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Market Power Estimation In The Chilean Cattle Market

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MARKET POWER ESTIMATION IN THE CHILEAN CATTLE MARKET

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"I never saw a wild thing sorry for itself. A small bird will drop frozen dead from a bough without ever having felt sorry for itself".

D. H. Lawrence

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Thanks my family and my friends, who always supports me.

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This thesis takes so long, anyway is just a beginning…

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ABSTRACT

Vasquez panizza, Rodrigo A. M.S., Purdue University, December 2014. Market Power Estimation in the Chilean Cattle Market. Major Professor: Dr. Joseph Balagtas.

The cattle market in Chile is constituted by cattle slaughtering firms and farmers; the industry demands cattle but also demands beef imports. Based in antecedents of market concentration in this sector, I make a system of equations model based on the NEIO approach to determine market power for the period April 1993 - December 2008. The results show that there is no market power in the aggregated market as well as in the disaggregated market by sex and age type, which is explained because the special features of this market in Chile.

CHAPTER 1: INTRODUCTION

1.1 Preface

In the last decade there has been a trend toward concentration in the sectors of food manufacturing and retailing, most frequently in developed countries (Sexton et al., 2007). However, this situation also has been seen in developing and poor countries (Sivramkrishna and Jyotishi, 2008). This concentration in the productive chains operates in two ways: horizontal (the number of firms on a certain level of the chain tends to decrease) or vertical (a single or a few firms have control over more points of a production chain) (Murphy, 2006). Both kinds of concentration change the structure of the market and could generate market power, which is defined as the ability of certain firm or group of firms to change the price above or below the competitive price of selling or buying, respectively (Perloff, 2011). This situation generates gains for the industrial and retail sector, but it can be harmful to farmers and consumers (Whithley, 2003). The farmers, especially the small ones, are affected by the market power from the buyer (monopsony or oligopsony), which often decreases the farmers income, potentially causing a loss of land and finally decreasing the number of farmers (Murphy, 2006).

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The meat sector, which is mainly compose of cattle, hogs and poultry; has been the object of several studies related to market power, especially in the U.S. This is mainly because the U.S. has shown high levels of industrialization and concentration in the last decades (Ward, 2001).

The focus of my research will be on Chile, because the agriculture sector in Chile is highly industrialized and there is evidence of market power in some markets: sugar (Marchant, 2004), pork (Marchant, 2006), milk (Barrientos et al., 2006), and corn (Pavez, 2007). Also, there is evidence that indicates that there could be oligopsony power in the Chilean cattle market, with similar characteristics to the U.S. market: high concentration and industrialization. In the last decades (Vargas and Foster, 2000); cattle farms have decreased in number, but have increased in size (Chile, 2008). All these elements have slowly and constantly weakened the cattle market, with tendencies to decrease the total number of cattle, decrease the prices paid to farmers, increase the sacrifice of females, and an increase of the imports of beef (Chile, 2009). The smaller cattle farmers are the most harmed group and if this tendency continues they will decrease more in number and become poorer.

The problem is that the beef industry in Chile is becoming more concentrated, creating potential for a few firms to gain market power, which could be used to pay a lower price to cattle farmers. Thus, the farmers' income decreases, making the farmers became poorer until they could finally lose their farms.

1.2 Objectives

The goal of this work is to find, based on the available information and selected techniques, if there is any evidence of Market Power from the transformation industry (slaughterhouses) in the Chilean cattle market.

The method selected to measure market power is the New Empirical Industrial Organization (NEIO) because allows to evaluate industry structural changes and market power in time. So being more dynamic than the Structure-Conduct-Performance (SCP) approach. Additionally NEIO approach fits better with the data available for Chilean Cattle Market

The hypothesis to be tested is that the parameter to measure market power will be different from zero, against the null hypothesis that this parameter will be equal to zero. This hypothesis will be tested thanks to a system of equations of inverse demand of cattle from the industry and supply of cattle from the farmers.

1.3 Thesis Structure

This thesis consists in 4 additional chapters: Literature Reviews, in which I want to show the available literature to make a context about market power, market power in agriculture, the Chilean Cattle Market, and the ways available to measure Market Power. Data, where I describe the available data, in order to make the models. Model Estimation, where I show the derivation of the model, then the results. And finally, conclusions, where I conclude based on the results and I give policy recommendations.

CHAPTER 2: LITERATURE REVIEW

2.1 Market Power

According to Murphy (2006) and Perloff (2011) market power is the ability of certain firm or group of firms to change the price above or below the competitive price of selling or buying respectively.

Market power could be measured in many ways: Two of the most common measures are: the Concentration Ratio (CR), which measures how much of the market is controlled by the largest firms; and the Herfindahl-Hirschman (HH) index, which is computed as the sum of the of the market share of each firm in the industry (Murphy, 2006).

2.1.1 Market Power from the Buyer

On the demand-side monopsony (one buyer) and oligopsony (few buyers) describes the situations of concentrated market power, who threats the competition and affects sellers with a less optimal situation than in perfect competition (Rogers and Sexton, 1994; Murphy, 2006; Sivramkrishna and Jyotishi, 2008), and also has a dead weight loss to society (Sivramkrishna and Jyotishi, 2008; Tribl, 2009), this situation happens, according to Cartensen (2004) because with the increase in the purchased amount of a specific good, the firm has an incentive to modify the price.

Rogers and Sexton (1994) argue the importance of oligopsony power in producer markets; furthermore, for understand this issue is required the use of models, which must have: Products, which often are perishable and large amounts, so with high transportation costs that at the end limits the selling options. Processors (buyers), with demand over a specific good, which have not substitutes. Farmers who produce particular goods and because of that they have high level of investments in their farms. And finally, institutions with seller power, like bargaining association could be present. The model also considers a concentrated market structure, costly product transportation, and potential non-competitive conduct among processor/handlers.

2.1.2 Harm of Market Power to Agriculture

Whitley (2003) examines the gains and losses of concentration in agriculture, where if any part of the chain is getting concentrated their market power will be increased, however, the problem is when only one of the parts of this chain is getting concentrated, and the others do not.

In agriculture, three groups are harmed by market power: farmers, farm workers and consumers (Murphy, 2006).

The farmers, especially the smaller ones from developing countries, are being affected for the modernization and concentration of the food industry, which generates a buyer's market power. Furthermore, this type of farmer lacks on organization, so their capacity to work united is limited and their problems with the production of crops make them harder to give a constant supply to the industry or retail (Murphy, 2006, Rogers and Sexton, 1994).

Farm workers are increasing in the world, because many poor farmers are losing their land, so they switch work to bigger farms, sometimes working in unfavorable conditions, this more frequent for immigrants or subcontracted workers. Farm workers receive lower wage than other sectors, like industry. Also the pressure from the industry and retail to keep low costs, makes to decrease wages. All this is complemented with their lack in organization and education (Murphy, 2006).

Finally, the third group affected by the market power in agriculture corresponds to consumers, because mostly the developed countries are concentrating market power over commodities and food retail trade, so the price of the food is increasing. In developing countries most poor farmers are poor consumers, so they are affected by low selling prices and high buying food prices. Moreover international trade does not ensure low prices, because most of the times the delivery of the food is in hands of retailers that increase the prices (Murphy, 2006; Sexton and Zhang, 2000).

2.1.3 Evidence of Market Power in Agriculture

Murphy (2006) compares the market power structure in agriculture with the hourglass shape: in both extremes, a very large amount of farmers, who sell their raw products, and consumers, who buy the processed products, and in the middle a small number of processors and distributors, who buy the product from farmers, make some transformation and sell it to the consumers. Several authors talk about this problem and analyze different cases (Rogers and Sexton, 1994; Sexton and Zhang, 2000; Sexton et al 2003; Carstensen, 2004; Crespi et al. 2012). Table 2.1 shows more research work about buyer's market power in agriculture; from this table, we can see that at least half of the articles talk about meat industry (cattle, hogs, poultry) and most of them are goods that require industrialized operations (meat, tomato sauce, orange juice, wood, tea, tobacco, fish, cocoa, vanilla, diary, etc.). Moreover, most of them occur in developed countries (U.S. and Europe), Sivramkrishna and Jyotishi (2008) said that maybe is because the developed countries have more data available than developing or poor countries.

Table 2.1. Examples of Studies about Market Power in the Agricultural-Food Sector

Sector/Country	Market Power Type	Market Power Presence	Article
Beef / U.S.	Oligopsony and oligopoly	Yes	Azzam and Pagoulatos, 1990
Beef / U.S.	Oligopsony	Yes	Azzam, 1997
Beef / U.S.	Oligopsony	Yes	Koontz and García, 1997
Beef / U.S.	Oligopsony	No	Muth and Wohlgenant, 1999
Beef / U.S.	Oligopsony	Yes	Hunnicutt, Crook and Bailey 2001
Beef / U.S.	Oligopsony	Yes	Chung and Tostao, 2008
Beef / U.S.	Oligopsony	Yes	Cai, Stiegert, Koontz, 2009
Beef / U.S.	Oligopsony	Yes	Crespi, Xia and Jones, 2010
Beef / U.S.	Oligopsony and oligopoly	Yes	Ji, 2011
Hogs / U.S.	Oligopsony	No	Sperling. 2002.
Hogs / German and Hungarian	Oligopsony	Yes	Bakucs et al., 2009
Hogs / U.S.	Oligopsony	Yes	Zheng and Vukina, 2009
Hogs / U.S.	Oligopsony	Yes	Wise and Trist, 2010.
Beef and Hogs / U.S.	Oligopsony	Yes	Koontz, 2003
Beef and Hogs / Canada	Oligopsony	Yes beef, no hogs	Quagrainie et al., 2003
Beef and hogs / Germany	Oligopsony and oligopoly	Yes	Weber and Anders, 2007
Beef and hogs / Germany	Oligopsony and oligopoly	Yes	Anders, 2008
Meat (bovine, hogs, lamb) / U.S.	Oligopsony	Yes	Ward, 2001
Broiler / U.S.	Monopsony	Yes	Vukina and Leegomonchai. 2006.
Broilers / U.S.	Monopsony	Yes	Key and MacDonald, 2008
Broilers / U.S.	Oligopsony	Yes	Liang et al., 2010
Catfish / U.S.	Oligopsony	Yes	Wiese, 2004
Catfish / U.S.	Oligopsony	No	Bouras and Engle, 2007
Salmon / U.K.	Oligopsony	No	Fofana and Jaffry, 2008

Table 2.1 Continued

Tomato / U.S.	Oligopsony	Yes	Just and Chern, 1980
Tomato / U.S.	Oligopsony	Yes	Durham, 1991
Tomato / U.S.	Oligopsony	Yes	Durham and Sexton, 1992
Potatoes / U.S.	Oligopsony	Yes	Richards, Patterson and Acharya. 2001
Potatoes / U.S.	Oligopsony and oligopoly	Yes	Katchova, Sheldon and Miranda, 2005
Cocoa Bean / Ivory Coast	Oligopsony	Yes	Wilcox and Abbott, 2004
Tea / India and Kenya	Oligopsony and oligopoly	Yes	Weerahewa, 2003
Tobacco / U.S.	Monopsony	Yes	Raper, Love and Shumway, 2000
Cigarette / Europe	Oligopsony	Yes	Delipalla and O`Donell, 2001
Vanilla Beans /from U.S. Importers	Oligopsony	Yes	Rakotoarisoa and Shapouri, 2001
Wood / U.S.	Oligopsony	Yes	Murray, 1995
Wheat / U.S.	Oligopsony	Yes	Russo, 2007
Rice / U.S.	Oligopsony	Yes	Crespi, Gao, Hanawa, 2005
Corn / U.S.	Oligopsony and oligopoly	Yes	Saitone, Sexton and Sexton, 2008
Oranges / U.S.	Oligopsony	Yes	Guci and Brown, 2007
Diary, meat and other foods / France	Oligopsony and Oligopoly	Yes	Gohin and Guyomard, 2000
Milk / Spain	Oligopsony	Yes	Alvarez et al., 2000
Milk / Turkey	Oligopsony and oligopoly	Yes	Hatirli et al., 2006
Milk / Ukrania	Oligopsony	No	Perekhozhuk, Grings and Glauben, 2008

2.1.4 Causes of Market Power in Agriculture

2.1.4.1 Concentration

There is a trend to concentration in food manufacturing and retailing sectors in U.S. and Western Europe (Sexton, 2000; Rogers, 2001; Connor, 2003; Sexton 2004, Sexton et al., 2007), for example Sexton (2000, page 1087) said that in the United States the CR4 index of some key industries have been raised a lot: “beef packing from 30% in 1978 to 86% in 1994, malt beverages from 40% in 1967 to 90% in 1992, wheat milling from 30% in 1969 to 77% in 1995, pasta manufacturing from 34% in 1967 to 78% in 1992”. He also said that CR6 index for supermarket retail sector increase from 32% in 1992 to 50% in 2000.

The concentration could operate in two ways: horizontal and vertical.

Horizontal integration: the index of concentration for some point in a production chain is high, i.e. production, transformation or retail; so the few firms have market power, for example: commercial seed market, heavy farm machinery, and commodities processing (Connor, 2003; Murphy, 2006).

Vertical integration: where one or few firms have control over more points of a production chain, i.e. production and transformation or transformation and retail; increasing their efficiency, welfare and market power; for example, the poultry and tobacco production in United States (Sexton, 2000; Murphy, 2006, Sexton et al. 2003; Gregra, 2003; Asirvatham and Bhuyan, 2004; Connor, 2003; Sexton, 2004; Sexton et al., 2007; Crespi et al. 2012). Furthermore, is related with a non-efficient share of the welfare generated by an expansion of exports (Sheldon, 2006). Consumers can obtain benefits from a vertically coordinated food markets, increasing their access to more products and at lower costs. On the other hand less efficient producers and intermediaries are harmed by this concentration (Sexton, 2000; Sperling, 2002; Sexton et al., 2007; Crespi et al. 2012).

2.1.4.2 Contracts

Contracts can be used to reduce market power; however, many times the contract could punish the producer if they do not produce a certain amount, can make the producer receive less price, assume all the risk of production or make the market less transparent, because the price discovery disappears (Murphy, 2006; Sivramkrishna and Jyotishi, 2008). For example, the contract called “captive supplies” is used to decrease the spot price in the cattle market in the United States, in fact, there is an inverse relation between this kind of contract and the spot price in regions that use the contract (Zhang and Sexton, 2000).

2.1.4.3 Organization

As mentioned before, farmers have problems to organize a market power to obtain benefits. The causes of this could be differences in land ownership, access to capital, competition, etc. By the other hand the industries and retail are very well organized, because they are in many cases a small number with same interests, and also they can form cartels to manipulate prices (Connor, 2003; Murphy, 2006), or go beyond their country to others (Sexton, 2000; Sexton et al., 2007). Furthermore, they could generate political influence (Murphy, 2006).

2.1.4.4 International Trade

With the expansion of global trade, many production chains were created and also new rules for agricultural trade are being negotiated at the WTO in Doha Agenda, to eliminate export subsidies and decrease domestic support and tariffs; which is positive in developed countries, but could generate problems in developing countries, where domestic markets need these regulations (Murphy, 2006). Moreover, some of the rules from WTO do not allow governments to provide some regulation to avoid trade problems, i.e. to increase or decrease production. This situation is taken as an opportunity to multinational industries and retailers to get market power (they increase their vertical concentration and have less regulation over them) and to form cartels; for example, in Africa there are many cases where countries need to increase domestic production, to replace imports (Connor, 2003; Sexton, 2004; Murphy, 2006; Sexton et al., 2007). Moreover, the welfare from the new agreements not reaches the farmers or the exporters, in the exporter commodity country, or the consumers in the importer country, because the highly vertically concentrated industries from developed countries (Sexton, 2004; Sheldon, 2006; Sexton et al., 2007).

2.1.4.5 Geographical Isolation

There is a relation between the geographical isolation and the incidence of market power, because if the farmers are far from trade centers, they can only sell their production to a few buyers, mainly middlemen. In fact, space modeling has become important to measured market power. Moreover, the problem becomes more serious if the product is perishable and bulk, common in agricultural goods; as well as high transportation costs (Rogers and Sexton, 1994; Zhang and Sexton, 2000; Susuki and Sexton, 2005; Tribl, 2009).

2.1.4.6 Other Causes

Several other issues can increase market power: increase of global commodity chains (Murphy, 2006); the existence of influential transnational brands, (Murphy, 2006); the lack of productive alternatives to farmers obligates them to depend on a single or few goods, reducing their bargaining power (Sivramkrishna and Jyotishi, 2008); the size of the farm: a bigger farm is less affected by the buyer power, because by its size, have some seller power to bargain (Sivramkrishna and Jyotishi, 2008); investment allows the increase in power and the differentiation with the others, i.e. most of the dominant agribusiness and supermarkets firms have high investment rates (Murphy, 2006); finally based on Sexton (2004) and Sheldon (2006) exists a relationship based between value added of commodities and market power, because there market power is related with the imports of raw products from developing countries to developed countries, but maybe if the products have some added value, the buyer market power could be decreased, because the product would be more “exclusive”.

2.1.5 Ways to Avoid Negative Implications of Market Power to Farmers

2.1.5.1 Form Cooperatives

Whitley (2003) argues that there are losses from concentration, but also gains: lower production costs, management gains, increased levels of competition, increased rates of innovation, and more efficient quality signaling. So farmers (also farm workers or consumers) can form cooperatives in order to produce an opposite force and obtain benefits (Novkovic, 2008; Sivramkrishna and Jyotishi, 2008; Tribl, 2009). Moreover, Tribl (2009) proposes to make marketing cooperatives between the industries and the farmers' cooperatives. The government could have a critical role guiding them with the legal framework (Murphy, 2006).

2.1.5.2 Contracts

If a contract is regulated by the government in favor of the farmers, contract farming could be a powerful tool to avoid some market power distortions, for example, sharing the risk, ensure a fair minimum price, and enable the correct information transfer (Murphy, 2006; Sivramkrishna and Jyotishi, 2008). Moreover, contracts between government and industries could be made improving environmental protection with incentives or penalties (Murphy, 2006). Finally, the government must regulate contracts, like captive supply, that could be used to harm producers (Zhang and Sexton, 2000).

2.1.5.3 Market Regulations

Like I said before, the local government can act establishing regulations to decrease market power in the country territory, however, it must configure these regulations with the rest of the countries to have coherency with the trade liberalization and globalization (Murphy, 2006). Even though, Sheldon (2006) and Sexton (2004) say that with trade liberalization from developed countries (i.e. lower import tariffs), developing countries can take advantage and export to these countries, generating welfare that could reach the farmers, if the market power of the industrial sector does not interfere. Additionally, regulations like Antitrust Laws ensure free competition and decrease the market power of firms (Connor, 2003), however, might be adapted to the time changes to make them efficient (Sexton, 2000). Moreover, creating a firm which buys all farmers' products at a fair price, and sells it to firms (Murphy, 2006). Finally, subsidies could work; however, the government must regulate the benefits to ensure the farmers get it and not the middlemen or firms that sell inputs to the farms, like the case of ethanol promotion presented by Saitone, Sexton and Sexton (2007).

2.1.5.4 Improve Transportation

Decrease transportation costs and/or improving infrastructure will help the whole market to increase space limits and add more buyers and sellers to the market (Susuki and Sexton, 2005).

2.2 Market Power in Cattle Beef Sector

In this thesis, I will focus on the market power in the cattle-beef sector. As shown in Table 2.1. there are many papers from beef sector market power, most of them from the U.S. finding presence of market power. This could be related with the lasts decades' trend towards concentration in food manufacturing and retailing (Ward, 2001; Sexton et al., 2007). However, this situation also has been seen in developing countries, and the lack of studies are just because lack of data (Sivramkrishna and Jyotishi, 2008). Like I said buyers' market power generates gains for the industrial and retail sector, harming especially small farmers, decreasing their income, potentially causing a loss of land and finally decreasing their number (Whithley, 2003; Murphy, 2006).

2.3 Market Power in Chilean Agriculture

There is no literature about measuring beef market power in Chile; however, there are works, which find evidence of concentration in other agricultural markets. Marchant (2004), measures monopsony power in the sugar marketing chain obtaining a market power index of 39.4% from the industry to the farmers for the period 1955-2002. Marchant (2006), estimates monopoly power in the pork industry, for the period 1975-2004, finding a power index of 7%. Barrientos et al. (2006), measures the level of concentration and market power in the market for fresh milk, finding for the period 1999-2005, a concentration index (c-4) around 26% and estimated market power index 0.32. Villar (2005) also measured the oligopsony power in Chilean dairy processing industry; however, does not find evidence of market power for 1986-1999. Finally, Pavez (2007), measures oligopsony power in the corn marketing chain in Chile, resulting in an exercise of oligopsony power in the long run equal to 4.68%, while in the short term 10.94%.

2.4 The Chilean Beef Sector

2.4.1 Cattle Production

The cattle production in Chile has been increased to 1 million heads for the year 2008. In the nineties and late-eighties there was a steady increase of 2.3% per year, however, in 1997 there was a slight decrease in the total sacrifices (INE, 2009c; Fundación Chile, 2000).

