led to higher market concentration for fluid milk processors. For instance, the two largest private fluid processing firms, Dean Foods and Suize Foods, merged in December 2001. In July 2002, Dean Foods purchased Land O'Lakes Inc.'s upper Midwest fluid milk operations and then acquired Horizon Organic Holding Corporation in 2004. Table 1.1 presents the top 10 largest dairy processors and manufacturers by the number of plants operated. As a result of mergers and acquisitions, between 1997 to 2004, the national four-firm concentration ratio grew faster than any other food processing sector and it accounted for approximately 45%.

The U.S. fluid milk industry is also marked by co-operative associations. In 1922, the Capper-Volstead Act gave co-operatives producing agricultural products certain exemptions from antitrust laws. It allowed dairy farmers to band together and help negotiate with milk processors using collective bargaining. The existence of marketing co-operatives makes agricultural markets distinguishable from other markets. Rogers and Sexton (1994) argue that "marketing co-operatives or bargaining associations, institutions of seller power, are present or potentially present in the market" (p. 1143). Marketing co-operatives might play a role in counterbalancing the processor's buyer power.

There has been the trend toward increasing consolidation among dairy co-operatives as several dairy co-operatives have merged since the 1940s. The number of co-operatives had declined to 155 in 2007 while the number of co-operatives was over 2,300 in the 1940s. Increasing concentration in dairy co-operatives has enabled them to have an improved bargaining position against milk handlers. Table 1.2 presents, in 2008, the United States' top 10 and 50 milk co-operatives (by volume) marketed about 48% and 79% of all fluid milk, respectively.

In addition to concentration, an organic label is considered a key strategy for differentiating products in the fluid milk industry. Sales of organic products in the United States were estimated at $35 billion in 2014. After fresh fruits and vegetables (43 percent), dairy has been the second top selling category of organically grown food in 2012, followed by packaged/prepared foods (11 percent), beverages (11 percent), bread/grains (9 percent), snack foods (5 percent), meat/fish/poultry (3 percent), and condiments (3 percent) (USDA, 2017). Organic labels are commonly considered a profitable marketing strategy in the fluid milk industry as producers use organic labels as a way of distinguishing and creating a unique brand for their products (Messer et al., 2015). These arguments could be supported by the fact that consumers are willing to pay a premium for organic attributes (Bernard and Bernard, 2009; Bonnet and Bouamra-Mechemache, 2015; Brooks and Lusk, 2010; Dhar and Foltz, 2005; Kanter et al., 2009; Kiesel and Villas-Boas, 2007; Wolf et al., 2011).

Due to these two key features of the U.S. fluid milk industry; 1) concentration in milk processing and the existence of co-cooperatives and 2) organic labeling, I use empirical industrial organization to study several issues in U.S. fluid milk industry. There have been few studies to investigate the economic implications of upstream and downstream firms' market power on price transmission and organic labeling from a producers' standpoint in the fluid milk market. For example, what is the role of upstream and downstream market power in determining the effect of potential supply shocks on price transmission? Does the organic label lead to higher sales? For this dissertation, these questions will be addressed.

In Chapter 2, I aim to examine the role of upstream and downstream market power in determining the effect of supply shocks on price transmission. The analysis is composed of three sections: theoretical, empirical, and simulation study.

In the theoretical section, I develop a conceptual framework that extends Villas-Boas and Hellerstein (2006) to account for 1) market power and 2) sequential vertical-pricing games between upstream and downstream firms. The equilibrium upstream and downstream firms' output price is derived as a function of supply shocks by substituting the equilibrium quantity into the demand and derived demand function. It shows that the effect of supply shocks on the equilibrium upstream and downstream firms' output price is a function of downstream and upstream market power. The comparative static and comparative static derivative of these effects with respect to the market power parameters leads to four propositions. A key proposition of this paper is the effect of a negative supply shock on the change in output price is diminished by the degree of its' market power.

In the empirical section, the inverse demand equation is estimated along with the downstream firms' supply relation and upstream firms' supply relation to identify demand, cost, and market power parameters. Time-series data on the price and quantity of U.S. fluid milk from January 2005 to December 2014 are used. The market power parameters show that they are consistent with symmetric Cournot behavior in the case of ten firms and four to ten firms for downstream and upstream firms, respectively.

In the simulation section, simulations at successive vertical stages are conducted given the estimates from the empirical study under two market power scenarios: 1) symmetric Cournot and 2) perfect competition. Consistent with the theoretical findings, I find that perfect competition always overestimates the impact of supply shocks on prices than a given degree of market power.

Chapter 3 attempts to quantify the economic value of the organic label from a producer's standpoint. This analysis consists of three sections: demand, supply, and a counterfactual analysis.

In the demand analysis, a structural econometric model of organic and conventional milk demand is estimated using weekly retail prices, aggregate market shares, and product characteristics. These data are aggregated by brand and week. Consistent with previous studies, I find that consumers are willing to pay a significant premium for organic milk products. Consumers willingness to pay for organic labeling is \$2.47 per gallon of milk. The deviation from the mean utility suggest that consumers' preference for price, 2% milkfat, plastic package, and organic are likely to be heterogeneous across consumers.

In the supply analysis, price-cost margins are computed based on the demand estimate. Given observed retail prices, marginal costs are recovered and regressed on the estimated marginal costs on the observable product characteristics. The average price-cost margins across products account for 38.32% of the retail price. I also find that producing organic increases the marginal costs by \$1.60 per gallon.

In the counterfactual scenarios, the following questions are addressed: What would happen if organic milk products are 1) replaced by conventional milk products or 2) are removed from the market? To answer these questions, two counterfactual analyses are investigated by 1) removing the organic attribute from consumer utility and marginal costs and 2) removing organic brands. The results show that the presence of organic labeling increases market share and producer surplus for organic milk brands by approximately 33 (when removing organic attributes) to 100% (when removing organic brands). Also, organic labeling decreases market shares and producer surplus for conventional brands. The impact on price, share, and producer surplus for conventional brands are greater when removing organic products from the market compared to removing the organic attribute.

In Chapter 4, the key findings and contributions from the two studies are summarized.

# Table and Figures

**Figure 1.1**: *Concentration for U.S. Fluid Milk Processors, 1992-2007*

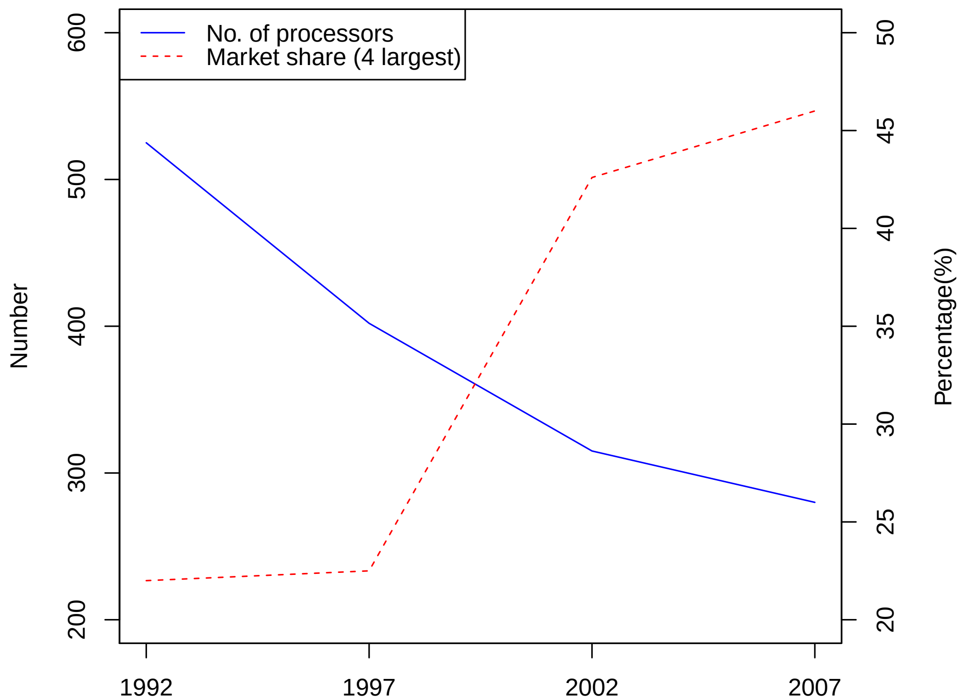


**Table 1.1**: *Top 10 U.S. Dairy Processors by Volume in 2008*

| Rank | Company | Sales ($ million) | Number of Plants |
|---|---|---|---|
| 1 | Dean Foods Co. | 12,454 | 81 |
| 2 | Kraft Foods North America Inc. | 4,800 | 16 |
| 3 | Saputo Inc. | 4,390 | 45 |
| 4 | Land O' Lake Inc. | 4,136 | 9 |
| 5 | Schreiber Food Inc. | 3,500 | 18 |
| 6 | Prairie Farms Dairy | 2,924 | 20 |
| 7 | Agropur Cooperative | 2,800 | 26 |
| 8 | Kroger Co. Dairy Operation | 2,500 | 19 |
| 9 | Leprino Food Co. | 2,500 | 9 |
| 10 | Darigold Inc. | 2,200 | 11 |

Source: Dairy Foods, https://www.dairyfoods.com/ext/resources/DF/Home/Files/PDFs/archives/d/df0809Dairy-100-table.pdf

**Table 1.2**: *Top 10 U.S. Dairy Co-operatives by Volume in 2008*

| Rank | Dairy Co-operative | Member milk volume (mil. lbs.) | Member farms |
|---|---|---|---|
| 1 | Dairy Farmers of America, Inc. | 37,900 | 10,178 |
| 2 | California Dairies, Inc. | 17,700 | 589 |
| 3 | Land O'Lakes, Inc. | 12,706 | 2,965 |
| 4 | Norhwest Dairy Association | 7,900 | 532 |
| 5 | Dairylea Cooperatives, Inc. | 5,914 | 2,264 |
| 6 | Associated Milk Producers, Inc. | 5,800 | 3,500 |
| 7 | Family Dairies USA | 5,751 | 3,563 |
| 8 | Foremost Farms USA | 4,990 | 2,356 |
| 9 | Manitowoc Milk Producers Cooperative | 4,857 | 2,945 |
| 10 | Select Milk Producers, Inc. | 4,629 | 79 |
| | Total for top 10 co-operatives | 90,465 | 25,412 |
| | | (48% of U.S.) | (37% of U.S.) |
| | Total for top 50 co-operatives | 150,699 | 43,448 |
| | | (79% of U.S.) | (65% of U.S.) |

Source: Hoards Dairyman, October 10, 2009, p. 613.

# Chapter 2

# Price Transmission and Supply Shocks: The Role of Upstream and Downstream Market Power

## 2.1 Introduction

Supply shocks are common in the food industry for a variety of reasons including animal diseases outbreaks (e.g., foot-and-mouth disease (FMD) and highly pathogenic avian influenza (HPAI)). Negative supply shocks can have considerable economic impacts to the various stakeholder groups including producers, processors, and the final consumer as highly contagious animal diseases can lead to a dramatic supply reduction, cause increases in farm prices, and eventually an increase in wholesale and retail prices.

In the past 10 years, several animal disease outbreaks have occurred in many parts of the world. The 2010-2011 FMD outbreaks in Korea caused significant economic impacts on livestock production. The number of culled animals were about 3.5 million head with more than 30% of the swine depopulated. With domestic supplies shrinking due to a mass hog depopulation, pork price sharply increased by 9.2% (Korea Rural Economic Institute (KREI), 2011). The 2014-2015 HPAI outbreak in commercial poultry had considerable economic impacts on U.S. poultry industry. More than 48 million birds were affected with 67% being laying hens and the remaining 33% were commercial turkeys. The large HPAI outbreak in the Midwestern U.S. caused an increase in national egg prices despite a decline in late 2014 as markets did adjust (Huang et al., 2016).

A growing literature investigates the *ex-ante* economic consequences of hypothetical animal disease outbreaks. Pendell et al. (2015) and Pendell et al. (2016) evaluate the economic consequences of hypothetical FMD and Rift Valley Fever outbreaks, respectively, from the releases of the viruses in the future National Bio and Agro-Defense Facility in Kansas. Thompson et al. (2019) estimates the economic impacts of business continuity on a hypothetical HPAI outbreak in the Midwestern United States. These previous studies use a partial equilibrium model to evaluate market-level impacts.

The partial equilibrium models used in the studies mentioned above utilized a competitive market framework assuming price-taking economic decision-makers. This may not be appropriate to evaluate the effect of supply shocks on prices when a market is highly concentrated. The increasing consolidation of the livestock, meat, and products industry may influence the effect of supply shocks on prices. Ignoring market power may under or overestimate the impact of supply shocks on prices throughout the supply chain. Thus, it is important to consider market power when measuring the effect of supply shocks on prices.

Several studies have focused efforts on investigating the degree of price transmission in the light of market power. McCorriston et al. (1998) consider factors (e.g., market power) which influence the degree of price transmission by deriving a price transmission elasticity. Weldegebriel (2004) develops a model of price transmission where both oligopoly and oligopsony power co-exist. Bunte and Peerlings (2003) perform simulations to show how market power could cause asymmetric price adjustments. Lloyd et al. (2006) constructs a theoretical model to highlight the linkage between market power and price transmission, but fail to link their theoretical framework with an empirical framework due to the difficulty in distinguishing market power and returns to scale.

A key difference between this research and previous studies is the use of structural estimation. Many of the previous studies have developed theoretical models of price transmission where imperfect competition exists. To quantify the effect of market power on price transmission, these papers use a simulation framework based on estimates from previous literature. To the best of our knowledge, the theoretical framework regarding the role of market power in determining the extent of price transmission has not been directly linked with an empirical framework. This leads us to the use of structural estimation that allows for linking of the theoretical framework with an empirical model.

There is a strand of literature that analyzes the effects of market power on a variety of topics in agricultural marketing literature. Russo et al. (2011) analyze the interaction of market power and government intervention, and shows that market power may reduce the net welfare benefits from removing agricultural support policies. Zhang and Sexton (2002) investigate the effects of downstream market power on optimal commodity promotion and finds that imperfect competition reduces farmer's optimal advertising expenditure. Sexton et al. (2007) study the role of downstream market power in agricultural trade liberalization and demonstrates that departures from the perfect competition can cause much of the benefits from trade liberalization. Saitone et al. (2008) analyze the effect of market power on the impacts of the ethanol subsidy. However, little is known about the effect of market power on prices at successive vertical stages when there are supply shocks.

Our objective is to investigate the role of upstream and downstream market power in determining the effect of potential supply shocks on price transmission. To do this, we develop a conceptual framework, which extends Villas-Boas and Hellerstein (2006)'s model of successive oligopoly to illustrate the effect of supply shocks on price accounting for 1) market power and 2) sequential vertical-pricing games. We also estimate a structural econometric model to determine demand, downstream and upstream firms supply, and market power parameters which are derived from the conceptual model. Using the estimated parameters, we simulate how market power impacts the effect of supply shocks on prices.

The new empirical industrial organization (NEIO) approach has been widely implemented to assess the degree of market power. We exploit an extension of the traditional NEIO framework (Villas-Boas and Hellerstein 2006). The model is applied to the production and marketing of U.S. fluid milk. By the 20th century, dairy farmers had formed co-operatives associations to offset fluid milk processors market power. Indeed, the nations top 50 milk co-operatives marketed about 79% of all farm milk in the United States (2013). Cakir and Balagtas (2012) adopted Villas-Boas and Hellerstein (2006)'s model of successive oligopoly to estimate oligopoly power of dairy co-operatives and processors-retailers. They find that both co-operatives and processor-retailer exert market power to raise their prices above marginal costs by approximately 9% and 1%, respectively.

Our contribution to the literature on the effects of market power is twofold. First, we develop a structural model to study how upstream and downstream firms' market power can affect price transmission. To the best of our knowledge, we are the first study to link the theoretical framework regarding price transmission and market power with an empirical framework. Methodologically, our model that estimates the magnitude of price transmission resulting from a supply shock in the fluid milk markets may also be applied to markets of other agricultural products. Second, the impact of supply shocks on price transmission, which is under study in this paper, is an important topic that deserves the attention of researchers.

The rest of the paper is organized as follows. Section 2.2 describes the main methodological contributions on the conceptual framework which enables us to link to an empirical framework. Section 2.3 provides an overview of the data. Section 2.4 presents the empirical model and its identification. Section 2.5 presents the empirical results for demand and supply relation for upstream and downstream firms and Section 2.6 presents simulation results. Finally, section 2.7 provides conclusions of these paper.

## 2.2 Conceptual Framework

We consider a flexible model setting to analyze the role of both upstream and downstream firms in the effect of supply shocks on pricing behavior. Following Cakir and Balagtas (2012), we assume an integrated producing and processing-retailing sector where the producing sector, which comprises of dairy farms and co-operatives, produces milk and then sells it to the processing-retailing sector which performs processing and then sells the products to final consumers at retail. We refer to milk producing and processing-retailing sectors as upstream firms and downstream firms, respectively. Both upstream and downstream firms may exhibit market power.

