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Measuring the effect of cold storage, captive supply, and concentration on the marketing margin in the U.S. pork industry

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MEASURING THE EFFECT OF COLD STORAGE, CAPTIVE SUPPLY, AND CONCENTRATION ON THE MARKETING MARGIN IN THE U.S. PORK INDUSTRY

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ABSTRACT

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This study investigates the implication of key decision variables at the control of processing firms in a concentrated industry. Succinctly, the decisions examined affect the firm's ability to buffer short run supply and demand fluctuations through storage and access to an alternative source of specialized inputs essential to production. What makes them different in the context of this research is a focus on high-throughput processing plants where capacity utilization can result in cost efficiencies and a high degree of market concentration where adjustments in quantity demanded of the specialized input can affect its price and where adjustments in the quantity supplied of output can also affect that price. These two effects cost reduction and market power have opposite effects of the prices of interest and the goal of this research is to estimate which dominates in explaining the marketing margins within the supply chain. This research also looks at the direct impact of concentration among the processing sector. The U.S. pork sector provides an excellent case study for empirical analysis.

The consolidation and industrialization in meat processing and the food retail industry in the past thirty years has added a new dimension to the U.S. food and agricultural markets. The increasing market concentration has not only piqued the interest of economists by but also public concerns about the competitive nature of markets along the entire supply chain from live animals to food products. As the size of meat packers is getting bigger, their key strategic variables may have more impact on the marketing margin than ever before. The results show that during a period of rapid consolidation, cold storage may have enabled firms to exploit market

power. However, during a period with less consolidation (since 2000), the effect of cold storage appears to be less significant and its dominant role shifted toward enhancing cost efficiency. Analyzing data from 2007 to 2014, the dominant role of captive supply appears to be in generating cost efficiencies by allowing better coordination between dynamic short run supply and demand and optimal capacity utilization. In summary, the results of this study indicate that with relatively stable market concentration, cold storage and captive supply have the potential to generate important cost efficiencies that are at least partially passed on to retailers, farmers, and further processors in excess of any adverse effects the use of these decision variables might create but in less stable circumstances the anti-competitive effects dominate the efficiency gains passed through the market.

CHAPTER 1. INTRODUCTION

1.1 Introduction

The industrialization and consolidation in the U.S food sector has changed the business of food production, processing, distribution, and retailing in just a few decades. With the emergence of mega-scale food processing companies and big box retailers, farmers, consumers, policy makers, and the media are worried about the potential for market power to erode the welfare of farmers and food consumers. Companies with large shares of the market have greater ability to create non-competitive price outcomes that benefit their profitability but may reduce the prices farmers receive and increase the price that consumers pay. This issue has not only piqued the public interest but also that of agricultural economists who study these markets. One important role of agricultural economics is to study such problems by developing behavioral hypotheses and testing them with observable data. The nature of such applied work also lends itself to providing suggestions to policy makers and promoting public understanding of economic issues. This thesis attempts to accomplish all of these roles by examining the behavior of firms from a profit maximization paradigm, testing possible outcomes with data, and providing some insight for policy makers and other interested parties.

The U.S meat processing industry is a typical case to study the market concentration issue. The meat packing sector has long received plenty of blame accusing them of using market power to decrease the prices they pay to farmers for live animals. In 1919 the US Federal Trade Commission (FTC) had reported the anti-competitive practices by the largest five firms in the meat packing industry that urge the Congress to pass the Packers and Stockyards Act in order to protect farmers, ranchers and con-

sumers. According to GIPSA, the four firm concentration ratio for pork packers has increased from 32.2% in 1985 to 65.5% at the end of 2014. Likewise, the four firm concentration ratio of the retail grocery stores has increased from 16.8% at 1993 to 36.4% leading to renewed concerns about the competitive nature of markets along the entire supply chain from live animals to food products.

This thesis not only focuses on market concentration but also the implication of two key strategic variables, cold storage stock and captive supply. Market concentration by itself is often associated with possible higher pricing power (Acharya & Caudill, 2011). This thesis takes that traditional view a step further by examining a couple of mechanisms (hereafter referred to as strategic variables) by which firms with large market share may control their output to manipulate prices while continuing to enjoy the benefits of economies of scale. It is important to note that only firms with substantial market share could do this unilaterally. It is possible that firms might collude to collectively withhold product or purchases from the market to manipulate price. This thesis does not explore such behavior other than to examine data at the aggregate level where firms following the same market signals may make similar production decisions resulting in a situation that could look collusive. There is no evidence that we are aware of which suggests active collusion by U.S. meat packers. The two strategic variables examined in this thesis are ones that have grown in importance in recent decades. They are cold storage and captive supplies. Cold storage is a commodity storage aimed to preserve the physical natural of perishable goods. (Williams & Wright, 1998) Captive supply is defined as livestock that is owned or sold by a packer more than 14 days prior to slaughter (GIPSA, 2002)

Marketing margin is the difference between price at any two market level. It is calculated as equation(1.1)

$$M_{ij} = P_j - P_i \tag{1.1}$$

M_ij is the marketing margin between market i and j, P_i and P_j is the price at i and j. Marketing margin is a measure of the efficiency of marketing system. The margin represents the cost to produce output from one stage to the next and the return to

those who doing the work. By using marketing margin as the dependent variable, it can cover the effect from most important factors in the market. The effect of market concentration and strategic variables on marketing margin is tested at three different levels: Farm-Retail, Wholesale-Retail and Farm-Wholesale. All extended models are based on the relative price spread model from Wohlgenant and Mullen. (Wohlgenant & Mullen, 1987) There are three extended models. Only one strategic variable is tested at one time. The packer and retailer concentration ratio are put in one model to examine how concentration affects the marketing margin at different points along the supply chain.

Earlier it was suggested that the strategic variables of interest have evolved in recent years as the industry faced greater consolidation, gained economies of scale, and captured technological gains. Thus, there are potentially competing roles that these variable may play in the meat packing sector. The first is that of a facilitator of market power by allowing the firms to adjust output in real time to avoid high live animal prices and/or low wholesale or retail prices thus inflating the marketing margins.The second is as a facilitator of logistical efficiency to allow the packing plant to operate at optimal capacity utilization regardless of the market supply of live animals or the demand for wholesale and retail meat products. The third role would depends on how strategic variable affect the marketing margin. One is the implication of strategic variable helps packers to apply pricing power that may increase the margin. The other one is the role of strategic variable is more like logistic tool that allow packers to reduce unit processing cost and pass the cost saving to farmers, retailers, and consumers. The research results indicate that within a relative stable market, the efficiency role of cold storage and captive supply dominate the anti-competitive role and generally lead to welfare gains for farmers and consumers. The consolidation and industrialization are not only increasing the size and scale of packing firms but also increasing the production efficiency and lowering overall cost of production to the benefit of all participants along the supply chain.

The remainder of this thesis is structured as follows: Chapter Two is an academic paper that introduces the background information about the research problem; contains a review of quantitative studies and previous research related to marketing margins and the meat sector; presents the most important econometric results; and summarizes the research findings. Chapter Three is a non-academic paper written for general public and policy makers who are concerned about the performance and efficiency of the meat industry. The appendices that follows are organized into three parts. Appendix A presents a set of potentially interesting extensions of the econometric model that were not included in the academic paper for technical reasons explained therein. For readers who are interested in these models or in building upon the research in this thesis, the detail test results can be found in the appendices. Appendix B contains graphs of the elasticities of marketing margins with respect to the strategic variables and market concentration ratio plotted over time. The purpose of presenting these graphs is to give readers a better view how these elasticities changed during the observed period. The last part of this thesis is the reference list that includes all cited literature for the entire thesis.

CHAPTER 2. RESEARCH APPROACH AND CONCLUSIONS

2.1 Introduction

Agricultural markets are often used as examples of a close approximation to perfectly competitive markets. The wave of industrialization and consolidation in meat processing and the food retail industry in the past thirty years has added a new dimension to the U.S. food and agricultural markets. According to GIPSA, the four firm concentration ratio for pork packers has increased from 32.2% in 1985 to 65.5% at the end of 2014. Likewise, the four firm concentration ratio of the retail grocery stores has increased from 16.8% at 1993 to 36.4% leading to renewed concerns about the competitive nature of markets along the entire supply chain from live animals to food products. Agricultural economists have expended tremendous efforts trying to quantify the implications of concentration on markets and prices. Landes and Posner developed an approach to analysis market power by using Lerner index. (Landes & Posner, 1981)

Consumer demand has also shifted to more value-added products that potentially increase the farm-retail marketing margin due to the added processing and marketing costs involved in providing convenience and food safety for example. When the market is examined in two stages, farm to wholesale and wholesale to retail, the two marketing margins may follow different patterns. For the pork industry, for example, the Wholesale-Retail margin has increased by 72% and Farm-Retail margin has increased by 51% from 1985 to 2014 while the Farm-Wholesale margin decreased 4% during the same time period.

One indicator of market performance is to examine prices at different points along the marketing channel. The effects of concentration, competition, and firm strategies

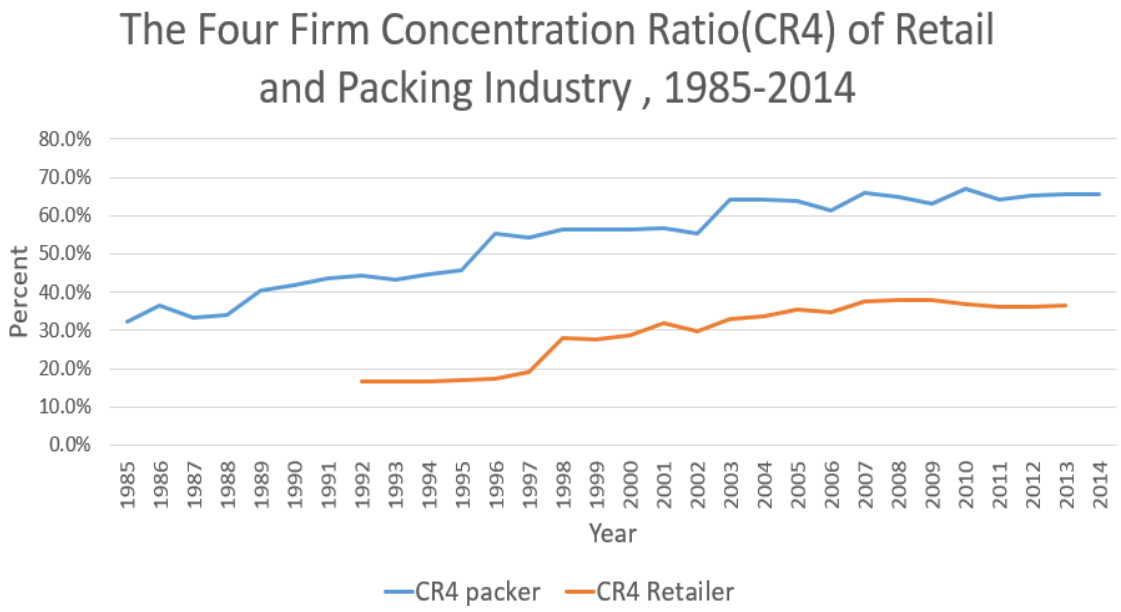

Figure 2.1. The Four Firm Concentration Ratio of Retail Industry and Packing industry

are reflected in the information carried in prices at different levels of the marketing channel as a farm commodity is transformed to wholesale and eventually retail product. The marketing margin for a farm product is defined as the difference in price between two points along the marketing channel. Gardner (Gardner, 1975) proposed three forces (shifts in retail demand, shifts in farm commodity supply, and shifts in marketing input supply) that impact the marketing margin in a perfectly competitive market and Holloway (Holloway, 1991) extended Gardner's model to imperfectly competitive markets. Wohlgenant and Mullen (Wohlgenant & Mullen, 1987) proposed three empirical specifications based on the demand function for the farm product in their paper and provided an empirical example by estimating the models for the U.S. beef sector. These empirical specifications have been widely accepted to explain marketing margins in a perfectly competitive market. (Kesavan, 1992) (Lusk, 2001)