From 2003-2008, steers correspond to the most sacrificed category, who represent more than half of the total benefit, followed by cows and heifers. The less sacrificed categories are oxen, bulls, and finally calves; because they are not raised primarily to produce meat (INE, 2009c).

Comparing the national forestry and agricultural censuses of 1976, 1997 and 2007, from 1976 to 1997, there was an increase in bovine cattle of 22% reaching a total of 4.1 million animals for 1997, then from 1997 to 2007, there was a slight fall of 7.5% represented by a decrease of 308,800 heads. This decline may be related to the steady increase in imports, the decline of small producers and growth of larger producers who have become dairy farmers, due to the complexity and the narrow margins of business production in cattle production Chile (INE, 2009c; INE, 2009d)

2.4.2 Carcass Production

The production of carcass beef follows the same trend of the sacrificed cattle. The minor changes between sacrifices and carcass beef can be explained by the amount of beef possessed by each category, being lower in the case of calves, heifers and cows and higher for bulls, steers, oxen and young bulls (Fundación Chile, 2000).

In recent years, the sacrifices of adult bellies (cows) and new bellies (heifers) have been increased, to 64% and 31% respectively for 2003 to 2008. This is serious because the bellies are considered fixed assets, and if the producers sacrifice the bellies compromises the future production. Furthermore, calves, oxen, bulls and young bulls, also have increases in sacrifice; most for calves with an increase of 123% for the same period. Finally, the lowest growth in sacrifices corresponds to steers, which are considered as the main category to produce meat (INE, 2009c; Manterola, Personal Communication, 2010).

2.4.3 Beef Consumption

Beef consumption had a steady increase from 14.2 kg/capita in 1986 to 25.6 kg/capita in 1997, and coincides with the increase in production and imports (Fundación Chile, 2000); then in the last decade still rise, but experienced a decline from 2006 to 2008. This could be explained by the higher consumer prices, lower per capita income and imports of beef (INE, 2009c). Moreover, beef consumption now is similar to pork (23.5 kg) and below poultry (33.2 kg), which changes the previous years' consume patterns (Amunátegui, 2008).

2.4.4 Imports

Imports have been decreased from 2006 to 2008, which may be related to the higher price of beef; supply problems linked with the main suppliers of beef, Argentina and Brazil, which have a drop in 2008 compared to 2007, because outbreaks of FMD. Moreover, Argentina, after its recover from the FMD problem, in 2008 imposed a tax on their own beef exports to avoid excessive price increases in the country, so Paraguay and Uruguay have supplied the lack of imports. Paraguayan beef has lower quality than Chilean, because the herds have zebu breeds, which are of minor quality (Amunategui, 2008).

During the early nineties the domestic demand for beef increased faster than the country's production, making necessary increasing imports, which were favored by the reduction of entry barriers, both commercial and sanitary (Fundación Chile, 2000; Maino et al., 1997). The beef imports (fresh or chilled beef without bones) are made by the Industrial Slaughter Plants, but also since the mid-nineties supermarkets chains (Monserrat, D & S, Unimarc and Jumbo) importation grew to between 17 and 23% of the total for 1997, reaching almost 60% by the year 2006 (Fundación Chile, 2000). Moreover, the imports of frozen beef by Slaughterhouses start to decrease in the nineties, because the involvement of net importers firms and companies associated with processed meat industry (Fundación Chile, 2000).

2.4.5 Exports

Beef exports in Chile, are relatively new and minor compared to imports. Chile exports to: The European Union (with the higher prices, but whose duty-free quota is exceeded), Mexico (with low prices), United States (without tariff since 2007), Japan and Cuba. Exports are not consolidated due to the very small amount of Slaughterhouses with export certificates, and low prices for producers. For the period 2003-2008, the exports has been growing steadily, however, in the years 2006 and 2007 has stabilized at a level less than half the peak reached in 2005 (INE, 2009; Amunátegui, 2008).

2.4.6 The Chilean Beef Marketing Chain

Figure 2.1 summarizes the Chilean beef marketing chain in the year 1998; now the only difference is the exports of beef. The main agents of the chain are: producers, cattle brokers, cattle livestock fairs, slaughterhouses, butcher shops, supermarkets and consumers. Additionally, importation of meat has taken a large and growing role, because lack of domestic supply, growing domestic demand, and the increase in trade agreements, i.e. Mercosur.

There is a tendency to concentration in the industry, decreasing the activity of middlemen and other agents. Like we said before the cattle sell is changing, decreasing middlemen, cattle brokers and fairs activity, towards to direct sell to slaughterhouses and supermarkets. In the case of the beef sale to final consumers, the importance of supermarkets and chain butcher shops have grown, but independent butcher shops have decreased to some neighborhoods in small cities (Fundación Chile, 2000; Fundación Chile, 2006; Sociedad de Fomento Fabril et al., 2004; ODEPA, 2007).

The geographic location is important because most of the cattle is produced in the south of the country, while the slaughtering of livestock is concentrated around large cities, as in Santiago, Osorno, Talca and Chillán, along the center and south of Chile. In these cities, the relationship between the number of animals slaughtered and the total stock of cattle is 303% for 1997, while the average for the country is just 26%. This concentration could be explained because of the lower transport cost of cattle compared with refrigerated beef and because most of the demand is concentrated in the biggest cities (Fundación Chile, 2000).

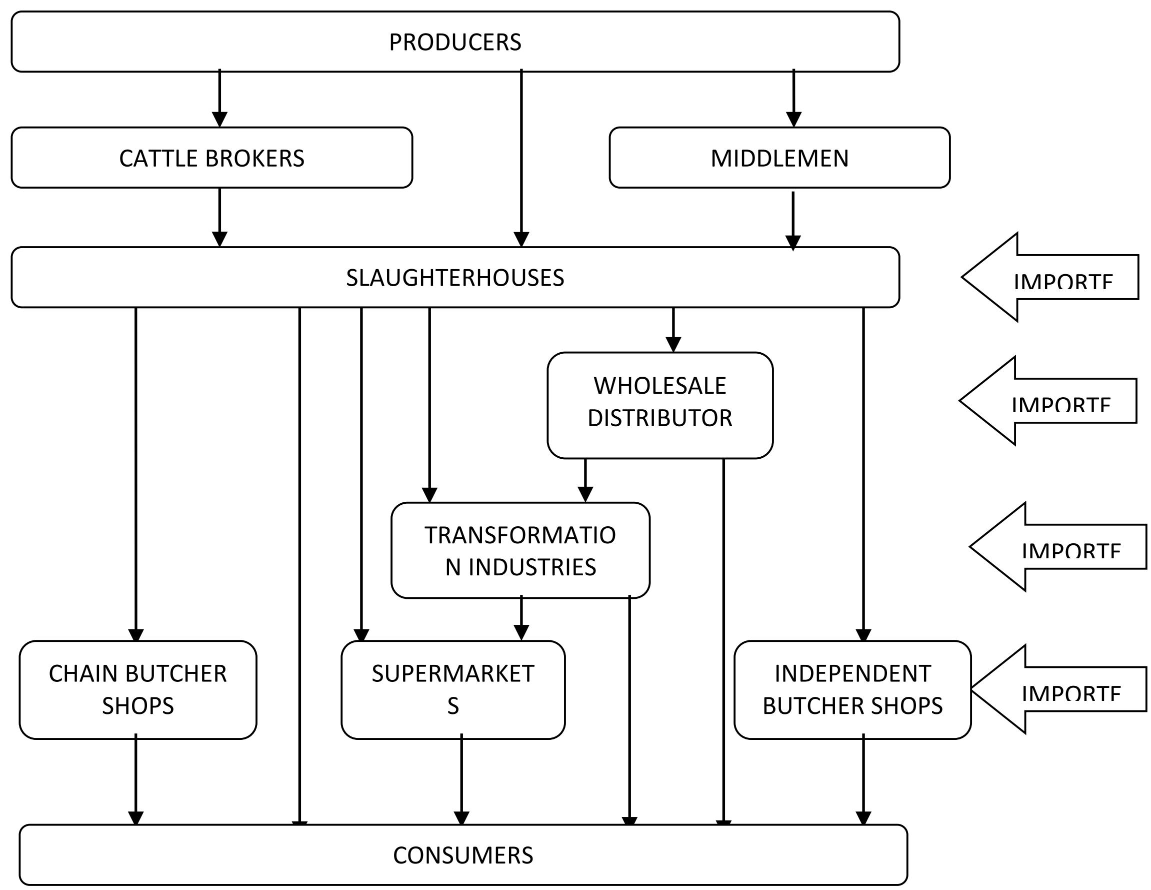

Figure 2.1. Chilean Beef Marketing Chain
Adapted from Fundación Chile (2000).

2.4.6.1 Cattle producers

There are different kinds of producers, based on the activity (breeding, rearing, cattle fattening), and farm characteristics (size, cattle breed, mode and operating costs). By 2001, there were about 185,000 independent cattle producers and no organization among the producers has been successful (Oficina de Estudios y Politicas Agrarias, 2007).

Production is based on beef, dairy and dual purpose cattle. The beef breeds only represent 25% of total beef cattle dedicated, and most of the meat produced in Chile is from discarded dairy breed steers, so beef is not high quality. The producers, based on their size, have substantial differences regarding their direct costs and total production costs (Campos et al., 2009; ODEPA, 2007; Fundación Chile, 2006; Fundación Chile , 2005; Dresdner, 2004).

The fattened up animal is sold to middlemen, such as cattle brokers, cattle fairs, slaughterhouses or supermarkets. Cattle brokers and fairs still remain valid, especially in areas of the south of Chile; however, have declined because the country's connectivity have been improved, and direct sales at the farm have grown, even contract sales with slaughter plants and supermarket chains (ODEPA, 2007; Chavarria et al., 2001, Fundación Chile, 2000; Maino et al., 1998).

The downward trend in producer prices observed since the nineties have led to a change of meat to milk production or mixed, incorporating Holstein breed semen to give the cattle some dairy breeds characteristics (Manterola, Personal Communication, 2010).

The Chilean small cattle producers are characterized by: use of naturalized pastures (low input) and produce wheat and forage; farms' surfaces at or below 30 ha; will to improve production but knowledge about constraints like lack of high-quality soils, minimal facilities and trade; poor genetic improvement, feed, productive and health management of the cattle; tendency to crossbreeding using beef breeds; they agree in the advantages of have their own slaughterhouse; the cattle sales are in most cases made in fairs, followed by sales to farmers' buyers, butchers and brokers (Chavarria et al., 2001).

2.4.6.2 Slaughterhouses

Slaughterhouses are one of the fundamental links since transform the living animal into beef carcass or beef. Higher standards for safety production imposed by the Chilean Beef Law 19.162[1] at the beginning of the nineties (Biblioteca Congreso Nacional de Chile, 2009) decreased their number. From the 164 slaughtering plants recognized by the government only a few are to leader plants, which have scale economies and high technological levels. By 2000, just 12 plants were located in the Metropolitan Region; processing almost 46% of the national production. Furthermore, the growth in production continues despite a significant reduction in the total number of slaughterhouses by 2007. Consequently the slaughterhouses formed a relatively stable group, with experience, trained workers, and standards of quality and hygiene, preventing the entry of new competitors (Fundación Chile, 2000; Luengo, 1998; Asociación Gremial de Plantas Faenadoras Frigoríficas de Carnes, 2007a and 2007b).

Slaughterhouses have a preference for large animals, over 500 Kg, instead of medium, from 250 to 300 kg range, because is faster to operate a large animal than two animals of lower weight. The problem is that a larger animal is often not best suited to produce for many livestock producers, especially extensive systems, since it implies higher costs (SAG, 2005; ODEPA 2007; Fundación Chile, 2000).

[1] Establishes a Mandatory Cattle Classification System, Classification and Nomenclature of the beef and Regulates the functioning of Slaughterhouses, Refrigerators and Establishments of the Meat Industry (Published in “Diario Oficial” in September 7th 1992, modified by the law Nº19.797, Published in “Diario Oficial” in April 3rd 2002 and then by the law 20.358, Published in “Diario Oficial” in July 3rd 2009)

In the year 2000, Chilean beef industry showed just 10 slaughterhouses operating 56% of the national livestock production with a higher technological level than the 105 remaining for that year: cold rooms to offer meat cuts, and facilities to produce sausages and burgers. In addition, major slaughterhouses operate vertically integrated importing meat and linked services to supermarkets, hotels, restaurants and retail outlets. There is also integration with the leather industry and livestock production. (Fundación Chile, 2000).

For 1997, the top three plants: Fridge Lo Valledor, Refrigerator O'Higgins SA (Friosa) and Darc Meat concentrated more than 25% of the overall national slaughter. The concentration observed in the market is greater considering partnerships between slaughterhouses, for example, Lo Valledor and O'Higgins fridges have the property of slaughterhouses in the city of Temuco and the slaughterhouse Comafri in the VI Region (both to the south of Chile), allow them to concentrate almost 30% of the national slaughter; with the obvious economies of scale and the advantage to distribute meat in the south of the country. Another example is the Chilean Slaughterhouse Plants Association, consisting of 16 plants, representing about 80% of the national cattle slaughter and higher technological level (Fundación Chile, 2000).

An important change happens in the middle of 2006, when the company AASA, owner of the biggest national slaughterhouse Lo Valledor, finished its activity because the increased costs and the low dollar price, moving business the south (Temuco, Concepción and Rancagua), where water is cheaper and can use other fuels than diesel and gas. AASA Business has the following plants: Fridge CAMER, Fridge Temuco SA, Agrolomas and

COMAFRI, producing approximately 312,000 heads of cattle a year or 31.05% of the total annual slaughter of cattle (Empresas AASA, 2010; Novoa, 2007).

2.4.7 Cattle Cycle

The cattle life cycle is determinant in the supply, and needs at least two years to produce steers, which are the main product for beef. Another option is produce part of the cycle, like breed male calves for fattening. By the other hand, females stay in the herd in order to produce more calves, and in the case of diary, produce milk. In order to produce milk the females needs to give birth; so after every milk cycle the steers generated could be sold. Figure 2.2 shows the life cycle for male and female cattle (Gutierrez, 2009; EPA, 2012a; EPA, 2012b).

Year 1		Year 2					Year 3			Year 4			Year 5	Year 6
Aug	Sep-Dic	Jan-Aug	Sep	Oct	Nov	Dic	Jan-Jun	Jul	Aug-Dic	Jan-Jul	Aug	Sep-Dic	Jan-Dic	Jan-Jul
Female Calf					Heifer						Cow			
Male Calf			Steer											

Figure 2.2. Cattle Life Cycle

2.5 Measuring Market Power in the Beef Sector

Without consider the SCP approach, there are many empirical papers measuring buyer market power in the cattle-beef sector (Table 2.2). My focus will be the live animal market, and the NEIO approach. So based on the data availability the work follows the ideas of: Schroeter (1988), Azzam and Pagoulatos (1990), Azzam and Park (1993), Stiegert, Azzam and Brorsen (1993), and Muth and Wohlgenant (1999).

Table 2.2. Empirical Papers Measuring Buyer Market Power in the Cattle-Beef Sector

Author (s)	Year	Approach
Schoeter	1988	NEIO
Azzam and Pagoulatos	1990	NEIO
Azzam and Park	1993	NEIO
Stiegert, Azzam and Brorsen	1993	NEIO
Koontz, Garcia and Hudson	1993	NEIO-Game Theory
Azzam*	1997	NEIO
Koontz and Garcia	1997	NEIO-Game Theory
Muth and Wohlgenant	1999	NEIO
Crespi and Sexton*	2004	NEIO
Crespi and Sexton	2005	Probabilities
Carlberg, Hogan and Ward	2009	NEIO-Game Theory
Cai, Stiegert and Koontz	2009	NEIO-Game Theory
Crespi, Xia and Jones*	2010	NEIO
Ji*	2011	NEIO
Chung and Tostao	2009	Nonparametric
Morrison*	2000	NEIO
Morrison*	2001	NEIO

*No data available to try these models

2.5.1 Schroeter (1988)

One of the first works in measure market power using NEIO in beef industry is Schroeter (1988), who applies the Appelbaum (1979, 1982) approach measuring monopoly and monopsony power using fixed proportions technology. This approach uses equal conjectural elasticities to measure both market powers, only differing in the elasticities of market demand for beef and cattle supply; he uses the following indexes (equations 2.1 and 2.2):

$$L^j = -\frac{\theta^j}{\eta} \tag{2.1}$$

$$M^j = \frac{\theta^j}{\epsilon} \quad (2.2)$$

Where:
L^j: Lerner Index, measure of relative price distortion of monopoly
M^j: Monopsony Price distortion index, measure of relative distortion of monopsony
θ^j: j^th firm`s conjectural elasticity
η: Elasticity of market demand
ϵ: Elasticity of cattle supply

To obtain those indexes, he elaborates a set of equations: cost function, demand, supply and the profit maximization equation for the j^th firm. However, because the absence of disaggregate data, he focus the model on industry aggregation, using two cost functions in Generalized Leontief form, for the inputs capital (equation 2.3) and labor (equation 2.4), a beef demand equation (equation 2.5), a cattle supply equation (equation 2.6), and the profit maximization equation (equation 2.7):

$$X_K = \left(b_{KK} + b_{LK}\left(\frac{w_L}{w_K}\right)^{1/2}\right)Q + b_K \quad (2.3)$$

$$X_L = \left(b_{LL} + b_{LK}\left(\frac{w_L}{w_K}\right)^{1/2}\right)Q + b_L \quad (2.4)$$

$$lnQ = a + \eta ln\left(\frac{P}{S_1}\right) + \gamma_1 ln\left(\frac{P_h}{S_1}\right) + \gamma_2 ln\left(\frac{P_c}{S_1}\right) + \gamma_3 ln\left(\frac{Y}{S_1}\right) + \gamma_4 ln(POP) \quad (2.5)$$

$$lnQ = b + \epsilon ln\left(\frac{w}{S_2}\right) + \delta_1 ln\left(\frac{P_f}{S_2}\right) + \delta_2 ln(C_s) \quad (2.6)$$

$$P\left(1 + \frac{\theta}{\eta}\right) = w\left(1 + \frac{\theta}{\epsilon}\right) + \left(b_{LL}w_L + 2b_{LK}(w_L w_K)^{1/2} + b_{KK}w_K\right) \quad (2.7)$$

Where:
X_L: Quantity of labor input
X_K: Quantity of capital input
w_L: Price of labor input
w_K: Price of capital labor
Q: Quantity of cattle = quantity of beef

P: Price of beef
S_1: Consumer price index
P_h: Wholesale price of pork
P_c: Wholesale price of chicken
Y: Per capita nominal income
POP: Population
w: Price of cattle
S_2: Farm output price index
P_f: Price of feed corn
C_s: Stock of cattle on farms

To determine the conjectural elasticity (θ) he adds equation 2.8 and substitutes it in the profit maximization equation (equation 2.7) to identify the parameter for every year of the study.

$$\theta_t = \theta_1 + \theta_2 w_L + \theta_3 w_K + \theta_4 t \qquad (2.8)$$

Where:
t: Annual time trend

Then he runs a system of equations from equation 2.4 through 2.7 (equation 2.3 could not be used because lack of reliable information for capital). The system is estimated in a quasi-first difference form by Full Information Maximum Likelihood (FIML) with U.S. beef packing annual data from 1951 to 1983.

The result shows a positive relation between cattle supply and stock, and statistically significant values for the conjectural elasticity (θ); which gives modest price distortions for the monopoly (3%) and monopsony (1%) in the lasts years of study. So he concludes that exist a little market power in the beef packing industry, and have been shown certain constant behavior since 1970, in spite of the increased concentration in this market.

2.5.2 Azzam and Pagoulatos (1990)

Azzam and Pagoulatos (1990) propose a model for test oligopsony power in output (meat) and input (cattle) markets with the possibility that the conjectural elasticities will not be equals. To make that the authors propose a simultaneous equations model of: a meat production function in translog functional form (equation 2.9) and four share equations for each of the inputs (livestock, labor, capital and non-livestock materials, equations 2.10 to 2.13), which come from the first order condition of the profit function of the meat firms.

$$lnQ = \beta_0 + \sum_{k=1}^{4} \beta_k lnX_k + \frac{1}{2}\sum_{k=1}^{4} \sum_{k=1}^{4} \beta_{kj} lnX_k lnX_j \qquad (2.9)$$

$$S_1 = \left(\frac{1-\left(\frac{\Theta}{\eta}\right)}{1+\left(\frac{\Phi}{\epsilon}\right)}\right)\left(\beta_1 + \sum_{k=1}^{4} \beta_{1j} lnX_j\right) \qquad (2.10)$$

$$S_2 = \left(1 - \left(\frac{\Theta}{\eta}\right)\right)\left(\beta_2 + \sum_{k=1}^{4} \beta_{2j} lnX_j\right) \qquad (2.11)$$

$$S_3 = \left(1 - \left(\frac{\Theta}{\eta}\right)\right)\left(\beta_3 + \sum_{k=1}^{4} \beta_{3j} lnX_j\right) \qquad (2.12)$$

$$S_4 = \left(1 - \left(\frac{\Theta}{\eta}\right)\right)\left(\beta_4 + \sum_{k=1}^{4} \beta_{4j} lnX_j\right) \qquad (2.13)$$

Where:
Q: is the total US commercial red meat (beef, pork, lamb and sheep)
X_j: The main inputs of the industry

Θ: Conjectural elasticity in output market
Φ: Conjectural elasticity in farm-input market
η: Price elasticity of output demand
ϵ: Price elasticity of input demand

$$S_k = \frac{w_k X_k}{PQ} \quad (2.14)$$

Where:
w_k: market rice of input k
X_k: quantity of input k
P: market meat price

The estimation method used is iterative nonlinear three stage least squares, with instrumental variables because the endogeneity of output and inputs, these variables were: labor wage, price of capital, price of materials, price of poultry, number of animal units as of 1 January, per-capita disposable income and time trend. Furthermore, the authors use exogenous point estimates for the price elasticities obtained.