In this paper, the linear pricing model is considered, where the upstream firms first set their output price ($p^u$) and the downstream firms follow by setting their output price ($p^d$) given the upstream firms prices ($p^u$). Also, we assume that the downstream firms' quantity ($Q^d$) is equal to the upstream firms' quantity ($Q^u$) and total quantity ($Q$) (i.e., $Q = Q^d = Q^u$).

The inverse demand for the downstream firms is given by

$$p^d = h(Q, Y, \delta) \tag{2.1}$$

where $Y$ represents the variables that shift the demand curve, and $\delta$ are parameters to be estimated.

Profit of the downstream firm $i$ ($\pi_i$) is

$$\pi_i = h(Q, Y, \delta)q_i - p^u q_i - C^d(q_i, R, \tau) \tag{2.2}$$

where $q_i$ is the output of firm $i$, $C^d$ is the cost function of a downstream firm, $R$ is the variables that shifts the cost function of the downstream firms, and $\tau$ are the unknown parameters of the cost function to be estimated.

There exists an identification problem since we have information only on aggregate supply and are not able to determine the parameters of each firm (e.g., demand, supply, and conduct parameter). Thus, we determine the average market parameters and then derive the supply relation for the industry, rather than each firm. The equilibrium in the industry is determined by the simultaneous solution of $n$ supply relations, demand function, and identity $Q = \sum q_i$.

We assume marginal costs of both downstream and upstream firms are increasing returns to scale, which is crucial to identify the conduct parameters. The marginal costs of the downstream firms, $c^d$, can be expressed as $c^d = \beta_d + \tau_d Q + \gamma_d R$ where $\beta_d$, $\tau_d$ and $\gamma_d$ are parameters to be estimated. Likewise, marginal costs of the upstream firms, $c^u$, are defined as $c^u = \beta_u + \tau_u Q + \gamma_u W$ where $W$ represents exogenous variables that affect cost of the upstream firms and $\beta_u$, $\tau_u$ and $\gamma_u$ are the upstream firms' costs parameters to be estimated.

We can set the downstream firms' perceived marginal revenue, $p^d + \lambda_d h'(Q)Q$, equal to the sum of the upstream firms' output price, $p^u$, and marginal cost of the downstream firms, $c^d$, to obtain the downstream firms' supply relation for the industry

$$p^d = p^u - \lambda_d h'(Q)Q + \beta_d + \tau_d Q + \gamma_d R. \tag{2.3}$$

$\lambda_d \in [0,1]$ is the conduct parameter for the downstream firms. If $\lambda_d = 0$, downstream firms behave as a price taker since equation (2.3) reduces to $p^d = p^u + c^d$, that is, price equals to marginal cost. The larger $\lambda_d$, the further away the industry is from perfect competition, with $\lambda_d = 1$ implying a monopoly.

From equation (2.3), the inverse derived demand faced by the upstream firms is derived as follows:

$$p^u = h(Q) + \lambda_d h'(Q)Q - \beta_d - \tau_d Q - \gamma_d R. \tag{2.4}$$

Setting the upstream firms' perceived marginal revenue, $p^u + \lambda_u[h'(Q)Q + \lambda_d h''(Q)Q^2 + \lambda_d h'(Q)Q]$, equal to marginal costs of the upstream firms, $c^u$, gives their supply relation:

$$p^u = -\lambda_u \lambda_d [h''(Q)Q^2 + h'(Q)Q] - \lambda_u h'(Q)Q + \beta_u + \tau_u Q + \gamma_u W \tag{2.5}$$

where $\lambda_u \in [0,1]$ is a parameter which measures the conduct of the upstream firms.

For simplicity, a linear demand function is assumed as follows:

$$Q = \alpha_0 + \alpha_1 p^d + \alpha_2 Y \tag{2.6}$$

which yields $h(Q) = -\frac{\alpha_0}{\alpha_1} + \frac{1}{\alpha_1}Q - \frac{\alpha_2}{\alpha_1}Y$ and $h'(Q) = \frac{1}{\alpha_1}$ and finally $h''(Q) = 0$.

To analyze how equilibrium prices change as the downstream and the upstream firms' market power change, we need equilibrium quantity and prices. First, we solve for market equilibrium quantity to derive the market equilibrium prices. By substituting the inverse derived demand, equation (2.4), into the perceived marginal revenue equation, (2.5), and adding a supply shock term, we solve for the equilibrium quantity, $Q^*$, as follows:

$$Q^* = \beta_1[\frac{\alpha_0}{\alpha_1} + \frac{\alpha_2 Y}{\alpha_1} + \beta_u + \gamma_u R + \beta_u + \gamma_u W + \tau_u X] \tag{2.7}$$

where $\beta_1 = \frac{\alpha_1}{(1+\lambda_u)(1+\lambda_d)-\alpha_1(\tau_u+\tau_d)}$ and $X$ indicates a (negative) supply shock where $X$ is a positive number. The detail derivation is illustrated in Appendix A.

If we substitute the equilibrium quantity from equation (2.7) into the linear demand function in equation (2.6) and rearrange terms, the equilibrium downstream firms' output price can be found as follows:[1]

$$p^d = \beta_2 + \beta_3 Y + \beta_4[\beta_u + \gamma_u R + \beta_d + \gamma_d W] + \beta_5 X \tag{2.8}$$

where

$$\begin{aligned}
\beta_2 &= \frac{-(\lambda_d + \lambda_u + \lambda_d\lambda_u) + \alpha_1(\tau_u + \tau_d)}{(1+\lambda_d)(1+\lambda_u) - \alpha_1(\tau_u + \tau_d)}(\frac{\alpha_0}{\alpha_1}), \\
\beta_3 &= \frac{-(\lambda_d + \lambda_u + \lambda_d\lambda_u) + \alpha_1(\tau_u + \tau_d)}{(1+\lambda_d)(1+\lambda_u) - \alpha_1(\tau_u + \tau_d)}(\frac{\alpha_2}{\alpha_1}), \\
\beta_4 &= \frac{1}{(1+\lambda_d)(1+\lambda_u) - \alpha_1(\tau_u + \tau_d)}, \quad \text{and} \\
\beta_5 &= \frac{\tau_u}{(1+\lambda_d)(1+\lambda_u) - \alpha_1(\tau_u + \tau_d)}.
\end{aligned}$$

The $\alpha_1$ parameter describes how demand for the downstream firms falls as its own price increase (i.e., it reflects the own-price elasticity of demand). The $\tau_u$ and $\tau_d$ parameters represent how the marginal costs of producing one more unit of a good for the upstream and downstream firms, respectively, increases as its supply increases (i.e., it reflects the elasticity of supply). Since $\alpha_1$ is negative, $\tau_u$ and $\tau_d$ are positive, $\lambda_u$ and $\lambda_d$ range between 0 to 1, a negative shock on supply leads to the higher downstream firms' output price, which is

[1] The detail derivation is illustrated in Appendix A.

theoretically plausible.

We also solve for equilibrium upstream firms' output price. From equation (2.3), the derived demand faced by the upstream firms can be written as:

$$Q = \beta_6[\frac{\alpha_0}{\alpha_1} + p^u + \frac{\alpha_2 Y}{\alpha_1} + \beta_d + \gamma_d R] \tag{2.9}$$

where $\beta_6 = \frac{\alpha_1}{(1+\lambda_d)-\alpha_1\tau_d}$. Substituting the derived demand faced by the upstream firms in equation (2.9) into the equilibrium quantity in equation (2.7), the equilibrium upstream firms' output price can be derived as:[2]

$$p^u = \beta_7 + \beta_8 Y + \beta_9[\beta_d + \gamma_d R] + \beta_{10}[\beta_u + \gamma_u W] + \beta_{11} X \tag{2.10}$$

where

$$\begin{aligned}
\beta_7 &= \beta_2, \\
\beta_8 &= \beta_3, \\
\beta_9 &= \beta_4, \\
\beta_{10} &= \frac{(1+\lambda_d) - \alpha_1\tau_d}{(1+\lambda_d)(1+\lambda_u) - \alpha_1(\tau_u + \tau_d)}, \quad \text{and} \\
\beta_{11} &= \frac{\tau_u[(1+\lambda_d) - \alpha_1\tau_d]}{(1+\lambda_d)(1+\lambda_u) - \alpha_1(\tau_u + \tau_d)}.
\end{aligned}$$

The comparative static and comparative static derivative of the parameters of interest, $\beta_5$ and $\beta_{11}$, indicates the effect of supply shocks on the change in the equilibrium upstream and downstream firms' output price, with respect to the conduct parameters in equations (2.8) and (2.10). This leads to the four propositions described below.

***Proposition 1***. The effect of a negative supply shock on the change in output price is diminished by the degree of its' market power. The effect of upstream firms' market power on the change in upstream firms' output price is larger than that of downstream firms' market

[2] The detail derivation is illustrated in Appendix A.

power on the change in downstream firms' output price.

***Proof:***

$$\frac{\partial \beta_5}{\partial \lambda_d} = \frac{-\tau_u(1+\lambda_u)}{\{(1+\lambda_d)(1+\lambda_u) - \alpha_1(\tau_u+\tau_d)\}^2} < 0$$

$$\frac{\partial \beta_{11}}{\partial \lambda_u} = \frac{-\tau_u(1+\lambda_u)[(1+\lambda_d) - \alpha_1\tau_d)}{\{(1+\lambda_d)(1+\lambda_u) - \alpha_1(\tau_u+\tau_d)\}^2} < 0$$

$$|\frac{\partial \beta_5}{\partial \lambda_d}| = \frac{\tau_u(1+\lambda_u)}{\{(1+\lambda_d)(1+\lambda_u) - \alpha_1(\tau_u+\tau_d)\}^2} \quad \leq \quad |\frac{\partial \beta_{11}}{\partial \lambda_u}| = \frac{\tau_u(1+\lambda_u)[(1+\lambda_d) - \alpha_1\tau_d)}{\{(1+\lambda_d)(1+\lambda_u) - \alpha_1(\tau_u+\tau_d)\}^2}$$

We plot the role of market power in determining the effect of supply shocks on price in Figure 2.1. An industry with more market power faces a steeper downward-sloping marginal revenue curve ($MR^M$), which means that each additional unit the industry with more market power sells brings in less revenue when compared to an industry with less market power. In other words, an industry with more market power has a less elastic marginal revenue curve. As the marginal revenue curve becomes steeper, the change in equilibrium quantity for the industry with more market power ($\Delta Q^M$) gets smaller as a result of a supply shock. Therefore, the magnitude of the change in the output price ($\Delta P^M$) is smaller when the firms have more market power.

The intuition behind this result is that firms with market power have the ability to adjust their output price through markup absorption. Under perfect competitive markets, for example, firms pass on the full extent of cost changes to their output price since they set price equal to marginal costs. On the other hand, under oligopoly markets, firms with market power do not pass the full extent of cost changes by absorbing their markup to offset a fall in sales (McCorriston et al. 1998). This theoretical prediction is in line with Bettendorf and Verboven (2000) and Bonnet et al. (2013) which point out markup absorption is more important in oligopolies than competitive markets and that in an oligopoly market, pass-through will be more incomplete.

***Proposition 2***. The effect of a negative supply shock on the change in downstream firms' output price is diminished by the degree of upstream firms' market power, $\lambda_u$.

***Proof:***

$$\frac{\partial \beta_5}{\partial \lambda_u} = \frac{-\tau_u(1+\lambda_d)}{\{(1+\lambda_d)(1+\lambda_u) - \alpha_1(\tau_u+\tau_d)\}^2} < 0$$

As shown in ***Proposition 1***, the extent of rising the upstream firms' output price due to the supply shock is weakened as upstream firms have more market power. From the standpoint of the downstream firms, the upstream firms' output price is considered as the marginal cost of producing one more unit of a good. As the change in marginal costs for downstream firms decreases, the change in downstream firms' output prices is decreasing. In other words, the degree of shifting the downstream firms' supply curve upward due to the higher marginal cost is less when the upstream firms have more market power. Therefore, upstream firms' market power weakens the effect of the supply shock on downstream firms' price.

***Proposition 3***. The impact of downstream firms' market power, $\lambda_d$, on the change in upstream firms' output price caused by a negative supply shock is ambiguous.

***Proof:***

$$\frac{\partial \beta_{11}}{\partial \lambda_d} = \frac{\tau_u\alpha_1(\tau_d\lambda_u - \tau_u)}{\{(1+\lambda_d)(1+\lambda_u) - \alpha_1(\tau_u+\tau_d)\}^2} \lesseqgtr 0$$

Downstream firms' market power affects the change in upstream firms' output price through two channels: 1) the change in equilibrium quantity, and 2) the change in the slope of the derived demand faced by the upstream firms. An increase in downstream firms' market power leads to 1) a smaller equilibrium quantity and 2) a steeper derived demand curve. Downstream firms' market power may weaken or strengthen depending on the degree of changes in 1) the equilibrium quantity and 2) the slope of the derived demand faced by the upstream firms. If the degree of change in the equilibrium quantity is larger (smaller) than the slope of derived demand, downstream firms' market power may decrease (increase) the change in upstream firms' output price.

Consider the case where $\tau_d = 0$. We find that $\frac{\partial \beta_{11}}{\partial \lambda_d}$ is positive, which indicates downstream firms' market power strengthens the effect of a supply shock on the upstream firms' output price. This result implies that when $\tau_d = 0$, the change in the slope of the derived demand curve caused by the increase in downstream firms' market power is dominant, compared to the change in equilibrium quantity. When $\tau_d$ is positive, the slope of upstream firms' supply curve gets steeper compared to $\tau_d = 0$. As a result, under the same level of a supply shock, the change in the upstream firms' output price gets smaller compared to $\tau_d = 0$. Therefore, the impact of downstream firms' market power on the change in upstream firms' output price is ambiguous.

***Proposition 4***. The price transmission between upstream firms and downstream firms is asymmetric. The effect of a negative supply shock on the change in upstream firms' output is larger than on the downstream firms' output price.

***Proof:***

$$\beta_5 = \frac{\tau_u}{(1+\lambda_d)(1+\lambda_u) - \alpha_1(\tau_u + \tau_d)} \quad \leq \quad \beta_{11} = \frac{\tau_u[(1+\lambda_d) - \alpha_1 \tau_d]}{(1+\lambda_d)(1+\lambda_u) - \alpha_1(\tau_u + \tau_d)}$$

As shown in ***Proposition 1***, downstream firms do not pass the full extent of the cost changes, increased upstream firms' output price, to their output price by absorbing their markup. Thus, the degree of pass-through from a supply shock is larger for the upstream firms than the downstream firms. This theoretical prediction is consistent with Cramon-Taubadel (1998) and Bunte and Peerlings (2003) which indicates that farm prices are not fully transmitted to consumer prices.

## 2.3 Data

The data used are aggregated monthly U.S. industry data on prices and quantities of fluid milk and prices of related products from January 2005 to December 2014. Retail prices, co-operative prices and the quantity of milk are obtained from the online database maintained by the USDA Agricultural Marketing Service (AMS). The retail price is calculated by taking the average across three types of retail stores: 1) the largest food store chains, 2) the second largest food store chains, and 3) convenience stores. We use the co-operative class 1 price as the upstream firms' price. They are converted to \$/lb assuming 1 gallon of fluid milk weighs 8 lbs. Per capita Real Disposable Income comes from the U.S. Bureau of Economic Analysis. Monthly averages of retail diesel and electricity prices are collected from the U.S. Energy Information Administration (EIA). U.S. monthly dairy costs of production are collected from USDA's 2005 (2005 – 2009) and 2010 (2010 – 2014) Agricultural Resource Management Survey (ARMS) of milk producers. All prices, income, and costs data are deflated by the consumer price index (January 2005 = 100). U.S. price indices for breakfast cereal, juices, cheese, coffee and tea, labor are collected from the Bureau of Labor Statistics of the U.S. Department of Labor. Labor price is the average hourly production worker earnings for the fluid milk industry. All indexes are normalized to January 2005 = 100. Table 2.1 provides summary statistics of the data.

## 2.4 Estimation Strategy

In order to identify demand, cost, and market power parameters, we estimate the inverse demand equation in equation (2.1), the downstream firms' supply relation in equation (2.3) and upstream firms' supply relation in equation (2.5) using time-series data on the price and quantity of U.S. fluid milk in each of $t = 1, ..., T$ periods.

The inverse demand for the downstream firms can be specified:

$$p_t^d = \delta_0 + \delta_1 Q_t + \delta_2 PJ_t + \delta_3 PJ_t Q_t + \delta_4 I_t + \delta_5 PBC_t + \delta_6 PCT_t + \delta_7 PC_t + \delta_8 D_t \qquad (2.11)$$

where $Q$ is quantity of fluid milk, $p^d$ is the retail price of fluid milk, $PJ$ is price of juices, $I$ is per capita income, $PBC$ is price of breakfast cereal, $PCT$ is price of coffee-tea, $PC$ is price of cheese, and $D$ is a seasonal dummy. Importantly, we interact the price of juices with quantity to identify the market power parameters. The price of juices shifts the demand curve through $\delta_2$ and it also determines the slope of the demand curve through $\delta_3$.