The traditional view of perfect competition belies the concentration that has occurred beyond the farm gate and more frequently researchers are examining the potential of market power from the food processing and retailing sectors. Often these concerns have focused on animal and meat industry where concentration at the processing sector has been more significant and comparisons between prices at different points in the marketing channel are easier to make because the raw commodity is straightforwardly transformed through a disassembly process into a relatively homogenous consumer good without tremendous mixing with other ingredients. Previous studies have focused on oligopoly power while Sexton expressed concern about both oligopsony and oligopoly power in the food sector due to the increasing concen-

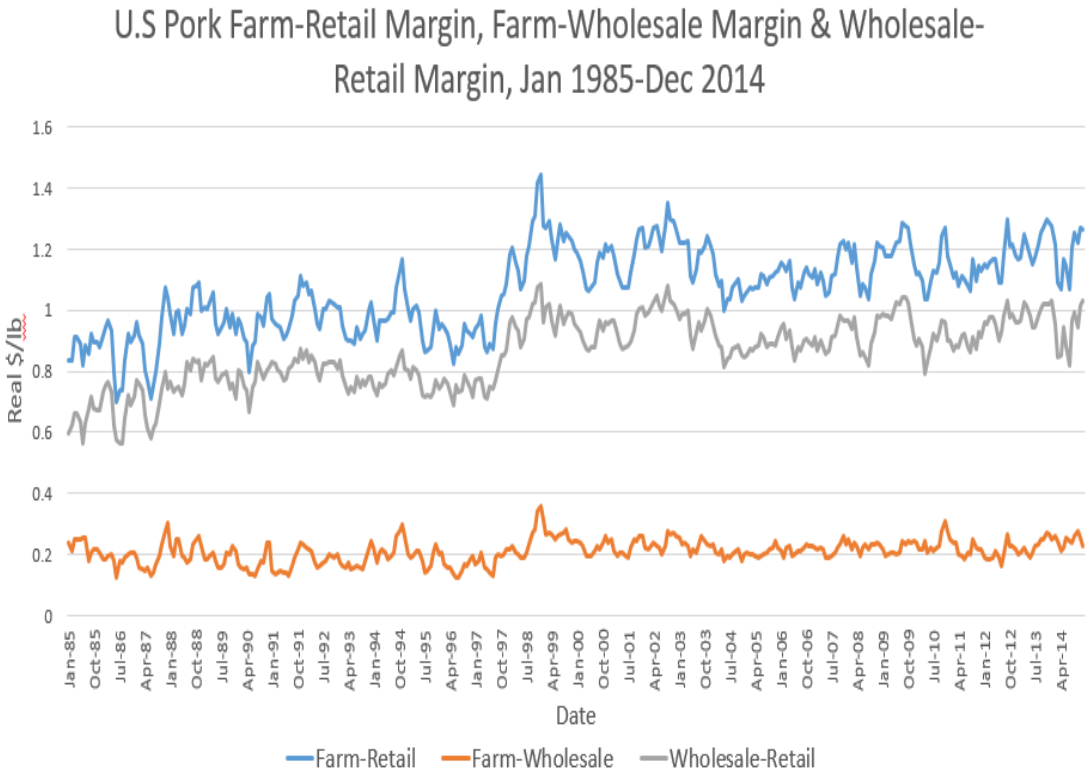

Figure 2.2. U.S Pork Farm-Retail, Farm-Wholesale, Wholesale-Retail Margin, Jan 1985-Dec 2014

tration in the major agricultural sectors (Sexton, 2000). He believed that there is a positive (negative) correlation between concentration and selling (purchasing) price in highly concentrated industries. Acharya (Acharya & Caudill, 2011) tested the farm-retail price transmission and concluded that the majority of market power is driven by concentration. When market power becomes more important, it affects the price. As the effect may vary between different levels along the supply chain, marketing margins are expected to be affected in a predictable manner. However, other previous studies have not consistently found statistical support for oligopsony and oligopoly power using a variety of methodological approaches. Appelbaum provided an empirical framework to test individual firm or industrys oligopoly power(Appelbaum, 1982). Azzam and Pagoulatos (Azzam & Pagoulatos, 1990) extended the conjectural approach in industrial organization to test both oligopoly and oligoposny behavior in the U.S meat industry. They found meat packing industry can exercise market power at both input(farm) and output(retail) market. Muth and Wohlgenant (Muth & Wohlgenant, 1999) built a model to measure the degree of oligopsony power in the beef packing industry and they found no evidence of oligopsony power in 1967-1993. As the concentration of the retail grocery industry increased from the mid-1990s, researchers became interested in the oligopsony power of retailers. Chung and Tostao (Chung & Tostao, 2012) separated the retailers' market power from the packers' in their study. Their result suggested that packers may exercise oligopsony market power at the farm-wholesale level while retailers' market power may have dominated the wholesale-retail market in the beef packing industry in 1970-1999. They did not conclude any correlation between marketing margin and market power.

With the rapid consolidation in agricultural markets, large companies typically control the majority of market share. A key aspect of Cournot competition is that firms simultaneously make their output decisions under the belief that these decisions do not affect the optimal decisions of their competitors. In this paper, the market is examined at two levels, farm to wholesale and wholesale to retail. Data from 2000 to 2014 were used to examine the effect of strategic variables and output decisions at

two levels. The paper also explores the potential for both oligopoly and oligopsony power of meat packers at the two market levels and retailers oligopsony power at the two market levels.

2.2 Theoretical Framework

2.2.1 Cournot Competition

The U.S meat processing industry is considered concentrated because it has a relatively high four firm concentration ratio. According to GIPSA, the four largest meat packers controlled about 68% of the market share in 2012. Meat packing plants process a single species of live animal to produce a species-specific boxed meat which is relatively homogeneous and has a large number of substitutes for consumers to choose between at the retail level. When a product is homogeneous in a concentrated industry, the optimal output strategy for an individual firm is Cournot behavior (Sexton, 2000). In such a concentrated industry, with more than one firm and a homogeneous product, each firm's output decision may affect the price received by all firms.

A linear approximation of the retailers inverse demand for wholesale is

$$R_w = F(Q_t, V) = \alpha - \beta * Q_t + \mu * V \tag{2.1}$$

Where Q_t is the total production from all meat packers, R_w is the wholesale market price, and V indicates other factors that may affect the wholesale price such as strategic variables at the control of the oligopolist/oligosonist and market power. The total industry production, Q_t, is the sum of output by all firms such that

$$Q_t = Q_i + \sum Q_j \tag{2.2}$$

The revenue for firm i is

$$Y_i = Q_i * R_w \tag{2.3}$$

It can be rewritten as

$$Y_i = Q_i * (\alpha - \beta * (Q_i + \sum Q_j) + \mu * V) \tag{2.4}$$

Q_j is the total production from all meat packers except firm i. The total revenue of firm i is not only dependent on its own output decision, but also all other firms' production. For simplicity, assume that all packers face the same supply of live animals and have the same mechanisms, if any, by which to discriminate the prices they pay for their specialized input (live animals). Thus, all packers are anticipated to pay the same price for the specialized input. If there is oligopsony power in the farm-to-wholesale market, firms may be able to negotiate a lower price to decrease their production cost while their revenue still depends on their own output decision and that of their competitors.

2.2.2 Lerner Index

The Lerner index has a long history of use in measuring a firms market power in terms of its ability to markup price above marginal cost. Arithmetically, the Lerner Index (L) is $L = \frac{P-MC}{P}$ where P is price and MC is the firms marginal cost. In the meat industry, the marginal cost of the meat packer is dominated by the cost of live animals and for further packer it is the wholesale carcass. Adjusting for retail or wholesale equivalence, the Lerner index for the meat packer can be approximated as $L = \frac{P_r - P_f}{P_r}$ or $\frac{MM}{P}$, where P_r is the retail price for pork, P_f is the live animal price at farm, MM is the marketing margin of pork. When the Lerner index is used as an index of market power for the industry, it can be expressed as $L = \frac{HHI}{\epsilon_d}$, where HHI is the Herfindahl index and d is the elasticity of demand. If the market is perfectly competitive with many firms, $P = MC$ and Lerner index is zero. If the market is characterized by monopoly, $L = \frac{P-MC}{P} = \frac{1}{\epsilon_d}$. Oligopoly is a

more complicated structure where the market is dominated by a few large firms. If one packer offers a higher price for live animals, all farmers would like to sell their animals to this company. Then other companies will try to match the higher price to fulfill their production needs. The market price will reach equilibrium that there is no difference (net of transactions costs) for farmers to sell their animals to one or another packer in a given market area. It is the same story when packers sell wholesale products to retailers. Retailers will not pay a higher/lower price unless there is quality difference in product or some other value proposition. Suppose all firms set their output quantities simultaneously, and market price is determined by total industry output. With capacity constraints and a dynamic market environment, Cournot competition is the best response of each firm to maximize its profit. When each firm has unlimited production capacity, and sets price simultaneously, market price will be the same as that under perfect competition (Bertrand equilibrium) and equal to the marginal cost. Each firm's profit is zero and the industry average Lerner index is zero. Whether the industry is under Cournot competition or Bertrand equilibrium or somewhere between these two equilibriums, depends on the firms' decisions on quantity or price. The Lerner index can be rewritten as follows:

$$L = \lambda * \frac{HHI}{\epsilon_d} \tag{2.5}$$

$$L = \frac{MM}{P} \tag{2.6}$$

$$MM = \lambda * \frac{HHI}{\epsilon_d} * P \tag{2.7}$$

Where λ is a function of aggregate strategic behaviors across the industry. $\lambda(\cdot)$is the i possible strategies that a firm might strategically use in an oligopoly market to maximize its profit. When all firms only strategy is to set their output quantity at the Cournot equilibrium level to maximize their profit, λ equals 1 and $L = \lambda * \frac{HHI}{\epsilon_d}$. When all firms only strategy is to set their output price as low as possible and maximize sales, λ will equal to zero. In general, however, firms employ a variety of

strategies at the same time. This paper treats λ as a function of strategic variables possessed by the firms that can be written as follows:

$$\lambda = \lambda(\cdot), \lambda \in [0, 1] \tag{2.8}$$

$$MM = \lambda(\cdot) * \frac{HHI}{\epsilon_d} * P \tag{2.9}$$

The industry level marketing margin (accepting that the live animal price and wholesale carcass price are good proxies for marginal cost at different stages of the supply chain) is dependent on the effect of strategy variables, the market concentration, the elasticity of demand and the retail price. How important is the implication of some key strategic variables for the meat industry? What is the impact of rising concentration? What is the interaction between market power and key strategic variables? In this paper, two potential strategic variables are examined that firms may employ. The models also examine the effect of market concentration. This is accomplished by building econometric models that exploit the underpinnings of the Lerner Index under Cournot competition and previous efforts to model the marketing margins in agriculture.