The result shows the presence of both, oligopoly and oligopsony power of 0.46 and 1.1 respectively.

2.5.3 Azzam and Park (1993)

Azzam and Park (1993), use Bresnahan (1982) approach with switching regression techniques to identify conduct changes in the cattle buying beef industry for the U.S. The authors assume fixed proportions between cattle and beef using two equations: cattle supply (equation 2.15) and beef demand (equation 2.16) to measure the market conduct parameter (θ) (equation 2.17). However, they add a switching technique, using a switching regression model (equation 2.18) to measure temporally changes in θ.

$$Q_{Bt} = \propto_0 + \propto_1 w_t + \propto_2 P_{ft} + \propto_3 C_t + \propto_4 w_t P_{ft} + \nu_t \quad (2.15)$$

$$w_t = \beta_0 + \theta_v Q_{Bt}^* + \beta_1 Q_{Bt} + \beta_2 Q_{pt} + \beta_3 Q_{ct} + \beta_4 I_t + \beta_5 W_t + \varepsilon_t \quad (2.16)$$

$$\theta_v = \theta_c + \lambda_t \delta \quad (2.17)$$

$$Q_{Bt}^* = -\frac{Q_B}{\propto_1 + \propto_4 P_{ft}} \quad (2.18)$$

Where:
Q_{Bt}: Production of beef (they assume quantity of beef is equal to quantity of cattle)
w_t: Price of slaughter steers.
P_{ft}: Price of No 2 yellow corn
C_t: Cattle inventory to January 1st
ν_t: Supply function random fluctuations
θ_v: Variable component of the measure of market conduct in factor market (cattle market)
θ_c: Constant component of the parameter
λ_t: Transition paths of coefficients.
Q_{pt}: Production of pork
Q_{ct}: Production of poultry
I_t: Nominal per capita disposable income
W_t: Production worker average hourly earnings in SIC 2011
ε_t: Demand function random fluctuations

Using annual data, they ran each equation separately, using OLS for the supply equation (previously tested for endogeneity using Wu-Hausman test) showing positive values for the price of slaughter steers. Then for the demand equation they used maximum likelihood with non-linear least squares techniques. The order of the polynomial of λ_t and the end and start of the time periods in which θ change was determined based on the maximum likelihood estimates.

Then the results show that $\theta$is not constant through the time period (1960-1987), so they determine three periods: 1960-1977, where $\theta_v = 0.0093$ which is extremely low and shows no evidence of oligopsony. 1978-1982, with a maximum value of $\theta_v = 0.031$;

and 1982-1987, with a decline in the parameter reaching $\theta_v = 0.016$, in both last periods the value of the parameter is statistically significant showing evidence of non-competitive behavior.

2.5.4 Stiegert, Azzam and Brorsen (1993)

Stiegert, Azzam and Brorsen (1993) explore the buyer market power and its relation with the cattle supply, determining if the firms use a pricing strategy defined by SCP approach (an increase in the supply decreases the cattle price) or by the average processing cost (APC) (an increase in the supply increases the cattle price) and how the markdown is affected by anticipated and unanticipated supply.

They use an equation for the anticipated and unanticipated supply (equation 2.19) estimated with OLS, and an empirical model, generated from a Generalized Leontief profit function, consisting on: a supply equation (equation 2.20), a cattle demand equation (equation 2.21), and labor demand equation (equation 2.22), incorporating restriction equations for the oligopsony industry markdown (equation 2.23) and (equation 2.24); and this model is running with each of the following specification equations of the markdown (M): linear (equation 2.25), quadratic (equation 2.26) and cubic (equation 2.27).

$$TFS = c_0 + c_1 COF_{-1} + c_2 COF_{-2} + c_3 CPL_{-1} + c_4 CPL_{-2} + c_5 D_1 + c_6 D_2 + c_7 D_3 + \mu_{TFS} \quad (2.19)$$

$$q = \beta_{qq} + \beta_{0q}\left(\frac{w_0^*}{p}\right)^{0.5} + \beta_{1q}\left(\frac{w_1}{p}\right)^{0.5} + \beta_{2q}\left(\frac{w_2}{p}\right)^{0.5} + d_1D_1 + d_2D_2 + d_3D_3 + l_1q_{-1} + \nu_1 \quad (2.20)$$

$$-x_0 = \beta_{00} + \beta_{0q}\left(\frac{p}{w_0^*}\right)^{0.5} + \beta_{10}\left(\frac{w_1}{w_0^*}\right)^{0.5} + \beta_{20}\left(\frac{w_2}{w_0^*}\right)^{0.5} + d_4D_1 + d_5D_2 + d_6D_3 + l_2q_{-1} + \nu_2 \quad (2.21)$$

$$-x_1 = \beta_{11} + \beta_{1q}\left(\frac{p}{w_1}\right)^{0.5} + \beta_{10}\left(\frac{w_0^*}{w_1}\right)^{0.5} + \beta_{21}\left(\frac{w_2}{w_1}\right)^{0.5} + d_7D_1 + d_9D_3 + l_3(x_1)_{-1} + \nu_3 \quad (2.22)$$

$$w_0^* = w_0\left(1 + \frac{\Phi}{\eta}\right) = w_0(1 + M) \quad (2.23)$$

$$M^* = C * \frac{\exp(M)}{1+\exp(M)} \quad (2.24)$$

$$M = a_0 + a_1\widehat{TFS} + a_2t + a_3\mu_{TFS} \quad (2.25)$$

$$M = a_0 + a_1\widehat{TFS} + a_2t + a_3\mu_{TFS} + a_4(\mu_{TFS})^2 \quad (2.26)$$

$$M = a_0 + a_1\widehat{TFS} + a_2t + a_3\mu_{TFS} + a_4(\mu_{TFS})^2 + a_5(\mu_{TFS})^3 \quad (2.27)$$

Where:
TFS: Total fed cattle supply
COF_{-1} , COF_{-2}: Lagged terms for cattle on feed
CPL_{-1} , CPL_{-2}: Lagged terms for cattle placements
D_1, D_2, D_3: Seasonal dummy variables
μ_{TFS}: Error term associated to the forecast of the cattle supply, equal to: $TFS - \widehat{TFS}$
$\widehat{TFS}$: Forecast for total fed cattle supply
q: Total output for beef packing
w_0^*, w_0: Retail equivalent fed cattle value
p: Retail equivalent carcass value
w_1: Labor cost to process one pound of beef
w_2: Average retail electricity prices
x_0: Total U.S. commercial beef production
x_1: Quantity of beef packing labor
Φ: Beef packing industry conjectural elasticity
η: Supply elasticity of beef production
M^*, M: Industry wide markdown in cattle prices

C: M upper bound in inverse logit transformation
t: Quarterly time trend

So they estimate the three systems ((2.20) trough (2.24) with (2.25), (2.26) and (2.27)) using quarterly data from 1972 through 1986 for the U.S. beef industry by iterative seemingly unrelated regression.

The result shows that the markdown is statistically significant in 31 of the 59 quarters, with a range between 0.1 to 3.8%. The authors consider this high, because using the average markdown value for the period of 1.31%, means a 17% of the average marketing margin, which is $1.54 for every 100 pounds of retail beef sold, which is equivalent to 62 million dollars per quarter of extra earnings for the industry. Finally the industry shows a tendency to the APC pricing in spite of SCP strategy in most of the periods.

2.5.5 Muth and Wohlgenant (1999)

Muth and Wohlgenant (1999) develop a model to measure oligopsony power in the beef industry, using variable proportions technology, without using specialized input quantities data, just the prices, thanks to the application of the envelope theorem. So they propose three functional forms for the first order condition (or demand relation) function: a linear reduced value marginal product (equation 2.28), a log-linear marginal product (equation 2.29) and a squared root marginal product (equation 2.30); and a short run supply equation (equation 2.31).

$$w_1 = -\left(\frac{\theta}{\delta_1+\delta_2}\right)\frac{C}{I}x_1 + \alpha_1 x_1 + \alpha_2 w_2 + \alpha_3 w_3 + \alpha_4 P \quad (2.28)$$

$$s_1 = \frac{w_1 x_1}{Pq} = -\theta\left(\frac{\partial w_1}{\partial x_1}\right)\frac{{x_1}^2}{Pq} + \alpha_1 + \gamma_{11} ln(x_1) + \gamma_{12} ln(w_2) + \gamma_{13} ln(w_3) + \gamma_{1p} ln(P)$$

(2.29)

$$r_1 = \frac{w_1}{P} = -\theta\left(\frac{\partial w_1}{\partial x_1}\right)\frac{x_1}{P} + \beta_{10} + \beta_{11}{x_1}^{1/2} + \beta_{12}{w_2}^{1/2} + \beta_{13}{w_3}^{1/2} + \beta_{1p}P^{1/2} \quad (2.30)$$

$$\frac{x_1}{I} = \delta_0 + \delta_1\frac{w_1}{C} + \delta_2\frac{w_1}{C}T + \delta_3 T \quad (2.31)$$

Where:
w_1: Cattle price
C: Feed corn price
I: Beginning of the year inventory of cattle
x_1: Cattle quantity
w_2: Price of labor
w_3: Price of energy
P: Wholesale price of beef
s_1: Cost share of cattle in production of beef
q: Beef quantity
r_1: Ratio of the price of cattle to the wholesale price of beef
T: Time trend
θ: Conjectural elasticity

For measure the conjectural elasticity (θ) they test three specifications: equal to zero, constant, and as a linear function of the time trend, equation (2.32):

$$\theta = \theta_0 + \theta_1 T \quad (2.32)$$

So they run the three systems of equations: (2.28) and (2.31), (2.29) and (2.31), (2.30) and (2.31) using the three stages least squares method with annual data for the period 1967-1993, in first differences. The instrument set for the estimation consider the exogenous variables of the model plus variables that influence demand for beef, such as: population, consumer expenditures, retail price of pork and poultry. Then each model was tested against the perfect competition model ($\theta = 0$) using the Gallant and Jorgenson`s method for test nonlinear restriction, resulting in the three models could not reject that $\theta = 0$ at 5% confidence level, so there is not oligopsony power.

2.6 Cattle Supply Functions Models

In order to identify an adequate supply function, I look for different models available in the literature.

2.6.1 Yver (1965)

Yver (1965) suggest a cattle supply estimation for the Argentinian market using annual data, including the climate factor to measure the variation on production:

$$O_{t+1} = \beta\alpha P_t + (1-\beta)O_t + (O_{t+1}^t - O_t^t) + \beta O_t^t \qquad (2.33)$$

$$O_{t+1}^t = A_0 + A_1 S_{t+1} + A_2 C_{t+1} + \mu_{t+1} \qquad (2.34)$$

Where:
O_{t+1}: Cattle production next period
O_t: Cattle production actual period
α: Long term cattle supply price elasticity when the model is expressed in log form.
P_t: Market price of cattle
O_t^t: Cattle expected production actual period
O_{t+1}^t: Cattle expected production next period,
S_{t+1}: Cattle stock next period, estimated through a constant born index.
C_{t+1}: Climate index, estimated using evapotranspiration index.

2.6.2 Tryfos (1974)

Tryfos (1974) tries to solve the problem of negative coefficient value for price of cattle in supply functions estimating a generic supply (equation 2.35) and stock (equation 2.36) functions simultaneous equation model. Then he applies it for cattle (equations 2.37 and 2.38), calves (equations 2.39 and 2.40), and other livestock with 3SLS using annual data 1951 through 1970.

$$I_t = \alpha_{10} + \alpha_{11}P_t + \alpha_{12}C_t + \alpha_{13}I_{t-1} + \mu_{1t} \tag{2.35}$$

$$S_t = \alpha_{20} + \alpha_{23}I_{t-1} + \alpha_{24}I_t + \mu_{2t} \tag{2.36}$$

$$IB_t = 1{,}207.5 + 0.254PB_t - 0.605CF_t + 0.863IB_{t-1} \tag{2.37}$$

$$SB_t = 1{,}076.5 + 1.833IB_{t-1} - 1.344IB_t \tag{2.38}$$

$$IV_t = 1{,}571.8 + 3.088PV_t - 1.182CF_t + 0.745IV_{t-1} \tag{2.39}$$

$$SV_t = 459.61 + 1.372IV_{t-1} + 0.238IM_{t-1} - 1.348IV_t \tag{2.40}$$

Where:
I_t: Cattle inventory
P_t: Cattle price
C_t: Cost of feed
I_{t-1}: Cattle inventory lagged
S_t: Cattle supply
IB_t: Beef cattle (beef cows, beef heifers and steers) in thousand heads
PB_t: Cattle weighted average price at public stockyards in $ per 100 lbs. deflated
CF_t: Index of livestock feed prices (1935-39=100) deflated
IB_{t-1}: Beef cattle (beef cows, beef heifers and steers) in thousand heads lagged
SB_t: Cattle total slaughter and exports in thousand heads
IV_t: Calves in thousand heads
PV_t: Calves weighted prices at public stockyards in $ per 100 lbs. deflated
IV_{t-1}: Calves in thousand heads lagged
SV_t: Calves total slaughter and exports in thousand heads
IM_{t-1}: Dairy cattle in thousand heads

2.6.3 Jarvis (1974)

Jarvis (1974) tests price response of Argentinian cattle producers with annual data from 1943/44-1965/66 using OLS and instrumental variables in a model composed of slaughter cattle equations for: total number of animals (equation 2.41), steers, cows, yearlings, heifers, calves, and bulls. He uses different functions because characteristics like sex or age of the animal make their response to price different; for example, the females have more slaughter elasticity than the males, because the reproductive feature; also the younger animals have more slaughter elasticity than the older animals.

$$S_t = \beta_1 H_t + \beta_2 t H_t + \beta_3 \frac{\dot{P}_t}{P_{t-1}} + \beta_4 P_{t-1} + \beta_5 P_{t-2} + \beta_6 P_{t-3} + \beta_7 P_{t-4} + \beta_8 \Delta RL_t +$$

$$\beta_9 \frac{\dot{C}_t}{C_{t-1}} + \beta_{10} C_{t-1} + \beta_{11} C_{t-2} + \beta_{12} C_{t-3} + \beta_{13} C_{t-4} + E_t \qquad (2.41)$$

Where:
S_t: Total number of animals slaughtered in year t
H_t: Number of animals in the herd in year t
t: Time trend
$\frac{\dot{P}_t}{P_{t-1}}$: Percentage change in price of beef relative to an index of grain prices.
P_t: Price of beef
ΔRL_t : Absolute change in rural labor force in year t
$\frac{\dot{C}_t}{C_{t-1}}$: Percentage change in climatic index in year t
C_t: Climatic index

He found a negative short-run price response to slaughter and a positive response for the long run. Concluding that when the price increases generate a decrease in the slaughter, increasing more the price and the future supply, but then decreasing the price and maybe increasing the feeding costs.

2.6.4 Arzac and Wilkinson (1979)

Arzac and Wilkinson (1979) develop an econometric model for the livestock and feed grain markets for the U.S. consisting in: consumer demand for meat equations, retail and producer price relations, livestock production, inventory and supply relations, demand and supply of feed grain and market clearing equations and identities. So in the livestock production, inventory and supply relations section they propose two equations for cattle supply: Fed beef supply (equation 2.42) and non-fed beef supply (equation 2.43).

$$XS_1 = 918.2 + 0.0223PF_1 - 0.1082PG_1 = 0.3161IP_{-2} - 0.6852Q_2 - 0.6107Q_3 - 0.2751Q_4 \qquad (2.42)$$

$$XS_2 = -2507.1 - 0.1625PF_5 + 0.067(KB + 0.56KD) + 0.077(KC_{-4} - ID) - 0.157IP4 + 0.085Q_2 + 0.302Q_3 + 0.317Q_4 \qquad (2.43)$$

Where:
XS_1: Fed beef production in m. lb.
PF_1: Producer price of fed beef in cents/cwt.
PG_1: Corn price in cents/10 bu.
IP_{-2}: Two periods lagged cattle and calves on feed, end of period in thousand heads.
Q_2, Q_3, Q_4: Seasonal dummy variables
XS_2: Non-fed beef production in m. lb.
PF_5: Price of feeder steers in cents/cwt.
$KKBB$: Inventory of beef cows at the beginning of the period in thousand heads
$KKDD$: Inventory of dairy cows at the beginning of the period in thousand heads
$KCKC_{-4}$: Four periods lagged net calf crop in thousand heads
$IDID$: Dairy herd replacement at the beginning of the period in thousand heads
$IPIP4$: Prior placement of cattle and calves on fed equals to: $IP4 = \frac{1}{4}\sum_{i=0}^{3} IP_{-t}$

These equations were estimated using truncated 2SLS with quarterly data from 1957 through 1975, finding in all the supply, inventory and production equations the expected signs for the coefficients.

2.6.5 Gutierrez, De Boer and Ospina (1982)

Gutierrez, De Boer and Ospina (1982) create a differentiate sex simultaneous equations model of supply and demand equations for the Colombian cattle sector from 1950 through 1970 using annual data. They separate the sex of the animals because the sales behavior could change depending on the sex; for example, if cattle price goes up, the farmer would like to increase the inventory of females through retention of heifers, generating a negative response. The same could happen for the male case; however, the farmer needs more resources and liquidity otherwise the response to the increase of cattle price will be positive. The supply-related equations are: Male stock (equation 2.44), female stock (equation 2.45), male supply (equation 2.46) and female supply (equation 2.47).

$$MM_2 = 1{,}453 + 4.287P_a + 0.339TC - 0.839P_c \tag{2.44}$$

$$FF_2 = 5{,}235 + 11.141P_a - 2.073TC - 4.236P_c + 1.738P_m \tag{2.45}$$

$$S_mS_m = 363 - 0.143P_a - 0.859TC - 2.049P_c + 0.357M_{2(t-1)} \tag{2.46}$$

$$S_fS_f = 61 - 2.05P_a + 0.108TC + 0.592P_c + 0.166F_{2(t-1)} \tag{2.47}$$

Where:
MM_2: Male stock (males over two years)

P_a: Average real price per head of adult cattle
TC: Total credit provided to the beef sector
P_c: Real price of cotton
F_2: Female stock (females over three years)
P_m: Real price of milk
S_m: Male sales
$M_{2(t-1)}$: One period lagged male stock
S_f: Female sales
$F_{2(t-1)}$: One period lagged female stock

They estimated the model using 3SLS, and the results show a positive response for the stock equations (2.44 and 2.45), but a greater response is shown by the females, which the authors attribute to the female capacity of generate greater future output. The supply equations (2.46 and 2.47) show a negative response in both cases. However, for the male equation the coefficient is low and non-significant.

2.6.6 Rucker, Burt and LaFrance (1984)

Rucker, Burt and LaFrance (1984) generate a model for cattle inventories in the U.S. and Montana with annual data from 1951 through 1979 using a generalization of the Maddala-Rao Maximum Likelihood procedure for rational lag models, allowing to divide the equations in non-stochastic and stochastic components. They propose two equations for the U.S.: Beef breeding herd inventory (equations 2.48 and 2.49) and total beef cattle inventory (equation 2.50).

$$B_t = -2{,}200 + 80.5\frac{P_b}{P_{co_{t-1}}} + 145P_{ca_{t-1}} - 88.1P_{ca_{t-2}} + 1.864E(B)_{t-1} - 0.89E(B)_{t-2} + 0.445\nu_{t-1} - 0.833\nu_{t-2} \qquad (2.48)$$

$$B_t = -233 - 794P_{co_{t-1}} + 159P_{ca_{t-1}} - 54.5P_{ca_{t-2}} + 1.781E(B)_{t-1} - 0.817E(B)_{t-2} + 0.534\nu_{t-1} - 0.806\nu_{t-2} \quad (2.49)$$

$$C_t = -16{,}300 + 0.0781H_{t-1} + 0.0918H_{t-2} + 293P_{ca_{t-1}} - 147P_{ca_{t-2}} + 1.869E(C)_{t-1} - 0.966E(C)_{t-2} + 0.355\nu_{t-1} - 0.642\nu_{t-2} \quad (2.50)$$

Where:
B_t: Breeding herd in thousand heads
$\frac{P_b}{P_{co_{t-1}}}$: One period lagged beef corn price ratio in \$ per cwt./\$per bu.
$P_{ca_{t-1}}, P_{ca_{t-2}}$: One and two period lagged calf price in \$ per cwt.
$E(B)_{t-1}, E(B)_{t-2}$: One and two period lagged expected value of breeding herd in thousand heads
ν_{t-1}, ν_{t-2}: One and two period lagged disturbance term
$P_{co_{t-1}}$: One period lagged corn price in \$ per cwt.
C_t: Total cattle in thousand heads
H_{t-1}, H_{t-2}: One and two period lagged hay production in thousand tons
$E(C)_{t-1}, E(C)_{t-2}$: One and two period lagged expected value of total cattle in thousand heads

They found statistically significant coefficients for calf price and inventory, but for the one lag period a positive response, and then for the two lag a negative response.