The slope of the demand curve is

$$\frac{\partial p}{\partial Q} = \delta_1 + \delta_3 PJ. \tag{2.12}$$

The marginal cost of downstream firms is linear as follows:

$$c^d = \beta_d + \tau_d Q_t + \gamma_2 W_t + \gamma_3 DI_t + \gamma_4 E_t + \gamma_5 D_t \tag{2.13}$$

where $W$ is labor price, $DI$ is diesel price, $E$ is electricity price, and $D$ is a seasonal dummy.

Substituting equations (2.12) and (2.13) into the retailers' supply relation in equation (2.3), we get

$$p_t^d - p_t^u = \beta_d + (\tau_d - \delta_1\lambda_d)Q_t - (\delta_3\lambda_d)PJ_tQ_t + \gamma_2 W_t + \gamma_3 DI_t + \gamma_4 E_t + \gamma_5 D_t. \tag{2.14}$$

The estimatable econometric equation for equation (2.14) is

$$p_t^d - p_t^u = \tau_0 + \tau_1 Q_t + \tau_2 PJ_tQ_t + \tau_3 W_t + \tau_4 DI_t + \tau_5 E_t + \tau_6 D_t \tag{2.15}$$

where $\tau_0 = \beta_d$, $\tau_1 = \tau_d - \delta_1\lambda_d$, $\tau_2 = -\delta_3\lambda_d$, $\tau_3 = \gamma_2$, $\tau_4 = \gamma_3$, $\tau_5 = \gamma_4$ and $\tau_6 = \gamma_5$. Therefore, the estimate of downstream firms' market power is given by $\lambda_d = -\frac{\tau_2}{\delta_3}$, where $\delta_3$ comes from the demand function. In addition, the estimate of downstream firms' supply parameter, $\tau_d = \tau_1 + \delta_1\lambda_d$, is identified.

The marginal cost of upstream firms is given as:

$$c^u = \beta_u + \tau_u Q_t + \gamma_6 F_t + \gamma_7 L_t + \gamma_8 EN_t + \gamma_9 D_t \tag{2.16}$$

where $F$ is price of feed, $L$ is price of labor, $EN$ is price of fuel, lube and electricity, and $D$ is a seasonal dummy.

Substituting equations (2.12) and (2.16) into the upstream supply relation in equation (2.5), we get

$$p_t^u = \beta_u + \{\tau_u - \delta_1\lambda_u(1+\lambda_d)\}Q_t - \{\delta_3\lambda_u(1+\lambda_d)\}PJ_tQ_t + \gamma_6F_t + \gamma_7L_t + \gamma_8EN_t + \gamma_9D_t \quad (2.17)$$

Cakir and Balagtas (2012) assume the regulated minimum price for class 1 milk is upstream firms' marginal cost of supplying milk to downstream firms, implying upstream firms' market power can be measured by their ability to raise prices above the regulated minimum price. However, market power is defined as the ability to set price profitably above marginal costs (Perloff et al., 2007). Since the regulated minimum price is greater than marginal costs for upstream firms and federal order changes take years and not designed to respond to temporary shift in costs (Sumner, 2018), it may be inappropriate to measure upstream firms' market power as their ability to set price above the regulated minimum price. Thus, instead of the minimum price, we use upstream firms' marginal costs information to measure upstream firms' market power.

The econometric equation for equation (2.17) is

$$p_t^u = \sigma_0 + \sigma_1Q_t + \sigma_2PJ_tQ_t + \sigma_3F_t + \sigma_4L_t + \sigma_5C_t + \sigma_6EN_t + \sigma_6D_t \quad (2.18)$$

where $\sigma_1 = \tau_u - \delta_1\lambda_u(1+\lambda_d)$, and $\sigma_2 = -\delta_3\lambda_u(1+\lambda_d)$. Therefore, the estimate of upstream firms' market power is given by $\lambda_u = -\frac{\sigma_2(1+\lambda_d)}{\delta_3}$, where the estimate of $\delta_3$ comes from the demand function. Additionally, the estimate of upstream firms' supply parameter, $\tau_u = \sigma_1 + \delta_1\lambda_u(1+\lambda_d)$ is identified.

Equations (2.11), (2.15) and (2.18) can be consistently estimated using two-stage least squares (2SLS). After estimating these equations, the parameters in the conceptual framework including the market power parameters ($\lambda_u$ and $\lambda_d$), demand parameter ($\alpha_1$), supply parameters ($\tau_d$ and $\tau_u$), and cost parameters ($\beta$ and $\gamma$) are identified.

## 2.5 Estimation Results

If the unobserved demand-side shock and supply-side shock that are correlated with quantity affect the prices, then the ordinary least square estimates of quantity would be bias and inconsistent. The exogenous demand and supply shifters are uncorrelated with both unobserved demand-side and supply-side shocks, but correlated with quantity. Thus, these exogenous variables are exploited as instruments for quantity.

The demand equation, supply relation for upstream and downstream firms can be consistently estimated using 2SLS, as in Porter (1983) and Agostini (2006).[3] This provides the parameters needed for the simulation analysis in Section 2.6. The results in column (1) of tables 2.2, 2.3, and 2.4 correspond to the model using monthly demand or supply shifters while the results in column (2) represents the results using quarterly demand or supply shifters.

Table 2.2 provides the results of the demand estimation of equation (2.11). The quantity coefficient have the expected negative sign. However, the coefficient of quantity is not statistically significant in column (1). The interaction term between the price of juices and quantity is not statistically significant in column (1) while it is statistically significant in column (2). The coefficients on income and price of substitutes and complements, juices, coffee-tea, and cheese are statistically significant in two specifications and, thus, seem to affect fluid milk demand.

Table 2.3 shows the results of the supply correspondence estimation of downstream firms in equation (2.15). The coefficient of the co-operative price is positive as expected, ranges between 0.699 and 0.915. The estimated coefficients for diesel and electricity prices are positive and statistically significant when using quarter supply shifters. The market power parameter of the downstream firm, $\lambda_d$, ranges from 0.093 to 0.138, which seems to be consistent with symmetric Cournot behavior in the case of ten firms. The coefficient of the market power parameter of the downstream firm is statistically different from zero. The statistically significant estimates of quantity in demand equation and supply relation of downstream firms

[3]The demand equation, supply relation for downstream firms and supply relation for upstream firms can be jointly estimated using three-stage least square (3SLS), which is relatively efficient. However, the downside of 3SLS is that misspecification may lead to inconsistent estimators. The advantage of using 2SLS is that it is robust to misspecification and allows consistency.

allow to have a statistically significant estimate of quantity on the marginal cost of downstream firms, and it ranges from 0.002 to 0.003. This represents a deviation from constant returns to scale.

Table 2.4 reports the results of the supply correspondence estimation of upstream firms in equation (2.18). The coefficients of labor and energy have the expected positive sign and statistically significant in both specifications. The market power parameter of the upstream firm, $\lambda_u$, ranges from 0.102 to 0.290, which are both statistically different from zero and imply a deviation from perfect competition. This range implies symmetric Cournot with four to ten firms. The estimate of quantity on the marginal cost of upstream firms is recovered from demand, upstream firms and downstream firms' supply correspondences. They have the expected positive sign and are between (0.0001, 0.0009). This is statistically significant in column (1) and implies that the hypothesis of constant returns to scale is rejected.

Our instruments, which are the exogenous demand and supply shifters, are strongly correlated with the quantity. We report the first stage regression in table A.1. Both regressions in columns (1) and (2) have F-statistics of 31.18 and 12.20 which is larger than the rule-of-thumb F-statistic threshold of 10 for testing for weak instruments (Staiger and Stock, 1997).

## 2.6 Simulation Results

To gain a broad perspective of the effects of supply shocks on prices under market power, we conduct simulations on the retail price and co-operative price as negative supply shocks range from 0 to 90% for two market power scenarios: 1) given market power (symmetric Cournot) and 2) perfect competition given the estimated market power parameters ($\lambda_u$ and $\lambda_d$), demand parameter ($\alpha_1$), supply parameters ($\tau_d$ and $\tau_u$), and cost parameters ($\beta$ and $\gamma$).

The retail price simulation results are summarized in figure 2.2 and table 2.5. Negative supply shocks lead to a higher retail price. Under the given degree of market power, retail price increases by \$0.035 to \$0.106 per lb as a reduction of fluid milk increases from 30% to 90%. When market power is not exercised by both upstream and downstream firms (i.e., perfect competition), retail price increases by \$0.042 to \$0.127 per lb as a reduction of fluid milk increases from 30% to 90%. These results are expected as pointed out in the ***Proposition 1*** where the firms with market power have the ability to adjust their price by absorbing markup while the firms pass on the full extent of cost changes on the price under perfect competitive markets. Thus, the perfect competition always overestimates the impact of supply shocks on retail price than the given degree of market power.

Similarly, figure 2.3 and table 2.6 summarize the simulation results on co-operative price. Negative supply shocks on supply lead to a higher co-operative price. Co-operative price increases by \$0.078 to \$0.233 per lb as a reduction of fluid milk increases from 30% to 90% under the given degree of market power. Under the perfect competitive market, co-operative price increases from \$0.087 to \$0.262 per lb. Consistent with retail price, the impact of supply shocks on co-operative is overestimated under the perfect competition than the given degree of market power.

While retail price increases by \$0.035 to \$0.106 per lb due to the supply shocks under the given degree of market power, the same magnitude of supply shocks increases the co-operative price by \$0.078 to \$0.233 per lb. The change in co-operative price due to a supply shock is about two times larger than the change in retail price under the same supply shocks. As discussed in ***Proposition 4***, the price transmission is asymmetric between upstream and downstream firms and the effect of the negative supply shocks on the co-operative price is larger than on retail price. Since both upstream and downstream firms adjust their output prices by absorbing their markup to offset a decrease in sales, the effect of the negative supply shocks on the co-operative price is larger.

Additional simulation analyses were conducted to enhance our understanding of how downstream and upstream firms' market power impact prices with a supply shock. To conduct the simulation analyses, we specify ranges of values for the market power parameters, $\lambda_u$ and $\lambda_d$, over the interval $\lambda_u, \lambda_d \in [0, 1]$. This allows us to demonstrate how the downstream firms' output price and upstream firms' output price change as market power parameters change. For these simulations, we assume a 50% negative supply shock.

Figure 2.4 depicts the effect of downstream firms' market power on the retail price and co-operative price under the 50% negative supply shock. When the given degree of downstream firms' market power is not exercised and it is assumed zero, the retail price increase from \$ 0.367 to \$ 0.433 per lb. However, the change in the retail price due to a supply shock decreases as downstream firms' market power increases. This result on retail price is consistent with ***Proposition 1***. On the other hand, the co-operative price seems to be relatively flat regardless of the degree of downstream firms' market power. This result is in line with ***Proposition 3*** where the impact of downstream firms' market power on the change in upstream firms' output price is ambiguous.

Next, we consider the impact of upstream firms' market power on prices. Figure 2.5 depicts the effect of upstream firms' market power on the retail price and co-operative price under the 50% negative supply shock. Both expected retail and co-operative prices decline as upstream firms exert additional market power. Besides, figure 2.5 indicates that the impact of upstream firms' market power on the change in the co-operative price is larger than in the retail price.

These simulation results emphasize the role of both downstream and upstream market power in analyzing the impact of supply shocks on prices. The results indicate that the prefect competition assumption overestimates the effect of supply shocks on prices while the monopoly assumption underestimates the effect of supply shocks on prices. These results suggest that it is important to account for the presence of market power when considering the impacts of a supply shock.

## 2.7 Conclusions

Given the increase in frequency and potential risks in supply shocks including foreign weather and animal disease globally, it is important to accurately measure the impact of supply shocks on prices at successive vertical stages. Previous literature has utilized partial equilibrium models assuming perfectly competitive markets, which may not be appropriate when a market is highly concentrated. Consequently, further attention needs to be paid to the issue of imperfect competition in determining the effect of a supply shock on prices.

In this article, we develop a conceptual framework to illustrate the role of market power on the change in prices due to supply shocks by accounting for imperfect competition and sequential vertical pricing games between upstream and downstream firms. Then, we use structural estimation to link the theoretical framework regarding the impact of market power on prices with an empirical framework. The estimated parameters from the empirical framework allow us to conduct simulation analyses to evaluate the change in retail and co-operative prices and have a better understanding of the role of market power in the change in prices. Our finding indicates perfect competition always overestimates the impact of supply shocks on prices than a given degree of market power.

# Table and Figures

**Table 2.1**: *Mean and Standard Deviations of Data*

| VARIABLES | (1) Units | (2) N | (3) mean | (4) sd |
|---|---|---|---|---|
| Cereal Price | Index | 120 | 106.2 | 5.219 |
| Juices Price | Index | 120 | 112.2 | 5.663 |
| Cheese Price | Index | 120 | 112.5 | 9.643 |
| Coffee-Tea Price | Index | 120 | 113.5 | 7.168 |
| Personal Income | $ | 120 | 31,663 | 1,347 |
| Wage | Index | 120 | 98.81 | 2.288 |
| Electricity | cents per kwt | 120 | 6.226 | 0.824 |
| Diesel | $ per gallon | 120 | 2.856 | 0.477 |
| Co-operative Price | $ per lb. | 120 | 0.153 | 0.0251 |
| Retail Price | $ per lb. | 120 | 0.367 | 0.0358 |
| Quantity | Mil. lbs | 120 | 368.6 | 19.89 |
| Feed | $ per cwt | 120 | 5.715 | 0.858 |
| Labor | $ per cwt | 120 | 1.334 | 0.0892 |
| Fuel | $ per cwt | 120 | 5.807 | 0.311 |

**Table 2.2**: *Demand Estimates*

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | Retail Price | | Retail Price | |
| VARIABLES | Coef | SE | Coef | SE |
| Quantity | -0.003 | 0.003 | -0.011*** | 0.004 |
| Quantity*Juices | 0.000 | 0.000 | 0.000*** | 0.000 |
| Personal Income | 0.000*** | 0.000 | 0.000*** | 0.000 |
| Cereal Price | -0.004* | 0.002 | -0.006*** | 0.002 |
| Juices Price | -0.018** | 0.008 | -0.038*** | 0.012 |
| Coffee-Tea Price | 0.004*** | 0.001 | 0.004*** | 0.001 |
| Cheese Price | 0.004*** | 0.001 | 0.003*** | 0.001 |
| Month = 2 | 0.053* | 0.028 | | |
| Month = 3 | 0.013 | 0.010 | | |
| Month = 4 | 0.038** | 0.018 | | |
| Month = 5 | 0.029* | 0.016 | | |
| Month = 6 | 0.077** | 0.036 | | |
| Month = 7 | 0.067** | 0.029 | | |
| Month = 8 | 0.027** | 0.012 | | |
| Month = 9 | 0.029** | 0.013 | | |
| Month = 10 | -0.000 | 0.008 | | |
| Month = 11 | 0.016 | 0.010 | | |
| Month = 12 | 0.005 | 0.009 | | |
| Quarter = 2 | | | 0.007 | 0.005 |
| Quarter = 3 | | | 0.009 | 0.006 |
| Quarter = 4 | | | -0.001 | 0.007 |
| Constant | 0.606 | 1.215 | 3.568** | 1.444 |
| Observations | 120 | | 120 | |
| R-squared | 0.708 | | 0.683 | |

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

**Table 2.3**: *Downstream Firms' Supply Correspondence Estimates*

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | Retail Price | | Retail Price | |
| VARIABLES | Coef | SE | Coef | SE |
| Quantity | 0.003*** | 0.000 | 0.003*** | 0.000 |
| Quantity*Juices | -0.000** | 0.000 | -0.000*** | 0.000 |
| Co-operative Price | 0.915*** | 0.144 | 0.699*** | 0.149 |
| Wage | -0.001 | 0.002 | -0.001 | 0.002 |
| Diesel | 0.008 | 0.007 | 0.012* | 0.007 |
| Electricity | 0.003 | 0.018 | 0.043*** | 0.011 |
| Month = 2 | 0.109*** | 0.019 | | |
| Month = 3 | 0.025* | 0.013 | | |
| Month = 4 | 0.071*** | 0.016 | | |
| Month = 5 | 0.060*** | 0.016 | | |
| Month = 6 | 0.141*** | 0.029 | | |
| Month = 7 | 0.118*** | 0.029 | | |
| Month = 8 | 0.045** | 0.019 | | |
| Month = 9 | 0.048** | 0.022 | | |
| Month = 10 | 0.001 | 0.012 | | |
| Month = 11 | 0.029** | 0.014 | | |
| Month = 12 | 0.016 | 0.013 | | |
| Quarter = 2 | | | 0.018* | 0.010 |
| Quarter = 3 | | | -0.009 | 0.012 |
| Quarter = 4 | | | -0.022*** | 0.008 |
| Constant | -0.868*** | 0.194 | -0.507** | 0.232 |
| $\lambda_d$ | 0.138** | 0.058 | 0.093*** | 0.024 |
| $\tau_d$ | 0.003*** | 0.000 | 0.002*** | 0.000 |
| Observations | 120 | | 120 | |
| R-squared | 0.442 | | 0.318 | |