2.3 Proposed Strategy Variables

2.3.1 Cold Storage

Cold storage is a commodity storage aimed to preserve the physical natural of perishable goods. (Williams & Wright, 1998) From Jan 1985 to Dec 2014, total pork production increased by 69% while total cold storage increased by 77%. Even though monthly pork in cold storage is more than 20% of total pork supply, little previous research has been done about cold storage as an important factor in the pork industry.

In the long-run, supply and demand will reach static equilibrium. However, in the short-run, when the biological cycle of live animal production sets a limit to

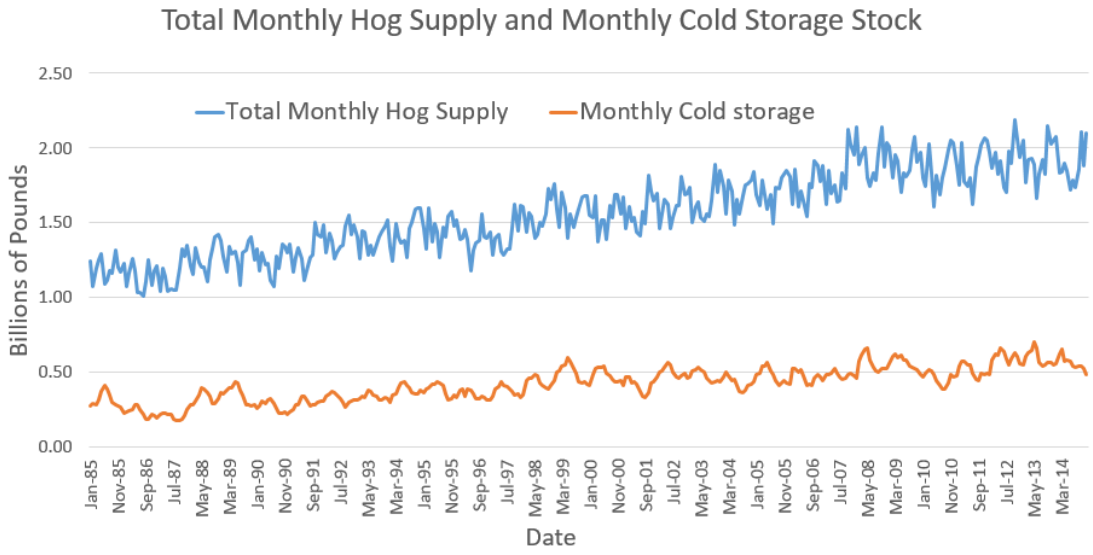

Figure 2.3. Total Pork Supply and Cold Storage Stock

the quantity supplied, the clearing of market is much more complex. It is not that disequilibrium occurs in the short run, although that might be temporarily the case in localized markets, but rather that prices and storage are forced to absorb most of the adjustment required to clear the short run market. Storage is an option to shift supply from one period to another. Cold storage acts as a short run buffer between supply and demand. If cold storage stock can be used as strategic variable by packers, hog packers may be able to buy fewer animals when the live animal price is high and release their cold storage stock to avoid paying higher prices for live animals to still meet short run demands of retailers. When the cash market price at the farm level is low, meat packers can buy more animals from growers but not flood the retail market with meat by increasing cold storage stocks. They can keep the processed meat in cold storage and release the stock when farm level price is high and/or when retail demand is high. If packers can use this strategy to increase profit, then it should be evident in the marketing margins. Cold storage

stock alternatively represent a logistical necessity that allows packers operate large-scale plants at optimal capacity utilization and thereby reduce unit processing cost. These cost savings at the wholesale level may be passed on to the retail level in the form of lower prices and/or to the farmers in the form of higher live animal prices. The role as strategic tool and logistic tool are not in conflict with each other, they can co-exist. However, they will have opposite directional effects on the marketing margin, in general. In order to describe this phenomenon, cold storage stock as an independent variable is introduced into a standard marketing margin model. The ability to store product, especially when that storage is either large in scale or implicitly coordinated across the industry due to the common market signals to the relatively few packers leads to a modeling innovation introduced in this paper.

2.3.2 Captive Supply

According to (GIPSA, 2002), captive supply is defined as livestock that is owned or fed by a packer more than 14 days prior to slaughter, livestock that is procured by a packer through a contract or marketing agreement that has been in place for more than 14 days, or livestock that is otherwise committed to a packer more than 14 days prior to slaughter. The percentage of captive supply in total hog supply increased from 29.4% in Jan 2007 to 34% in Dec 2014.

Captive supply can benefit packers by two ways, maintain the output reliability and improving the cost efficiency. Captive supply helps packers to maintain a reliable production level to fulfill the pork demand from the retail market. In order to reach the maximum production efficiency and lowest processing cost, packing plants need to maintain very high levels of capacity utilization on a daily basis. When the cash market price is high, packers who own captive supplies can use their captive supplies instead of purchasing live animals from the cash market. The option to have captive supply will decrease the demand for live animals and thus their price.

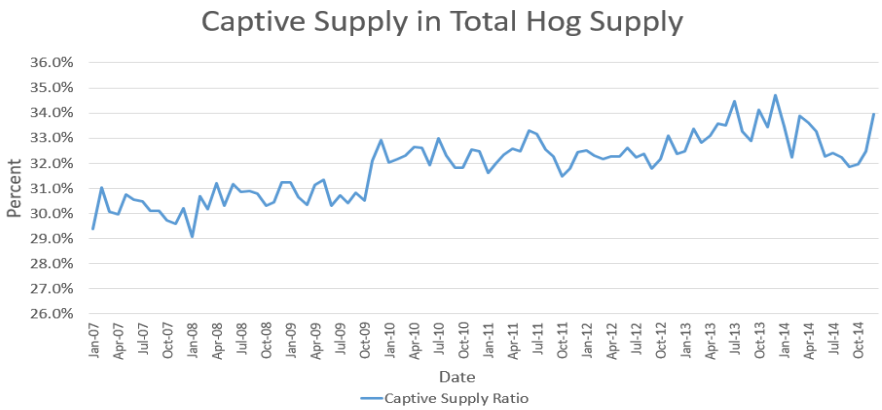

Figure 2.4. The Percentage of Captive Supply in Total Hog Supply

Researchers and farmers have long been concerned about the adverse effect on cash market price. Ward and Schroeder(Ward & Schroeder, 1998) were the first to estimate the total captive supply inventory impact on the cash market traction price and no significant adverse effects were found. Zhang and Sexton (Zhang & Sexton, 2000) found that in a concentrated spatial market captive supply can be used by packers to manipulate the spot market price. Although much research has been conducted about the correlation between captive supply and farm price, researchers did not pay much attention on its impact on wholesale price and retail price. The cost efficiency potentially gained by use of captive supply could be passed upward through the supply chain to result in lower wholesale and/or retail price. And the impacts of captive supply on Farm-Retail margin and Farm-Wholesale margin are unknown. When meat packers benefit from captive supply, there are two possible outcomes. If packers do not share benefits with retailers, the marketing margin is expected to be larger due to low cash market price. If wholesalers share the benefit with retailers, the Farm-Wholesale and Farm-Retail margin is expected to be unchanged or smaller.

In this paper, the impact of captive supply on Farm-Wholesale and Farm-Retail margin is evaluated. While most previous research used annual data for empirical analysis, this paper uses monthly data in an effort to better identify the short run implications of strategic behavior. The statistical analysis is based on U.S pork industry data. Pork is good case study industry to examine in this context because it is one of the most significant commodities in the U.S. meat complex, has seen substantial consolidation among processors, has experienced growth in cold storage utilization, heavily utilizes captive supply, and is relatively easily tracked as a product through the supply chain from farm to retail.

The short-run supply of pork is limited by the production cycle of hogs. According to USDA, only 5% of hogs were grown under production contracts in 1992 but this has increased to over 70% in 2009. While 70% of the hogs in the U.S. may be produced under production contracts, it is important to point out that meat packers are not the originators of most of those contracts. Typically, the contracting principal is

an intermediary that produces baby pigs, contracts the grow-out of those pigs with farmer agents, and then markets to meat packers through a variety of marketing contract arrangements that depend on spot market prices or past spot market prices.

The percentage of captive supply in total hog supply has remained relative stable at around 30% from 2007 to 2014. The top four pork packers had 65.5% of market share of total slaughter at the end of 2014. USDA produces monthly cold storage reports that contain end-of-month stocks of commodities like meats. Data are collected from warehouses that normally store commodities for 30 days or more (USDA, 2016). The captive supply data is collected from the national weekly mandatory price reports of purchased swine from USDA (USDA, 2007).The percentage of captive supply is calculated by dividing the monthly quantity of packer owned and packer sold swine by total monthly supply of swine. GIPSA has reported the four firm concentration for meat-packing industry in the annual report of Packers and Stockyards programs(GIPSA, 1996-2013). USDA has collected the annual four firm concentration data of the grocery retailers from 1992 to 2013 (USDA, 2015) GIPSA only reported the four firm concentration ratio for packers annually and USDA only published the four firm concentration ratio for retailers on an annual frequency. Because monthly concentration data is not publicly available, this paper uses the annual data by holding the concentration ratio constant for twelve months in a year. The consolidation and industrialization from 1980s to mid-1990s created dramatic changes to the U.S meat industry culminating in a dramatic structural change in the pork industry and the lowest recorded live hog prices in U.S. history in 1999. The estimated models were divided to two different time periods to eliminate the effect from dramatic structural change. This structural change occurred just prior to 2000 as packer consolidation and high supply of live hogs led to some of the lowest hog prices in U.S. history. As a result, there was massive restructuring at the farm level in the industry and a more stable concentration in the packing sector has been the general case thereafter.