2.6.7 Foster and Burt (1992)

Foster and Burt (1992) develop a dynamic model for heifers (2.51) and cows (2.52) inventories[2] incorporating the sequential order and the biological constraints of cattle production. The lag model was applied to the U.S. cattle industry using annual data from 1965 through 1990 using Burt`s (1980) non-stochastic difference equation (NSDE).

[2] For simplicity we are not showing in the model the values for the AR(n) coefficients.

$$H_t = -251.9 + 38.5P_{t-1} + 0.103C_{t-2} + 1.31E(H)_{t-1} + E(H)_{t-2} + 1{,}007.9D_{1975}$$

(2.51)

$$C_t = -401.1 + 215.5P_{t-2} + 0.409H_{t-1} + 0.801E(C)_{t-1} \quad (2.52)$$

Where:
H_t: Replacement heifers in thousand heads
H_{t-1}: Lagged replacement heifers in thousand heads
P_{t-1}, P_{t-2}: Lagged calf price in dollars
C_t: Mature cows in thousand heads
C_{t-2}: Lagged mature cows in thousand heads
$E(H)_{t-1}, E(H)_{t-2}, E(C)_{t-1}$: Implicit functions of parameters in the equations.
D_{1975}: Dummy variable for 1975

They found a positive response of inventories respect to the calf price.

2.6.8 Marsh (1994)

Marsh (1994) creates a partial adjustment model for cattle supply based on farmer`s input and output price dynamics effects on the short, intermediate and long terms. He uses monthly data from January 1978 through June 1991 in a model composed of two equations: Feed supply (equation 2.53) and placement demand (equation 2.54)[3], and determines the coefficients using 2SLS with autoregressive errors and lagged dependent variables entered as non-stochastic difference equations. The use of monthly data is considered better by the author than annual data, because reflects biological growth, producer`s decisions alternatives and technical rigidities. The results show a negative coefficient for the same month fed animal price, but positive for the same term

[3] For simplicity the model is showed in linear form and not showing the values for the AR(n) coefficients and seasonal dummy variables (each for the twelve months of the year)

one month lagged; so just the short-term price supply elasticity is negative, and the intermediate and long terms are positive and greater.

$$Q_f^S = 29.8 - 7.3P_{ft} + 8.9P_{ft-1} - 1.4P_{It-2} - 147.7P_{Ct} + 356.2P_{Ct-1} - 218.9P_{Ct-2} + 45.6D_S + 0.06I_n + 1.0Q_{ft-1}^S \quad (2.53)$$

$$Q_f^D = 59.4 + 11P_{ft} - 9.6P_{ft-1} - 4.5P_{It} + 3.5P_{It-1} - 9.3P_{Ct} - 0.1I_n + Q_{ft-1}^D \quad (2.54)$$

Where:
Q_f^S: Fed marketings, quantity of fed steers and heifers marketed for slaughter, thousand head.
P_{ft}: Price of choice slaughter steers, dollars per hundredweight.
P_{ft-1}: Lagged fed cattle price, dollars per hundredweight.
P_{ft}: Price of feeder steers, dollars per hundredweight.
P_{ft-1}, P_{ft-2}: Lagged feeder cattle price, dollars per hundredweight.
P_{Ct}: Price of #2 yellow corn, dollars per bushel.
P_{Ct-1}, P_{Ct-2}: Lagged corn prices, dollars per bushel.
D_S: Number of working slaughter days per month.
I_n: Inventory of cattle on feed, 7 major feeding states, thousand head.
Q_f^D: Feeder placements, quantity of cattle placed on feed, 7 major feeding states, thousand head.
Q_{ft-1}^S, Q_{ft-1}^D: Lagged dependent variables, thousand head.

2.6.9 Ward, Koontz and Schoeder (1998)

Ward, Koontz and Schroeder (1998) determine the captive supplies' impacts on the market prices for fed cattle, using transaction records from U.S. slaughter plants, from April 5 1992 to April 3 1993. They try three models: how market transaction prices are affected by the delivery of fed cattle from a captive supply inventory, how prices changes if buyers owns a cattle inventory, and the difference between cash price and price for fed cattle bought under captive supply. They found in general not large negative effects of captive supplies over fed cattle prices.

2.6.10 Nerlove and Fornani (1998)

Nerlove and Fornani (1998) develop a dynamic quasi rational expectations (QRE) model for the U.S. beef cattle supply based on three parts: cattleman behavior, feedlot and marketing sectors and consumer demand for retail beef. The cattleman behavior shows the supply of cattle to slaughter and the keeping of heifers to the breeding herd. They show the results for the equations of steer sales (equation 2.55), heifer sales plus herd addition (equation 2.56) and heifer sales (equation 2.57)[4]. The model was estimated using QRE generated from quarterly ARIMA model data from 1944I to 1990IV.

$$S_t = -2{,}6 + 0.278M_t + 15.1s_t - 3.71s^*_{t+1} + 0.182IM_t \quad (2.55)$$

$$H_t + \delta_t = 1{,}014 + 0.211F_t + 3.09h_t - 8.93h^*_{t+1} + 0.135IF_t \quad (2.56)$$

$$H_t = -164.4 + 0.20F_t + 19.54h_t - 0.72\delta_t - 16.05h^*_{t+1} + 0.19IF_t \quad (2.57)$$

Where:
S_t: Steers sales (steers sold for feedlot placement or slaughter)
M_t: Stock of steers
s_t: Deflated sales price of steers
s^*_{t+1}: Expected future price of steers
IM_t: Male animals four periods of age
H_t: Heifers sales (heifers sold for feedlot placement or slaughter)
δ_t: Gross investment (heifers added to the reproductive herd)
F_t: Stock of heifers
h_t: Deflated sales price of heifers
h^*_{t+1}: Expected future price of heifers

[4] Unrestricted model

IF_t: Female animals four periods of age

The results show a positive response of supply for the current prices and negative one for the expected future prices.

2.6.11 Espinosa et al. (2000)

Espinosa et al. (2000) using annual data from 1986 through 1997 for 139 double purpose cattle farms, located in Mexico, divided in 2 groups: low and medium technological level, they develop an econometric model consisting of one profit function, two supply functions (for milk and beef) and five input demand functions, using the seemingly unrelated regression estimation method (SUR). The farm beef supply equation for low (equation 2.58) and medium (equation 2.59) tech levels are[5]:

$$C_{a1} = -0.01P_l + 0.002P_c - 0.01P_t - 0.001P_s - 0.001P_p - 0.001P_m + 0.006P_d + 0.06P_{am} + 0.04M_{eg} + 0.18M_{ag} + 0.02I_{nv} \qquad (2.58)$$

$$C_{a2} = -0.02P_l + 0.002P_c + 0.004P_t + 0.001P_s - 0.01P_p - 0.001P_m - 0.001P_d + 0.09P_{am} + 0.06M_{eg} + 0.18M_{ag} + 0.02I_{nv} \qquad (2.59)$$

Where:
C_{a1}: Amount of beef produced in tons by low technological level farmers
C_{a2}: Amount of beef produced in tons by medium technological level farmers
P_l: Milk price received by farmers
P_c: Beef price received by farmers
P_t: Labor Price
P_s: Supplements price
P_p: Barbed wire price

[5] Values of interaction parameters are not included

P_m: Parasiticide price
P_d: Diesel price
P_{am}: Improved grassland, percentage of hectares with improved grasslands of the total cattle surface
M_{eg}: Genetic improvement, percentage of cows with European breeding of the total cows
M_{ag}: Cattle management, amount in thousands of pesos of management costs, technical assistance and feed supplements
I_{nv}: Investment

The results show a negative response to the price of milk and a positive response to the price of beef, and the magnitude is almost the same in low and medium technological level.

2.6.12 Aadland and Bailey (2001)

Aadland and Bailey (2001) develop a model to measure short-run cattle supply for the U.S. cattle industry using annual data from 1944 through 1999. The model was made just for female animals and separating the cattle in cows (unfed beef, low quality) and heifer calves (fed beef, high quality) generating a system of equations with an inventory function for female calves, a unit cost function, two markup equations (for cows and heifers), two retail beef demand equations (for cows and heifers), and two first-order conditions for the profit maximization of the rancher (for cows and heifers).

They estimate the parameters using the Hansen`s generalized methods of moments, and then use impulse response functions to measure the short-run supply effects of transitory and permanent changes in the prices of calves and then of simultaneously prices of calves and cows. For the increase of price of calves, they obtain positive short run supply response from heifers, and negative from cows; and for increase simultaneously of price of calves and cows they obtain positive response for the transitory shock, and negative for the permanent shock.

2.6.13 Benítez-Ramírez at al. (2010)

Benítez-Ramírez et al. (2010) develop a simultaneous equations model for the Mexican beef market using monthly data from 1995 through 2003. The model consists of one equation of supply (equation 2.60) related with three price transmission equations (equation 2.61, 2.62, 2.63), one equation for demand, and an identity of balance of external trade equation. The system was estimated using 2SLS. The results show positive values for the price coefficient and four months lagged price, and negative value for the two months lagged price of live cattle.

$$OCANAL_t = 45{,}760{,}510 + 567{,}644PBCR_t + 1{,}411{,}570PBCR_{t-4} - 3{,}591{,}943PBPR_{t-2} + 594{,}242PECANALR_t - 2{,}721{,}657PSORR_t + 0.544OCANAL_{t-1} \quad (2.60)$$

$$PBCR_t = 6.686 + 0.562PBDHR_t \quad (2.61)$$

$$PBDHR_t = 26.163 + 0.234PIBDHR_t \quad (2.62)$$

$$PCCBR_t = 7.089 + 1.286PBDHR_t \quad (2.63)$$

Where:
$OCANAL_t$: Domestic production of beef carcass expressed in kg
$PBCR_t$: Beef carcass wholesale price ($/kg)
$PBCR_{t-4}$: Beef carcass real wholesale price with four months lag ($/kg)

$PBPR_{t-2}$: Real price of entrance to slaughterhouse of the live cattle with two months lag ($/kg)
$PECANALR_t$: Real monthly price of exportation of beef carcass ($/kg)
$PSORR_t$: Real CIF price of importation of sorghum ($/kg)
$OCANAL_{t-1}$: One period lag of domestic production of beef carcass expressed in kg
$PBDHR_t$: Price of national boneless meat ($/kg)
$PIBDHR_t$: Real price of importation of boneless beef ($/kg)
$PCCBR_t$: Real price of consumer meat

CHAPTER 3: DATA

3.1 Description of Variables

The data to construct the model corresponds to a monthly time series from April 1993 to December 2008, from Chilean Government Institutions. The detail of the data, variable transformations and sources are detailed in Table 3.1. The aggregate data correspond to the data from the complete cattle sector (cows, heifers, veal, bulls, oxen and steers). The disaggregated data corresponds to separate data from: cows, heifers, oxen and steers. All these variables were chosen based on the features of the Chilean Cattle Market, and the details are given in section 4.1.2. Finally is important to notice that in order to capture the cattle cycle dynamics I prefer to use monthly data instead of yearly.

Table 3.3. Detail of the Used Variables.

Meaning	Measure Unit	Source	Observations
Farm Price of cattle (Aggregated and disaggregated)	Chilean Pesos ($) per Kg	Oficina de Estudios y Políticas Agrarias (2013)	Nominal prices deflated using Chilean Wholesale Price Index, base December 2008.
Wholesale price of beef (Aggregated and disaggregated)	Chilean Pesos ($) per Kg	Oficina de Estudios y Políticas Agrarias (2013)	Nominal prices deflated using Chilean Wholesale Price Index, base December 2008. For the heifers wholesale price, there is no data available, so I use the data for average wholesale beef as a proxy..
Quantity of cattle sold, which I assume is the same quantity of processed beef sold (Aggregated and disaggregated)	Kg of carcass	Instituto Nacional de Estadísticas (1994, 1995,1996,1997,1998, 1999, 2000, 2009a)	Also bulls and veal for instrumental variable use
Table 3.1. ContinuedWholesale price of corn	Chilean Pesos ($) per Kg	Oficina de Estudios y Políticas Agrarias (2013) and Muñoz (2012)	Nominal prices deflated using Chilean Wholesale Price Index, base December 2008
Wholesale Price of Urea	Chilean Pesos ($) per Kg	Oficina de Estudios y Políticas Agrarias (2013)	Nominal prices deflated using Chilean Wholesale Price Index, base December 2008.
Inventory of cattle* (Aggregated and disaggregated)	Heads of cattle	Oficina de Estudios y Políticas Agrarias (2013)	The data is available annually for years: 1993-1997 , 2000 and 2007, so I interpolate the other years, and then use the annual quantity equal for all the months of that year.
Farm Price of Milk	Chilean Pesos ($) per liter (L)	Oficina de Estudios y Políticas Agrarias (2013)	Nominal prices deflated using Chilean Wholesale Price Index, base December 2008.
Monthly or quaterly Time trend			
Wage Cost	Chilean Pesos ($) per month per worker	Instituto Nacional de Estadísticas (2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009b)	Nominal costs deflated using Chilean Wholesale Price Index, base December 2008.
Electricity cost	Pesos ($) per Kilowatt hour (KWh)	Comisión Nacional de Energía (2013)	Nominal electricity Prices from Chilean Interconnected Central System (SIC) Alto Jahuel deflated with UF** Value, base December 2008

Table 3.1. Continued

Wholesale Price of Ammonium phosphate	Chilean Pesos ($) per Kg	Oficina de Estudios y Políticas Agrarias (2013)	Nominal prices deflated using Chilean Wholesale Price Index, base December 2008. Used as Instrumental Variable only
Quantity of Imported Beef (Aggregated)	Kg beef	Servicio Nacional de Aduanas (2009)	Used as Instrumental Variable only
CIF Price of Beef Imports (Aggregated)	Chilean Pesos ($) per Kg	Servicio Nacional de Aduanas (2009)	Prices deflated using Producers Price Index for the U.S. (U.S. Bureau of Labor Statistics, 2013) and then transformed to Chilean Pesos using monthly equivalence value Chilean Pesos-Dollars. Used as Instrumental Variable only
Retail Price of pork	Chilean Pesos ($) per Kg	Oficina de Estudios y Políticas Agrarias (2013)	Nominal prices deflated using Chilean Retail Price Index, base December 2008. Used as Instrumental Variable only
Retail price of poultry	Chilean Pesos ($) per Kg	Oficina de Estudios y Políticas Agrarias (2013)	Nominal prices deflated using Chilean Retail Price Index, base December 2008. Used as Instrumental Variable only
Wholesale price of oats	Chilean Pesos ($) per Kg	Oficina de Estudios y Políticas Agrarias (2013)	Nominal prices deflated using Chilean Wholesale Price Index, base December 2008. Used as Instrumental Variable only
Monthly Dummy			Monthly dummy variable from January to November for measure the effect of monthly market power
Quarterly Dummy			Monthly dummy variable from the first to the third quarter for measure the effect of monthly market power

*Only time series which is annually.
**UF means "Unidad de Fomento", which is a unit of account used in Chile for determining the cost of Real Estate, values of housing and any secured loan, either private or of the Chilean government.

Is important to mention that the Chilean Whole Price Index is from Oficina de Estudios y Políticas Agrarias (2012), the U.S. Dollar prices is from Banco Central (2013), and the U.S. PPI is from the U.S. Bureau of Labor Statistics (2013).

All the econometric tests and the system of equations were made with the econometrics software EVIEWS 8 Student Version (HIS Global Inc., 2013)

3.2 Data Plots

3.2.1 Aggregate Data

Figures 3.1 to 3.5 show the plots for the aggregate variables in time, these figures show the differences and patterns among the time series.

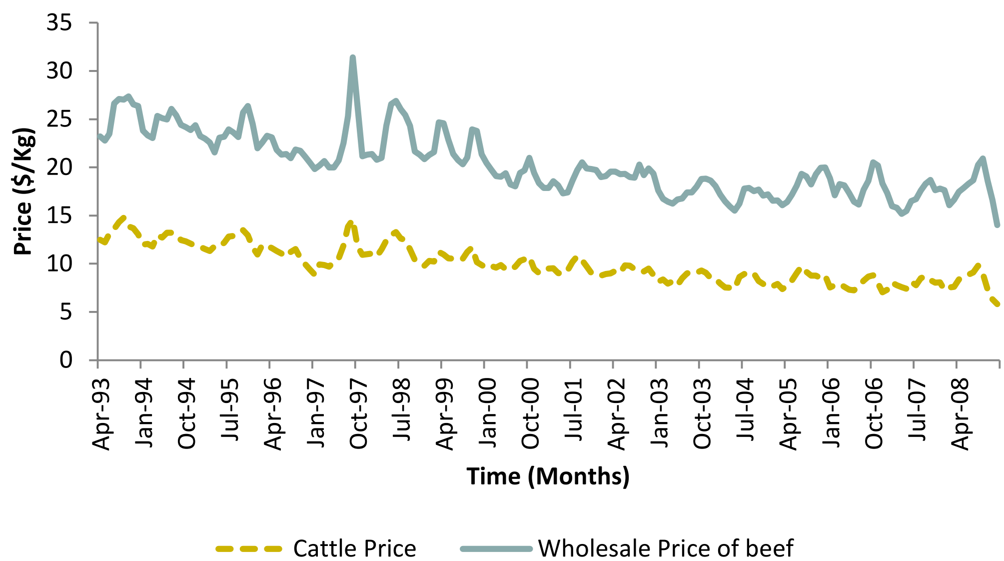

Figure 3.3. Wholesale and Farm Prices (Real Prices Dec 2008)
Elaborated from: Oficina de Estudios y Políticas Agrarias (2013)

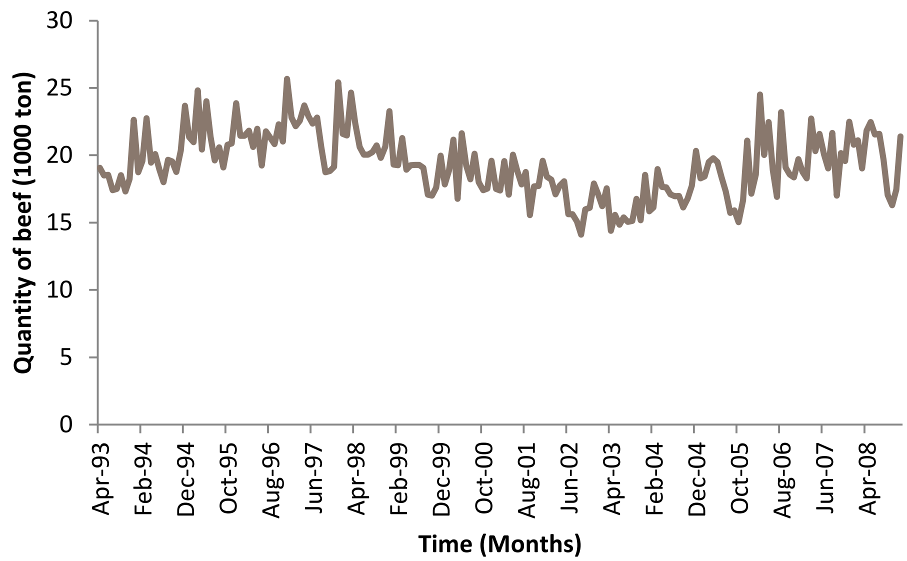

Figure 3.4. Cattle Sold
Elaborated from: Instituto Nacional de Estadísticas (1994, 1995, 1996, 1997, 1998, 1999, 2000, 2009a)

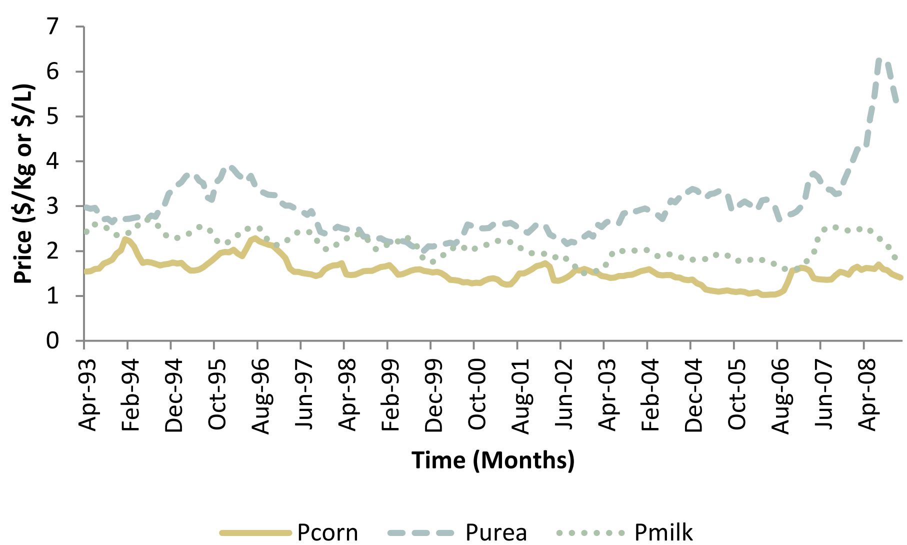

Figure 3.5. Prices of Wholesale Corn (Pcorn) and urea (Purea), and Farmer Milk (Pmilk)
Elaborated from: Oficina de Estudios y Políticas Agrarias (2013) and Muñoz (2012)