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

**Table 2.4**: *Upstream Firms' Supply Correspondence Estimates*

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | Co-operative Price | | Co-operative Price | |
| VARIABLES | Coef | SE | Coef | SE |
| Quantity | 0.002*** | 0.000 | 0.001*** | 0.000 |
| Quantity*Juices | -0.000*** | 0.000 | -0.000*** | 0.000 |
| Feed | -0.001 | 0.002 | -0.001 | 0.002 |
| Labor | 0.107*** | 0.027 | 0.103*** | 0.025 |
| Energy | 0.059*** | 0.003 | 0.052*** | 0.003 |
| Month = 2 | 0.025*** | 0.007 | | |
| Month = 3 | 0.005 | 0.004 | | |
| Month = 4 | 0.020*** | 0.005 | | |
| Month = 5 | 0.015*** | 0.005 | | |
| Month = 6 | 0.035*** | 0.008 | | |
| Month = 7 | 0.029*** | 0.008 | | |
| Month = 8 | 0.007 | 0.005 | | |
| Month = 9 | 0.006 | 0.006 | | |
| Month = 10 | -0.008** | 0.004 | | |
| Month = 11 | 0.001 | 0.004 | | |
| Month = 12 | -0.004 | 0.004 | | |
| Quarter = 2 | | | 0.005** | 0.003 |
| Quarter = 3 | | | -0.000 | 0.003 |
| Quarter = 4 | | | -0.009*** | 0.003 |
| Constant | -0.644*** | 0.085 | -0.417*** | 0.065 |
| $\lambda_u$ | 0.290*** | 0.026 | 0.102*** | 0.010 |
| $\tau_u$ | 0.001*** | 0.000 | 0.000 | 0.000 |
| Observations | 120 | | 120 | |
| R-squared | 0.870 | | 0.859 | |

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

**Figure 2.1**: *Impact of Supply Shock under Oligopoly Power*

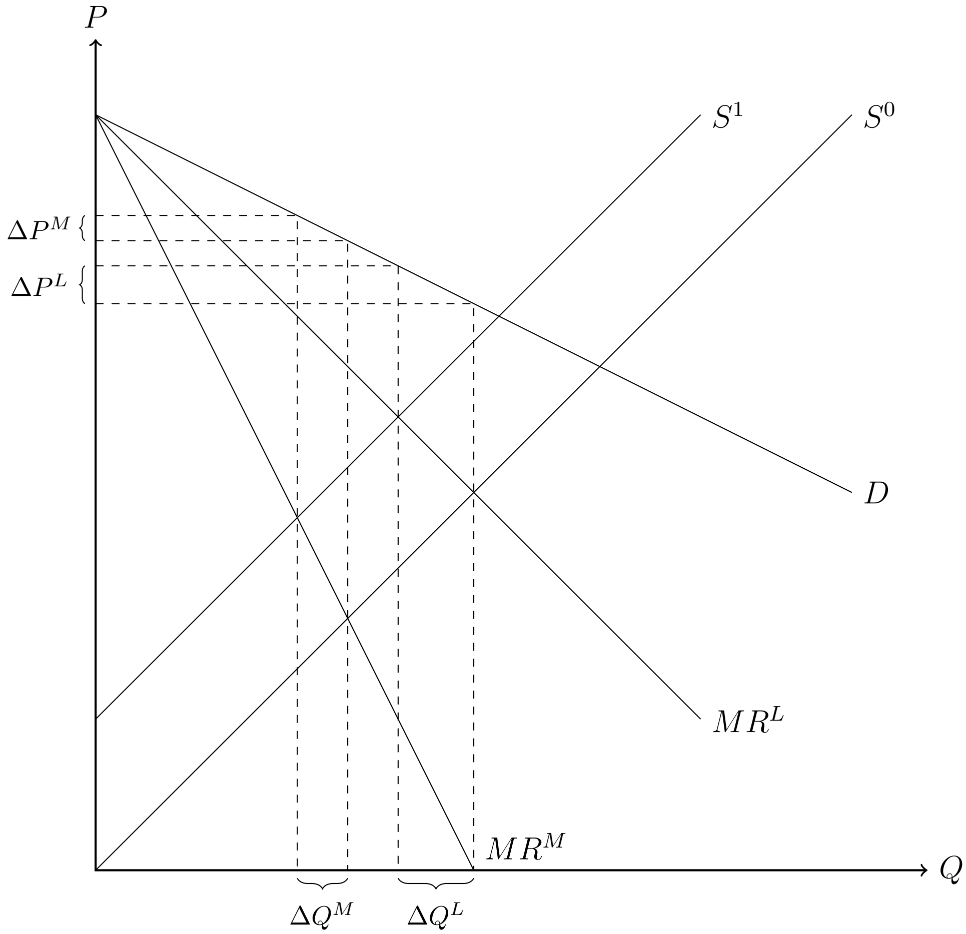


**Figure 2.2**: *Impact of Supply Shocks on Retail Rrice*

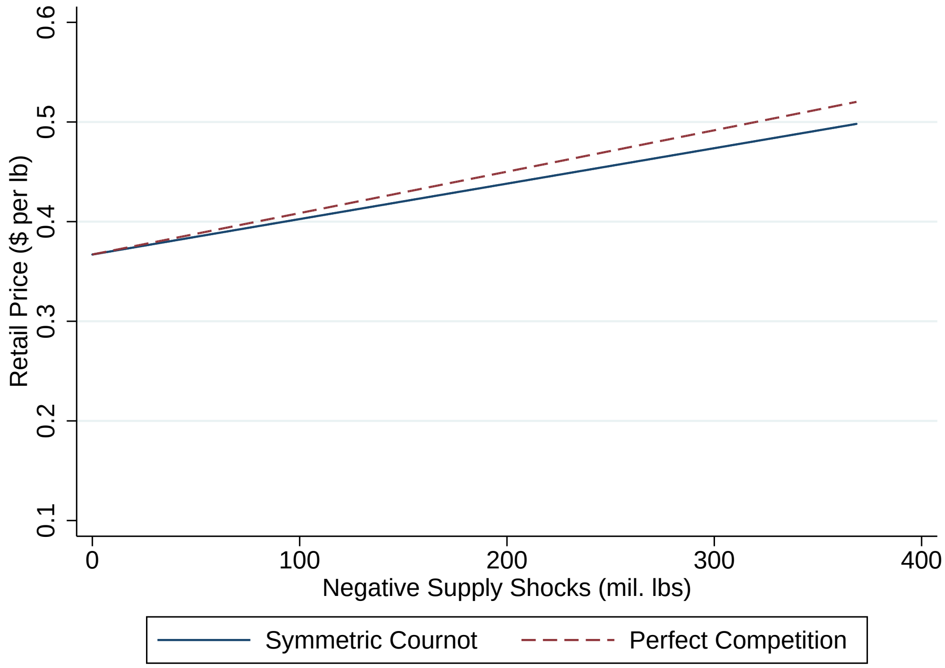



**Table 2.5**: *Impact of Supply Shocks on Retail Price*

| % supply shocks | Symmetric Cournot | Perfect competition |
|---|---|---|
| (-) 30% | \$0.035 per lb ↑ | \$0.042 per lb ↑ |
| (-) 45% | \$0.053 per lb ↑ | \$0.064 per lb ↑ |
| (-) 60% | \$0.071 per lb ↑ | \$0.085 per lb ↑ |
| (-) 75% | \$0.089 per lb ↑ | \$0.106 per lb ↑ |
| (-) 90% | \$0.106 per lb ↑ | \$0.127 per lb ↑ |

**Figure 2.3**: *Impact of Supply Shocks on Co-operative Price*

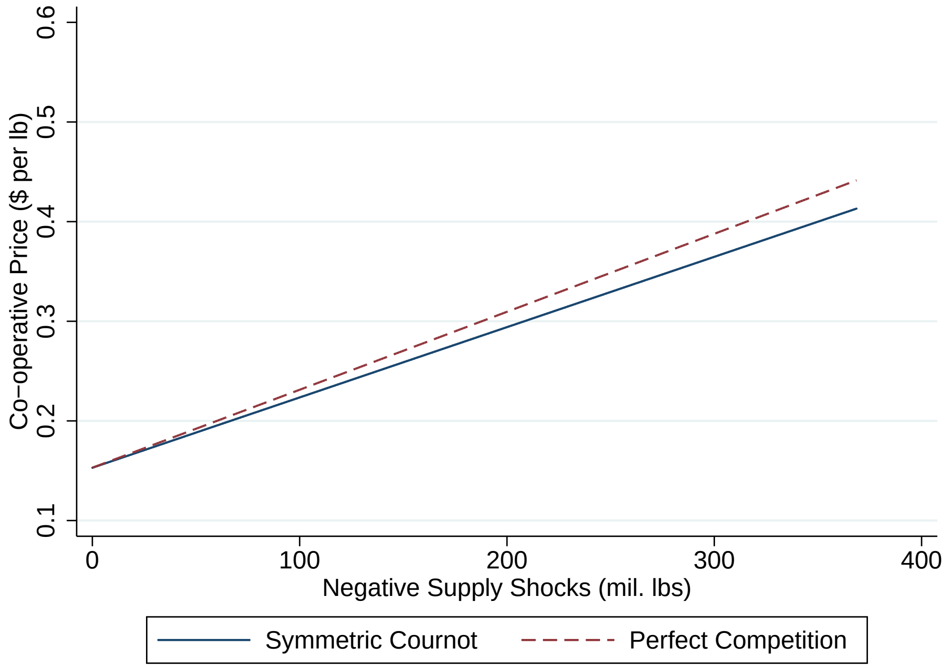



**Table 2.6**: *Impact of Supply Shocks on Co-operative Price*

| % supply shocks | Symmetric Cournot | Perfect competition |
|---|---|---|
| (-) 30% | \$0.078 per lb ↑ | \$0.087 per lb ↑ |
| (-) 45% | \$0.117 per lb ↑ | \$0.131 per lb ↑ |
| (-) 60% | \$0.156 per lb ↑ | \$0.175 per lb ↑ |
| (-) 75% | \$0.194 per lb ↑ | \$0.218 per lb ↑ |
| (-) 90% | \$0.233 per lb ↑ | \$0.262 per lb ↑ |

**Figure 2.4**: *The Effect of Downstream Market Power on Retail and Co-operative Price*

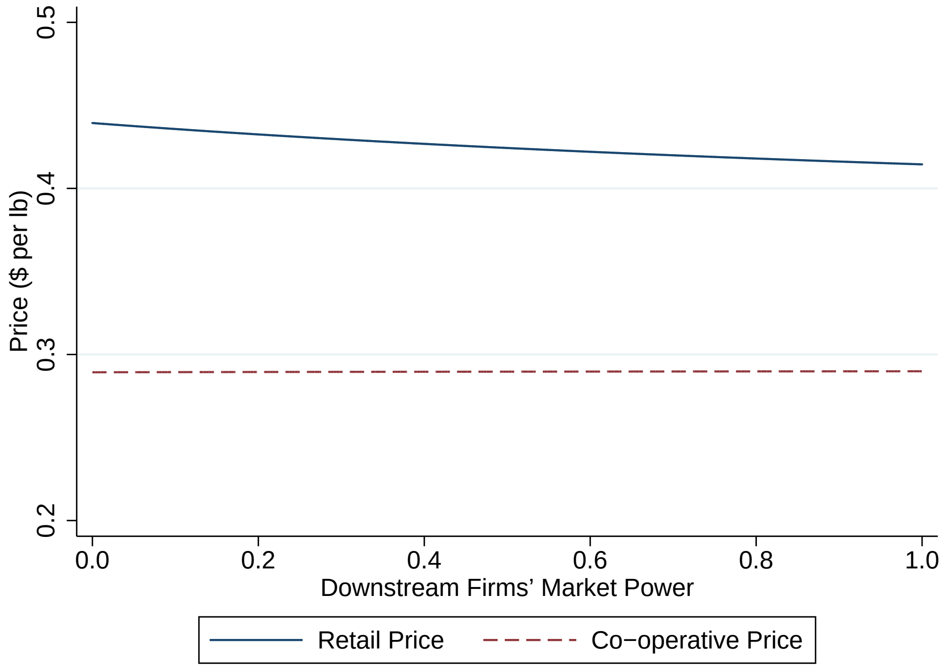
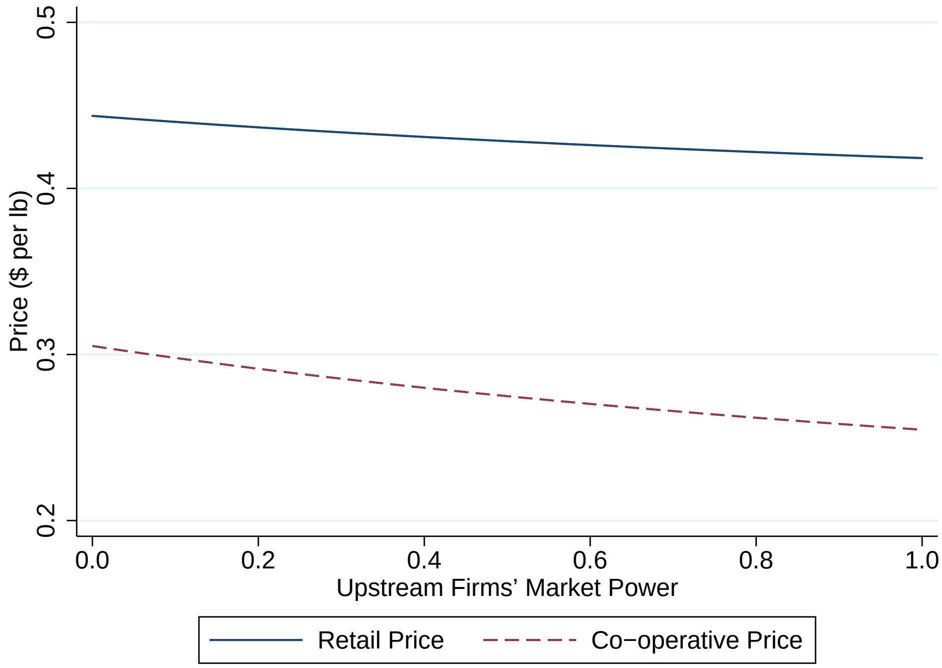


**Figure 2.5**: *The Effect of Downstream Market Power on Retail and Co-operative Price*



# Chapter 3

# Economic Value of Organic Labeling in the Fluid Milk Market

## 3.1 Introduction

The organic food and drink industry has grown rapidly over the past two decades. By 2014, the entire U.S. organic market was estimated to be worth $35 billion, a nearly ten-fold increase from 1997 (USDA, 2017). Within the organic sector, dairy has played a leading role: Dairy has been the second-largest category of organic food, accounting for 15% of U.S. organic food sales in 2012. Double-digit demand growth for organic milk products has occurred despite high price premiums.

A large literature has found that consumers are willing to pay a premium for credence attributes using stated or revealed preference data. Bernard and Bernard (2009) find that consumers were willing to pay $0.73 per gallon for milk labeled as organic using an auction experiment. Dhar and Foltz (2005) use revealed preferences of consumers to study consumer benefits from the organic label and rBST-free milk using U.S. supermarket scanner data. Kiesel and Villas-Boas (2007) estimate that U.S. households value the added USDA organic seal on milk containers at $0.23, which equated to an increase in annual consumer welfare of $2.1 billion. Kanter et al. (2009) find that the introduction of rBST-free and organic milk reduces consumers' willingness to purchase conventional milk using experimental economics. Brooks and Lusk (2010) determine consumer preferences for new attributes (milk from cloned cows) in the market using both stated and revealed preferences. Wolf et al. (2011) use a choice experiment to examine the value of various fluid milk attributes from consumers' viewpoint. Consumers of organic products are willing to pay a premium because they perceive organic to be healthier, better for the environment, and better for animal welfare (Bonnet and Bouamra-Mechemache, 2015).

Producing organic may be viewed as a product differentiation strategy that can generate shifts toward organic products as consumers are willing to pay a premium for organic milk. Thus, producing organic should be thought of as a profitable marketing strategy. However, few studies have attempted to measure the economic worth of organic to producers, nor the extent to which producers capture the additional surplus created by organic labeling. To the best of our knowledge, no previous study has explicitly measured the extent to which organic creates surplus for fluid milk firms.

The objective of this study is to provide new econometric evidence on the economic worth of organic labeling from a producers standpoint. Using weekly data on retail prices, aggregate market shares, and product characteristics, we estimate a structural econometric model of organic and conventional milk demand. This demand model provides the foundation for determining the impact of organic labeling on market shares, price premiums, and profits for both organic and conventional milk brands.