2.4 The Empirical Models

2.4.1 The Basic Framework

Wohlgenant and Mullen (Wohlgenant & Mullen, 1987) proposed a set of alternative empirical specifications for the marketing margin using beef as their example. In perfectly competitive markets, the price of farm output depends on the quantity of agricultural commodity produced, retail level price, and marketing input prices. The relationship can be described by an inverse derived demand function for the farm product as follows:

$$P_f = f(Q, P_r, C) \tag{2.10}$$

Where P_f is the price of farm output, Q is the quantity of agricultural commodity produced, P_r is the retail price of product, C is a variable represents all marketing input cost. Eq. (2.10) can be rewritten as relative farm output price to retail price.

$$\frac{P_f}{P_r} = f(Q, 1, \frac{C}{P_r}) = g(Q, \frac{C}{P_r}) \tag{2.11}$$

Relative farm-retail marketing margin measures the marketing margin in retail units (assuming a fixed proportions at a given time disassembly process in meat processing). The farm-retail marketing margin is $MM = P_r - P_f$. The relative marketing margin is equal to one minus relative farm price to retail price. Relative farm price is eq. (2.11) so we can write the relative farm-retail marketing margin as eq. (2.12)

$$\frac{MM}{P_r} = 1 - \frac{P_f}{P_r} = 1 - g(Q, \frac{C}{P_r}) = h(Q, \frac{C}{P_r}) \tag{2.12}$$

Farm-retail marketing margin, can be rewritten as the function (2.13)

$$MM = P_r * h(Q, \frac{C}{P_r}) = K(P_r, P_r * Q, C) \tag{2.13}$$

Wohlgenant and Mullen (Wohlgenant & Mullen, 1987) tested three competing empirical specifications for the farm- retail marketing margin for beef.

$$MM = a_0 + a_1 * P_r + a_2 * C + \epsilon_1 \tag{2.14}$$

$$MM = b_1 * P_r + b_2 * P_r Q_t + b_3 * C + \epsilon_2 \tag{2.15}$$

$$MM = d_0 + d_1 * Q_t + d_2 * C + \epsilon_3 \tag{2.16}$$

MM is the farm-retail marketing margin for hog, dollar per pound, P_r is the retail price for pork, dollar per pound, Q_t is per capita pork production (total production divided by total population), marketing cost index C is the average of producer production index and wage index, 1997=100. All pork price data were deflated by the U.S city average seasonally adjusted pork CPI. Eq(2.14) is the mark up pricing model; Eq(2.15) is the relative marketing margin model; Eq(2.16) is the real marketing margin formulation. Wohlgenant and Mullen (Wohlgenant & Mullen, 1987) concluded that eq(2.15), the relative marketing margin specification, is preferred. Eq(2.15) is selected as the basic model and it is expanded to measure how strategic variables and market concentration will affect the marketing margin.

2.4.2 Marketing Cost Index

Prior to 1980 USDA published a Food Marketing Cost index to measure the changes in prices of food processing inputs, wholesaling and retailing (Harp, 1980). The index included the cost of labor, packaging materials, transportation services, energy, advertising, rent, maintenance and repair, business services, property tax and insurance, supplies, and interest. The purpose of this index is to explain the difference between farm prices and retail price. According to the USDA report in 1980, the marketing cost index was constructed by aggregating forty price series. Seventeen of these prices are from PPI while 10 of them are from CPI. Labor cost is 46.8% of the total index which is far more than the second important price series, the packaging cost (Harp, 1980). Another research paper based on industry survey data also indicated that labor cost is the most important price series in the animal processing industry. In this case, the researchers interviewed managers of eight pork processing firms that accounted for 70% of industry market share. Hayenga (Hayenga, 1998) divided the pork marketing cost by fixed cost and variable cost as table 2.1.

Table 2.1.
Pork Slaughter and Processing Cost 1996-97

	Variable costs,$/head	Fixed costs, $/head
Single shift		
Average	22	6
Range	(20,25)	(3,10)
Double Shift		
Average	20	3.00
Range	(16,25)	(1,6)

Compared to a single shift plant, a double shift plant reduces the fixed cost per unit of output by 50% or more and may reduce the variable cost by 10% on average. Labor cost is approximately 47% of variable cost based on the data mentioned above. Based on table 2.2, labor cost is on average $10.34/head for single shift plant and $9.40/head for a double shift plant. The labor cost accounts 38% of total processing cost in a single shift plant. If the processor switches to two shifts, the share of labor in total cost increases to 43%. While USDA has discontinued publication of the marketing cost index, labor cost appears to be the single most important item for the slaughter industry. Therefore, the labor cost per unit of output is used in this paper to reflect intermediate processing costs. Labor cost per unit of output is computed by dividing the real wage per hour (BLS, 2016) by the slaughter industry labor productivity index (BLS, 2016).

2.4.3 The Extended Models and Test Results at Different Market Level

For each model, the marketing margin is tested at three levels: farm-wholesale, wholesale-retail, and farm-retail. At farm-wholesale level, wholesale price is used as the independent variable instead of retail price. In this paper, empirical specifications

are estimated using U.S monthly data from January 2000 to December 2014. There are several reasons to pick post-2000 period.

The meat processing industry experienced industrialization and consolidation between 1980s to late 1990s but has been more stable after 2000. The four firm concentration ratio increased by 75% from 1985 to 1999 while it has only increased by 16% between 2000 to 2014. Before 2000, meat processors were focused on mergers and upgrading of their production plants to obtain more market share. When the market became relatively stable, meat processors focus more on vertical integration and new product that meet consumer preference. According to Lawrence, Schroeder, and Hayenga's survey of 20 largest U.S pork packers in 1995, packers had started or planned to adapt a vertical coordination arrangement. (Lawrence, Rhodes, Grimes, & Hayenga, 1998) Another survey in 1999 of the 11 largest pork packers showed that packers' needed shift to more quality control and product consistency to respond the demand from retailers and the ultimate consumers. The survey in 1999 also found that the branding programs by packers had grown rapidly as packers tried to differentiate their products. (Zering & Martinez, 2004) (Lawrence, Schroeder, & Hayenga, 2001)

The increasing contractual relationship between hog farmers and meat processors is changing the structure of the hog industry. From 1997 to 1999, it is easy to see the spike of marketing margin from figure 2.2 that is due to the historic low farm price. As the live hog price tumbled to historic lows, the market volatility changed the structure of hog production. More farmers became involved in contract production with hog processors and intermediaries.

Initial estimation of the models was plagued by autocorrelation. This is supported by DurbinWatson statistics for those regression that range from 0.57 to 1.45 suggesting severe autocorrelation. There is substantial investment in the physical capital of live hog production at any given time. This investment takes the form of physical facilities for production, feed manufacture, and breeding stock. This investment is teamed with a biological production process that involves a gestation of almost four

Table 2.2.
Own Price Elasticity of Hog/Pork Supply and Demand at Different Market Level

Own Price Elasticity	Farm	Processing	Retail	Source
hog demand	-0.51			Wohlgenant, 1989
pork demand		-0.71		Brester ,2004
pork demand			-0.79	Brester ,2004
hog supply	0.41			Lemieux and Wohlgenant, 1989
pork supply		0.44		Brester ,2004
pork supply			0.73	Brester ,2004

months and up to six months for feeding pigs to slaughter weight. The combination results in substantial inertia in supply and thus the price of live hogs. Likewise, the capital investments in meat processing tend to result in a strong incentive to maintain a high level of daily capacity utilization and thus stable at other points along the supply chain. Thus, it is likely that the autocorrelation measured in the initial models is structural in nature and best handled with lagged dependent variables rather than a serially correlated random component in the regression

In all tables, the margin is the dependent variable on the left side of the equation and the lagged margin is the lagged dependent variable on the right side of the equation. From Table 2.2 it can be seen that the elasticity of supply and demand at the farm level are more inelastic than at other points along the marketing channel. If there is a strategic variable that processors can use to affect the market, farmers will likely bear more of the effect on prices.

The first extended model introduces cold storage as a strategic variable in Eq(2.15). It is defined as cold storage per capita, the quantity of cold storage on the final day of the previous month divided by US monthly population. If the cold storage stock is high and the information is publicly available, wholesalers will expect higher supply in the current period. They can purchase less from farmers lowering the farm

price, ceteris paribus. The marketing margin is expected to be larger with higher cold storage stock. The extended model adds a lag dependent variable to correct for autocorrelation. Earlier it was pointed out that cold storage may be used as a means of manipulating prices and as a means of capturing logistical efficiencies. Even though the focus in this paper is the primarily on the 2000 to 2014 period, it is interesting to compare how cold storage stock affected the marketing margin under the different market conditions represented by the pre- and post-2000 periods.

The second extended model introduces captive supply as a strategic variable in the basic model. The Mandatory Price Report started from 2007 and thus there is not enough data available to compare the pre- and post-2000 period. The observation period for estimating the extended models with captive supply is from 2007 to 2014.

The last extended model is the basic model with the packer concentration ratio and retailer concentration ratio. In the earlier discussion of the Lerner index, it was shown that the marketing margin depends on the aggregate strategic behavior, the Herfindal Index or market concentration, the own price elasticity of demand and the retail price. The last model examines how concentration affects the marketing margin at different points along the supply chain. The best market concentration indicator available is the four firm concentration ratio. USDA only reported the retail CR4 ratio from 1993 to 2013. Again, there is insufficient data to examine the pre-2000 time period so the paper estimates these models only for the 2000 to 2013 time period.Estimates of this model for the 1993 to 2013 period were qualitatively similar to those presented.

2.4.4 Extended Model at Farm-Wholesale Level

Regression results for the farm-wholesale level are reported in table 2.3. At Farm-Wholesale level, the effect of wholesale price on Farm-Wholesale margin depends on two things, the coefficient of wholesale price and the interaction term with quantity. The bounds of the observed quantity data are from 4.89 to 7.07 pounds per capita.

The quantity threshold is 4 pounds for basic model, 7.6 pounds for the extended model with cold storage before 2000, 4.7 pounds for the extended model with cold storage after 2000, 1.7 pounds for the extended model with captive supply and 5.3 pounds for the extended model with concentration ratios. For the basic model, the extended model with cold storage after 2000, and the extended model with captive supply, the quantity level necessary to result in a negative marginal effect is unlikely in the observation period and the effect of wholesale price on Farm-Wholesale margin is positive as expected. However, in the pre-2000 period the effect of wholesale price on Farm-Wholesale margin is negative for the extended model with cold storage and the negative marginal effect is also possible for the extended model with concentration ratio. The estimated coefficient of marketing cost index is positive in the Farm-Wholesale level model but only statistically significant in the basic model and the extended model with cold storage before 2000. The estimated coefficient of cold storage is statistically significant and negative in pre- and post- 2000 period. The mean elasticity of cold storage per capita at Farm-Wholesale level is -0.17 in 1985-1999 and -1.13 in 2000-2014. The two estimated coefficient are not statistically different between the time periods. The elasticity estimates, however, suggests that from 1985 to 2014 the efficiency gains of logistical use of cold storage much more strongly dominate any remaining anti-competitive effects on the Farm-Wholesale margin.