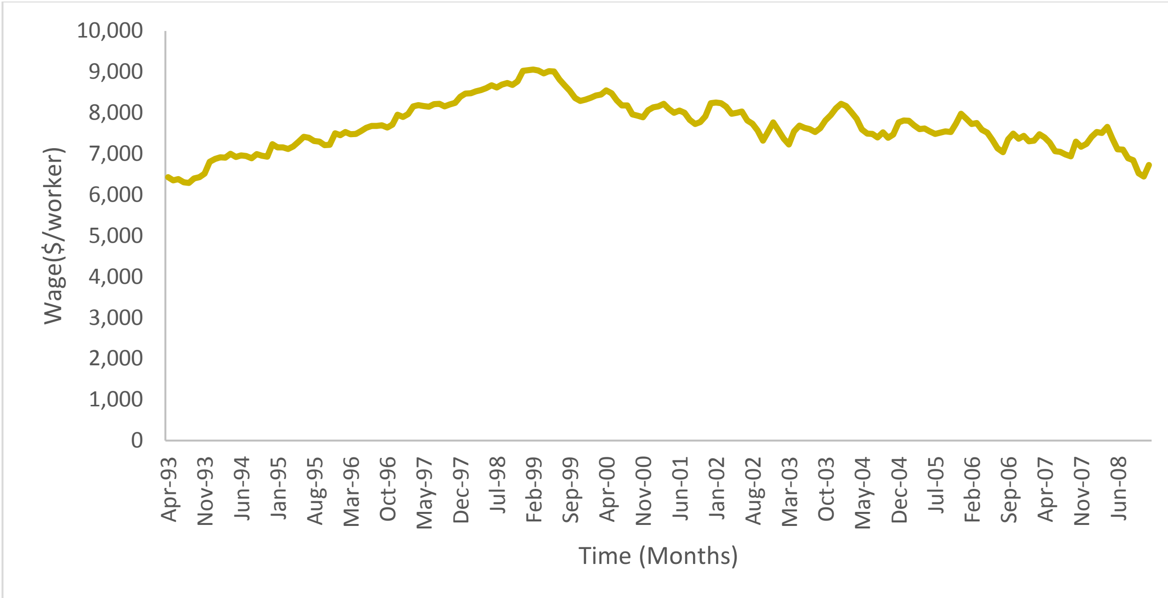

Figure 3.6. Wage Cost
Elaborated from: Instituto Nacional de Estadísticas (2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009b)

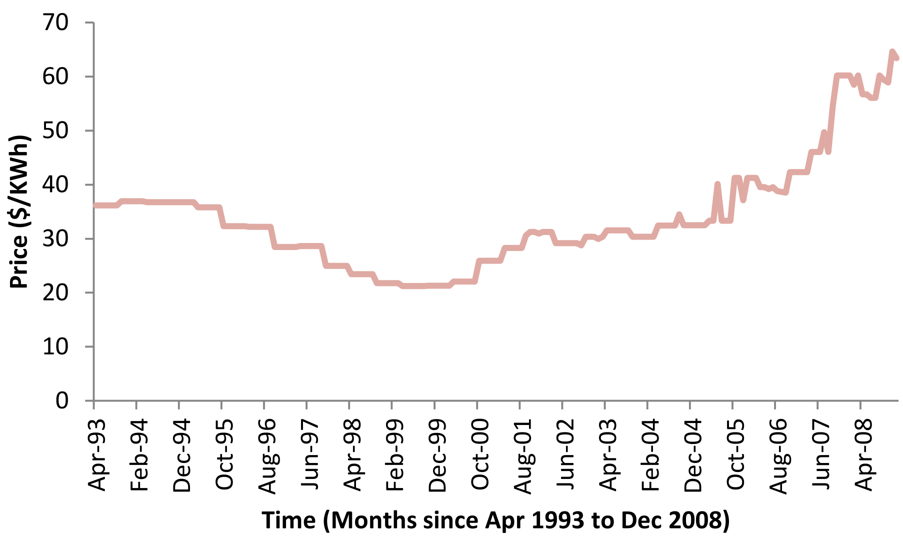

Figure 3.7. Electricity Price
Elaborated from: Comisión Nacional de Energía (2013)

3.2.2 Disaggregated Data

Figures 3.6 to 3.9 show the plots for disaggregate variables in time, these figures show the differences and patterns among the time series.

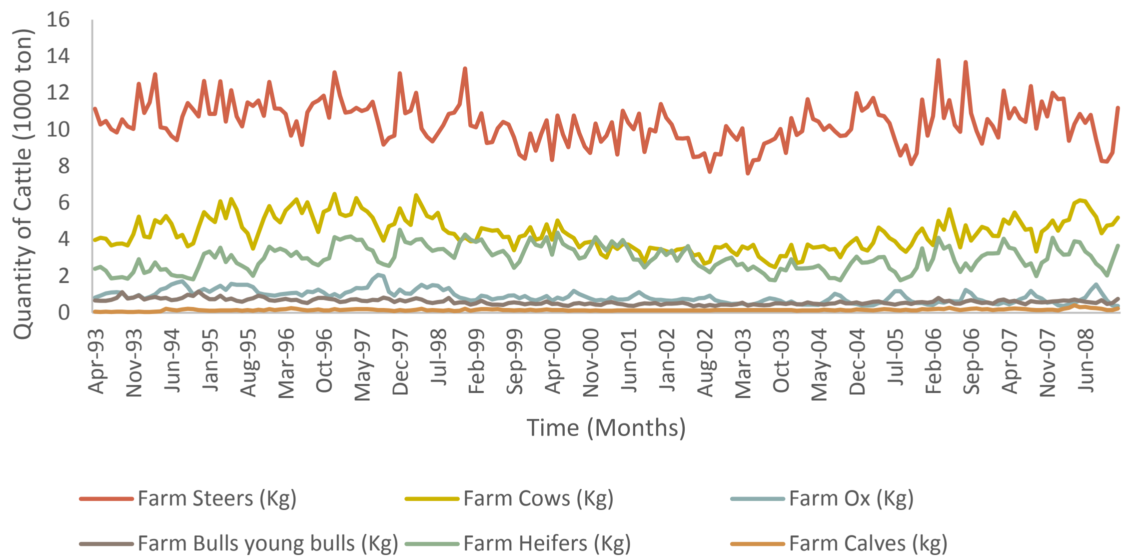

Figure 3.8. Farm Cattle Supply to Slaughterhouses
Elaborated from: Oficina de Estudios y Políticas Agrarias (2013)

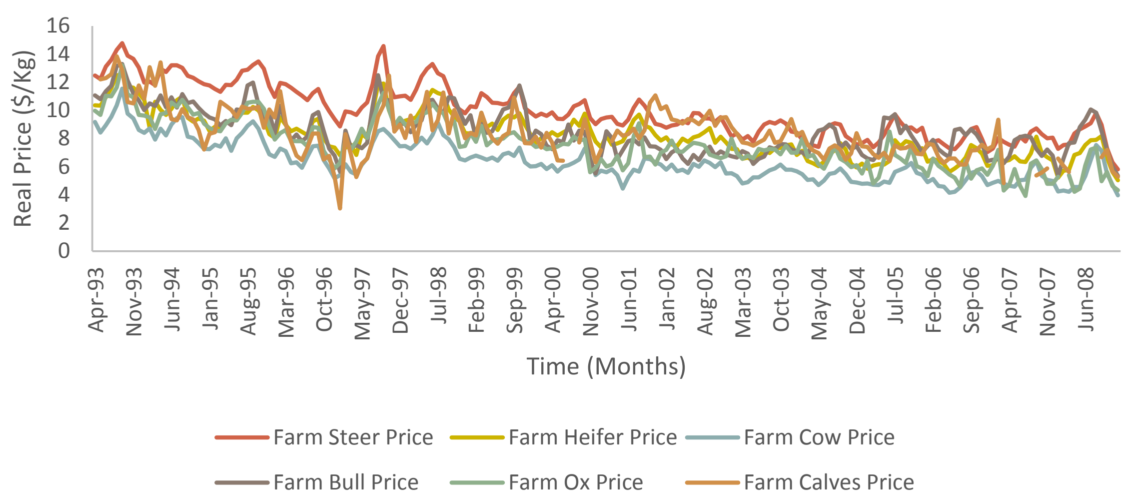

Figure 3.9. Farm Cattle Prices (Real Prices Dec 2008)
Elaborated from: Oficina de Estudios y Políticas Agrarias (2013)

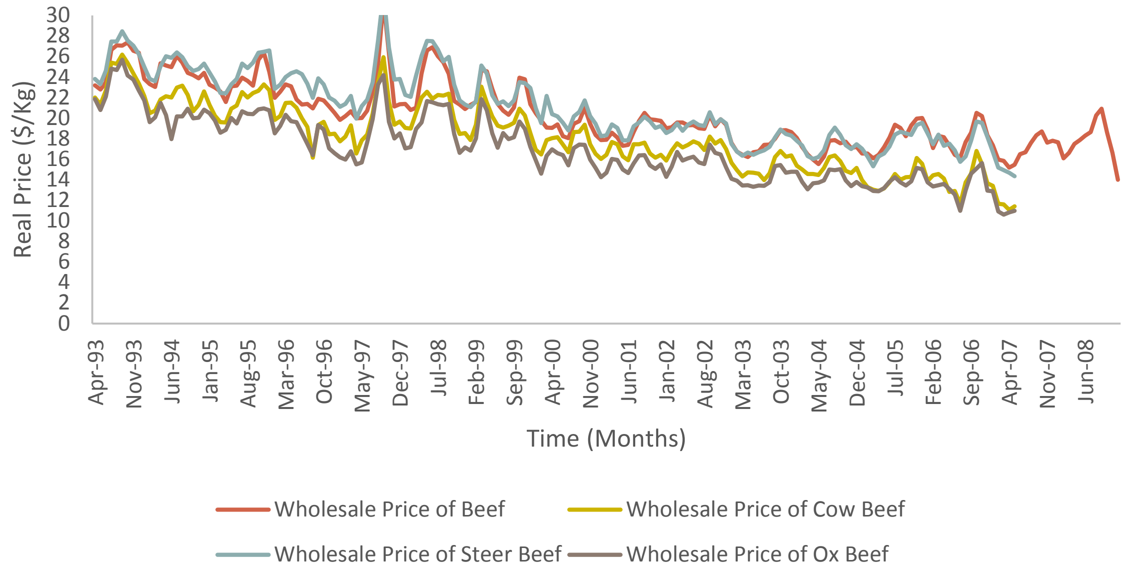

Figure 3.10. Wholesale Beef Prices (Real Prices Dec 2008)
Elaborated from: Oficina de Estudios y Políticas Agrarias (2013)

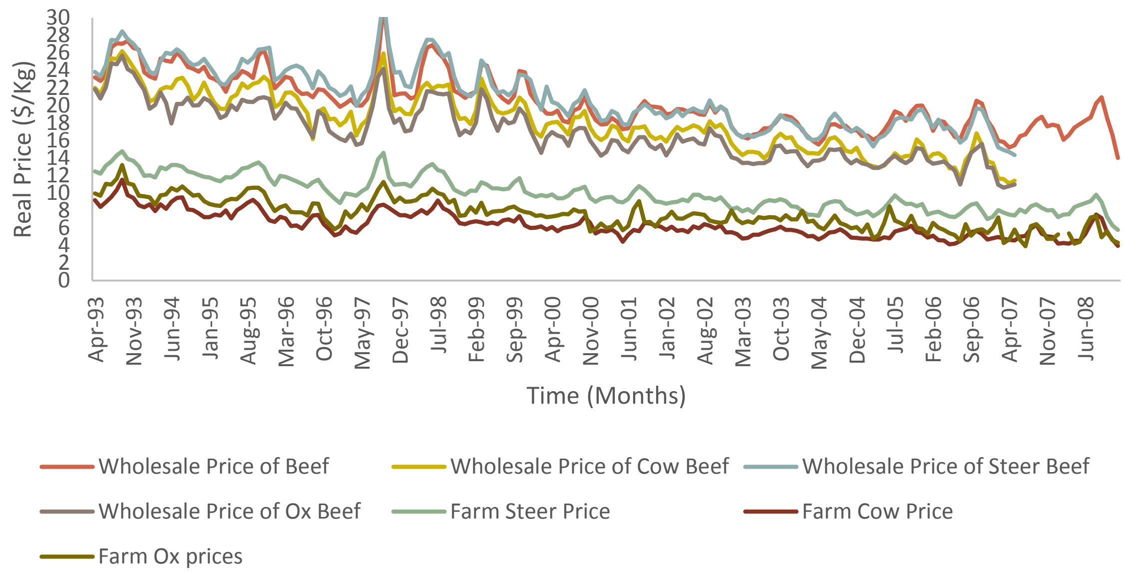

Figure 3.11. Wholesale and Farm Prices (Real Prices Dec 2008)
Elaborated from: Oficina de Estudios y Políticas Agrarias (2013)

CHAPTER 4: MODEL ESTIMATION

4.1 Selecting the Appropriated Model

After try several models (shown in table 4.1.), I decided to select 2 models: Aggregated modified Muth and Wohlgenant model and the modified sex separate model based on Muth and Wohlgenant. The reason to select those models is because they provide a better model of the Chilean Cattle Market (variables used) and give the same results using a simplier approach. Those models derivation will be explained ahead.

Table 4.4. Models Tried

	Model	Time Series	Comments
1	Aggregate Muth and Wohlgenant (1999) based model*	Monthly	3 models with 2 equations each, in 4 scenarios
2	Aggregate Muth and Wohlgenant (1999) based model with inverse supply*	Monthly	3 models with 2 equations each, in 4 scenarios
3	Aggregate Muth and Wohlgenant (1999) based model*	Quarterly	3 models with 2 equations each, in 4 scenarios
4	Aggregate Muth and Wohlgenant (1999) based model with inverse supply*	Quarterly	3 models with 2 equations each, in 4 scenarios
5	Alternative aggregate model*	Monthly	1 model with 2 equations, in 3 scenarios
6	Alternative aggregate model with inverse supply*	Monthly	1 model with 2 equations, in 3 scenarios
7	Alternative aggregate model*	Quarterly	1 model with 2 equations, in 3 scenarios
8	Alternative aggregate model with inverse supply*	Quarterly	1 model with 2 equations, in 3 scenarios
9	Alternative Sex separate model*	Monthly	4 models with 2 equations, in 3 scenarios
10	Alternative Sex separate model*	Monthly	4 models with 2 equations, in 3 scenarios
11	Aggregate Muth and Wohlgenant (1999) based model with AR(1) process*	Monthly	1 model with 2 equations, in 4 scenarios
12	Aggregate Muth and Wohlgenant (1999) based model with AR(1) process and first difference*	Monthly	1 model with 2 equations, in 4 scenarios
13	Modified Aggregate Muth and Wohlgenant (1999) based model with AR(1) process*	Monthly	1 model with 2 equations, in 4 scenarios
14	Modified Aggregate Muth and Wohlgenant (1999) based model with AR(1) process and seasonal difference*	Monthly	1 model with 2 equations, in 4 scenarios
15	Modified Sex separate Muth and Wohlgenant (1999) based model with AR(1) process*	Monthly	4 models with 2 equations, in 4 scenarios
16	Modified Sex separate Muth and Wohlgenant (1999) based model with AR(1) process and seasonal difference*	Monthly	4 models with 2 equations, in 4 scenarios
17	Modified Aggregate Muth and Wohlgenant (1999) based model with AR(1) and AR(2)	Monthly	4 models with 2 equations, in 4 scenarios
18	Modified Sex separate Muth and Wohlgenant (1999) based model with AR(1) and AR(2)	Monthly	4 models with 2 equations, in 4 scenarios

4.1.1 Derivation of Muth and Wohlgenant (1999) Model

I detail the derivation of Muth and Wohlgenant (1999) model because is the main theoretical basis of my work, because requires less data than the rest of the models.

They start the model with a profit equation for a representative firm "i" that buy cattle from farmers and sell the beef into the wholesale market (equation 4.1):

$$\pi_i = Pf_i(X_{1i}, X_i) - w_1 X_{1i} - w`X_i \qquad (4.1.)$$

Where:
π_i= Profit
P= Deflated output price
$f_i(X_{1i}, X_i)$= Output (beef) production function
X_{1i}= Main input (cattle) quantity
X_i= Vector of quantities of other inputs, like energy or labor.
w_1= Main input (cattle) price
$w`$= Deflated price of other inputs, like energy or labor.

Deriving the profit (equation 4.1) respect to quantity of cattle (X_1), for the case of perfect competition for the output and inputs I have (equation 4.3):

$$\frac{\partial \pi_i}{\partial X_{1i}} = P\frac{\partial f_i(X_{1i}, X_i)}{\partial X_{1i}} - w_1\frac{\partial X_{1i}}{\partial X_{1i}} - 0 = 0 \qquad (4.2.)$$

$$w_1 = P\frac{\partial f_i(X_{1i}, X_i)}{\partial X_{1i}} \qquad (4.3.)$$

Deriving the profit (equation 4.1.) respect to quantity of cattle (X_1), for the case of imperfect competition for the main input (X_1) market, but perfect competition for the other inputs and output, I have:

$$\frac{\partial \pi_i}{\partial X_{1i}} = P\frac{\partial f_i(X_{1i}, X_i)}{\partial X_{1i}} - w_1\frac{\partial X_{1i}}{\partial X_{1i}} - X_{1i}\frac{\partial w_1}{\partial X_{1i}} - 0 = 0 \qquad (4.4)$$

Multiplying $\left(-X_{1i}\frac{\partial w_1}{\partial X_{1i}}\right)$ by$\left(\frac{\partial X_1}{\partial X_1}\frac{X_1}{X_1}\right)$:

$$P\frac{\partial f_i(X_{1i}, X_i)}{\partial X_{1i}} - w_1 - X_{1i}\frac{\partial g(X_1, Z)}{\partial X_{1i}}\frac{\partial X_1}{\partial X_1}\frac{X_1}{X_1} = 0 \qquad (4.5)$$

Where:
$g(X_1, Z) = w_1$, price function of X_1
Z= Vector of cattle supply shifters (i.e. price of cattle food)

Making some arrangements:

$$w_1 + \frac{\partial X_1}{\partial X_{1i}}\frac{X_{1i}}{X_1}\frac{\partial g(X_1,Z)}{\partial X_1}X_1 = P\frac{\partial f_i(X_{1i},X_i)}{\partial X_{1i}} \qquad (4.6)$$

Now averaging all firms in industry. So applying sum operator and dividing by the total (n) to the expressions relative to cattle quantity:

$$w_1 + \frac{1}{n}\sum_{i=1}^{n}\left[\left(\frac{\partial X_1}{\partial X_{1i}}\frac{X_{1i}}{X_1}\right)\left(\frac{\partial g(X_1,Z)}{\partial X_1}X_1\right)\right] = \frac{P}{n}\sum_{i=1}^{n}\left(\frac{\partial f_i(X_{1i},X_i)}{\partial X_{1i}}\right) \qquad (4.7)$$

Where:
$\left(\frac{\partial X_1}{\partial X_{1i}}\frac{X_{1i}}{X_1}\right) = \theta$, conjectural elasticity for market power. $\theta = 0$, is perfect competition, $\theta = 1$, is monopsony, $0 < \theta < 1$, some degree of oligopsony power.