To estimate the economic value of organic labeling, we use the model estimates to simulate two counterfactual analyses in which 1) organic milk products are replaced by conventional milk products, and 2) organic milk products are removed from the market. In other words, we simulate counterfactuals in which 1) organic milk products no longer contain an organic label and the marginal cost falls to the level of conventional products, and 2) previously conventional milk products are the only products that remain on the market. The first counterfactual is constructed as follows. First, we remove organic labels from organic milk products by subtracting the additive separable effect of organic labeling in the consumer's utility function. Second, we subtract the additive organic effect on firms' marginal costs. The third step uses the Bertrand-Nash equilibrium conditions to compute counterfactual prices; that is, milk prices in an environment when the organic label does not exist. In the fourth step, we use the model to determine counterfactual market shares for all milk brands in the counterfactual environment. The final step combines all of this information to compute changes in producer surplus, as well as the degree to which producers are able to extract the additional surplus created by an organic. The second counterfactual is established as follows. First, we remove organic products from consumers' choice sets, we then find the set of equilibrium first-order conditions without organic milk products. Second, counterfactual market shares are calculated given the counterfactual prices. Finally, we compute changes in producer surplus based on counterfactual markups and market shares.

The rest of the paper is organized as follows. Section 3.2 provides an overview of the data. Section 3.3 describes the structural empirical model. Section 3.4 offers results while Section 3.5 provides the counterfactual analysis. Finally, a section 3.6 provides the conclusion of the paper.

## 3.2 Data

Prices and market shares were obtained from Information Resources Inc. (IRI) scanner data. Information Resources Inc. scanner data is a Chicago based marketing research firm specializing in archiving and analyzing store and household-level scanner data in randomly selected U.S. markets. For the milk industry, IRI data provide weekly sales information for a large number of retail stores, as well as information on several milk product characteristics, including an indicator for organic labeling. The dairy markets are fairly localized, so only a few brands appear in several regions (Choi et al., 2013). Thus, this study focuses on purchases in a Northeastern metropolitan market over a time period of 53 weeks in 2012.[1] A market is defined as a city-week combination; each time period is considered a market. For each market, we randomly sample 200 draws from a normal distribution to capture

[1]The organic attribute of private label products is only revealed in 2012. Thus, we decide to focus only on 2012.

unobserved consumer heterogeneity.

Market shares for each product are defined by the aggregate quantity divided by the total potential market size. The potential market size is typically calculated by multiplying the total population of each metropolitan city by the average U.S. per capita consumption (Nevo, 2001). However, Miller and Weinberg (2017) find that this generates a reasonable amount of cross-region heterogeneity in "outside good shares"; the consumers may decide not to purchase any of the brands, plausibly due to regional differences in the proportion of supermarkets that report to IRI. Following Miller and Weinberg (2017), we define the total potential market size to be 150% percent of the maximum observed unit sales in each market. This approach mitigates the problems posed by the mismatch between population and IRI-reported sales volumes. The market share of the outside good is computed as the difference between one and the sum of the inside goods' market share. In this paper, we focus on the 100 products with the highest market share, which account for approximately 95% of the sales in the data.[2]

We define a product as a combination of brand and product characteristics. Product characteristics include 1) size (0.125 gallons, 0.25 gallons, 0.5 gallons, 0.75 gallons, and 1 gallon), 2) fat content (fat free, low fat(1%), reduced-fat (2%), and whole milk), 3) package (carton, plastic), 4) lactose labeling information (lactose free, full lactose), and 5) organic labeling information (organic, conventional).[3] Products with the same brand and product characteristics, but sold in different stores are also aggregated as the same product. Average prices are computed by dividing weekly sales revenue by weekly unit sales.

Table 3.1 shows prices and revenue-based market shares by brands, based on retail scanner data. The average price over all products is $6.31 per gallon. The average price of organic milk products is higher than the average price of non-organic milk price products by $2.23 per gallon. The average price of private label brands is cheaper than the average price of national brands by $0.62 per gallon. Organic milk products account for 61.09% of retail

[2] Restricting the analysis to the top brands does not alter the results. Nevo (2001) states that "In principle, the estimates of price sensitivity should not be biased by this sample selection, and indeed some analysis performed with different samples suggests this is the case" (p.334).

[3] Private labels are aggregated into a single brand.

revenue while non-organic products account for 38.91% of total retail revenue. The revenue-based market shares of private label brands are fairly similar to that of national brands. The three national organic brands – Horizon Organic, Organic Valley, and Stonyfield Organic – account for approximately 10.38% of total retail revenue and 17.42% of organic retail revenue. Thus, most of organic sales come from private label brands.[4]

## 3.3 The Structural Model

A structural econometric model is used to estimate the impacts of organic on profit, price, and market share of not only the own firm, but its competitors as well. The use of a structural model allows one to run counterfactual scenarios. The econometric model for this paper is a standard discrete choice demand model in a differentiated product setting (Berry et al., 1995; Nevo, 2000, 2001). The price-cost margins are recovered from the demand estimates without observing actual costs.

### 3.3.1 Demand Side

A random-coefficients logit model is employed to estimate consumer preferences for milk. The indirect utility of consumer $i$ from purchasing product $j$ in market $t$ can be written as

$$U_{ijt} = d_j + d_m + x_j\beta_i - \alpha_i p_{jt} + \xi_{jt} + \epsilon_{ijt} \tag{3.1}$$

where $d_j$ represents a product fixed effect capturing the intrinsic preference for product $j$, $d_m$ are dummies for the monthly unobserved determinants of demand, $x_j$ are observable product characteristics, $p_{jt}$ is the shelf price of product $j$ at time period $t$, $\xi_{jt}$ is the unobserved (by econometrician) product characteristic, and $\epsilon_{ijt}$ is an independent and identically distributed type 1 extreme value distributed (i.i.d) error term capturing idiosyncratic preferences.

Since the observable product characteristics, $x_j$, are time-invariant, the product fixed effects, $d_j$, absorb the observable product characteristics and, thus, the taste parameters, $\beta$,

[4] Prices and product characteristics for the top 100 products are reported in Appendix B.

cannot be identified. To identify the taste coefficients, $\beta$, we regress the estimated brand fixed effects on the characteristics, as in the minimum-distance procedure (Chamberlain, 1982; Nevo, 2001).

The random coefficients, $\beta_i$ and $\alpha_i$, represent the unknown consumer taste parameters for the product characteristics and price, respectively. These coefficients vary across consumers according to

$$[\alpha_i, \beta_i]' = [\alpha, \beta]' + \Sigma \upsilon_i \tag{3.2}$$

where $\upsilon_i$ a vector that captures the unobserved consumer characteristics and $\Sigma$ captures the unobserved heterogeneity due to random shocks $\upsilon_i$. Unobserved consumer characteristics $\upsilon_i$ has a standard multivariate normal distribution, $\upsilon_i \sim N(0, 1)$.

The mean utility of each product $j$, $\delta_{jt}$, is given by

$$\delta_{jt} = d_j + d_m + x_j \beta - \alpha p_{jt} + \xi_{jt}. \tag{3.3}$$

The deviation from the mean utility that captures the effects of the random coefficient, $\mu_{ijt}$, is given by

$$\mu_{ilt} = [p_{jt}, x_{jt}](\Sigma \upsilon_i). \tag{3.4}$$

The indirect utility from consuming $j$ can be rewritten as

$$U_{ijt} = \delta_{jt} + \mu_{ijt} + \epsilon_{ijt} \tag{3.5}$$

where the first term is the mean utility which is common to all consumers. The last two terms represent a mean-zero heteroskedastic deviation from the mean utility that captures the effects of the random coefficients.

To allow for the possibility of consumer $i$ not purchasing any of the brands, an outside good is included in the model. The outside option permits substitution between the considered products (i.e., inside goods) and a substitute or not purchasing milk at all. The mean level of utility for the outside good, $\delta_{0t}$, is normalized to zero.

The set of individual attributes that lead to the choice of product $j$ is

$$A_{jt} = \{(v_i, \epsilon_i) | u_{ijt} \geq u_{ilt} \quad \forall l = 0, 1, ..., J\}. \tag{3.6}$$

Given that $\epsilon_{ijt}$ is independent and identically distributed with an extreme value type 1 density, the market share of product $j$ in market $t$ is:

$$s_{jt} = \int_{A_{jt}} \left( \frac{\exp(\delta_{jt} + \mu_{ijt})}{1 + \sum_{l=1}^{J} \exp(\delta_{lt} + \mu_{ilt})} \right) d\phi(\upsilon) d\upsilon. \tag{3.7}$$

The predicted product market share given in equation (3.7) can be approximated by the logit smoothed, accept-reject simulator given by

$$s_{jt} = \frac{1}{ns} \sum_{i=1}^{ns} \frac{\exp(\delta_{jt} + \mu_{ijt})}{1 + \sum_{l=1}^{J} \exp(\delta_{lt} + \mu_{ilt})} \tag{3.8}$$

where $ns$ is the number of draws.

The own- and cross-price elasticities of the market share, $s_{jt}$, are defined by

$$\eta_{jkt} = \frac{\partial s_{jt}}{\partial p_{kt}} \cdot \frac{p_{pk}}{s_{jt}} \begin{cases} -\frac{p_{jt}}{s_{jt}} \int \alpha_i s_{ijt}(1 - s_{ijt}) d\phi(\upsilon) d\upsilon & \text{if j=k,} \\ \frac{p_{kt}}{s_{jt}} \int \alpha_i s_{ijt} s_{ikt} d\phi(\upsilon) d\upsilon & \text{otherwise} \end{cases} \tag{3.9}$$

where $s_{ijt} = \frac{\exp(\delta_{jt}+\mu_{ijt})}{1+\sum_{l=1}^{J} \exp(\delta_{lt}+\mu_{ilt})}$ is the probability of individual $i$ purchasing product $j$ in market $t$.

### 3.3.2 Supply Side

The market we study is an oligopoly with multi-product firms. Assuming that firms simultaneously choose prices as in a Bertrand-Nash model of differentiated products, the profit of firm $F$ is given by

$$\pi_F = \sum_{j \in F} (p_j - mc_j) M s_j(p) \tag{3.10}$$

where $s_j$ is the market share of product $j$ produced by firm $F$, $M$ is the size of the market, and $mc_j$ is the marginal cost for product $j$ produced by firm $F$. The first-order condition for any product $j$ is given by

$$s_j(p) + \sum_{r \in F} (p_r - mc_r) \frac{\partial s_r(p)}{\partial p_j} = 0. \tag{3.11}$$

Let $\Omega$ be defined as the firm's ownership structure where the element $\Omega_{ij}$ equals 1 when both products $i$ and $j$ are sold by the same retailer, 0 otherwise. Let $\Delta$ be a matrix of first-order derivatives of product market shares with respect to prices, where $\Delta_{ij} = \frac{\partial s_i}{\partial p_j}$. Then, the system of first-order conditions is expressed in vector notation as follows

$$p - mc = -(\Omega * \Delta)^{-1} s(p). \tag{3.12}$$

The marginal costs can be solved for as follows

$$\widehat{mc} = p + (\Omega * \Delta)^{-1} s(p). \tag{3.13}$$

Once the marginal costs are recovered, we regress the estimated marginal costs on the observable product characteristics. We specify the following function for the estimated marginal costs:

$$\widehat{mc} = X_j \beta + d_b + d_q + \epsilon_{jt} \tag{3.14}$$

where $X_j$ is a vector of the observable product characteristics (size, fat content, package, lactose labeling information, and organic labeling information), $d_b$ represents the brand fixed effects, $d_q$ are dummies for the quarter fixed effect, and $\epsilon_{jt}$ is the error term.

### 3.3.3 Estimation

In the case of the standard logit model, the mean utility $\delta_{jt}$ can be obtained analytically and is given by $\delta_{jt} = ln(S_{jt}) - ln(S_{0t})$, where $ln(S_{jt})$ is the observed market share of product $j$ in market $t$ and $ln(S_{0t})$ is the observed market share of the outside good. Since a linear function of the parameters to be estimated is given and the left-hand side is directly observable from the data along with price and observable product characteristics, we can estimate $\alpha$ and $\beta$ using ordinary least square (OLS) or two stage least square (2SLS).

One problematic feature of the standard logit model is its unreasonable cross substitution pattern. In the standard logit model, the cross-price elasticities imply that a change in the price of a product changes the demand of all other substitute products by the same percentage. It comes from the assumption that the random shock is identically independently distributed. The random coefficients logit model mitigates the unreasonable cross substitution pattern by generating a correlation of the random shocks to utility with brands.

The estimation strategy used for the model is the Generalized Methods of Moments (GMM) used by Berry (1994), Berry et al. (1995), Nevo (2000), and Nevo (2001). The GMM objective function is constructed by a product of instruments and the structural error term, $\xi_{jt}$, where

$$\xi_{jt} = \delta_{jt} - (x_j\beta - \alpha p_{jt}). \tag{3.15}$$

The GMM optimization problem is

$$\min_{\theta_1,\theta_2} \xi' Z \Phi^{-1} Z' \xi \tag{3.16}$$

where $Z$ is a set of instruments that are orthogonal to the error term and $\Phi^{-1}$ is the the standard weighting matrix. Let $\theta = (\theta_1, \theta_2)$ be a vector of all parameters of the model where $\theta_1$ is a vector of the linear parameters and $\theta_2$ is a vector of the non-linear parameters. Equation (3.16) is a function of both $\theta_1$, the linear parameters, and the mean utility, $\delta_{jt}$. By taking the the first-order condition of the objective function with respect to the linear parameters, $\theta_1$, we can derive the linear parameters as follows

$$\theta_1 = \begin{pmatrix} \alpha \\ \beta \end{pmatrix} = (X'Z\Phi^{-1}Z'X)^{-1}X'Z\Phi^{-1}Z'\delta \tag{3.17}$$

Note that after $\theta_1$ is substituted by the first-order condition of the objective function, $\delta_{jt}$ is the only unknown in equation (3.17). Then, the structural error term only enters the mean utility, $\delta$.

Now we can solve for the mean utility, $\delta$, by setting the observed product shares, $S_{jt}$, equal to the predicted product shares, $s_{jt}$,

$$S_{jt} = s_{jt}(\delta_{jt}; \theta_2). \tag{3.18}$$

As mentioned above, in the logit model, $\delta$ can be computed analytically by $\delta_{jt} = ln(S_{jt}) - ln(S_{0t})$. On the other hand, in the random coefficients model, the system of equations in (3.18) is non-linear and should be solved numerically for $\delta_{jt}$. It can be solved by using the contraction mapping suggested by Berry et al. (1995).

In the random coefficient model, $\theta$ is obtained by Method of Simulated Moments following (Nevo, 2000)'s estimation algorithm. We minimize the objective function using the Nelder-Mead non-derivative (Simplex) search algorithm. The Nelder-Mead search algorithm is more robust and mitigates the sensitivity issue of the initial value in a quasi-Newton method which is based on a user-supplied gradient. Following Villas-Boas (2007), the optimum obtained with the Nelder-Mead algorithm is passed to a gradient-based quasi-Newton algorithm to find a minimum of the simulated GMM objective function.

The intuition behind the estimation technique is that the mean level of utility, $\delta_{jt}$, must be such that the observed product market shares equal the predicted product market shares. With the values of $\delta_{jt}$, we substitute them into the objective function and solve for $\theta$.

In summary, the estimation procedure is as follows:

1. Guess values of mean utility, $\delta$, and nonlinear parameters, $\theta_2$;

2. Given $\delta$ and $\theta_2$, compute predicted market shares;

3. Given $\theta_2$, search for $\delta$ that equates the predicted market shares and the observed market shares;

4. Given $\delta$, compute the structural error error term, $\Delta\xi_{jt}$;

5. Form the GMM objective function as a function of $\theta$;

6. Search for the value of $\theta$ that minimizes the GMM objective function;

7. Repeat steps (2)–(6) with different starting values from (1) until the minimum GMM objective is found; and

8. Iterate on steps (2)–(7) until optimal GMM estimators are recovered.

### 3.3.4 Instruments

The identifying assumption to estimate the model is

$$E[\xi|Z] = 0 \tag{3.19}$$

where $\xi$ is the demand unobservables and $Z$ is the set of instruments. Equation (3.19) implies that the demand unobservables should be mean independent of the set of instruments. If price is correlated with the unobserved product characteristics, then the price estimate would be inconsistent. Thus, it requires a set of exogenous instrumental variables.

Prices consist of marginal costs and a markup term. The markup term is a function of the unobserved product characteristics, which is also correlated with unobserved consumer preference in the demand equation. Thus, prices are not exogenous to unobserved changes in product characteristics, so a set of instruments for the price is needed.

The instruments which control for the endogeneity issue of the price should be correlated with the underlying variable, price, but independent of the unobserved error terms. There are several ways to instrument for prices. Berry et al. (1995) use characteristics that enter cost, but not demand. Nevo (2001) relies on the use of prices of the product in other markets. Villas-Boas (2007) uses prices of inputs interacted with a product dummy variable to generate variations by products. We follow Villas-Boas (2007) and use manufacturer level input price changes interacted with brand dummies as instrumental variables. It is reasonable since the prices of inputs are uncorrelated with unobserved product characteristics, but correlated with the shelf display price. In addition, the intuition for interacting input prices with brand dummies is that it allows each input to enter the production function of each milk product differently.