The estimated coefficient of captive supply is negative for the Farm-Wholesale level model. Packers should experience a higher margin between farm and wholesale level if captive supply was being used strategically to decrease the farm price. But the result suggests that during this period increasing captive supply actually decreased the marketing margin. If marketing margin is viewed as the aggregation of marketing cost, the logistical efficiency gains from increasing captive supply dominated any other possible adverse effects. The estimated coefficient of CR4 packer and CR4 retailer are both negative and not statistically significant at Farm-Wholesale level. The cost reduction from consolidation and industrialization appears to generate efficiency in meat processing industry which dominates any market power exerted and results in

Table 2.3.
Regression Results of Basic Model and Extended Models at Farm-Wholesale Level

	Basic Model	CS (1987-1999)	CS (2000-2014)	Captive Supply	CR4 Packer and Retailer
Margin	FWMM	FWMM	FWMM	FWMM	FWMM
Pw	-0.080***	-0.183***	-0.084***	-0.04	-0.128***
	(-2.84)	(-5.85)	(-3.02)	(-0.93)	(-3.65)
PwQs	0.020***	0.024***	0.018***	0.023***	0.024***
	(3.92)	(3.39)	(3.54)	(3)	(4.58)
MCI($/index)	0.612 **	1.210*	0.389	0.837	0.576
	(2.34)	(1.8)	(1.4)	(1.2)	(1.62)
CS per capita		-0.027**	-0.015**		
		(-2.51)	(-2.29)		
Captive Supply				-0.151	
				(-0.74)	
CR4 Packer					-0.034
					(-0.47)
CR4 Retailer					-0.035
					(-0.31)
lag.Margin	0.597	0.695	0.6	0.55	0.54
Adjusted R^2	0.501	0.756	0.513	0.477	0.505

*the coefficient statistically significant at 10% level

**the coefficient statistically significant at 5% level

***the coefficient statistically significant at 1% level

a lower Farm-Wholesale margin. The regression results are consistent with earlier research done by Chung and Tostao that efficiency effects are larger than the market power effects for the meat packing industry.

2.4.5 Extended Model at Wholesale-Retail Level

Regression results for the farm-wholesale level are reported in table 2.4. For all models at Wholesale-Retail level, the estimated coefficient of retail price is positive. In the extended model with cold storage before 2000, the estimated coefficient of

cold storage is positive and statistically significant. In the later time period, the estimated coefficient of cold storage is negative but not statistically significant. The two estimated coefficients of cold storage are statistically different between the time periods. These results suggest that during the period when the pork industry was rapidly consolidating cold storage was being used strategically to affect prices and this effect dominated any logistical efficiency gains. However, the result suggests that in the more stable recent years, if anything, the efficiency gains of logistical use of cold storage dominate any remaining strategic effects on prices. The changing sign of cold storage is an evidence of changing marketing strategic for meat processors. Instead of simply obtaining more market share through consolidation, their strategic focus may have shifted to supply reliability and satisfying consumer demand by differentiating product mix.

The estimated coefficient of captive supply is negative and statistically significant for the Wholesale-Retail level model. The negative coefficient suggests that during this period increasing captive supply will not only decrease the Farm-Wholesale margin but also the margin at Wholesale-Retail level. The exclusive contract relationship between farmers and processors, or captive supply, is one form of vertical integration to help large scale processors to work as reliable suppliers of boxed meat and negotiate for higher wholesale price in the market. In the last extended model, the estimated coefficient of CR4 packer is negative but statistically significant at Wholesale-Retail level. When larger packers have market power at Wholesale-Retail market, the margin gets smaller as expected because packers would like to charge more on wholesale price that decrease the price difference between wholesale and retail level.

Based on table 2.4, the estimated coefficient of retailer concentration ratio is positive and statistically significant at Wholesale-Retail level. When the retailer concentration increases, their oligoposony power allow them negotiate for lower wholesale price such that the Wholesale-Retail margin increases. The absolute value of estimated coefficient for CR4 packer is smaller than the estimated coefficient of CR4 retailer. The mean elasticity at Wholesale-Retail level for CR4 packer is -0.154 while

Table 2.4.
Regression Results of Basic Model and Extended Models at Wholesale-Retail Level

	Basic Model	CS (1987-1999)	CS (2000-2014)	Captive Supply	CR4 Packer and Retailer
Margin	WRMM	WRMM	WRMM	WRMM	WRMM
Pr	0.132***	0.154***	0.129***	0.249***	0.194***
	(2.77)	(3.27)	(2.71)	(2.72)	(3.47)
PrQs	0.009**	0.022***	0.008**	0.011*	0.008**
	(2.37)	(4.24)	(1.96)	(1.81)	(2.24)
MCI($/index)	0.969***	-3.617***	0.718	0.969	1.03*
	(1.95)	(-3.80)	(1.28)	(0.66)	(1.66)
CS per capita		0.049***	-0.014		
		(3.08)	(-0.96)		
Captive Supply				-1.142***	
				(-2.48)	
CR4 Packer					-0.245**
					(-2.00)
CR4 Retailer					0.324*
					(1.69)
lag.Margin	0.726	0.767	0.758	0.659	0.733
Adjusted R^2	0.683	0.862	0.683	0.616	0.75

*the coefficient statistically significant at 10% level

**the coefficient statistically significant at 5% level

***the coefficient statistically significant at 1% level

it is 0.112 for CR4 retailer. It is because the average concentration ratio at processing level is much higher than the average concentration ratio at retail level in this period. If the retail concentration ratio keeps increasing in the future, the elasticity may change and have a larger effect on the marketing margin.

2.4.6 Extended Model at Farm-Retail Level

The marketing margin at Farm-Retail level is the sum of marketing margin at Farm-Wholesale Level and Wholesale-Retail level. As the Wholesale-Retail margin

takes the larger share of Farm-Retail margin, most of their estimate results have the same sign and similar patterns while the Farm-Wholesale margin is different from the other two. Regression results for the Farm-Retail level are reported in table 2.5. Combining the cold storage effect at Farm-Wholesale level and Wholesale-Retail level, the estimated coefficient of cold storage is positive and statistically significant at the Farm-Retail level before 2000. In the post-2000 model, the estimated coefficient of cold storage is negative but not statistically significant. The two estimated coefficient of cold storage are statistically different between the time periods. Just like the Wholesale-Retail level, the changing sign of cold storage at Farm-Retail level is an evidence of changing marketing strategy for meat processors. The wholesalers focus may have shifted to supply reliability and satisfying consumer demand by differentiating product mix. The estimated coefficient of captive supply is negative and statistically significant at the Farm-Retail level. Instead of keeping the efficiency gain at the wholesale level, packers pass their cost saving to retailers that captive supply has significant effect at Farm-Retail that overall marketing margin is reduced.

Based on table 2.5, the estimated coefficient of retailer concentration ratio is positive and statistically significant at Farm-Retail level. When the retailers have more market power, they can put more price pressure to wholesalers. According to table 2.2, eventually farmers will bear most of the price pressure because their own price supply elasticity is relatively inelastic and the overall marketing margin will increase. The negative estimated coefficient of CR4 packers indicates that cost reduction from consolidation and industrialization appears to dominates any market power exerted because the estimates suggest that the overall Farm-Retail margin is decreasing with higher packer concentration. Even though the estimated coefficient of CR4 packer is smaller than the estimated coefficient of retailers, the mean absolute elasticity at the Farm-Retail level for CR4 packer (0.208) is larger than that of CR4 retailer (0.161). Currently, the concentration at the processing level is much higher than the concentration at the retail level. If the retail concentration ratio keeps

Table 2.5.
Regression Results of Basic Model and Extended Models at Farm-Retail Level

	Basic Model	CS (1987-1999)	CS (2000-2014)	Captive Supply	CR4 Packer and Retailer
Margin	MM	MM	MM	MM	MM
Pr	0.205***	0.158***	0.203***	0.433***	0.284***
	(3.64)	(2.58)	(3.6)	(4.41)	(4.12)
PrQs	0.019***	0.042***	0.017***	0.023***	0.018***
	(3.98)	(5.83)	(3.43)	(3.38)	(3.86)
MCI($/index)	2.031***	-4.202***	1.643**	3.430**	2.34*
	(3.39)	(-3.45)	(2.51)	(2.19)	(3.02)
CS per capita		0.049**	-0.024		
		(2.39)	(-1.43)		
Captive Supply				-1.552***	
				(-3.11)	
CR4 Packer					-0.342**
					(-2.25)
CR4 Retailer					0.495**
					(2.08)
lag.Margin	0.654	0.751	0.691	0.513	0.65
Adjusted R^2	0.703	0.875	0.705	0.665	0.742

*the coefficient statistically significant at 10% level

**the coefficient statistically significant at 5% level

***the coefficient statistically significant at 1% level

increasing in the future, the elasticity may change and have a larger effect on Farm-Retail margin.

2.5 Summary and Conclusion

Farmers and researchers have been concerned about the increasing marketing concentration and possible strategic behavior in livestock and meat markets for decades. This paper expands on previous research by examining some new variables that could either be exploited through imperfect competition or be the source of operational effi-

ciencies. When the market experienced rapid consolidation and industrialization, the strategic use of cold storage to manipulate prices appears to have been its dominant role. During the more stable period since 2000, the dominant role of cold storage appears to have shifted to one of logistical efficiency. The effect of cold storage stock on marketing margins become less significant and negative.

Concern is often expressed about the potential for captive supply to depress live animal price. This paper examines this possibility via its effect on the marketing margin based on most recent eight-year data from 2007 to 2014. However, no statistically significant effects between captive supply and marketing margin at Farm-Wholesale and Farm-Retail level were found. Based on the result in this paper, captive supply is more likely generating logistical efficiencies by allowing better coordination between dynamic short run supply and demand.

Overall, the strategic variables examined (cold storage and captive supply) show some negative effects on marketing margin after 2000. However, evidence is found that support their use in allowing processors maintain optimal levels of capacity utilization. The lower costs are at least partially passed back to farmers in the form of higher live animal prices and on to consumers in the form of lower retail prices. In addition, farmers who contract to grow out captive supply animal are bearing less market risk (Johnson & Foster, 1994).

Most previous research has focused on packers market power as the packing industry is more concentrated compared to farmers and retailers. Chung and Tostao considered both market power from processors and retailers at Farm-Wholesale level. They found packers are unlikely to exercise market power on retail prices but may exercise some market power on the farm price. In this paper, we test the wholesaler concentration and retailer concentration as two independent variables in an extended model. The wholesale concentration shows a negative effect on the marketing margin. The retail concentration has a positive effect on the marketing margin. In the traditional view, a high concentration ratio implies oligopoly/oligoposony power which would be harmful for another party in the market. In the meat industry, consolida-

tion and industrialization are not only increasing the size and scale of packing firms but also increasing the production efficiency and lower overall cost of production. Large packers reduce their processing and packing cost by using new technologies like double shift plants and decreasing the labor cost per unit of output. Within a relative stable market, tools like cold storage and captive supply have the potential to generate important cost efficiencies but in less stable circumstances firms may be able to use them to strategically affect prices. If the meat industry experiences another wave of consolidation or industrialization, other market participants should be wary of how activities like cold storage and captive supply will affect prices.

CHAPTER 3. STRATEGIC VARIABLES BY MEAT PACKERS: TOOLS OF HIGHER MARGIN OR LOWER COST

3.1 Introduction

In the past thirty years, meat packers have received plenty of blame accusing them of using their large presence in the market to decrease the prices they pay to farmers for live animals. Because only meat packers purchase live animals from farmers, either through some kind of contract or the cash market, it is easy to understand why farmers, policy makers, and media reporters may associate a lower farm share of retail price with meat packers procurement strategies. As Figure 3.1 shows that the farm price as the percentage of retail price fell consistently from 1985 through 1999 before becoming more stable.