Making arrangements for the whole industry and using θI get:

$$w_1 + \theta\frac{\partial g(X_1,Z)}{\partial X_1}X_1 = P\frac{\partial f(X_1,X)}{\partial X_1} \qquad (4.8)$$

Where:
$\frac{\partial f(X_1,X)}{\partial X_1}$= Average Marginal product of X_1 (from all over all firms)
$\frac{\partial g(X_1,Z)}{\partial X_1}$= Average Marginal cost of X_1(from all over all firms)
θ= Average input conjectural elasticity (from all over all firms)

Equation 4.8 requires data of quantity of non-specialized inputs (X, i.e. labor, energy, capital) because are components of the marginal product of cattle$\left(\frac{\partial f(X_1,X)}{\partial X_1}\right)$, but maybe data is not available, like the case of Chilean Cattle Industry. So for this reason the authors apply the envelope theorem to the firm profit equation. Thus after doing this I do not need the quantity of other inputs (i.e. labor, energy), just the prices. So this could be interpreted like they assume that the production could be separated between the non-specialized inputs and the main input, which is an strong assumption, however for the case of the Chilean Cattle Market, this values have not changed drastically between the years of study so we can assume a constant value for them and use this model assumption. The model assume two non-specialized (labor and energy) the new firm profit function is:

$$\pi(P, X_1, Z, w_2, w_3) = Pf(X_1, X_2^*, X_3^*) - g(X_1, Z)X_1 - w_2 X_2^* - w_3 X_3^* \quad (4.9)$$

Where:
w_2= Deflated price of labor
w_3= Deflated price of energy
X_2^*= Optimal quantity of labor conditioned to the level of specialized input (X_1), defined as the function X_2^*=$X_2(P, X_1, w_2, w_3)$
X_3^*= Optimal quantity of energy conditioned to the level of specialized input (X_1), defined as the function X_3^*=$X_3(P, X_1, w_2, w_3)$

Now applying FOC with respect to the specialized input (X_1), where the non-specialized inputs (X_2, X_3) are purchased in perfect competition, the specialized input (X_1) is purchased in a no competitive market, and the output ($f(X_1, X_2^*, X_3^*)$) is sold in perfect competition.

$$\frac{\partial \pi}{\partial X_1} = P\frac{\partial f(X_1, X_2^*, X_3^*)}{\partial X_1} + P\frac{\partial f(\cdot)}{\partial X_2^*}\frac{\partial X_2^*}{\partial X_1} + P\frac{\partial f(\cdot)}{\partial X_3^*}\frac{\partial X_3^*}{\partial X_1} - \theta\frac{\partial g(X_1, Z)}{\partial X_1}X_1 - w_1 - w_2\frac{X_2^*}{\partial X_1} - w_3\frac{X_3^*}{\partial X_1} = 0 \quad (4.10)$$

Making some arrangements:

$$w_1 + \theta\frac{\partial g(X_1, Z)}{\partial X_1}X_1 = P\frac{\partial f(\cdot)}{\partial X_1} + \left(P\frac{\partial f(\cdot)}{\partial X_2^*} - w_2\right)\frac{\partial X_2^*}{\partial X_1} + \left(P\frac{\partial f(\cdot)}{\partial X_3^*} - w_3\right)\frac{\partial X_3^*}{\partial X_1} \quad (4.11)$$

So because they assume perfect competitive market where X_2 and X_3 where purchased, I have:

$$w_1 + \theta \frac{\partial g(X_1,Z)}{\partial X_1} X_1 = P \frac{\partial f(\cdot)}{\partial X_1} + \frac{\partial X_2{}^*}{\partial X_1} + \frac{\partial X_3{}^*}{\partial X_1} \qquad (4.12)$$

Then applying the envelope theorem (holding X_2, X_3 at their optimal determined levels).

$$w_1 = -\theta \frac{\partial g(X_1,Z)}{\partial X_1} X_1 + P \frac{\partial f[X_1, X_2(P, X_1, w_2, w_3), X_3(P, X_1, w_2, w_3)]}{\partial X_1} \qquad (4.13)$$

So now the marginal product is defined over the prices (w_2, w_3) instead of the quantities (X_2, X_3) of non-specialized inputs. Now applying the logic for identify oligopoly power (only the reduced form parameters of the marginal cost function are required to obtain the market power) to this model, the degree of oligopsony power can be estimated using the "reduced-form value marginal product specification" as follows:

$$w_1 = -\theta \frac{\partial g(X_1,Z)}{\partial X_1} X_1 + \alpha_1 X_1 + \alpha_2 w_2 + \alpha_3 w_3 + \alpha_4 P \qquad (4.14)$$

So to complete the model I need a supply equation, so they use a short-run supply response from cattle producers:

$$\frac{x_1}{I} = \delta_0 + \delta_1 \frac{w_1}{C} + \delta_2 \frac{w_1}{C} T + \delta_3 T \qquad (4.15)$$

Where:
C: Regular corn price
I: Inventory of cattle
T: Time trend
$\frac{x_1}{I}$= Slaughter inventory ratio

To complete the identification I need to find $\left(\frac{\partial g(X_1,Z)}{\partial X_1}\right)$ from the supply equation, so solving w_1:

$$\delta_1 \frac{w_1}{C} + \delta_2 \frac{w_1}{C} T = -\delta_0 + \frac{x_1}{I} - \delta_3 T \qquad (4.16)$$

$$w_1 \left(\frac{\delta_1}{C} + \frac{\delta_2}{C} T\right) = -\delta_0 + \frac{x_1}{I} - \delta_3 T \qquad (4.17)$$

$$w_1 = \frac{-\delta_0 - \delta_3 T + \frac{x_1}{I}}{\frac{\delta_1}{C} + \frac{\delta_2}{C} T} \qquad (4.18)$$

$$w_1 = -\frac{\delta_0}{\frac{1}{C}(\delta_1 + \delta_2 T)} - \frac{\delta_3 T}{\frac{1}{C}(\delta_1 + \delta_2 T)} + \frac{\frac{x_1}{I}}{\frac{1}{C}(\delta_1 + \delta_2 T)} \qquad (4.19)$$

$$w_1 = -\frac{\delta_0}{\frac{1}{C}(\delta_1 + \delta_2 T)} - \frac{\delta_3 T}{\frac{1}{C}(\delta_1 + \delta_2 T)} + \frac{C}{I(\delta_1 + \delta_2 T)} X_1 \qquad (4.20)$$

Now differentiating with respect to x_1 I get

$$\frac{\partial w_1}{\partial X_1} = \frac{C}{I}\left(\frac{1}{\delta_1 + \delta_2 T}\right) = 0 \qquad (4.21)$$

Remember that $w_1 = g(X_1, Z)$, so I have:

$$\frac{\partial g(\cdot)}{\partial X_1} = \frac{C}{I}\left(\frac{1}{\delta_1 + \delta_2 T}\right) \qquad (4.22)$$

Now substituting this expression in equation 4.22 yield to the final empirical specification of the FOC (demand relation):

$$w_1 = -\theta \left[\frac{C}{I}\left(\frac{1}{\delta_1 + \delta_2 T}\right)\right] X_1 + \alpha_1 X_1 + \alpha_2 w_2 + \alpha_3 w_3 + \alpha_4 P \qquad (4.23)$$

$$w_1 = -\left(\frac{\theta}{\delta_1 + \delta_2 T}\right) \frac{C}{I} X_1 + \alpha_1 X_1 + \alpha_2 w_2 + \alpha_3 w_3 + \alpha_4 P \qquad (4.24)$$

So with supply and demand equations (4.15 and 4.24) I can make up the system of equations.

In addition the authors measure if the model is sensitive to changes in the functional form of the demand equation, so they add two alternatives functional forms: first order partial derivative of a log-linear form and of a generalized Leontief form.

The log linear form comes from the assumption that the log derivative of $f(\cdot)$ with respect to X_1 in equation (4.13) is linear in the logarithms so:

$$\frac{\partial f(\cdot)}{\partial X_1} = \frac{q}{X_1}\left(\alpha_1 + \gamma_{11}ln(X_1) + \gamma_{12}Ln(w_2) + \gamma_{13}Ln(w_3) + \gamma_{1p}Ln(P)\right) \quad (4.25)$$

Where:
$q = f(\cdot)$, Quantity of beef

Substituting this expression into equation (7)

$$w_1 = -\theta\frac{\partial g(\cdot)}{\partial X_1}X_1 + \frac{Pq}{X_1}\left(\alpha_1 + \gamma_{11}ln(X_1) + \gamma_{12}Ln(w_2) + \gamma_{13}Ln(w_3) + \gamma_{1p}Ln(P)\right) \quad (4.26)$$

Then multiplying by: $\frac{X_1}{Pq}$:

$$s_1 = \frac{w_1 x_1}{Pq} = -\theta\left(\frac{\partial g(\cdot)}{\partial x_1}\right)\frac{{x_1}^2}{Pq} + \alpha_1 + \gamma_{11}ln(x_1) + \gamma_{12}ln(w_2) + \gamma_{13}ln(w_3) + \gamma_{1p}ln(P)$$

(4.27)

Where:
s_1: Cost share of cattle in production of beef

For the generalized Leontief form the Marginal product from the equation (4.14) is approximated by:

$$\frac{\partial f(\cdot)}{\partial X_1} = \beta_{10} + \beta_{11}{x_1}^{1/2} + \beta_{12}{w_2}^{1/2} + \beta_{13}{w_3}^{1/2} + \beta_{1p}P^{1/2} \quad (4.28)$$

Then substituting in equation

$$r_1 = \frac{w_1}{P} = -\theta\left(\frac{\partial g(\cdot)}{\partial x_1}\right)\frac{x_1}{P} + \beta_{10} + \beta_{11}{x_1}^{1/2} + \beta_{12}{w_2}^{1/2} + \beta_{13}{w_3}^{1/2} + \beta_{1p}P^{1/2}$$

(4.29)

Where:
r_1: Ratio of the price of cattle to the wholesale price of beef

So they finally have 3 models to determine market power: the short-run supply equation (4.14) and one demand, but trying with three kinds of functional forms of the demand function: a linear reduced value marginal product (4.24), a log-linear marginal product (4.27) and a squared root marginal product (4.29).

$$w_1 = -\left(\frac{\theta}{\delta_1+\delta_2 T}\right)\frac{C}{I}x_1 + \alpha_1 x_1 + \alpha_2 w_2 + \alpha_3 w_3 + \alpha_4 P \quad (4.24)$$

$$s_1 = \frac{w_1 x_1}{Pq} = -\left(\frac{\theta}{\delta_1+\delta_2 T}\right)\frac{C}{I}\frac{{x_1}^2}{Pq} + \alpha_1 + \gamma_{11}ln(x_1) + \gamma_{12}ln(w_2) + \gamma_{13}ln(w_3) + \gamma_{1p}ln(P)$$

(4.27)

$$r_1 = \frac{w_1}{P} = -\left(\frac{\theta}{\delta_1+\delta_2 T}\right)\frac{C}{I}\frac{x_1}{P} + \beta_{10} + \beta_{11}{x_1}^{1/2} + \beta_{12}{w_2}^{1/2} + \beta_{13}{w_3}^{1/2} + \beta_{1p}P^{1/2} \quad (4.29)$$

$$\frac{x_1}{I} = \delta_0 + \delta_1\frac{w_1}{C} + \delta_2\frac{w_1}{C}T + \delta_3 T \quad (4.15)$$

Where:
w_1: Cattle price
C: Regular corn price
I: Inventory of cattle
x_1: Cattle quantity
w_2: Price of labor
w_3: Price of energy
P: Wholesale price of beef
s_1: Cost share of cattle in production of beef
q: Beef quantity
r_1: Ratio of the price of cattle to the wholesale price of beef
T: Time trend
θ: Conjectural elasticity

For measure the conjectural elasticity (θ) they test three specifications: θ equal to zero, θ as a constant, and as a linear function of the time trend, equation 4.30:

$$\theta = \theta_0 + \theta_1 T \qquad (4.30)$$

4.1.2 Adapting Muth and Wohlgenant Model to Chilean Cattle Market

In order to use Muth and Wohlgenant model I need to modify the demand and supply equations according to the Chilean reality, because like we said before the Chilean Cattle Market features special characteristics like: Beef producers are poor and low qualified, beef is a byproduct of milk production, types of production: central intensive, and south extensive, geographical and market concentration of beef packing, beef law (1993) and increasing demand, increasing role of importation and cattle cycle. Unfortunatelly I cannot include all of these in the model because lack of data for the case of the small beef producers, the difference in geographic concentration and the increasing role of supermarkets in the industry. Also for the case of the importance in imports and the increase for demand of beef, these two are not well adapted into the Muth and Wohlgenant market power model. However, the rest of the features are included like I explain in the nexts paragraphs.

For the demand equation, I will use the similar variables: price of electricity and cost of wage, because according to Maino et al. (1997) energy and labor are the most important components of the total cost of processing the animal, representing between 54.2% and 83.3%.

Then for the supply function I include more variables in order to have a better description. The first group of included variables corresponds to inputs to produce cattle:

corn as one of the main components of the diet in intensive production systems (feedlots) and urea, a fertilizer used to improve the quality of the grasslands in extensive production systems. Remember that extensive and intensive production systems exist in Chile (Verdugo, 2004);

I add farmer's price of milk as a variable, because like I said before the Chilean beef production is related to milk production, in fact, the beef breeds only represent 25% of total beef cattle dedicated to the country (Campos et al., 2009; Oficina de Estudios y Políticas Agrarias, 2007; Fundación Chile, 2006; Fundación Chile, 2005; Dresdner, 2004).

Also I will include a lagged term for the quantity of the cattle sold by farmers, in order to model the behavior of the cattle farmer; who acts according to the cattle life cycle, so they make the decision to produce anticipated.

So the Chilean cattle supply will be:

$$\frac{Q}{I} = \delta_0 + \delta_1 P^f + \delta_2 P^{urea} + \delta_3 P^{corn} + \delta_4 P^{milk} + \delta_5 Q_{12} + \delta_6 T \qquad (4.31)$$

Where:
P^{urea}= Wholesale Price of Urea
P^{corn}= Wholesale price of corn
P^{milk}= Farm Price of Milk
T= Time trend
Q_{12}^{f}= 12 months lagged quantity of cattle sold

To complete the identification I need to find $\left(\frac{\partial P^f}{\partial Q}\right)$ from the supply equation, so solving equation (4.31) for P^f:

$$P^f = \frac{\frac{Q}{I} - \delta_0 - \delta_2 P^{urea} - \delta_3 P^{corn} - \delta_4 P^{milk} - \delta_5 Q_{12} - \delta_6 T}{\delta_1} \qquad (4.32)$$

$$P^f = \frac{\frac{Q}{I}}{\delta_1} - \frac{\delta_0}{\delta_1} - \frac{\delta_2 P^{urea}}{\delta_1} - \frac{\delta_3 P^{corn}}{\delta_1} - \frac{\delta_4 P^{milk}}{\delta_1} - \frac{\delta_5 Q_{12}}{\delta_1} - \frac{\delta_6 T}{\delta_1} \quad (4.33)$$

$$P^f = \frac{1}{I\delta_1} Q - \frac{\delta_0}{\delta_1} - \frac{\delta_2 P^{urea}}{\delta_1} - \frac{\delta_3 P^{corn}}{\delta_1} - \frac{\delta_4 P^{milk}}{\delta_1} - \frac{\delta_5 Q_{12}}{\delta_1} - \frac{\delta_6 T}{\delta_1} \quad (4.34)$$

Now differentiating with respect to Q I get:

$$\frac{\partial P^f}{\partial Q} = \frac{1}{I\delta_1} = 0 \quad (4.35)$$

Now substituting this expression in the Chilean demand equation (4.14) yield to the final empirical specification of the FOC (demand relation):

$$P^f = -\left[\frac{\partial P^f}{\partial Q}\right][\theta]Q + \alpha_1 Q + \alpha_2 P^{wage} + \alpha_3 P^{elec} + \alpha_4 P^w + \varepsilon_t \quad (4.36)$$

$$P^f = -\theta\left[\frac{1}{\delta_1}\right]\frac{Q}{I} + \alpha_1 Q + \alpha_2 P^{wage} + \alpha_3 P^{elec} + \alpha_4 P^w + \varepsilon_t \quad (4.37)$$

Also for the measure the conjectural elasticity (θ) I will use the equation 4.30, so the final system of equation will be:

$$P^f = -(\theta_0 + \theta_1 T)\left[\frac{1}{\delta_1}\right]\frac{Q}{I} + \alpha_1 Q + \alpha_2 P^{wage} + \alpha_3 P^{elec} + \alpha_4 P^w + \varepsilon_t \quad (4.38)$$

$$\frac{Q}{I} = \delta_0 + \delta_1 P^f + \delta_2 P^{urea} + \delta_3 P^{corn} + \delta_4 P^{milk} + \delta_5 Q_{12} + \delta_6 T \quad (4.31)$$

Also, like Muth and Wohlgenant (1999) I will test the model for a fixed conjectural elasticity (θ), so the model will be:

$$P^f = -(\theta_0)\left[\frac{1}{\delta_1}\right]\frac{Q}{I} + \alpha_1 Q + \alpha_2 P^{wage} + \alpha_3 P^{elec} + \alpha_4 P^w + \varepsilon_t \quad (4.39)$$

$$\frac{Q}{I} = \delta_0 + \delta_1 P^f + \delta_2 P^{urea} + \delta_3 P^{corn} + \delta_4 P^{milk} + \delta_5 Q_{12} + \delta_6 T \quad (4.31)$$

Also I will try the monthly dummy model for the conjectural elasticity (θ):

$$\theta = \theta_0 + \theta_1 Jan + \theta_2 Feb + \theta_3 Mar + \theta_4 Apr + \theta_5 May + \theta_6 Jun + \theta_7 Jul + \theta_8 Aug + \theta_9 Sep + \theta_{10} Oct + \theta_{11} Nov \quad (4.40)$$

4.2 Market Power Estimation in Chilean Cattle Market

4.2.1 The Aggregate Model

So as discussed before I follow the NEIO approach from Muth and Wohlgenant (1999), I tried a model which consists in a demand equation (in a linear reduced value marginal product (equation 4.38)), and a supply function adapted to the Chilean cattle market (equation 4.31),

$$P^f = -(\theta)\left[\frac{1}{\delta_1}\right]\frac{Q}{I} + \alpha_1 Q + \alpha_2 P^{wage} + \alpha_3 P^{elec} + \alpha_4 P^w + \varepsilon_t \qquad (4.39)$$

$$\frac{Q}{I} = \delta_0 + \delta_1 P^f + \delta_2 P^{urea} + \delta_3 P^{corn} + \delta_4 P^{milk} + \delta_5 Q_{12} + \delta_6 T \qquad (4.31)$$

Where:
P^f: Chilean cattle farm price
C: Chilean wholesale corn price
I: Inventory of Chilean cattle
Q: Cattle quantity
P^{wage}: Chilean price of labor
P^{elec}: Chilean price of electricity
P^w: Chilean wholesale price of beef
T: Monthly time trend
θ: Conjectural elasticity

For measure the conjectural elasticity (θ) I tried the three used specification plus a new one a monthly based dummy in the form of equation 4.40.

4.2.2 The Sex Separate Model

Following the same approach from the aggregate model I generate separate models for: cows, heifers, steers and oxen (based in the data availability). So I have four new models, consisting in four short-run supply equations and four demand equations, in a linear reduced value marginal product in the form:

Cows:

$$P^f{}_{cow} = -\theta_{cow}\left(\frac{1}{\delta_1}\right)\frac{Q_{cow}}{I_{cow}} + \alpha_1 Q_{cow} + \alpha_2 P^{wage} + \alpha_3 P^{elec} + \alpha_4 P^{w}{}_{cow} \tag{4.41}$$

$$\frac{Q_{cow}}{I_{cow}} = \delta_0 + \delta_1 P^f{}_{cow} + \delta_2 P^{urea} + \delta_3 P^{corn} + \delta_4 P^{milk} + \delta_5 Q_{cow12} + \delta_6 T \tag{4.42}$$

Heifers:

$$P^f{}_{hheih} = -\theta_{hei}\left(\frac{1}{\delta_1}\right)\frac{Q_{hei}}{I_{hei}} + \alpha_1 Q_{hei} + \alpha_2 P^{wage} + \alpha_3 P^{elec} + \alpha_4 P^{w}{}_{hei} \tag{4.43}$$

$$\frac{Q_{hei}}{I_{hei}} = \delta_0 + \delta_1 P^f{}_{hei} + \delta_2 P^{urea} + \delta_3 P^{corn} + \delta_4 P^{milk} + \delta_5 Q_{hei12} + \delta_6 T \tag{4.44}$$

Steers:

$$P^f{}_{ste} = -\theta_{ste}\left(\frac{1}{\delta_1}\right)\frac{Q_{ste}}{I_{ste}} + \alpha_1 Q_{ste} + \alpha_2 P^{wage} + \alpha_3 P^{elec} + \alpha_4 P^{w}{}_{ste} \tag{4.45}$$

$$\frac{Q_{ste}}{I_{ste}} = \delta_0 + \delta_1 P^f{}_{ste} + \delta_2 P^{urea} + \delta_3 P^{corn} + \delta_4 P^{milk} + \delta_5 Q_{ste12} + \delta_6 T \tag{4.46}$$

Oxen:

$$P^f{}_{ox} = -\theta_{ox}\left(\frac{1}{\delta_1}\right)\frac{Q_{ox}}{I_{ox}} + \alpha_1 Q_{ox} + \alpha_2 P^{wage} + \alpha_3 P^{elec} + \alpha_4 P^{w}{}_{ox} \tag{4.47}$$

$$\frac{Q_{ox}}{I_{ox}} = \delta_0 + \delta_1 P^f{}_{ox} + \delta_2 P^{urea} + \delta_3 P^{corn} + \delta_4 P^{milk} + \delta_5 Q_{ox12} + \delta_6 T \tag{4.48}$$

In this way I will run the 4 system separately and obtain the conjectural hypothesis for each of the animal classes.