Since raw milk prices are regulated under marketing orders and do not vary over time, we use weekly commodity trading prices of nonfat dry milk powder and whole milk powder for the industrial sector and retail diesel prices to instrument for prices of milk products following Kiesel and Villas-Boas (2007). In other words, we interact 1) nonfat dry milk powder, 2) whole milk powder and 3) diesel prices with product dummies. Weekly commodity trading prices and retail diesel prices were collected from Livestock Marketing Information Center (LMIC) and the U.S. Energy Information Administration, respectively.

## 3.4 Results

Table 3.2 presents the results from the logit estimation where we regress $ln(S_{jt}) - ln(S_{ot})$ on the observed product characteristics. Columns (1) – (2) report the OLS estimates while columns (3) – (4) correspond to the IV estimates. Both regressions include brand dummy variables and monthly fixed effects. In both specifications, the mean price coefficients, $\alpha$, are negative and statistically significant. The variable of interest, organic label, is statistically significant, with estimated coefficients of 1.250 and 1.451 in the OLS and IV specifications, respectively. This indicates that organic labeling has a positive effect on consumer utility.

Columns (5) – (6) provide the estimated coefficients from the random coefficient model. The results of linear coefficients are seem plausible in terms of sign and are similar to the standard logit estimation results. Consumers prefer cheaper products with a mean price estimate of -0.563. The variable of interest, organic labeling, exhibits a positive and significant value and thus indicates the positive impact of the organic label on consumer utility. The price and organic coefficient indicate that consumers are willing to pay a significant premium for organic milk products. In particular, the mean willingness to pay for organic labeling can be estimated by the organic labeling coefficient divided by the price coefficient and it is \$2.47 per gallon of milk.

Table 3.2 also reports deviations from the mean estimates. The standard deviation of price, 2% milkfat, plastic package, and organic are statistically significant, suggesting that consumers' preference for these characteristics are likely to be heterogeneous. On the other hand, consumers' preference for milk size, fat-free, whole milk, and lactose-free are homogenous across consumers as their estimates of the standard deviations are statistically insignificant.[5]

Table 3.3 reports average own and cross-price elasticities by brand calculated from the demand equation estimation results. Average own and cross-price elasticities range from -2.167 to -4.208 and 0.013 to 0.016, respectively. The average own-price elasticities for organic brands is -3.770, which is higher than those of conventional brands (-2.922). It indicates that purchases of organic milk are more sensitive to changes in own prices compared to conventional milk. This result is consistent with previous studies (Alviola and Capps, 2010; Bonnet and Bouamra-Mechemache, 2015; Dhar and Foltz, 2005).

Given the estimated demand estimates, we compute the price-cost margin estimate with a random coefficient demand model using equation (3.12). Table 3.4 provides the average price-cost margins by brand. Across all 100 products, the average price-cost margin is \$2.23 per gallon, which accounts for 38.32% of the retail price. The average margin for private label products is higher than other brands.

Table 3.5 reports estimation results for marginal cost function. Each column reports the effect of organic labeling on the marginal cost for different model specifications. Column (1) reports the results without brand fixed effects and quarter fixed effects. Columns (2) and (3) present the results with brand fixed effects and with both brand effects and quarter fixed effects, separately. The results indicate that producing organic increases marginal costs by \$1.62 to \$1.64 per gallon. The products with larger package sizes have a lower marginal cost. The plastic package leads to a decrease in marginal cost compared to the carton package while lactose-free increases marginal cost.

[5]The first stage $R$-squared and $F$-statistic of the IV specification indicate that our instruments, which is the interaction between nonfat dry milk powder, whole milk powder and diesel price with product dummies, are strongly correlated with the price variable. The first stage $R$-squared is 0.98 and $F$-statistic is 745.38 which is substantially larger than the rule-of-thumb F-statistic threshold of 10 for testing for weak instruments. The $F$-test to test for zero coefficient associated with instruments is rejected at any significance level. These suggest that the instruments used in the demand model are valid.

## 3.5 Counterfactuals

To analyze the impact of organic labeling on market shares, price premiums, and profits, we assume two counterfactual environments. In the first counterfactual environment, we answer the following question: what would market shares, price premiums, and profits for organic products have been if they were sold as conventional products instead of organic products. To do so, we remove the organic labeling attribute from the consumers' utility function and marginal costs function, respectively.[6] In the second counterfactual environment, we assume there are no organic products by removing organic products from the choice set. Here we are interested in what market shares, price premiums, and profits for both organic and conventional milk producers would have been if organic brands had exited the market instead of becoming conventional products.

### 3.5.1 Removing Organic Attribute

In our demand estimation, we find that organic labeling has a positive and statistically significant effect on consumer utility. We also show that the organic characteristic leads to a higher marginal cost. Given these findings, we explore the economic value of organic in the U.S. milk market by translating 1) the positive effect of organic labeling on consumer utility and 2) the higher marginal cost of producing organic into the price premium and sales.

**Change in Market Share**

In order to assess the effect of organic on the price-cost margin and sales, we analyze the extent to which organic characteristic generates shifts in market share. We run the counterfactual analysis by assuming the absence of the organic characteristic and compare it with a regime where the organic characteristic exists.

We calculate the new market share of organic milk products in an environment where consumers choose a product 1) without the extra "utility" generated by organic labeling and

[6] In the first counterfactual scenario, we remove private label organic brands. Otherwise, there exists two different private label conventional brands in the counterfactual environment, which is not realistic.

2) with decreased product prices as the marginal costs of producing organic falls to the level of conventional products.

Therefore, the counterfactual indirect utility of each organic product, $U_{ijt}^c$, can be derived by excluding the positive values of the organic labeling effect and applying decreased marginal costs:

$$U_{ijt}^c = \delta_{jt}^c + \mu_{ijt}^c + \epsilon_{ijt}. \tag{3.20}$$

With the counterfactual indirect utility, we calculate the counterfactual market share of the organic products in the absence of organic as follows

$$s_{jt}^c = \frac{1}{ns} \sum_{i=1}^{ns} \frac{\exp(\delta_{jt}^c + \mu_{ijt}^c)}{1 + \sum_{l=1}^J \exp(\delta_{lt}^c + \mu_{ilt}^c)}. \tag{3.21}$$

### Change in Price Premium

We now turn to calculate the counterfactual price-cost margin. To calculate the new equilibrium price, we need to estimate the counterfactual marginal costs of producing milk. The counterfactual marginal costs, $\widehat{mc}^c$, can be derived by assuming the organic characteristic is absent in the marginal cost function for organic products. In other words, we assume that the marginal costs of producing organic milk products fall to the level of conventional products as the organic milk products are replaced by conventional milk products. Given the counterfactual market share and marginal costs, the counterfactual price premium generated by the absence of organic can be calculated as follows:

$$p^* = \widehat{mc}^c - (\Omega * \Delta)^{-1} s(p^*)^c \tag{3.22}$$

where $p^*$ is the counterfactual price with the absence of the organic characteristics and $\widehat{mc}^c$ are the counterfactual marginal costs recovered.

New equilibrium prices will be solved by the use of a numerical algorithm. The algorithm finds the new equilibrium prices which solves the FOC under the counterfactual experiment given the estimated demand parameters, product characteristics, and the marginal costs.

New equilibrium prices indicate what the firms charge without the existence of organic labeling. By comparing the initial price, $p$, and the counterfactual prices, $p^*$, we can assess how much of the price premium due to the organic. The profit function in equation (3.10) allows the counterfactual profit to be estimated.

### 3.5.2 Removing Organic Products

In this counterfactual, we assume there are no organic products available as a choice to the consumers. Counterfactual conventional products' prices solve the set of equilibrium first-order conditions with the absence of organic products, as follows:

$$p^{**} = mc - (\Omega^c * \Delta)^{-1} s(p^{**}) \tag{3.23}$$

where $p^{**}$ is counterfactual price with the absence of organic products. $\Omega^c$ is the counterfactual firm's ownership structure with the absence of organic products.

Determining the economic value of organic by removing organic products requires an assumption; the marginal costs of producing conventional milk are the same with or without the presence of organic products. Given the counterfactual price with the absence of organic products, we also calculate the counterfactual market share.

### 3.5.3 Counterfactuals Results

Given our finding that organic label has a positive impact on consumer utility and increases the marginal costs of producing milk, we assess the economic value of organic in the fluid milk market by conducting two counterfactual analyses.

Table 3.6 summarizes the changes in market share with the presence of the organic label. Column (1) shows the results from removing the organic attribute. The results indicate that the presence of an organic label increases the market share for organic brands by approximately 33% compared to producing conventional milk. The presence of an organic label decreases market shares for conventional brands by 2.59% to 5.58% since some consumers who purchase organic products are likely to switch to conventional products with the absence of organic products. These results show that the positive impact of consumers' willingness to pay for organic products on market share exceeds the negative impact of increasing marginal costs due to organic production. The presence of organic labeling leads consumers to organic products despite of higher price. Column (2) presents the results from removing organic products. No market share would have been expected for organic brands if the organic brands exit the market rather than producing conventional brands, as described in column (1). The results in column (2) also show that market shares for conventional brands would have increased if organic brands exit the business. These results imply that organic consumers would have switched to conventional milk brands when organic brands no longer exist in the market.

Having shown that there is an increase in the market share for organic milk brands when removing the organic attribute and organic products, we calculate the equilibrium prices by solving the set of equilibrium first-order conditions under two counterfactual environments from equation (3.22) and (3.23). Table 3.7 presents the equilibrium price changes with the presence of the organic label. The results in column (1) show that the equilibrium price changes for previously organic brands would have decreased about by \$1.6. These results are mainly attributed to a decrease in the marginal costs of producing conventional milk compared to organic milk, as shown in table 3.5. However, the degree of change in equilibrium prices is slightly smaller than that of changes in marginal costs since firms do not pass the full extent of cost changes into their prices and the effect of changes in market share is relatively small. The conventional milk brands would have charged higher prices if the organic brands produce conventional products rather than organic products as consumers for organic products are likely to switch conventional milk products with the absence of organic label described in table 3.6. Column (2) presents the change in the equilibrium prices when removing organic products. As consumers switch to conventional milk with the absence of organic brands, conventional milk brands would charge higher prices for their products under the counterfactual scenario. Thus, the organic label leads to a decrease in conventional milk prices.

Profit for producers can be calculated by multiplying the price-cost margin by the size of the market and the market share. Table 3.8 describes producer welfare changes with the presence of an organic label. The presence of an organic label increases producer surplus for organic milk by approximately 33%, which is similar to the changes in market share. Producer surplus for conventional milk brands would have increased by about 4% to 7% if the organic brands produce conventional products while it might have increased by about 8% to 12% if the organic brands exit the market.[7] In summary, the impact on price, share, and producer surplus for conventional brands are greater when removing organic products compared to removing the organic attribute. The conventional milk brands would have benefited more from organic brands' exiting the market than producing conventional milk.

## 3.6 Conclusions

The organic food and drink industry has grown substantially over the past two decades; however, the economic value of organic from a producer standpoint is rarely known. This paper investigates the economic worth of organic in the fluid milk market using weekly scanner data on retail prices and market shares. A structural econometric model is used to estimate demand estimators on U.S. fluid milk over a time period of 53 weeks in 2012. Given the demand estimates, we recover the price-cost margins and conduct the two counterfactual scenarios; what would happen if organic brands 1) produce conventional products instead of organic products or 2) exit the fluid milk market? To do this, we 1) remove the organic attribute from the consumer utility and marginal costs and 2) remove organic brands.

In this study, we find that consumers are willing to pay a significant premium for organic milk products. Consumers' willingness to pay for the organic label is \$2.47 per gallon of milk. The results from marginal cost function indicate that producing organic increases the marginal costs by approximately \$1.6 per gallon of milk. Using these results, we estimate the impacts of organic on market share, price, and producer surplus of not only the own

[7] Organic milk brands earn approximately \$1.6 to \$3.3 million in extra revenue from staying in the organic milk business. Note that the IRI sample covers more than 20% of the relevant population in most cities (Nevo, 2001).

firm, but its competitors as well with two counterfactual analyses. The presence of organic labeling increases market shares and producer surplus organic milk brands by about 33 to 100%. On the other hand, it decreases market shares and producer surplus for conventional brands. We also find that the impact on price, market share, and producer surplus for conventional brands are greater when removing organic products compared to removing the organic attribute, as expected.

# Table and Figures

**Table 3.1**: *Price and Revenue Shares*

| Brand | Price ($/gallon) | Shares (%) |
|---|---|---|
| ELMHURST DAIRY | 4.554 | 3.727 |
| FARMLAND | 5.214 | 0.601 |
| FARMLAND DAIRIES | 4.964 | 1.683 |
| FARMLAND SPECIAL REQUEST SKIM | 8.182 | 4.942 |
| GARELICK FARMS | 4.071 | 0.123 |
| HOOD LACTAID | 8.930 | 8.290 |
| HOOD SIMPLY SMART | 7.328 | 0.189 |
| HORIZON ORGANIC | 9.435 | 3.291 |
| LEHIGH VALLEY DAIRY FARMS | 5.928 | 0.087 |
| MOUNTAINSIDE FARMS | 6.562 | 0.305 |
| ORGANIC VALLEY | 9.025 | 2.637 |
| PRIVATE LABEL | 5.860 | 50.710 |
| SMART BALANCE | 7.195 | 0.851 |
| SMART BALANCE HEART RIGHT | 7.096 | 0.174 |
| STONYFIELD ORGANIC | 8.641 | 4.452 |
| TUSCAN DAIRY FARMS | 5.371 | 12.163 |
| TUSCAN DAIRY FARMS O. T. M | 7.037 | 0.290 |
| TUSCAN TRUMOO | 4.833 | 0.317 |
| WELSH FARMS | 3.963 | 0.251 |
| | | |
| National brands | 6.479 | 44.375 |
| Private label | 5.860 | 50.710 |
| Non-organic products | 5.866 | 33.994 |
| Organic products | 8.097 | 61.091 |

**Table 3.2**: *Parameter Estimates For Alternative Demand Models*

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | OLS Logit | | IV Logit | | RC | |
| VARIABLES | Estimate | SE | Estimate | SE | Estimate | SE |
| Linear parameters | | | | | | |
| Price | -0.341*** | 0.009 | -0.475*** | 0.022 | -0.563*** | 0.049 |
| 0.25 gallon | 0.233*** | 0.051 | 0.477*** | 0.027 | 0.674*** | 0.027 |
| 0.5 gallon | 0.487*** | 0.099 | 0.617*** | 0.091 | 0.848*** | 0.091 |
| 0.75 gallon | 0.327** | 0.157 | 0.604*** | 0.134 | 0.848*** | 0.139 |
| 2% milkfat | 0.141** | 0.061 | 0.160*** | 0.054 | -0.265*** | 0.044 |
| Fat free | 0.168*** | 0.062 | 0.273*** | 0.050 | 0.195*** | 0.057 |
| Whole | 0.300*** | 0.071 | 0.452*** | 0.032 | 0.418*** | 0.045 |
| Plastic | 0.296*** | 0.093 | 0.136* | 0.080 | 0.041 | 0.083 |
| Lactose free | 1.141*** | 0.099 | 1.356*** | 0.062 | 1.361*** | 0.068 |
| Organic | 1.250*** | 0.079 | 1.451*** | 0.043 | 1.392*** | 0.034 |
| Constant | 0.450*** | 0.094 | 0.469*** | 0.080 | 0.313*** | 0.087 |
| Nonlinear parameters | | | | | | |
| Price | | | | | 0.106*** | 0.032 |
| 0.25 gallon | | | | | 0.142 | 0.406 |
| 0.5 gallon | | | | | 0.089 | 0.938 |
| 0.75 gallon | | | | | 0.822 | 0.621 |
| 2% milkfat | | | | | 1.172*** | 0.417 |
| Fat free | | | | | 0.441 | 0.404 |
| Whole | | | | | 0.109 | 0.351 |
| Plastic | | | | | 0.860** | 0.416 |
| Lactose free | | | | | 0.029 | 0.430 |
| Organic | | | | | 0.368* | 0.195 |
| Constant | | | | | 0.139*** | 0.042 |
| Observations | 5,300 | | 5,300 | | 5,300 | |

Note: Standard errors appear in parentheses. Asterisks ***,**, and * denotes significance at the 0.01, 0.05, and 0.10 level, respectively. All regressions include product, monthly, and geographic market location dummy variables.
Estimates from the Generalized Least Square regression of estimated product fixed effects on non-price product characteristics.