Figure 3.1. Farm Price as the Percentage of Retail Price

The main reason why meat packers are an easy target for criticism is because the meat packing sector is much more concentrated in economic terms than the livestock farming sector. The American public also has a romanticized image of farming as opposed to the impersonal factory image of animal slaughter and meat processing done by meat packers.

These differing perceptions may also contribute to the tendency to level blame for low farm prices at the packing industry. The large size of meat packing companies means that they may have the market power to negotiate lower prices paid to farmers and also higher wholesale prices received from retailers. Facing this higher cost, retailers would raise the price consumers pay for meat products at grocery store. The difference between price at any two market levels is known as the marketing margin. For example, the farm to wholesale marketing margin is the wholesale price of meat minus the farm price of the live animals adjusted for the yield of meat per pound of live animal. For packers, farm price is what meat packers pay for live animals as an input and the wholesale price is what they receive from selling the meat products to retailers and further processors. By dividing the Farm-to-Retail margin into two parts, Farm-to-Wholesale Margin and Wholesale-to-Retail Margin, it is easy to see that Farm-to-Retail and Wholesale-to-Retail margins have increased from 1985 to 2014 while Farm-to-Wholesale margin is relative stable around \$0.2/lb in real terms.

In the past thirty years, there are several reasons explaining the enlarge margin between Farm-to-Retail and Wholesale-to-Retail level. First, the increasing demand for boxed meat increased the packing cost at processing level. With more dual-earner families, consumers are preferring ready to cook products that also increased the packaging and further processing cost. A portion of these added costs is born by consumers in the form of higher retail prices and a portion is born by processors and farmers in the form of lower prices for their products. These all effect the marketing margins at the different points along the supply chain. Second, both the wholesale and retail sector are highly concentrated and may be in a position to affect prices in their favor through various production and marketing strategies. Third, efficiency

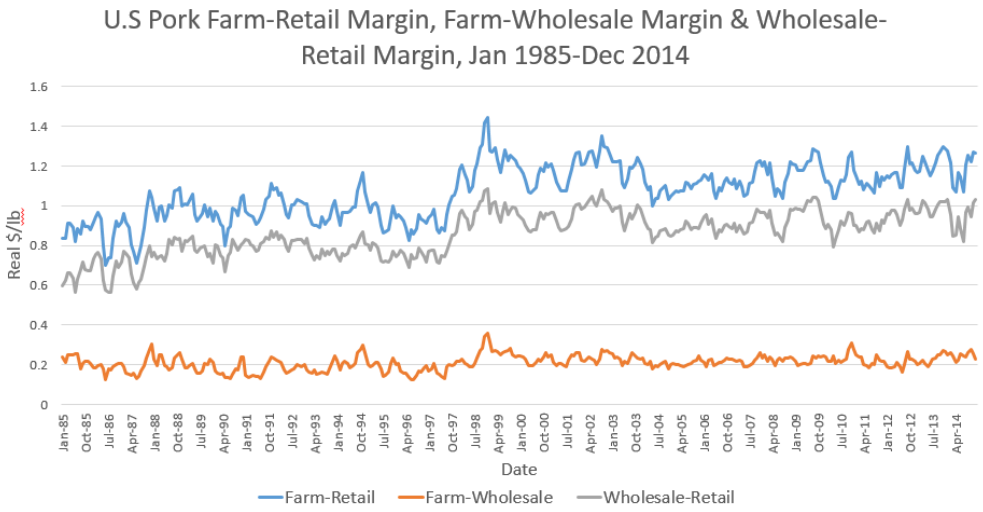

Figure 3.2. U.S Pork Farm-to-Retail, Farm-to-Wholesale, Wholesale-to-Retail Margin, Jan 1985-Dec 2014

gains at different levels along the marketing channel result in cost savings. These cost savings get distributed along the marketing channel. For example, increased scale in the meat packing sector has led to lower costs that may result in higher prices for live animals paid to farmers and lower wholesale prices paid by retailers and further processors. The efficiency gains are not limited to the meat packers. The average hog farm size has increased from 804 head in 1992 to 4730 head in 2004 base on live hog sales (Key & McBrid, 2008). At the same time, the per pound feed to hog weight gain has increased almost 80% and the labor use has decreased to only one sixth what it was previously. (Key & McBrid, 2008).

A larger marketing margin implies a higher gross margin if everything that could affect the marketing margin is held equal. Therefore, society has an interest in knowing whether and how packers are exercising their pricing power. Do they use any specific strategies to enlarge the price difference? Do packers have more pricing power with increasing concentration and contracting in their industry? In this article, two possible strategic variables are examined: cold storage and captive supply.

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3.2 The Meat Packing Industry (structure change and cause)

The four-firm concentration ratio, or CR4, is a widely used measure of industry concentration. It is the sum of market share of the four largest firms. According to the Grain Inspection, Packers and Stockyards Administration (GIPSA), the four firm concentration ratio for pork packers in the United States increased from 32.2% in 1985 to 65.5% by the end of 2014 while the four firm concentration ratio for beef packers increased from 39% in 1985 to 85% by the end of 2012. According to the Department of Justice, pork packers are moderately concentrated and beef packers are highly concentrated (of Justice, 2015). It is important for us to understand the driving force of sharp consolidation and industrialization in the past thirty years. Like any public or private business, one of the goals of meat packers is profit which is highly reflected in the marketing margin because live animals represent the largest portion of meat packer cost of production. Table 1 shows that the average processing cost per head was $5 lower if pork packers moved from single shift to double shift in 1996-1997. That means if everything else remained the same, packer margins would increase by $5 per head. According to the CME, the gross pork packer margin in the same year was only $10-$15 per head. If packers chose to switch from single shift to double shift, their per head margin would likely have increased by 33% to 50%. Meanwhile, they would have earned this increased margin over a much larger volume. MacDonald and Ollinger (Macdonald & Ollinger, 2005) found that with larger-scale

Table 3.1.
Pork Slaughter and Processing Cost 1996-97

	Variable costs,$/head	Fixed costs, $/head
Single shift		
Average	22	6
Range	(20,25)	(3,10)
Double Shift		
Average	20	3.00
Range	(16,25)	(1,6)

(Hayenga, 1998)

plants the average industry processing cost for beef packers decreased by 35.3%. They also found large plants have higher fixed costs such as capital and labor cost and to be competitive these plants must process a large volume of animals each day. If the production volume falls short, then the short-term processing cost can rise sharply. For meat packers that own larger processing plants, a larger and consistent flow of live animal is required in order to maintain competitiveness. All these phenomena have promoted the consolidation and industrialization in the meat packing industry.

3.3 Strategic Variables

Meat packing industry is a typical oligopoly/oligoposony industry that a small number of firms have the large majority of market share. There are many possible strategic variables they can use to apply their pricing power. Cold storage is one of them. Cold storage is defined as a commodity storage aimed to preserve the physical natural of perishable goods. (Williams & Wright, 1998) For example, total pork production increased by 69% while total pork cold storage stock increased by 77% from 1985 to 2014. As cold storage stock is more than 20% of total pork supply, it becomes an important variable to affect to supply and demand at the wholesale level.

One possibility is that large meat packers can use cold storage as a buffer to buy more animals from farmers when the cash price is low and sell the meat out of cold storage when farm price is high or retail demand is high. Another possibility is that meat packers use cold storage as logistical tool to operate their plants at the optimal level and thus reduce the unit cost of production. When the retail demand is high, releasing the cold storage stock can also help to increase the pork supply and lower the retail price.

Another possible strategic variable is captive supply. Captive supply is an exclusive contract between farmers and packers that the livestock is owned or fed by a packer for more than 14 days before slaughter. For example, the percentage of captive supply in total hog supply is 32% in 2014. Previous research focused on whether this exclusive contract will negatively affect the farm price. When more hog production is contract-based, the demand for live animals from the cash market will decrease and eventually depress the farm price of live animals. On the anther hand, farmers who are involved in the captive supply production face less market risk. The captive supply may help packers to purchase live animals at higher efficiency and lower cost or to buffer live animal supply shortages and keep their processing plants operating at optimal capacity utilization.

3.4 Our Research

The increasing concentration in the U.S meat packing industry has not only piqued the public interest but also that of agricultural economist. The pork industry data is used as sample case in this study. Based on the research, some interesting results are found. The estimate effect of cold storage on marketing margin is not always the same.

When the pork industry was rapidly consolidating from early 1980s to late 1990s, the cold storage effect on the Farm-to-Retail and Wholesale-to-Retail margin was positive. This suggests that the market power strategic use of cold storage during

that time outweighed the efficiency gains that cold storage use might have created. When the market was more stable (post 2000), the cold storage effect on the marketing margin was negative and less statistically significant. The efficiency gains from having large cold storage capacity appear to dominate any strategic effects during that time. That is, cold storage in recent years appears to have allowed meat packers to maintain consistent and optimal production levels that reduce their processing cost per unit. Some of these efficiency gains appear to be passed on to farmers in the form of higher live animal prices and to retailers and consumers in the form of lower wholesale and retail prices.

The changing effect of cold storage on marketing margins is evidence of the changing role of strategic variables under different market conditions and that while concentration may lead to anti-competitive behavior the scale efficiencies gained can lead to a situation where other market participants also gain.Most previous research focused on the effect of captive supply on live animal price. This research focuses on the impact of captive supply on the marketing margin.

If captive supply has been used strategically to decrease the farm price, to the a wider marketing margin should be observed with increasing captive supply. Analysis of the data tells us a different story that with increasing captive supply the margin is getting smaller. It would appear that the use of captive supplies, during the observed time period from 2007 to 2014, improved plant efficiency and that this effect dominated any anti-competitive effect on prices. Finally, the concentration effect on the marketing margin is tested. The cost reduction from consolidation and industrialization appears to generate efficiency in the pork packing industry which dominates any market power exerted and results in a lower margin.

Despite the high level of concentration, there is not substantial evidence that packers are exercising pricing power in such a way that it exceeds efficiency gains from economies of scale. Strategic variables such as cold storage and captive supply are more likely to generate a net reduction in the marketing margin as efficiencies are partially shared with other participants in the supply chain - including consumers

and dominate the effects of anti-competitive behavior. In the observation period, the major effect of increasing concentration is helping packers achieve higher efficiency and lower cost. Policy makers should likely keep an eye on the stability of the meat packing sector. If any major event in the future changes the relative market stability, they should closely examine how packers use strategic variables such as cold storage and captive supplies and the implications for prices and marketing margins.

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APPENDICES

Appendix A: Alternative Models

A.1 Extended Model with Interaction Term

In order to understand the relationship between strategic variables and market concentration, this paper tested the standard model eq.2.15 with cold storage, packer concentration and the interaction terms. Most cold storage is owned by packers so the interaction term is cold storage stock with packer concentration ratio. Captive supply is excluded from interaction term because the data is limited and it did not show any significant effect on the marketing margin. The regression result is summarized in table A.1. Multicollinearity is a problem in the regression and as a result the marketing cost index, cold storage per capita, CR4 packer and the interaction term are all statistically insignificant.