For measure the conjectural elasticities (θ) I tried the same approaches tested in the aggregate model.

Extra notes about the estimation:

-Here I do not use first differences forms (M&W uses them), because I do not find any different results using it.

-Inventory variable is an annual variable, not monthly, so I repeat the same value for all the 12 months of the correspondent year.

-M&W Use annual data (26 observations), I use monthly from April 1993 to December 2008 (189 observations)

-3 Stages Least Squares was tested using Eviews 8 software, with Cattle Price (P^f), Cattle quantity (Q), Inventory (I) and wholesale price of beef (P^w) as endogenous variables, the rest are exogenous, and also I add other instrumental variables: Wholesale Price of Ammonium phosphate, Quantity of Imported Beef, CIF Price of Beef Imports, Retail Price of pork and Retail price of poultry, quantity of veal, quantity of bulls, wholesale price of oats, and also the one period lagged variables correspondent to each equation and dummy variables. In Appendix A I compare the different instrumental variables based on their correlation with the endogenous variables. Also based on those tables we can conclude that the instruments used are weak and in some cases they do not accomplished a low correlation with LHS variables and high correlation with RSH variables. So to deal with this issue we tried with lagged terms of the same variables, finding better instruments.

-I also run the model in weighted OLS and weighted 2SLS, in order to have a comparison values for the 3SLS models, results for all the AR(1) process models are shown in Appendix C.

-I run the model with first order autoregressive terms AR(1) and second order AR(1) AR(2) too, for each equation of the system in order to look for serial correlation.

-In order to check for relevant structural changes in the elasticities of supply and demand during the period of study, I try running the model adding interaction terms, between price of corn and price of urea, finding only statistical significant results for the aggregated model, however not for the sex separate models. So I do not include this in the final results.

-In the supply function I get rid of the constant term, because without it the model fits better

4.3 Econometric Tests

I tested the model for unit root in variables and residues, cointegration of the residues, and serial correlation of the residues. Also I test for normality of the residues; however this additional test is shown in appendix section B.

4.3.1 Augmented Dickey Fuller over Variables

I test for Stationarity of the variables with the Augmented Dickey Fuller (ADF) test (Table 4.2), finding beef wholesale price (P^{w}), wholesale price of corn (P^{corn}), farmers price of milk (P^{milk}), farm price of cow ($P^{f}{}_{cow}$), wholesale price of cow beef ($P^{w}{}_{cow}$), farm price of heifers ($P^{f}{}_{hei}$), wholesale price of heifer beef ($P^{w}{}_{hei}$), wholesale $price\ of\ steer\ beef$($P^{w}{}_{ste}$), farm price of oxen ($P^{f}{}_{ox}$), wholesale price of oxen beef ($P^{w}{}_{ox}$) and oxen lagged 12 months (Q_{ox12}) stationary at level form. Then the rest of the variables are stationary at first difference form, with exception of heifer`s inventory (I_{hei})

and heifers lagged 12 months (Q_{hei12}), which are stationary in second difference form. So these results tell me that I the variables for the models are stationary in first difference form, so the variables must be included in the model in first difference form, in order to deal with non-stationarity and to deal with problems in the statistical inference from the variables; the model was tried in first difference without obtaining any substantial difference with the model in level form. Also because of these results I make the same test, however for the residues of each model.

Table 4.5. Augmented Dickey Fuller over variables

Variable	Level p-value	First Difference p-value	Second Difference p-value
P^f	0.1635	0.0000***	0.0000***
Q	0.7226	0.0000***	0.0000***
I	0.2677	0.0000***	0.0000***
P^{wage}	0.1894	0.0000***	0.0000***
P^{elec}	0.9992	0.0000***	0.0000***
P^w	0.0870*	0.0000***	0.0000***
P^{urea}	0.6450	0.0000***	0.0000***
P^{corn}	0.0438**	0.0000***	0.0000***
P^{milk}	0.0033***	0.0000***	0.0000***
Q_{12}	0.1193	0.0000***	0.0000***
$P^f{}_{cow}$	0.0509*	0.0000***	0.0000***
Q_{cow}	0.7363	0.0017***	0.0000***
I_{cow}	0.7117	0.0000***	0.0000***
$P^w{}_{cow}$	0.0526*	0.0000***	0.0000***
Q_{cow12}	0.6740	0.0025***	0.0000***
$P^f{}_{hei}$	0.0840*	0.0000***	0.0000***
Q_{hei}	0.2874	0.0010***	0.0000***
I_{hei}	0.9714	0.4098	0.0000***
$P^w{}_{hei}$	0.0872*	0.0000***	0.0000***
Q_{hei12}	0.3171	0.0081	0.0000***
$P^f{}_{ste}$	0.1169	0.0000***	0.0000***
Q_{ste}	0.1879	0.0000***	0.0000***
I_{ste}	0.9981	0.0000***	0.0000***
$P^w{}_{ste}$	0.0841*	0.0000***	0.0000***
Q_{ste12}	0.3306	0.0000***	0.0000***
$P^f{}_{ox}$	0.0670*	0.0000***	0.0000***
Q_{ox}	0.5914	0.0001***	0.0000***
I_{ox}	0.9248	0.0000***	0.0000***
$P^w{}_{ox}$	0.0213**	0.0000***	0.0000***
Q_{ox12}	0.0084***	0.0000***	0.0000***

4.3.2 Augmented Dickey Fuller over Residues

Testing the ADF Test for the residuals of the models (Table 4.3), from each equation and also as a group, I found that all the models reject the null hypothesis of unit root in their residues, except for: the aggregate model with AR(1) term (constant, variable and dummy equations), the oxen model with AR(1) and AR(2) terms (dummy equation); which show unit root in the residues as group. So based on these results we can conclude that the residues from almost all the models do not have unit root, so they are stationary in level form.

Table 4.6. ADF Over Residues of the Models

Model	θ Specification	Individual Level p-value	Common Level p-value
Aggregate Model AR(1)	Constant θ	0.0000	0.2396
	$\theta_0 + \theta_1 T$	0.0000	0.8122
	$\theta = 0$	0.0000	0.0000
	Dummy	0.0000	0.3720
Aggregate Model AR(1)AR(2)	Constant θ	0.0000	0.0000
	$\theta_0 + \theta_1 T$	0.0000	0.0000
	$\theta = 0$	0.0000	0.0000
	Dummy	0.0000	0.0000
Cow AR(1)	Constant θ	0.0000	0.0000
	$\theta_0 + \theta_1 T$	0.0000	0.0000
	$\theta = 0$	0.0000	0.0000
	Dummy	0.0000	0.0000
Cow AR(1)AR(2)	Constant θ	0.0000	0.0000
	$\theta_0 + \theta_1 T$	0.0000	0.0000
	$\theta = 0$	0.0000	0.0000
	Dummy	0.0000	0.0000
Heifer AR(1)	Constant θ	0.0000	0.0000
	$\theta_0 + \theta_1 T$	0.0000	0.0000
	$\theta = 0$	0.0000	0.0000
	Dummy	0.0000	0.0000
Heifer AR(1)AR(2)	Constant θ	0.0000	0.0000
	$\theta_0 + \theta_1 T$	0.0000	0.0000
	$\theta = 0$	0.0000	0.0000
	Dummy	0.0000	0.0000
Ox AR(1)	Constant θ	0.0000	0.0000
	$\theta_0 + \theta_1 T$	0.0000	0.0000
	$\theta = 0$	0.0000	0.0000
	Dummy	0.0000	0.0000
Ox AR(1)AR(2)	Constant θ	0.0000	0.0000
	$\theta_0 + \theta_1 T$	0.0000	0.0000
	$\theta = 0$	0.0000	0.0000
	Dummy	0.0000	0.3104
Steer AR(1)	Constant θ	0.0000	0.0000
	$\theta_0 + \theta_1 T$	0.0000	0.0000
	$\theta = 0$	0.0000	0.0000
	Dummy	0.0000	0.0000
Steer AR(1)AR(2)	Constant θ	0.0000	0.0000
	$\theta_0 + \theta_1 T$	0.0000	0.0000
	$\theta = 0$	0.0000	0.0000
	Dummy	0.0000	0.0000

4.3.3 Johansen Cointegration Test

Testing for cointegration with Johansen Test (Table 4.4), among all the variables shows cointegration in the trace and maximum eigenvalue tests. So in the long run the variables are cointegrated for all the models. So the variables for each of the models are well behaved relative to stationarity and they do not origin problems relative to statistical inference.

Table 4.7. Johansen Cointegration Test Results

Model	Variables	Trace Test	Maximum Eigenvalue Test
Aggregate Model	$P^f, Q, I, P^{wage}, P^{elec}, P^w, P^{urea}, P^{corn}, P^{milk}, Q_{12}$	2 Coint eqs at 0.05 level	2 coint eqs at 0.05 level
Cow Model	$P^{wage}, P^{elec}, P^{urea}, P^{corn}, P^{milk}, P^f{}_{cow}, Q_{cow}, I_{cow}, P^w{}_{cow}, Q_{cow12}$	3 Coint eqs at 0.05 level	2 Coint eqs at 0.05 level
Heifer Model	$P^{wage}, P^{elec}, P^{urea}, P^{corn}, P^{milk}, P^f{}_{hei}, Q_{hei}, I_{hei}, P^w{}_{hei}, Q_{hei12}$	1 Coint eqs at 0.05 level	1 Coint eqs at 0.05 level
Steer Model	$P^{wage}, P^{elec}, P^{urea}, P^{corn}, P^{milk}, P^f{}_{ste}, Q_{ste}, I_{ste}, P^w{}_{ste}, Q_{ste12}$	3 Coint eqs at 0.05 level	1 Coint eqs at 0.05 level
Ox Model	$P^{wage}, P^{elec}, P^{urea}, P^{corn}, P^{milk}, P^f{}_{ox}, Q_{ox}, I_{ox}, P^w{}_{ox}, Q_{ox12}$	4 Coint eqs at 0.05 level	2 Coint eqs at 0.05 level

4.3.4 Durbin Watson Test for Serial Correlation

The models show mainly positive serial correlation or no serial correlation in inverse demand and supply equations, after running the Durbin Watson test (Table 4.5). Is important to notice that before use the AR terms the equations shows negative serial correlation, so based on those previous results I decide to include AR terms in the model.

Also I tried first difference and seasonal difference, however not finding any improvements I discard those models.

Table 4.8. Durbin Watson Test results

Model	Equation	M&W	Cow	Heifer	Ox	Steer
zeroar1ar2	Inv. Dem	NO	NO	NO	NO	NO
	Supply	NO	NO	NO	NO	NO
constar1ar2	Inv. Dem	+	+	NO	+	+
	Supply	NO	NO	NO	NO	NO
varar1ar2	Inv. Dem	+	+	NO	+	+
	Supply	NO	NO	NO	NO	NO
dumar1ar2	Inv. Dem	NO	?	+	+	+
	Supply	?	NO	NO	NO	NO
zeroar1	Inv. Dem	NO	NO	?	NO	NO
	Supply	-	+	?	NO	NO
constar1	Inv. Dem	+	+	+	+	?
	Supply	-	+	+	NO	NO
varar1	Inv. Dem	+	+	+	+	+
	Supply	-	+	+	NO	NO
dumar1	Inv. Dem	+	?	+	+	+
	Supply	-	+	+	NO	NO

+=positive serial correlation, -=negative serial correlation, NO=no serial correlation, ?=not conclusive test

4.4 Aggregate Model Results

I run the model with 3SLS with AR(1) terms for supply and demand equations, finding that some of the coefficient for AR(1) are close to one, so I run the model with the coefficients for AR(1) and AR(2) shows less close to one. The results for the models are shown in Tables 4.6 and 4.7.

Table 4.9. Results from M&W Model for the Chilean Cattle Market with AR(1) Terms

Coef	$\theta = 0$	Constant θ	$\theta_0 + \theta_1 T$	Monthly Dummy
θ_0		-0.113427	0.404693	-0.013536
θ_1			-0.001498	-0.000902
θ_2				-0.002816
θ_3				-0.000794
θ_4				-0.001213
θ_5				-0.001018
θ_6				-0.00247
θ_7				-0.003637
θ_8				-0.004617
θ_9				-0.004378
θ_{10}				-0.003162
θ_{11}				-0.001478
α_1	0.0000000692*	-0.000000334	0.000000573	-0.000000047
α_2	-0.000158*	-0.000685	-0.000157	-0.0000373
α_3	-0.016777**	-0.048248	-0.08508	-0.037048***
α_4	0.42197***	0.366597**	0.354626*	0.305621***
$AR(1)$	0.553101***	0.999288***	0.989451***	0.61766***
δ_1	0.11079	0.122204	0.09915	0.017922
δ_2	0.20103	0.287413**	0.253341*	5.059165***
δ_3	0.448069	0.494016	0.527159	0.442458
δ_4	0.950397***	0.750543**	0.892758**	1.076911***
δ_5	0.049857	0.054916	0.048256	-0.310371**
δ_6	0.002599	0.002244	0.002174	-0.007149**
$AR(1)$	0.569891***	0.559965***	0.558267***	0.583454***

Statistical Significance: ***1%, **5%, *10%

In the expected demand equation, I find an statistically non significant and close to zero relation between farm price of cattle (P^f) and Cattle quantity Q, which could be explained because the technology approximates a constant return to scale, therefore the effect of output prices in input prices dominates (Muth and Wohlgenant, 1999).

The coefficients for the wage and electricity inputs shows negative values for all the electricity and wage cost cases, but electricity shows a little more statistical significance; this could indicate that the energy is a more determinant input in the cost structure of the slaughterhouses. Also, like Muth and Wohlgenant (1999) indicates, the negative relation between inputs and cattle prices is explained by two opposite effects on input demand for cattle: if input price increase generates substitution away from the input and toward an increase in demand for cattle; however the increase in price of input also generates decrease in the production of the output and so on a decrease in the demand for cattle. For this cases the negative effect predominates.

The coefficient for the wholesale price of beef is positive and statistically significant in almost all the models, which make sense because an increase in the price of processed beef will increase the price of cattle. This also could be indicating price transmission from slaughterhouses to producers.

The AR(1) parameter shows highly statistical significant values, but only close to one in the cases of constant and variable conjectural elasticity (θ); this indicates positive serial correlation of the errors.

The supply function shows a statistically non significant and positive relation between the ratio cattle quantity and Inventory ($\frac{Q}{I}$) and the farm price of cattle (P^f); which is sign expected, but the statistical non significance could be showing issues related with the structure of the cattle in Chile, mainly for milk production so beef is a sub product of the milk market.

The coefficient for the price of urea shows positive and statistically significant values for all the models, which is not expected, because it was considered an input in extensive cattle, systems based in pastures, so a cost component.

The coefficient for the price of corn shows positive and statistically non significant values; this also does not make sense because is the main input for intensive production.

The coefficient for the farm price of milk is statistically significant in all models, and shows positive values, which is not expected because if the prices of the milk increase, the sacrificed animals must decrease in a milk production based cattle.

The coefficient for the one year (12 months) lagged quantity of sacrificed cattle is positive and statistically non significant for the models except for the monthly dummy that is significant and negative, which make sense in relation with the seasonality of the cattle cycle, and for the case of the dummy, this seasonality is disaggregated. The time trend coefficient shows similar results that the lagged quantity of sacrificed animals.

The AR(1) coefficient shows values positives and highly statistically significant, but not close to one, so show not serial correlation for this function.

The values for the conjectural elasticities show mainly negative values between zero and negative one, and statistically not significant, so are equivalent to zero. The negative signs are different from Muth and Wohlgenant Model, but the non statistical significance is the same. So this indicates not market power or imperfect market structure for cattle buyers. The dummy model coefficients do not show any significant parameters for the monthly dummy variables, however, shows different values in each dummy, which could be interpreted as a variation in the market power through the year.

The cattle conjectural elasticity (θ) measures the percentage change in the total packing industry purchase of cattle when a particular firm purchase change in 1%, this is expected to be positive related, so the increase of a particular firm in 1% will increase the purchase of all the industry in certain percentage. The expected values for this elasticity are from 0, in case of perfect competition (because there are so many firms in the industry so, none of them could influence the rest), 1 for the monopsonistic case (because in that case, there will be a one by one response, so there is only one firm the whole market) and also intermediate values, showing degrees of oligopsony. So based on that interpretation, negative values or greater than 1, are not expected, however, in our results we have some negative values but in general very close to zero. Without these exceptions, the results are very similar to the original Muth and Wohlgenant (1999) paper, they said about the negative values are possible just because the sample variation. Other explanation could be just a negative response to the purchase of a firm, so if a firm purchase cattle increase in 1% the industry reduces the purchase in certain percentage, which could be possible under some conditions of information and a different strategy from the rest of the industry, in which the industry tries to contract in response to an expansion of some firm or maybe related with geographical distance.

Table 4.10. M&W Model for the Chilean Cattle Market with AR(1) and AR(2) Terms

Coef	Constant θ	$\theta_0 + \theta_1 T$	$\theta = 0$	Monthly Dummy
θ_0	0.085062	0.135633		0.113862
θ_1		0.000225		-0.023429
θ_2				0.026456
θ_3				-0.025077
θ_4				0.014362
θ_5				-0.019716
θ_6				0.02246
θ_7				0.002613
θ_8				0.038419
θ_9				0.0086
θ_{10}				0.032468
θ_{11}				-0.01427
α_1	-0.00000198	-0.0000035	0.0000000712**	0.0000000158
α_2	0.00089	0.001436	-0.0000943	0.00034
α_3	-0.111485	-0.037726	-0.017903**	0.033382
α_4	0.264439	0.07971	0.397538***	0.287225***
$AR(1)$	-0.539847	-0.937695*	-0.000994	0.990233***
$AR(2)$	1.472484***	1.93985***	0.572268***	0.013946
δ_1	-0.011796	-0.011803	-0.016119	-0.115303
δ_2	0.296284**	0.309428**	0.25966*	7.37166***
δ_3	0.859099**	0.872199**	0.717731**	0.258583
δ_4	1.061371***	1.031684***	1.054433***	0.57483*
δ_5	0.037891	0.039258	0.07945	-0.264451***
δ_6	0.00153	0.001471	0.001859	-0.010056***
$AR(1)$	0.309384***	0.310997***	0.269229***	0.459365***
$AR(2)$	0.405945***	0.40519***	0.425723***	0.346851***

Statistical Significance: ***1%, **5%, *10%

The model with AR(1) and AR(2) terms shows different parameters values than the AR(1) model: In the inverse demand equation I have more positive values for the conjectural elasticity, some positive values for the price of cattle in response at the quantity, which is not expected. Also the price of wage coefficient is mainly positive, which is also unexpected.

The AR terms are far from 1, the only exception is the dummy model which shows a close to one AR(1) term. In the supply of cattle equation I have a negative relation between quantity-inventory and price of cattle which is not expected. Also the significance of the coefficient of price of urea, price of corn and price of milk increase their significance.

So the new model gives us a decrease on the frequency of serial correlation, with respect at the relations between variables does not give us relevant results.