**Table 3.3**: *Mean Estimated Own and Cross-price Elasticities*

| Brand | Own price | Cross-price |
|---|---|---|
| ELMHURST DAIRY | -2.418 | 0.015 |
| FARMLAND | -2.715 | 0.015 |
| FARMLAND DAIRIES | -2.614 | 0.016 |
| FARMLAND SPECIAL REQUEST SKIM | -3.772 | 0.013 |
| GARELICK FARMS | -2.222 | 0.016 |
| HOOD LACTAID | -4.056 | 0.014 |
| HOOD SIMPLY SMART | -3.534 | 0.014 |
| HORIZON ORGANIC | -4.208 | 0.014 |
| LEHIGH VALLEY DAIRY FARMS | -3.039 | 0.017 |
| MOUNTAINSIDE FARMS | -3.255 | 0.014 |
| ORGANIC VALLEY | -4.090 | 0.014 |
| PRIVATE LABEL | -2.760 | 0.014 |
| PRIVATE LABEL (organic) | -3.298 | 0.015 |
| SMART BALANCE | -3.475 | 0.014 |
| SMART BALANCE HEART RIGHT | -3.444 | 0.014 |
| STONYFIELD ORGANIC | -3.957 | 0.014 |
| TUSCAN DAIRY FARMS | -2.751 | 0.015 |
| TUSCAN DAIRY FARMS O. T. M | -3.429 | 0.014 |
| TUSCAN TRUMOO | -2.549 | 0.015 |
| WELSH FARMS | -2.167 | 0.016 |

**Table 3.4**: *Summary Statistics on Prices, Product Markups and Recovered Marginal Costs*

| Brand | Price ($/gallon) | Markups ($/gallon) | MC ($/gallon) |
|---|---|---|---|
| ELMHURST DAIRY | 4.554 | 1.924 | 2.629 |
| FARMLAND | 5.214 | 1.923 | 3.291 |
| FARMLAND DAIRIES | 4.964 | 1.912 | 3.052 |
| FARMLAND SPECIAL REQUEST SKIM | 8.182 | 2.208 | 5.973 |
| GARELICK FARMS | 4.071 | 1.833 | 2.238 |
| HOOD LACTAID | 8.930 | 2.278 | 6.652 |
| HOOD SIMPLY SMART | 7.328 | 2.073 | 5.255 |
| HORIZON ORGANIC | 9.435 | 2.276 | 7.159 |
| LEHIGH VALLEY DAIRY FARMS | 5.928 | 1.950 | 3.978 |
| MOUNTAINSIDE FARMS | 6.562 | 2.017 | 4.545 |
| ORGANIC VALLEY | 9.025 | 2.233 | 6.792 |
| PRIVATE LABEL | 5.510 | 3.024 | 2.486 |
| PRIVATE LABEL (organic) | 6.693 | 3.148 | 3.545 |
| SMART BALANCE | 7.195 | 2.074 | 5.121 |
| SMART BALANCE HEART RIGHT | 7.096 | 2.058 | 5.038 |
| STONYFIELD ORGANIC | 8.641 | 2.226 | 6.415 |
| TUSCAN DAIRY FARMS | 5.371 | 2.102 | 3.269 |
| TUSCAN DAIRY FARMS O. T. M | 7.037 | 2.053 | 4.984 |
| TUSCAN TRUMOO | 4.833 | 1.895 | 2.938 |
| WELSH FARMS | 3.963 | 1.832 | 2.131 |

**Table 3.5**: *Marginal Cost Function Estimation*

| VARIABLES | (1) | (2) | (3) |
|---|---|---|---|
| 0.25 gallon | 1.418*** | 1.803*** | 1.803*** |
| | (0.0455) | (0.0298) | (0.0297) |
| 0.5 gallon | 1.348*** | 1.126*** | 1.126*** |
| | (0.0320) | (0.0152) | (0.0152) |
| 0.75 gallon | 2.059*** | 0.627*** | 0.627*** |
| | (0.0741) | (0.0469) | (0.0467) |
| 2% milkfat | 0.0661* | -0.00437 | -0.00437 |
| | (0.0346) | (0.0151) | (0.0151) |
| Fat free | 0.0930** | 0.155*** | 0.155*** |
| | (0.0366) | (0.0188) | (0.0188) |
| Whole | -0.0676** | 0.0168 | 0.0168 |
| | (0.0335) | (0.0163) | (0.0163) |
| Plastic | -1.200*** | -0.597*** | -0.597*** |
| | (0.0387) | (0.0339) | (0.0339) |
| Lactose free | 1.977*** | 0.300*** | 0.300*** |
| | (0.0700) | (0.0848) | (0.0846) |
| Organic | 1.637*** | 1.619*** | 1.619*** |
| | (0.0399) | (0.0350) | (0.0350) |
| Constant | 2.993*** | 2.009*** | 2.025*** |
| | (0.0504) | (0.0432) | (0.0447) |
| Brand Fixed Effects | | Y | Y |
| Quarter Fixed Effects | | | Y |
| Observations | 5,300 | 5,300 | 5,300 |
| R-squared | 0.735 | 0.940 | 0.940 |

Note: Robust standard errors appear in parentheses. Asterisks ***,**, and * denotes significance at the 0.01, 0.05, and 0.10 level, respectively.

**Table 3.6**: *Change in Share with the Presence of an Organic Label*

| Brand | (1) Difference (%) | (2) Difference (%) |
|---|---|---|
| ELMHURST DAIRY | -4.63 | -7.59 |
| FARMLAND | -4.76 | -7.64 |
| FARMLAND DAIRIES | -4.81 | -7.70 |
| FARMLAND SPECIAL REQUEST SKIM | -5.46 | -9.49 |
| GARELICK FARMS | -4.75 | -7.42 |
| HOOD LACTAID | -5.50 | -9.41 |
| HOOD SIMPLY SMART | -5.58 | -9.78 |
| HORIZON ORGANIC | 33.29 | 0.245* |
| LEHIGH VALLEY DAIRY FARMS | -5.30 | -8.94 |
| MOUNTAINSIDE FARMS | -5.51 | -9.67 |
| ORGANIC VALLEY | 33.48 | 0.204* |
| PRIVATE LABEL | -2.59 | -4.38 |
| PRIVATE LABEL (organic) | 0.274* | 0.274* |
| SMART BALANCE | -5.50 | -9.61 |
| SMART BALANCE HEART RIGHT | -5.52 | -9.65 |
| STONYFIELD ORGANIC | 33.29 | 0.360* |
| TUSCAN DAIRY FARMS | -4.32 | -7.00 |
| TUSCAN DAIRY FARMS O. T. M | -5.47 | -9.58 |
| TUSCAN TRUMOO | -4.66 | -7.41 |
| WELSH FARMS | -4.67 | -7.25 |

Note: Specification (1) presents the result from removing organic attribute. In specification (2), the result from removing organic products is presented. * shows absolute change (%) in share.

**Table 3.7**: *Equilibrium Prices with the Presence of an Organic Label*

| | | (1) | | (2) | |
|---|---|---|---|---|---|
| Brand | With organic | Without organic | Difference | Without organic | Difference |
| ELMHURST DAIRY | 4.554 | 4.567 | -0.014 | 4.579 | -0.026 |
| FARMLAND | 5.214 | 5.225 | -0.011 | 5.235 | -0.021 |
| FARMLAND DAIRIES | 4.964 | 4.975 | -0.011 | 4.985 | -0.022 |
| FARMLAND SPECIAL REQUEST SKIM | 8.182 | 8.208 | -0.026 | 8.237 | -0.055 |
| GARELICK FARMS | 4.071 | 4.080 | -0.009 | 4.088 | -0.017 |
| HOOD LACTAID | 8.930 | 8.959 | -0.029 | 8.993 | -0.063 |
| HOOD SIMPLY SMART | 7.328 | 7.345 | -0.018 | 7.365 | -0.037 |
| HORIZON ORGANIC | 9.435 | 7.830 | 1.605 | 0.000 | 9.435 |
| LEHIGH VALLEY DAIRY FARMS | 5.928 | 5.940 | -0.012 | 5.952 | -0.024 |
| MOUNTAINSIDE FARMS | 6.562 | 6.578 | -0.017 | 6.597 | -0.035 |
| ORGANIC VALLEY | 9.025 | 7.421 | 1.604 | 0.000 | 9.025 |
| PRIVATE LABEL | 5.510 | 5.564 | -0.054 | 5.601 | -0.092 |
| PRIVATE LABEL (organic) | 6.693 | 0.000 | 6.693 | 0.000 | 6.693 |
| SMART BALANCE | 7.195 | 7.213 | -0.018 | 7.232 | -0.038 |
| SMART BALANCE HEART RIGHT | 7.096 | 7.113 | -0.017 | 7.131 | -0.036 |
| STONYFIELD ORGANIC | 8.641 | 7.029 | 1.612 | 0.000 | 8.641 |
| TUSCAN DAIRY FARMS | 5.371 | 5.391 | -0.021 | 5.408 | -0.037 |
| TUSCAN DAIRY FARMS O. T. M | 7.037 | 7.054 | -0.007 | 7.073 | -0.036 |
| TUSCAN TRUMOO | 4.833 | 4.843 | -0.010 | 4.853 | -0.020 |
| WELSH FARMS | 3.963 | 3.972 | -0.009 | 3.979 | -0.016 |

Note: $ per gallon. Specification (1) presents the result from removing organic attribute. In specification (2), the result from removing organic products is presented.

**Table 3.8**: *Producer Welfare Changes with the Presence of an Organic Label*

| Brand | (1) Difference (%) | (2) Difference (%) |
|---|---|---|
| ELMHURST DAIRY | -5.24 | -9.02 |
| FARMLAND | -5.38 | -8.83 |
| FARMLAND DAIRIES | -5.44 | -8.91 |
| FARMLAND SPECIAL REQUEST SKIM | -6.49 | -12.19 |
| GARELICK FARMS | -5.22 | -8.39 |
| HOOD LACTAID | -6.77 | -12.36 |
| HOOD SIMPLY SMART | -6.45 | -11.74 |
| HORIZON ORGANIC | 32.83 | 2,045,908* |
| LEHIGH VALLEY DAIRY FARMS | -5.96 | -10.29 |
| MOUNTAINSIDE FARMS | -6.34 | -11.57 |
| ORGANIC VALLEY | 32.98 | 1,640,015* |
| PRIVATE LABEL | -3.93 | -7.66 |
| PRIVATE LABEL (organic) | 3,274,667* | 3,274,667* |
| SMART BALANCE | -6.34 | -11.60 |
| SMART BALANCE HEART RIGHT | -6.31 | -11.55 |
| STONYFIELD ORGANIC | 33.05 | 2,767,213 |
| TUSCAN DAIRY FARMS | -5.22 | -8.88 |
| TUSCAN DAIRY FARMS O. T. M | -6.39 | -11.48 |
| TUSCAN TRUMOO | -5.25 | -8.53 |
| WELSH FARMS | -5.17 | -8.22 |

Note: Specification (1) presents the result from removing organic attribute. In specification (2), the result from removing organic products is presented. * shows absolute change ($) in producer welfare.

# Chapter 4

# Summary

Given the increase in frequency and potential risks of supply shocks in the food industry, it is important to accurately measure the impact of supply shocks on prices at successive vertical stages. Although organic labeling should be thought of as a profitable marketing strategy, little is known about the economic value of organic labeling to producers. In this dissertation, those issues will be examined by focusing on the U.S. fluid milk industry.

In the first essay, I investigate the role of upstream and downstream market power in determining the effect of supply shocks on price transmission. A structural econometric model is used to measure seller market power and simulate results to analyze how market power impacts the effects of supply shock on prices in the U.S. fluid milk industry. The estimation results suggest that the assumption of perfect competition for upstream and downstream firms in the U.S. fluid milk industry is rejected. The slope of the marginal cost of downstream and upstream firms represents a deviation from constant to returns to scale. The simulation results show that perfect competition overestimates the impact of a supply shock on prices than a given degree of market power.

Some caveats are worth nothing. First, this paper does not account for heterogeneity in upstream and downstream firms' market power across regions. With a limited number of observations, it is difficult to take heterogeneous market power parameters into account. Thus, this paper estimates the average market power parameters in the U.S. milk market and explores the impact of supply shocks on price transmission at the national level.

Second, I assume a simple linear pricing model, double-marginalization, where upstream firms will set their output price and downstream firms follow by setting downstream firms' output price. Several studies assess welfare effects under different models of vertical relationships between upstream and downstream firms such as two-part tariffs, manufacturer-level collusion model, retail-level collusion model, and monopolist model (Bonnet and Dubois, 2010; Bonnet et al., 2013; Bonnet and Réquillart, 2013; Villas-Boas, 2007). A potential extension to this paper is to explore the role of upstream and downstream market power in determining the effect of supply shocks on price transmission under different vertical relationships between upstream and downstream firms in addition to double-marginalization. This would allow policy-makers to have a better understanding of the economic consequences of the potential supply shocks.

In the second essay, I estimate a structural econometric model of organic and conventional milk demand. This demand model provides the foundation for determining the impact of organic labeling on market shares, price premiums, and profits for both organic and conventional milk brands. The demand estimates represent that the mean willingness to pay for organic labeling is \$2.47 per gallon of milk. The results from supply side indicates that the average price-cost margin is \$2.23 per gallon, accounting for 38.32% of the retail price. Also, producing organic increases marginal costs by \$1.64 per gallon. The results from counterfactual analyses indicate that the presence of organic labeling increases market shares and producer surplus organic milk brands by about 33 (when removing organic attributes) to 100% (when removing organic brands). On the other hand, it decreases market shares and producer surplus for conventional brands. Additionally, the impact on price, market share, and producer surplus for conventional brands are greater when removing organic products compared to removing the organic attribute.

Despite the findings on the impact of organic labeling on market shares, price premiums, and profits for both organic and conventional milk brands, there are shortcomings. This paper did not take vertical relationships between manufacturer and retailer into account and assumes an integrated manufacturer-retailer for the U.S. fluid milk industry. A potential extension of this paper is to examine retailers and manufacturer vertical relationships and calculate the economic value of organic labeling for manufacturer and retailer separately.

This dissertation has some implications for the literature. First, the first essay highlights the importance of market power on price transmission at successive vertical stages. The results from the conceptual model and simulations imply that perfect competition assumption is inappropriate to measure the impact of supply shocks on price transmission since perfect competition overestimates the impact of a supply shock on prices than a given degree of market power. Methodologically, the model that estimates the degree of price transmission resulting from a supply shock can be applied to markets of other agricultural products. Second, the second essay adds to the organic literature in the fluid milk market by focusing on the economic worth of organic from a producers viewpoint. Despite the expansion of the organic food and drink industry, few studies attempted to measure the economic value of organic labeling in producer surplus and it is under researched whether an organic label creates value for the producer and, if so, how much the extent to which organic label creates surplus for fluid milk firms. A related study by Bonnet and Bouamra-Mechemache (2015) find that an organic label permits the existence of higher margins by computing and comparing margins for organic brands and conventional brands. They did not, however, explicitly estimate the counterfactual where the absence of organic is assumed. To the best of our knowledge, this is the first study to measure the economic worth of organic labeling from a producer's viewpoint by conducting counterfactual analyses. Third, the second essay conducted the analysis based on structural models, which allows to describe the mechanisms behind product sales through which effects operate. Thus, the second essay provides the framework for understanding how an organic labeling may translate into producer surplus through changes in consumer utility, market share, and equilibrium price.