A.2 Extended Model with Relative Market Power Ratio

The relative market power ratio is packer concentration ratio divided by retail concentration ratio. This ratio can tell the shift of relative market power between wholesalers and retailers and allows both variables to enter the regression simultaneously. They are highly collinear and this approach imposes an implicit restriction that the coefficient on the wholesale concentration variable is equal to the coefficient on the inverse of the retail concentration variable. The relative market power ratio is expected to increase if wholesaler concentration ratio increase at a faster speed than retailer concentration ratio. The regression results are summarized in table A.2. The estimated coefficient of the relative market power ratio is consistently negative and statistically significant at Farm-Retail level and Wholesale-Retail level. When the wholesaler concentration ratio increases faster than retailer concentration ratio, the relative market power ratio will increase and the Farm-Retail margin and Wholesale-Retail margin will decrease. If retail industry is concentrating at a faster speed, than the relative market power will decrease and the Farm-Retail margin and Wholesale-

Table A.1.
Regression Result of Extended Model with Interaction Term

	Standard Mode+ interaction term		
Margin	MM	WRMM	FWMM
Pr	0.189***	0.118**	
	(3.22)	(2.39)	
PrQs	0.019***	0.009**	
	(3.67)	(2.26)	
MCI($/index)	1.168	0.286	0.224
	(1.56)	(0.45)	(0.72)
Pw			-0.091***
			(-3.2)
PwQs			0.019***
			(3.62)
CS per capita	0.176	0.212	-0.103
	0.66	(0.94)	(-0.89)
CS * CR4 Packer	-0.316	-0.359	0.139
	(-0.75)	(-1.01)	(0.76)
CR4 Packer	0.374	0.460	-0.279
	(0.53)	(0.78)	(-0.93)
lag.Margin	0.681	0.75	0.595
Adjusted R^2	0.706	0.684	0.512

*the coefficient statistically significant at 10% level

**the coefficient statistically significant at 5% level

***the coefficient statistically significant at 1% level

Retail will increase. It seems like the fast-rising retailer concentration after 2000 is more response to the enlarger marketing margin. The regression for Farm-Wholesale

level is problematic because the autocorrelation problem cant be solved by adding lag dependent variable or other approaches typically undertaken in such cases.

Table A.2.
Regression Result of Extended Model with Relative Market Power Ratio

	Standard Mode+ relative market power ratio		
Margin	MM	WRMM	FWMM
Pr	0.296***	0.206***	
	(4.57)	(3.9)	
PrQs	0.018***	0.007**	
	(3.85)	(2.13)	
MCI($/index)	2.633***	1.290**	0.770**
	(3.9)	(2.4)	(2.4)
Pw			-0.117***
			(-3.47)
PwQs			0.023***
			(4.43)
W/R ratio	-0.099**	-0.065*	0.002
	(-2.21)	(-1.81)	(0.1)
Lag.Margin	0.654	0.737	0.549
Adjusted R^2	0.743	0.75	0.504

*the coefficient statistically significant at 10% level

**the coefficient statistically significant at 5% level

***the coefficient statistically significant at 1% level

A.3 Extended Model with Both Strategic Variables and Market Concentration Ratio

Two strategic variables and two market concentration ratios have been added to the core model. The regression result is summarized in table A.3. Compare with extend model only has the concentration ratio, the two concentration ratio are not statistically significant in this model. At Farm-Wholesale level, the marketing cost index, captive supply and CR4 packer are not statistically significant. The models are problematic because the autocorrelation problem cant be solved by adding lag dependent variable. It may due to high multicollinearity between variables.

Table A.3.
Regression Result of Extended Model with Both Strategic Variables and Market Concentration Ratios

	Standard Model+ strategic variable + market concentration ratio	
Margin	MM	FWMM
Pr	0.599***	
	(5.39)	
PrQs	0.018***	
	(2.59)	
MCI($/index)	2.576	0.538
	(1.4)	(0.59)
Pw		-0.144***
		(-2.62)
PwQs		0.028***
		(3.5)
CS per capita	-0.010	-0.026**
	(-0.47)	(-2.33)
Captive Supply	-1.811***	0.401
	(-3.2)	(1.44)
CR4 Packer	-0.071	0.199
	(-0.2)	(1.07)
CR4 retailer	0.593	0.532
	(0.58)	(1.02)
Lag. Margin	0.551	0.425
Adjusted R^2	0.73	0.509

*the coefficient statistically significant at 10% level

**the coefficient statistically significant at 5% level

***the coefficient statistically significant at 1% level

Appendix B: Elasticity of Margin at Different Market Level

B.1 Cold Storage Elasticity of Farm-Retail Margin

The cold storage effect on marketing margin before and after 2000 in the main paper is estimated. The figure B.1 has shown that cold storage elasticity of F-R margin was positive before 2000 and become negative after 2000. The sharp drop is due to the change of coefficient sign. When the market is relative stable after 2000, the cold storage elasticity of Farm-Retail Margin is less fluctuated too.

B.2 Cold Storage Elasticity of Farm-Wholesale Margin

The estimated coefficient sign of cold storage at F-W level is always negative and statistically significant. The elasticity becomes relatively stable after 2000. Based on the figure B.2, cold storage tends to have higher and more consistent impact on the marketing margin at Farm-Wholesale level than the other two marketing margins.

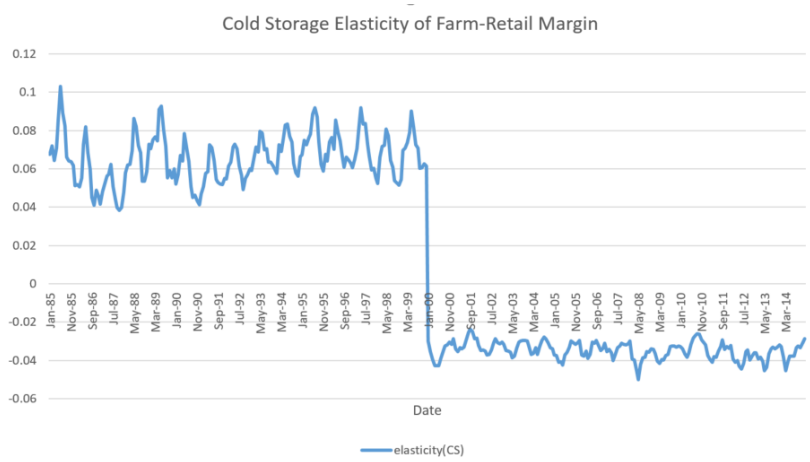

Figure B.1. Cold Storage Elasticity of Farm-Retail Margin

B.3 Cold Storage Elasticity of Wholesale-Retail Margin

The shift of elasticity at Wholesale-Retail level is very similar to the elasticity at Farm-Retail level. Both coefficient signs change after 2000 causing the decline in the graph in figure B.3. The elasticity becomes relative stable after 2000.

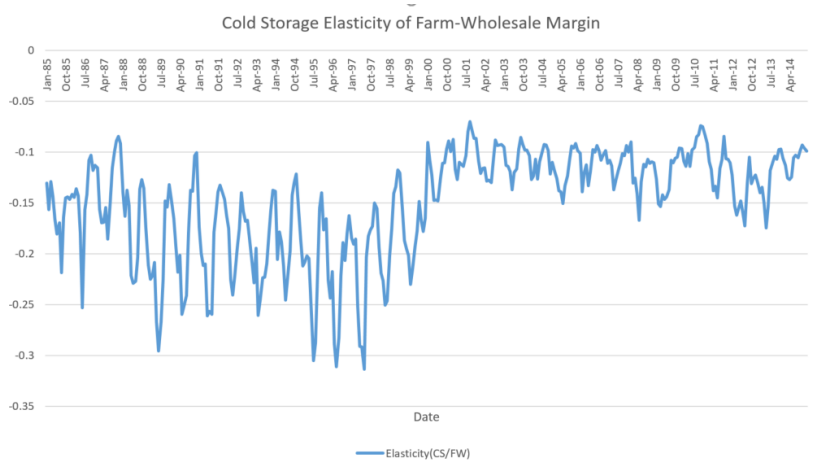

Figure B.2. Cold Storage Elasticity of Farm-Wholesale Margin

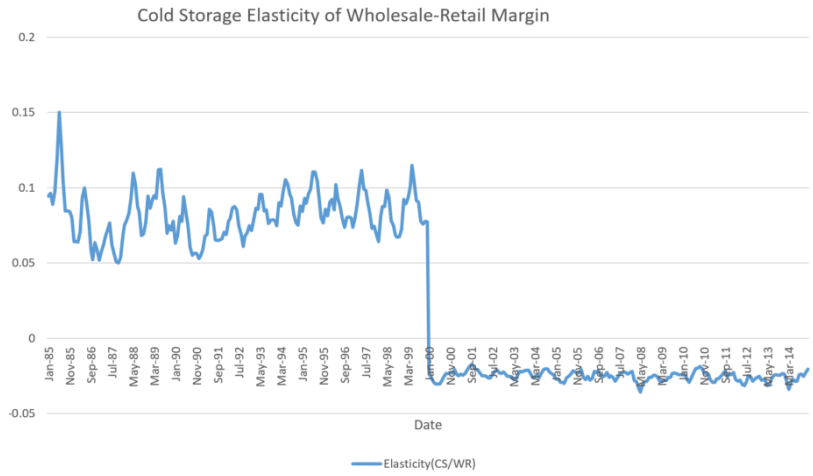

Figure B.3. Cold Storage Elasticity of Wholesale-Retail Margin

B.4 Captive Supply Elasticity of Farm-Retail Margin

Base on figure 4.1 and figure B.4, the captive supply elasticity of Farm-Retail margin is larger than the cold storage elasticity of Farm-Retail margin. That means 1% change in captive supply will have a greater impact on the Farm-Retail margin than a 1% change in cold storage.

B.5 Captive Supply Elasticity of Farm-Wholesale Margin

By comparing figure B.4 and figure B.5, it is easy to see the absolute value of the captive supply elasticity of Farm-Wholesale margin is smaller than the captive supply elasticity of Farm-Retail margin. That means 1% change in captive supply will have a bigger impact on the Farm-Retail margin than on the Farm-Wholesale margin.

B.6 Captive Supply Elasticity of Farm-Wholesale Margin

According to figure B.6, the CR4 packer elasticity of Farm-Retail Margin is in the range from -0.14 to -0.22. The mean elasticity is -0.19 that means if CR4 Packer increases by 1% the Farm-Retail margin will on average decrease by 0.19%.

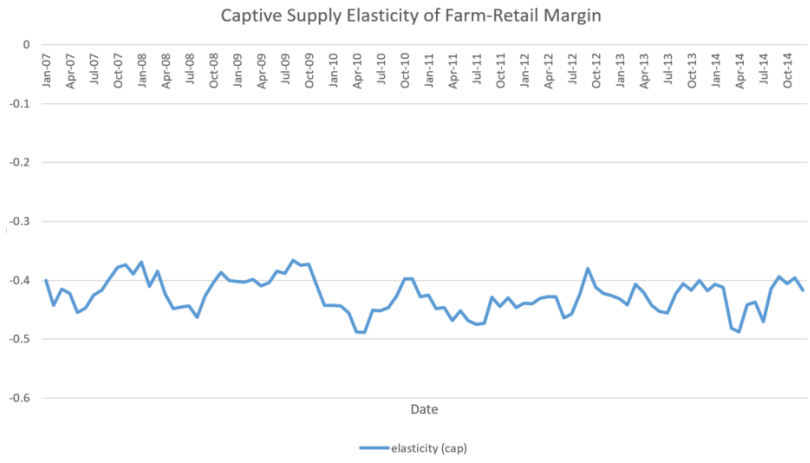

Figure B.4. Captive Supply Elasticity of Farm-Retail Margin

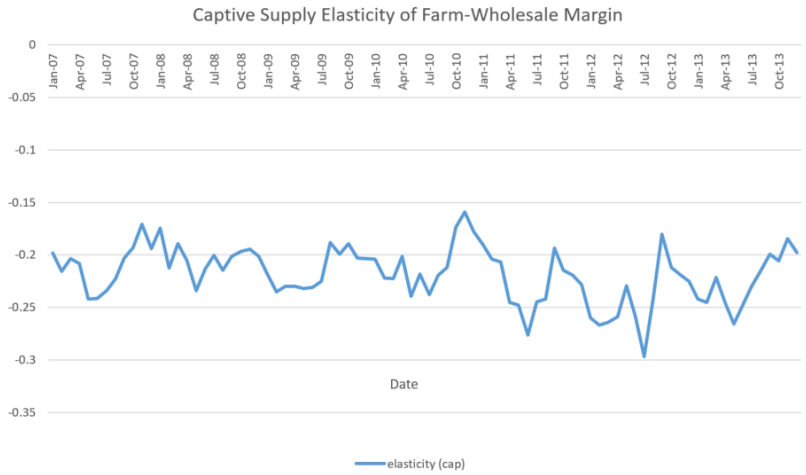

Figure B.5. Captive Supply Elasticity of Farm-Wholesale Margin

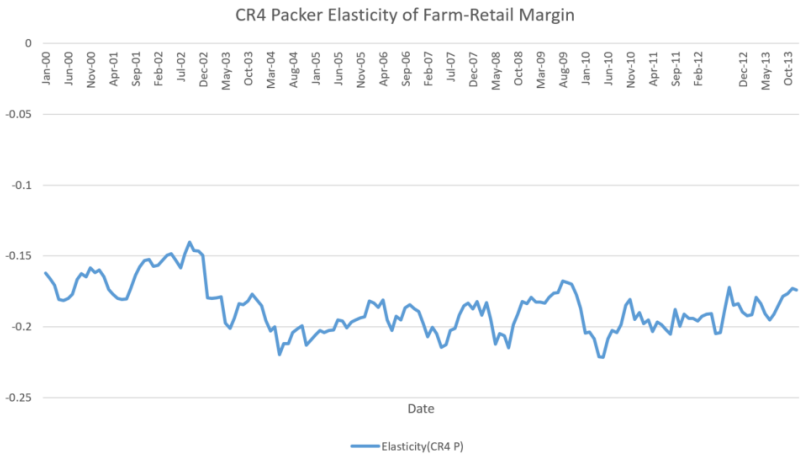

Figure B.6. CR4 Packer Elasticity of Farm-Retail Margin

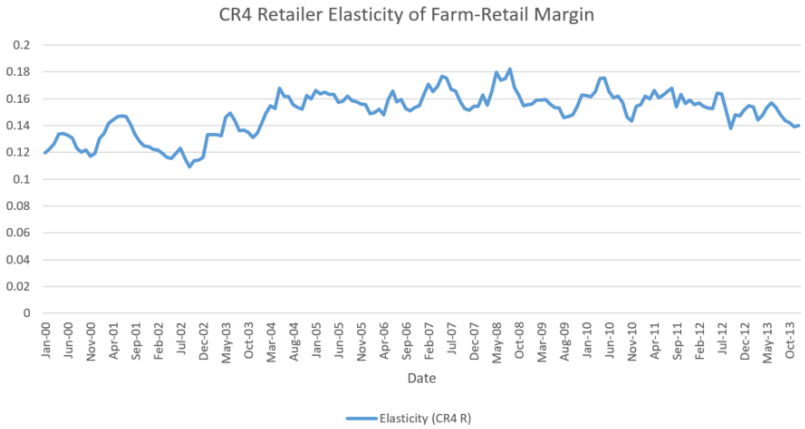

Figure B.7. CR4 Packer Elasticity of Farm-Retail Margin

B.7 CR4 Retailer Elasticity of Farm-Retail Margin

According to figure B.7, the CR4 packer elasticity of Farm-Retail Margin is in the range from 0.11 to 0.18. The mean elasticity is 0.15. When the CR4 retail elasticity increases by 1%, then the Farm-Retail margin may increase from 0.11% to 0.18%. The margin will get wider with a higher CR4 retail.

B.8 CR4 Packer Elasticity of Wholesale-Retail Margin

The moving pattern of CR4 packer elasticity of Wholesale-Retail margin in figure B.8 is very similar to the CR4 packer elasticity of Farm-Retail margin in figure B.6. The CR4 packer elasticity of Wholesale-Retail Margin is in the range from -0.13 to -0.21. The mean elasticity is -0.17.

B.9 CR4 Retailer Elasticity of Wholesale-Retail Margin

According to figure B.9, the CR4 retailer elasticity of Wholesale-Retail Margin is in the range from 0.09 to 0.15. The mean elasticity is 0.12.

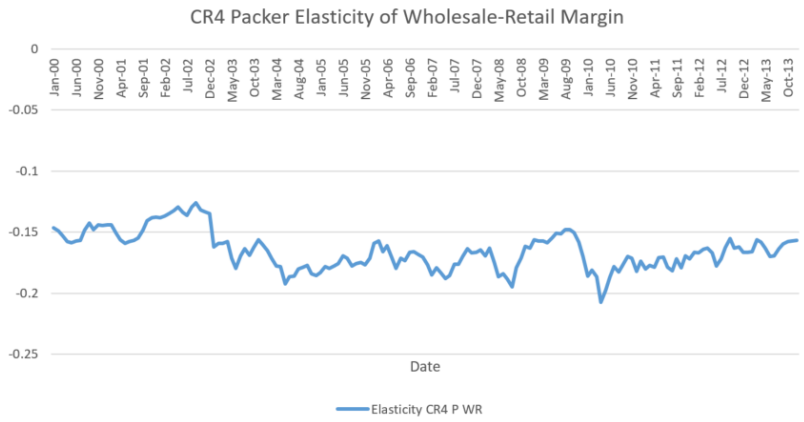

Figure B.8. CR4 Packer Elasticity of Wholesale-Retail Margin

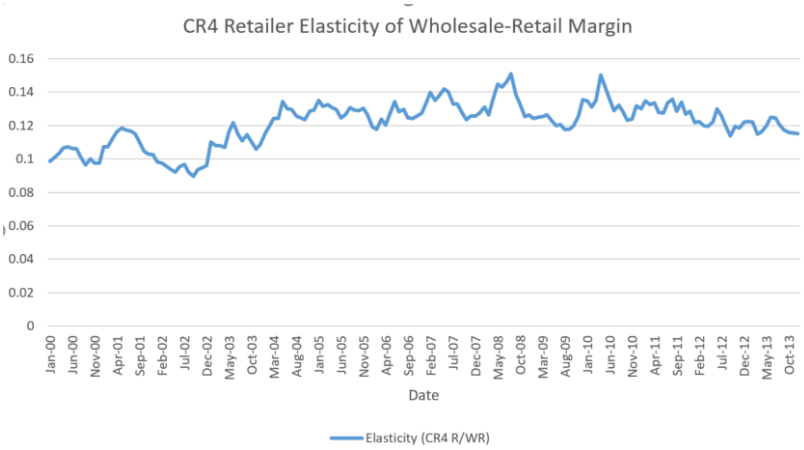

Figure B.9. CR4 Retailer Elasticity of Wholesale-Retail Margin

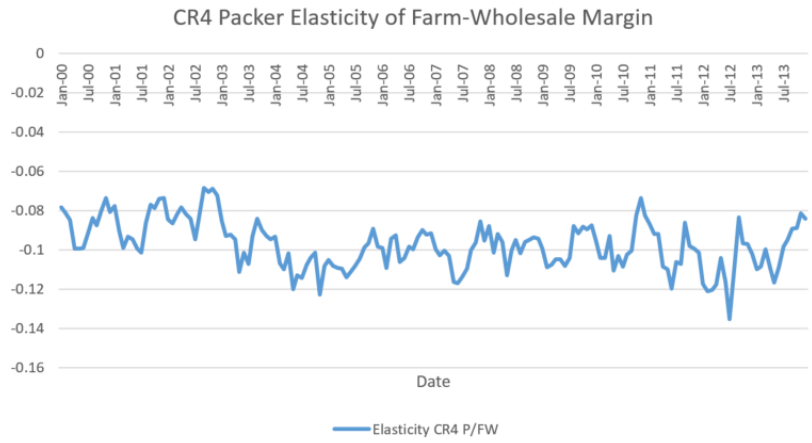

Figure B.10. CR4 Packer Elasticity of Farm-Wholesale Margin

B.10 CR4 Packer Elasticity of Farm-Wholesale Margin

The CR4 packer elasticity of Farm-Wholesale Margin is in the range from -0.07 to -0.14. The mean elasticity is -0.10. The estimate coefficient of CR4 packer is not statistically significant.

B.11 CR4 Retailer Elasticity of Farm-Wholesale Margin

The CR4 packer elasticity of Farm-Wholesale Margin is in the range from -0.04 to -0.08. The mean elasticity is -0.06. Based on figure B.10 and B.11, CR4 retailer has less impact on Farm-Wholesale margin than CR4 packer. The estimated coefficient of CR4 retailer is also not statistically significant.

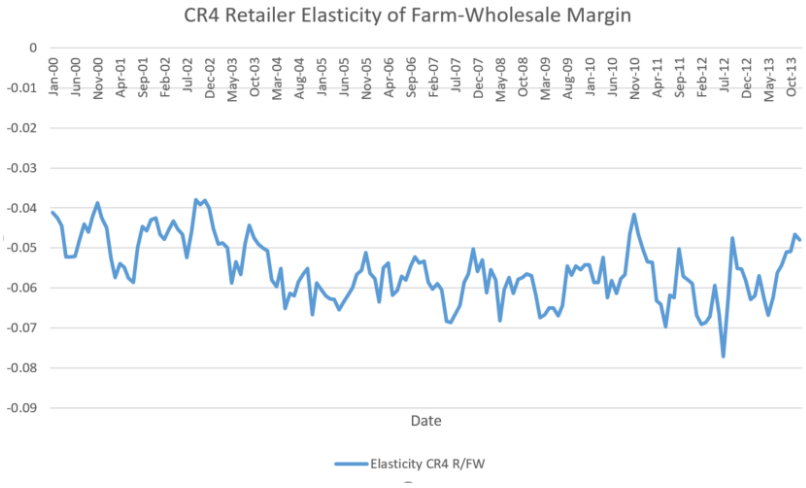

Figure B.11. CR4 Packer Elasticity of Farm-Wholesale Marginsec