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# Appendix A

# Appendix to Chapter 2

This appendix provides the derivation of the equilibrium downstream firms and upstream firms' output price and reports the results of the first stage regression. First, we rearrange equation (2.4) when the marginal costs curve of the upstream firms shifts to the left due to a supply shock, as follows:

$$\begin{aligned} &h(Q) + \lambda_d h'(Q)Q - \beta_d - \tau_d Q - \gamma_d R + \lambda_u[h'(Q)Q + \lambda_d h''(Q)Q^2 + \lambda_d h'(Q)Q] \\ &= \beta_u + \gamma_u W + \tau_u(Q + X) \end{aligned} \tag{A1}$$

$h(Q)$, $h'(Q)$, and $h''(Q)$ are replaced with $-\frac{\alpha_0}{\alpha_1} + \frac{1}{\alpha_1}Q - \frac{\alpha_2}{\alpha_1}Y$, $\frac{1}{\alpha_1}$, and 0, respectively:

$$\begin{aligned} &-\frac{\alpha_0}{\alpha_1} + \frac{1}{\alpha_1}Q - \frac{\alpha_2}{\alpha_1}Y + \frac{\lambda_d}{\alpha_1}Q - \beta_d - \tau_d Q - \gamma_d R + \lambda_u[\frac{1}{\alpha_1} + \frac{\lambda_d}{\alpha_1}Q] \\ &= \beta_u + \gamma_u W + \tau_u(Q + X) \end{aligned} \tag{A2}$$

We rearrange the equation (A2) to solve for the equilibrium output after supply shocks, $Q^*$:

$$
\begin{aligned}
Q^* &= \frac{\alpha_1}{(1+\lambda_u)(1+\lambda_d) - \alpha_1(\tau_u+\tau_d)}[\frac{\alpha_0}{\alpha_1}] \\
&+ \frac{\alpha_1}{(1+\lambda_u)(1+\lambda_d) - \alpha_1(\tau_u+\tau_d)}[\frac{\alpha_2 Y}{\alpha_1}] \\
&+ \frac{\alpha_1}{(1+\lambda_u)(1+\lambda_d) - \alpha_1(\tau_u+\tau_d)}[\beta_d + \gamma_d R + \beta_u + \gamma_u W] \\
&+ \frac{\alpha_1}{(1+\lambda_u)(1+\lambda_d) - \alpha_1(\tau_u+\tau_d)}[\tau_u X].
\end{aligned} \tag{A3}
$$

Given $Q = \alpha_0 + \alpha_1 p^d + \alpha_2 Y$, we solve for $p^d$:

$$
p^d = \beta_2 + \beta_3 Y + \beta_4[\beta_u + \gamma_u R + \beta_d + \gamma_d W] + \beta_5 X. \tag{A4}
$$

where

$$
\begin{aligned}
\beta_2 &= \frac{-(\lambda_d+\lambda_u+\lambda_d\lambda_u) + \alpha_1(\tau_u+\tau_d)}{(1+\lambda_d)(1+\lambda_u) - \alpha_1(\tau_u+\tau_d)}(\frac{\alpha_0}{\alpha_1}), \\
\beta_3 &= \frac{-(\lambda_d+\lambda_u+\lambda_d\lambda_u) + \alpha_1(\tau_u+\tau_d)}{(1+\lambda_d)(1+\lambda_u) - \alpha_1(\tau_u+\tau_d)}(\frac{\alpha_2}{\alpha_1}), \\
\beta_4 &= \frac{1}{(1+\lambda_d)(1+\lambda_u) - \alpha_1(\tau_u+\tau_d)}, \quad \text{and} \\
\beta_5 &= \frac{\tau_u}{(1+\lambda_d)(1+\lambda_u) - \alpha_1(\tau_u+\tau_d)}.
\end{aligned}
$$

Additionally, the upstream firms' inverse derived demand in equation (2.4) can be rewritten as:

$$
p^u = -\frac{\alpha_0}{\alpha_1} + \frac{1}{\alpha_1}Q - \frac{\alpha_2}{\alpha_1}Y + \lambda_d\frac{1}{\alpha_1}Q - \beta_d - \gamma_d R - \tau_d Q. \tag{A5}
$$

Solving for $Q$:

$$
\begin{aligned}
Q = & \frac{\alpha_1}{(1+\lambda_d) - \alpha_1\tau_r} p^u \\
& + \frac{\alpha_1}{(1+\lambda_d) - \alpha_1\tau_r} [\frac{\alpha_0}{\alpha_1}] \\
& + \frac{\alpha_1}{(1+\lambda_d) - \alpha_1\tau_r} [\frac{\alpha_1 Y}{\alpha_2}] \\
& - \frac{\alpha_1}{(1+\lambda_d) - \alpha_1\tau_r} [\beta_d + \gamma_d R].
\end{aligned} \tag{A6}
$$

At the equilibrium output after supply shocks, $Q^*$, shown in equation (A3), the equilibrium upstream firms' output price can be expressed as follows by substituting equation (A3) into equation (A5):

$$
p^u = \beta_7 + \beta_8 Y + \beta_9[\beta_d + \gamma_d R] + \beta_{10}[\beta_u + \gamma_u W] + \beta_{11} X \tag{A7}
$$

where

$$
\begin{aligned}
\beta_7 &= \beta_2, \\
\beta_8 &= \beta_3, \\
\beta_9 &= \beta_4, \\
\beta_{10} &= \frac{(1+\lambda_d) - \alpha_1\tau_d}{(1+\lambda_d)(1+\lambda_u) - \alpha_1(\tau_u + \tau_d)}, \quad \text{and} \\
\beta_{11} &= \frac{\tau_u[(1+\lambda_d) - \alpha_1\tau_d]}{(1+\lambda_d)(1+\lambda_u) - \alpha_1(\tau_u + \tau_d)}.
\end{aligned}
$$

**Table A.1**: *First Stage Regression Results*

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | Quantity | | Quantity | |
| VARIABLES | Coef | SE | Coef | SE |
| Personal Income | 0.001 | 0.002 | -0.001 | 0.003 |
| Cereal Price | -1.536** | 0.754 | -3.524*** | 1.167 |
| Juices Price | 1.518* | 0.798 | 3.562*** | 0.919 |
| Coffee-Tea Price | 0.780 | 0.496 | 0.633 | 0.810 |
| Cheese Price | -0.804** | 0.314 | -0.185 | 0.568 |
| Wage | -1.020* | 0.521 | -1.083 | 0.899 |
| Diesel | 5.602* | 2.897 | 8.801* | 5.144 |
| Electricity | 3.231 | 6.985 | -27.049*** | 6.809 |
| Feed | -2.288 | 1.749 | -5.711** | 2.400 |
| Labor | 44.851 | 27.586 | 128.002*** | 41.934 |
| Energy | -5.206* | 2.901 | -7.842 | 5.088 |
| Month = 2 | -35.982*** | 3.031 | | |
| Month = 3 | -6.447** | 2.986 | | |
| Month = 4 | -21.006*** | 3.574 | | |
| Month = 5 | -16.091*** | 3.865 | | |
| Month = 6 | -45.008*** | 5.434 | | |
| Month = 7 | -37.430*** | 6.447 | | |
| Month = 8 | -13.711** | 6.175 | | |
| Month = 9 | -15.533*** | 4.768 | | |
| Month = 10 | -1.535 | 3.432 | | |
| Month = 11 | -8.527** | 3.349 | | |
| Month = 12 | -1.227 | 3.372 | | |
| Quarter = 2 | | | -1.728 | 4.614 |
| Quarter = 3 | | | 11.401* | 5.957 |
| Quarter = 4 | | | 12.176*** | 4.221 |
| Constant | 413.034*** | 138.476 | 465.733** | 197.109 |
| Observations | 120 | | 120 | |
| R-squared | 0.876 | | 0.619 | |

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

# Appendix B

# Appendix to Chapter 3

Table B.1: Descriptive Statistics

| | | | | | |
|---|---|---|---|---|---|
| ELMHURST DAIRY | 5.073 | 0.001 | 0.25 | 1% | Carton |
| ELMHURST DAIRY | 5.082 | 0.001 | 0.25 | 2% | Carton |
| ELMHURST DAIRY | 5.126 | 0.001 | 0.25 | Fatfree | Carton |
| ELMHURST DAIRY | 5.021 | 0.001 | 0.25 | Whole | Carton |
| ELMHURST DAIRY | 4.585 | 0.001 | 0.5 | 1% | Plastic |
| ELMHURST DAIRY | 4.570 | 0.002 | 0.5 | 2% | Plastic |
| ELMHURST DAIRY | 4.632 | 0.001 | 0.5 | Fatfree | Plastic |
| ELMHURST DAIRY | 4.501 | 0.004 | 0.5 | Whole | Plastic |
| ELMHURST DAIRY | 4.012 | 0.002 | 1 | 1% | Plastic |
| ELMHURST DAIRY | 3.985 | 0.002 | 1 | 2% | Plastic |
| ELMHURST DAIRY | 4.118 | 0.001 | 1 | Fatfree | Plastic |
| ELMHURST DAIRY | 3.936 | 0.006 | 1 | Whole | Plastic |
| FARMLAND DAIRIES | 5.608 | 0.002 | 0.5 | 2% | Plastic |
| FARMLAND DAIRIES | 5.619 | 0.003 | 0.5 | Whole | Plastic |
| FARMLAND DAIRIES | 4.498 | 0.001 | 1 | 1% | Plastic |
| FARMLAND DAIRIES | 4.548 | 0.002 | 1 | 2% | Plastic |
| FARMLAND DAIRIES | 4.547 | 0.002 | 1 | Whole | Plastic |
| FARMLAND S.R. SKIM | 9.833 | 0.002 | 0.25 | Fatfree | Carton |
| FARMLAND S.R. SKIM | 7.433 | 0.015 | 0.5 | Fatfree | Carton |

| Brand | Price | Share | Size | Fat | Package | Lactosefree | Organic |
|---|---|---|---|---|---|---|---|
| FARMLAND S.R. SKIM | 7.279 | 0.001 | 0.5 | Fatfree | Carton | Y | |
| FARMLAND | 5.633 | 0.001 | 0.5 | 1% | Plastic | | |
| FARMLAND | 5.564 | 0.001 | 0.5 | Fatfree | Plastic | | |
| FARMLAND | 4.444 | 0.001 | 1 | Fatfree | Plastic | | |
| GARELICK FARMS | 4.092 | 0.000 | 1 | 2% | Plastic | | |
| GARELICK FARMS | 4.050 | 0.000 | 1 | Whole | Plastic | | |
| HOOD LACTAID | 10.561 | 0.001 | 0.25 | 2% | Carton | Y | |
| HOOD LACTAID | 10.789 | 0.001 | 0.25 | Fatfree | Carton | Y | |
| HOOD LACTAID | 8.989 | 0.003 | 0.5 | 1% | Carton | Y | |
| HOOD LACTAID | 8.827 | 0.004 | 0.5 | 2% | Carton | Y | |
| HOOD LACTAID | 9.001 | 0.004 | 0.5 | Fatfree | Carton | Y | |
| HOOD LACTAID | 8.947 | 0.002 | 0.5 | Whole | Carton | Y | |
| HOOD LACTAID | 7.996 | 0.002 | 0.75 | 1% | Plastic | Y | |
| HOOD LACTAID | 7.975 | 0.003 | 0.75 | 2% | Plastic | Y | |
| HOOD LACTAID | 8.199 | 0.004 | 0.75 | Fatfree | Plastic | Y | |
| HOOD LACTAID | 8.011 | 0.003 | 0.75 | Whole | Plastic | Y | |
| HOOD SIMPLY SMART | 7.328 | 0.001 | 0.5 | Fatfree | Carton | | |
| HORIZON ORGANIC | 9.368 | 0.002 | 0.5 | 1% | Carton | | Y |
| HORIZON ORGANIC | 9.360 | 0.003 | 0.5 | 2% | Carton | | Y |
| HORIZON ORGANIC | 9.559 | 0.002 | 0.5 | Fatfree | Carton | | Y |
| HORIZON ORGANIC | 9.455 | 0.003 | 0.5 | Whole | Carton | | Y |
| LEHIGH VALLEY | 5.928 | 0.000 | 0.5 | 2% | Plastic | | |
| MOUNTAINSIDE FARMS | 6.626 | 0.000 | 0.5 | 1% | Carton | | |
| MOUNTAINSIDE FARMS | 6.558 | 0.000 | 0.5 | 2% | Carton | | |
| MOUNTAINSIDE FARMS | 6.501 | 0.000 | 0.5 | Whole | Carton | | |
| ORGANIC VALLEY | 8.962 | 0.002 | 0.5 | 1% | Carton | | Y |
| ORGANIC VALLEY | 9.180 | 0.002 | 0.5 | 2% | Carton | | Y |
| ORGANIC VALLEY | 8.965 | 0.002 | 0.5 | Fatfree | Carton | | Y |
| ORGANIC VALLEY | 8.995 | 0.002 | 0.5 | Whole | Carton | | Y |
| PRIVATE LABEL | 6.124 | 0.001 | 0.25 | 1% | Carton | | |
| PRIVATE LABEL | 6.014 | 0.001 | 0.25 | 1% | Plastic | | |
| PRIVATE LABEL | 6.111 | 0.002 | 0.25 | 2% | Carton | | |

| Brand | Price | Share | Size | Fat | Package | Lactosefree | Organic |
|---|---|---|---|---|---|---|---|
| PRIVATE LABEL | 6.033 | 0.002 | 0.25 | 2% | Plastic | | |
| PRIVATE LABEL | 6.086 | 0.001 | 0.25 | Fatfree | Carton | | |
| PRIVATE LABEL | 5.937 | 0.002 | 0.25 | Fatfree | Plastic | | |
| PRIVATE LABEL | 6.175 | 0.003 | 0.25 | Whole | Carton | | |
| PRIVATE LABEL | 6.048 | 0.003 | 0.25 | Whole | Plastic | | |
| PRIVATE LABEL | 7.542 | 0.003 | 0.5 | 1% | Carton | | Y |
| PRIVATE LABEL | 4.987 | 0.015 | 0.5 | 1% | Plastic | | |
| PRIVATE LABEL | 7.522 | 0.003 | 0.5 | 2% | Carton | | Y |
| PRIVATE LABEL | 4.967 | 0.019 | 0.5 | 2% | Plastic | | |
| PRIVATE LABEL | 7.412 | 0.001 | 0.5 | Fatfree | Carton | | |
| PRIVATE LABEL | 7.447 | 0.003 | 0.5 | Fatfree | Carton | | Y |
| PRIVATE LABEL | 7.065 | 0.001 | 0.5 | Fatfree | Carton | Y | |
| PRIVATE LABEL | 4.929 | 0.014 | 0.5 | Fatfree | Plastic | | |
| PRIVATE LABEL | 6.866 | 0.000 | 0.5 | Whole | Carton | | |
| PRIVATE LABEL | 7.413 | 0.003 | 0.5 | Whole | Carton | | Y |
| PRIVATE LABEL | 5.022 | 0.022 | 0.5 | Whole | Plastic | | |
| PRIVATE LABEL | 3.717 | 0.048 | 1 | 1% | Plastic | | |
| PRIVATE LABEL | 6.090 | 0.001 | 1 | 1% | Plastic | | Y |
| PRIVATE LABEL | 3.790 | 0.068 | 1 | 2% | Plastic | | |
| PRIVATE LABEL | 6.072 | 0.001 | 1 | 2% | Plastic | | Y |
| PRIVATE LABEL | 3.572 | 0.035 | 1 | Fatfree | Plastic | | |
| PRIVATE LABEL | 5.872 | 0.002 | 1 | Fatfree | Plastic | | Y |
| PRIVATE LABEL | 3.833 | 0.067 | 1 | Whole | Plastic | | |
| PRIVATE LABEL | 5.586 | 0.005 | 1 | Whole | Plastic | | Y |
| SMART BALANCE H.R. | 7.096 | 0.001 | 0.5 | Fatfree | Carton | | |
| SMART BALANCE | 7.160 | 0.002 | 0.5 | Fatfree | Carton | | |
| SMART BALANCE | 7.229 | 0.002 | 0.5 | Fatfree | Carton | Y | |
| STONYFIELD ORGANIC | 8.569 | 0.003 | 0.5 | 1% | Carton | | Y |
| STONYFIELD ORGANIC | 8.664 | 0.004 | 0.5 | 2% | Carton | | Y |
| STONYFIELD ORGANIC | 8.585 | 0.003 | 0.5 | Fatfree | Carton | | Y |
| STONYFIELD ORGANIC | 8.744 | 0.004 | 0.5 | Whole | Carton | | Y |
| TUSCAN DAIRY FARMS O.T.M | 7.037 | 0.001 | 0.5 | Fatfree | Carton | | |

| Brand | Price | Share | Size | Fat | Package | Lactosefree | Organic |
|---|---|---|---|---|---|---|---|
| TUSCAN DAIRY FARMS | 6.674 | 0.001 | 0.25 | 1% | Plastic | | |
| TUSCAN DAIRY FARMS | 6.683 | 0.001 | 0.25 | 2% | Plastic | | |
| TUSCAN DAIRY FARMS | 6.602 | 0.001 | 0.25 | Fatfree | Plastic | | |
| TUSCAN DAIRY FARMS | 6.655 | 0.002 | 0.25 | Whole | Plastic | | |
| TUSCAN DAIRY FARMS | 5.370 | 0.005 | 0.5 | 1% | Plastic | | |
| TUSCAN DAIRY FARMS | 5.334 | 0.007 | 0.5 | 2% | Plastic | | |
| TUSCAN DAIRY FARMS | 5.379 | 0.005 | 0.5 | Fatfree | Plastic | | |
| TUSCAN DAIRY FARMS | 5.295 | 0.009 | 0.5 | Whole | Plastic | | |
| TUSCAN DAIRY FARMS | 4.125 | 0.008 | 1 | 1% | Plastic | | |
| TUSCAN DAIRY FARMS | 4.116 | 0.012 | 1 | 2% | Plastic | | |
| TUSCAN DAIRY FARMS | 4.137 | 0.006 | 1 | Fatfree | Plastic | | |
| TUSCAN DAIRY FARMS | 4.077 | 0.014 | 1 | Whole | Plastic | | |
| TUSCAN TRUMOO | 5.383 | 0.001 | 0.5 | 1% | Plastic | | |
| TUSCAN TRUMOO | 4.283 | 0.001 | 1 | 1% | Plastic | | |
| WELSH FARMS | 4.006 | 0.000 | 1 | 1% | Plastic | | |
| WELSH FARMS | 3.956 | 0.001 | 1 | 2% | Plastic | | |
| WELSH FARMS | 3.927 | 0.001 | 1 | Whole | Plastic | | |