4.5 Sex Separate Models Results

I run the model with 3SLS with AR(1) terms for supply and demand equations, finding that some of the coefficient for AR(1) are close to one (Tables 4.8, 4.9, 4.10 and 4.11), so I run the model with AR(1) and AR(2), decreasing the AR values close to one (Tables 4.12, 4.13, 4.14, 4.15)

Table 4.11. Results from Cows Model for the Chilean Cattle Market with AR(1) Terms

Coef	$\theta = 0$	Constant θ	$\theta_0 + \theta_1 T$	Monthly Dummy
θ_0		0.014904	0.136496	0.064011
θ_1			-0.000523	0.003832
θ_2				0.008781
θ_3				-0.001434
θ_4				0.000623
θ_5				-0.004402
θ_6				0.003434
θ_7				0.013361
θ_8				0.020392
θ_9				0.026625
θ_{10}				0.017368
θ_{11}				0.00743
α_1	-0.000229	-0.000821	-0.002552	-0.000542
α_2	-0.0000815	-0.000934	-0.00069	-0.000631
α_3	0.009031	-0.079686	-0.050948	-0.041323
α_4	0.429783***	0.294599*	0.2233	0.160006
$AR(1)$	0.557895***	1.000395***	1.0027***	0.99844***
δ_1	-0.0000551	-0.0000487	-0.0000426	-0.0000642
δ_2	0.000454***	0.000451***	0.000467***	0.000491***
δ_3	0.000206	0.000184	0.000155	0.0000249
δ_4	0.000336	0.000309	0.000276	-0.00015
δ_5	0.00000028**	0.000000294***	0.000000301***	0.000000573***
δ_6	-0.00000229	-0.00000229	-0.00000231	-0.00000229*
$AR(1)$	0.679891***	0.678171***	0.678019***	0.608137***

Statistical Significance: ***1%, **5%, *10%

Table 4.12. Heifers Model for the Chilean Cattle Market with AR(1) Terms

Coef	$\theta = 0$	Constant θ	$\theta_0 + \theta_1 T$	Monthly Dummy
θ_0		0.096648	0.147009	0.147392
θ_1			-0.000111	0.014721
θ_2				0.023043
θ_3				0.009867
θ_4				0.018312
θ_5				0.013716
θ_6				0.035699
θ_7				0.053509
θ_8				0.066465
θ_9				0.082695
θ_{10}				0.050893
θ_{11}				0.027155
α_1	-0.000834***	-0.003757	-0.005047	-0.000431
α_2	0.000454***	-0.000839	-0.000716	-0.000867
α_3	-0.025429**	-0.124756	-0.127045	-0.05334
α_4	0.395976***	0.398953	0.412853	0.433002
$AR(1)$	0.64477***	1.000516***	1.001268***	0.935918***
δ_1	-0.0000481	-0.0000512	-0.0000516	-0.0000993
δ_2	0.000522***	0.000484***	0.00049***	0.000554***
δ_3	-0.000161	-0.000164	-0.000163	-0.000442
δ_4	0.000274	0.000403	0.000396	0.000444
δ_5	0.00000125***	0.0000012***	0.0000012***	0.00000144***
δ_6	-0.00000162	-0.00000148	-0.00000146	-0.00000352
$AR(1)$	0.533496***	0.554705***	0.55517***	0.506656***

Statistical Significance: ***1%, **5%, *10%

Table 4.13. Steers Model for the Chilean Cattle Market with AR(1) Terms

Coef	$\theta = 0$	Constant θ	$\theta_0 + \theta_1 T$	Monthly Dummy
θ_0		0.350145	-0.389632	-0.081918
θ_1			0.002743	0.032668**
θ_2				0.047872***
θ_3				0.019978**
θ_4				0.058782**
θ_5				0.040824**
θ_6				0.063608***
θ_7				0.064204***
θ_8				0.059571***
θ_9				0.060249**
θ_{10}				0.050125**
θ_{11}				0.045088**
δ_1	-0.00064*	-0.00061*	-0.000649*	-0.000837***
α_1	0.0000742	-0.001461	0.000141	0.000677
α_2	-0.000115	-0.001151	-0.000703	-0.000593**
α_3	-0.003783	-0.136785	-0.080555	-0.022377
α_4	0.492122***	0.475844**	0.386797*	0.446652***
$AR(1)$	0.574103***	0.999398***	0.992939***	0.745687***
δ_1	-0.00064*	-0.00061*	-0.000649*	-0.000837***
δ_2	0.000917*	0.001061**	0.000961**	0.000722
δ_3	0.001276	0.001172	0.001267	0.000139
δ_4	0.004744***	0.004147***	0.004419***	0.004444***
δ_5	0.00000111***	0.00000118***	0.00000118***	0.00000164***
δ_6	0.0000197**	0.0000191**	0.0000189**	0.0000137**
$AR(1)$	0.517728***	0.514437***	0.513712***	0.507513***

Statistical Significance: ***1%, **5%, *10%

Table 4.14. Results from Oxen Model for the Chilean Cattle Market with AR(1) Terms

Coef	$\theta = 0$	Constant θ	$\theta_0 + \theta_1 T$	Monthly Dummy
θ_0		0.025277	-0.033908	-0.028276
θ_1			-0.0000689	-0.016027
θ_2				-0.011939
θ_3				0.005243
θ_4				0.003833
θ_5				-0.000179
θ_6				-0.00759
θ_7				-0.002081
θ_8				-0.013636
θ_9				-0.010544
θ_{10}				-0.027639
θ_{11}				-0.011753
δ_1	0.0000479	0.0000524	0.0000557	0.000208
α_1	0.000874	0.004486	-0.000944	0.001563
α_2	0.000099	-0.000619	0.0000833	0.000448
α_3	-0.036827***	0.016011	0.250649	0.135839
α_4	0.427495***	0.173254	-0.133716	-0.010799
$AR(1)$	0.437014***	0.99788***	1.031923***	1.021729***
δ_1	0.0000479	0.0000524	0.0000557	0.000208
δ_2	0.001804***	0.0018***	0.001759***	0.001851***
δ_3	-0.002199***	-0.002208***	-0.002217***	-0.002516***
δ_4	0.000849	0.000853	0.001053	-0.000818
δ_5	0.00000348***	0.00000346***	0.00000322***	0.00000559***
δ_6	-0.0000152***	-0.0000152***	-0.000016***	-0.0000076
$AR(1)$	0.683773***	0.683737***	0.690659***	0.706557***

Statistical Significance: ***1%, **5%, *10%

The results show: statistically significant market power parameters for the steers in all monthly dummies. Cows and heifers show a negative relation between price and quantity in the demand equation and also in the supply equation, which could be related with the inverse relation that the female animals have in the stock, also non statistically significant coefficients, which also could be related with the same. The oxen show positive relation price quantity in both equations, but also non significant. The steers by the other side, show negative relation for the price and quantity in demand equation, but positive for the supply equations, so is an expected result, which is also statistically significant for the quantity if cattle.

The parameters of the prices of wage and energy show negative and non statistically significant values. Respect to the wholesale price of beef, all shows positive and significant values.

All the animals show positive supply response to the price of the fertilizer (P^{urea}), but the heifers and oxen have negative values for the price of corn (P^{corn}), both could be related with the production system and the food supplementation through corn, which could be critical in intensive systems for heifers, which make sense based on the milk industry.

The price of milk shows positive response in the female animal which is not expected, but could be explained because the prices of milk will not determine the sacrifices of female cattle.

Finally all animals show positive response from the 12 months lagged cattle supply, and most of the times statistically significant. So in general terms the sex separate models allow us to identify more characteristics of this industry which is the expected for a disaggregated model.

The most important finding is in the monthly dummy model Table 4.10, the steer model shows all of the conjectural elasticity parameters with statistically significant coefficients, which could be a clear indicator of market power in the steer market. This market power issue does not appears in the female cattle (heifers or cows) because is an investment to keep them in the herd for the milk and to keep the production. Also there is significant result for the case of the oxen (table 7d) but this is a marginal case, because the oxen are just sold after they finish their lifespan as farmer`s tool. The rest of the farmers, for example from the diary sector, have the steers like disposal material from the milk production system, so they can try to get rid of these animals when they are young or if they choose to keep them they can just use cheap extensive systems based on pastures, so not expecting a better price. Maybe this strategy could be used by the farmers who fat the animals, low cost production, that also allows expanding the period to sell. By the other hand the expected demand for this model shows an AR(1) coefficient close to one, indicating serial correlation of the errors, which is negative for the model. Anyway this results do not show evidence of market power from this market, because the monthly market power (constant parameter plus monthly dummy) do not show statistically significant results.

The AR(1) for the case of the demand function shows values closed to one in the constant and variable conjectural elasticity model. The AR(1) for the supply function are far from one.

Table 4.15. Cows Model for the Chilean Cattle Market with AR(1) and AR(2) Terms

Coef	$\theta = 0$	Constant θ	$\theta_0 + \theta_1 T$	Monthly Dummy
θ_0		-0.53721	-0.536977	0.076594
θ_1			-0.00000559	0.005115
θ_2				0.011226
θ_3				-0.001539
θ_4				0.001083
θ_5				-0.004549
θ_6				0.005083
θ_7				0.017031
θ_8				0.025458
θ_9				0.032869
θ_{10}				0.021454
θ_{11}				0.00951
α_1	-0.000112	0.003585	0.003582	-0.000529
α_2	-0.000101	-0.00034	-0.000334	-0.000576
α_3	0.006082	0.068884	0.06946	-0.049619
α_4	0.415673***	0.617972	0.615695	0.175237
$AR(1)$	0.615375***	1.422447**	1.423092**	1.002295**
$AR(2)$	-0.099272	-0.532147	-0.532341	-0.003479
δ_1	-0.000085	-0.0000813	-0.0000813	-0.0000785
δ_2	0.000416***	0.000415***	0.000415***	0.000393***
δ_3	0.000228	0.000204	0.000204	0.000137
δ_4	0.000126	0.000103	0.000103	-0.000148
δ_5	0.000000413***	0.000000429***	0.000000429***	0.000000582***
δ_6	-0.00000115	-0.00000118	-0.00000118	-0.000000849
$AR(1)$	0.427292***	0.423153***	0.423139***	0.388816***
$AR(2)$	0.335841***	0.33522***	0.335236***	0.351044***

Statistical Significance: ***1%, **5%, *10%

Table 4.16. Heifers Model for the Chilean Cattle Market with AR(1) and AR(2) Terms

Coef	$\theta = 0$	Constant θ	$\theta_0 + \theta_1 T$	Monthly Dummy
θ_0		0.006213	0.054369	0.132153
θ_1			-0.000109	0.015985
θ_2				0.025074
θ_3				0.010548
θ_4				0.020374
θ_5				0.01569
θ_6				0.040449
θ_7				0.060842
θ_8				0.076251
θ_9				0.094598
θ_{10}				0.057773
θ_{11}				0.030743
α_1	-0.00088***	-0.001277	-0.001844	0.0000384
α_2	0.000856***	0.000393	0.000456	-0.000856
α_3	-0.021154	-0.029595	-0.029931	-0.03605
α_4	0.237585***	0.263264**	0.269024**	0.408383
$AR(1)$	0.589308***	0.391898	0.395983	1.045531
$AR(2)$	0.252177***	0.605091	0.602453	-0.083662
δ_1	-0.000124	-0.000113	-0.000114	-0.000115
δ_2	0.000388**	0.000398**	0.000403**	0.000404**
δ_3	0.000185	0.00013	0.000134	-0.000083
δ_4	0.000312	0.000457	0.000453	0.000404
δ_5	0.00000134***	0.00000126***	0.00000126***	0.00000144***
δ_6	-0.000000562	-0.00000166	-0.00000166	-0.00000247
$AR(1)$	0.398736***	0.383873***	0.383963***	0.367719***
$AR(2)$	0.284057***	0.29729***	0.297331***	0.312253***

Statistical Significance: ***1%, **5%, *10%

Table 4.17. Steers Model for the Chilean Cattle Market with AR(1) and AR(2) Terms

Coef	$\theta = 0$	Constant θ	$\theta_0 + \theta_1 T$	Monthly Dummy
θ_0		0.036261	0.019855	0.031322
θ_1			0.0000263	-0.02152
θ_2				-0.016029
θ_3				0.006237
θ_4				0.005659
θ_5				0.001704
θ_6				-0.004695
θ_7				0.002489
θ_8				-0.008058
θ_9				-0.005528
θ_{10}				-0.029736
θ_{11}				-0.016676
α_1	0.001058*	0.010322	0.008779	0.004248
α_2	0.00019*	-0.000241	0.000122	0.000968
α_3	-0.033958***	0.031406	0.049005	0.142935
α_4	0.369249***	0.515869	0.176416	0.038322
$AR(1)$	0.385905***	1.29365***	1.39119***	1.419164***
$AR(2)$	0.161887**	-0.39646	-0.484212	-0.415258
δ_1	0.00000356	0.0000219	0.0000209	0.000201
δ_2	0.001791***	0.001786***	0.001765***	0.001864***
δ_3	-0.002098***	-0.002104***	-0.002098***	-0.002424***
δ_4	0.000887	0.000854	0.001099	-0.000768
δ_5	0.0000036***	0.00000355***	0.00000317***	0.00000534***
δ_6	-0.0000151***	-0.0000151***	-0.0000161***	-0.00000788
$AR(1)$	0.735359***	0.73133***	0.742477***	0.682083***
$AR(2)$	-0.078429	-0.073661	-0.088592	0.018053

Statistical Significance: ***1%, **5%, *10%

Table 4.18. Oxen Model for the Chilean Cattle Market with AR(1) and AR(2) Terms

Coef	Constant θ	$\theta_0+\theta_1 T$	$\theta=0$	Monthly Dummy
θ_0		0.715902	0.079555	1.235205
θ_1			0.002321	0.032523
θ_2				0.065794
θ_3				0.034809
θ_4				0.067951
θ_5				0.054805
θ_6				0.074675
θ_7				0.06948
θ_8				0.067704
θ_9				0.051915
θ_{10}				0.05646
θ_{11}				0.061333
α_1	0.0000416	-0.002058	-0.000949	-0.002674
α_2	-0.0000759	0.00069	-0.000485	0.004128
α_3	-0.0028	-0.200299	-0.028486	-0.122575
α_4	0.492051***	0.607172	0.404718	1.057155*
$AR(1)$	0.622723***	1.83391***	1.947331*	1.939838***
$AR(2)$	-0.060767	-0.844289	-0.94702	-0.939672***
δ_1	-0.000812***	-0.000811***	-0.000812***	-0.000878***
δ_2	0.000853*	0.000848	0.000855*	0.000883*
δ_3	0.001513	0.001546	0.001516	0.000562
δ_4	0.004708***	0.004633***	0.00464***	0.004315***
δ_5	0.00000129***	0.0000013***	0.0000013***	0.0000016***
δ_6	0.0000169*	0.0000169*	0.0000168*	0.000013*
$AR(1)$	0.465702***	0.464856***	0.464917***	0.46556***
$AR(2)$	0.097658	0.099979	0.099697	0.076826

Statistical Significance: ***1%, **5%, *10%

The results with the AR(1)AR(2) model do not show major difference than the AR(1) model, the most notable difference is that the steers model do not show any more statistically significant conjectural elasticities, and of course the values for the coefficient of the AR(1) value, change mostly in the inverse demand equation with values greater than one in most the cases.

4.5.1 Additional Hypothesis Testing for Steers Market Power

Because I find conjectural elasticity parameters significant for the steers in the AR(1) model, I calculate the total monthly conjectural elasticity: which is equal to the constant value plus the monthly value, this give us the results in the Figure 4.1.

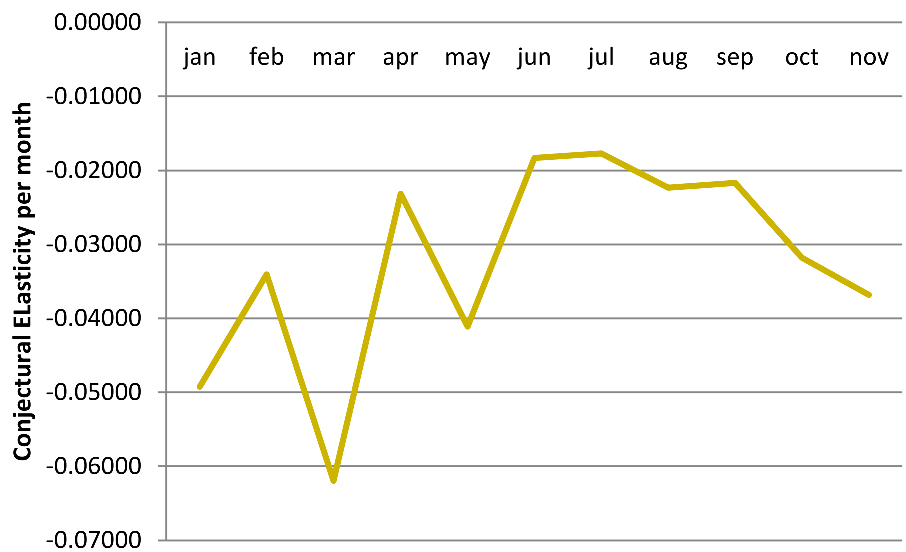

Figure 4.12. Conjectural Elasticity Values though the Months of a Year

Now looking at the significance of the sum of the individual coefficients, I try the Wald test and a t-test (Table 4.16), finding mostly statistically significant values for the case in which I multiply the dummy variable by the number times the month appears in the series. For the case with no multiplication I find all values not significant.

Table 4.19. Significance of the Sum of Coefficients to Determine Conjectural Elasticity

Model	p-value	T-test
C(1) +C(13)=0	No significant	No significant
C(1) +C(14)=0	No significant	No significant
C(1) +C(15)=0	No significant	No significant
C(1) +C(16)=0	No significant	No significant
C(1) +C(17)=0	No significant	No significant
C(1) +C(18)=0	No significant	No significant
C(1) +C(19)=0	No significant	No significant
C(1) +C(20)=0	No significant	No significant
C(1) +C(21)=0	No significant	No significant
C(1) +C(22)=0	No significant	No significant
C(1) +C(23)=0	No significant	No significant

Also I check with the Wald test (Table 4.17) if all the monthly coefficients have an effect together, but the result cannot reject the null hypothesis that this coefficient have an effect together, so then I tried with some of the coefficients that are related with periods of the year when the steers are ready to sell (from July), and in that case I find statistically significant values for periods of three months following July (July, august, September or august, September, October), but if I move more to the end the year and beginning of the next year (September, October, November or October, November, January) I do not find any statistical significance. I also test for month not related in time (i.e. January, May, October) and the result was not significant. These results make sense because if the steers complete their cycle at the end of July, the steers are ready to be sold after the fattening period, so the farmers want to sell the animals in order to recover the money and avoid more cost. If the farmers just fat animals will be in disadvantage, for the previous reasons, and also because if the animal is not a beef breed, the amount of beef per animal is lower and also the costs are higher because the efficiency of conversion is lower. And the most of the cattle is sold in those first months after the end of the cycle.

Table 4.20. Wald Test Chi-Squared p-values for AR(1) Monthly Dummy Model

Test H0	p-value
$\theta_{jul} = \theta_{aug} = \theta_{sep} = 0$	0.0532
$\theta_{aug} = \theta_{sep} = \theta_{oct} = 0$	0.0556
$\theta_{sep} = \theta_{oct} = \theta_{nov} = 0$	0.1182
$\theta_{oct} = \theta_{nov} = \theta_{jan} = 0$	0.1127
$\theta_{jan} = \theta_{may} = \theta_{oct} = 0$	0.1103
$\theta_{jan} = \theta_{feb} = \theta_{mar} = \theta_{apr} = \theta_{may} = \theta_{jun} = \theta_{jul} = \theta_{aug} = \theta_{sep} = \theta_{oct} = \theta_{nov} = 0$	0.6692

4.6 Results Analysis

In all the regression models I cannot find any evidence of market power in the Chilean Cattle Market, however this could be explained mainly by two reasons: special features of the Chilean Cattle Market and the nature of market power estimation.

Firstly the Chilean Cattle Market, like I said before, is different from other countries` cattle markets, these differences can be summarized in:

1) Beef producers are poor and low qualified

2) Beef is a byproduct of milk production

3) Types of production: central intensive, and south extensive

4) Geographical and Market Concentration of Beef Packing

5) Beef Law (1993) and increasing demand for beef

6) Increasing role of importation

So based on this is expected to not find any market power evidence, because first of all the main cattle supply to slaughterhouses is cattle from the milk industry, so is an industry based on byproducts, where the milk farmers try to sell the males and old females, as a secondary way to earn money, which could give them some market power to sell or at least do not care to much about the selling price. Also the concentration of slaughterhouses because of Beef Law, is mixed with the increasing role of supermarkets in the industry and the dramatically increase in imports, consequently the supermarkets and imports compensate the concentration in slaughterhouses.

Secondly, looking at the results from other authors looking market power in a country with a developed cattle industry, like United States, they also in some cases do not find any significant market power evidence, or none. First of all Muth and Wohlgenant (1999), which is the main paper for this research, do not find evidence in market power for the U.S. Cattle Market. The rest of the analyzed paper have different findings: Schroeter (1988) and Azzam and Pagoulatos (1990) find little evidence of buyers` market power (1% and 1.1% respectively), however Schroeter (1988) concludes that in spite of increased concentration in this industry the market power remains constant. Similar is the case of Azzam and Park (1993), who find different values for θ for three periods: 1960-1977 ($\theta_v = 0.0093$) which is extremely low and shows no evidence of oligopsony; 1978-1982 ($\theta_v = 0.031$); and 1982-1987 ($\theta_v = 0.016$). So the last two periods show little evidence of market power, however as the same as Schroeter (1988), they said that the market power remains constant, or even decrease a little, which is not expected because in that period of time the concentration increases; consequently an increase in concentration could be related with a decrease in market power.

Finally there is an important detail to add, the buyers` market power value is determined by conjectural hypothesis (θ), but also for the elasticity of cattle supply (ϵ); so market power from the buyer: $M = \frac{\theta}{\epsilon}$. In this case I never found statistically different from zero values for θ, so market power always is zero for this research; however for some cases could be that you can find small values of θ, but also small values for ϵ, and get a very high market power value.

CHAPTER 5: CONCLUSION

5.1 Conclusion

The beef market in Chile, is characterized by a demand for live animals consists mainly of slaughtering companies which are concentrated near the big cities of the country, and that since the mid-nineties have start to decline, thus increasing market concentration. The supply of cattle is given by producers who are mainly from the south of Chile. There is a decline in animal production, compared to previous years, despite the increasing demand for meat, which has been partly satisfied by increased imports and sacrifice of belly, which does not guarantee future maintain stable production. The decrease is due among other things to the low yield per hectare of business because of their higher production costs and low prices paid.

The aggregate model shows coefficients with non-expected values, but then in the sex separate model I find details about some of those results. Anyway still there are issues to be addressed more deeply.

The conjectural elasticities values are statistically significant equal to zero in almost all the models, the only exception is the steer monthly dummy model where I find significant values for the market power parameter for all the months, this could suggest that market power is exercised on the market for steers and also depends on the seasonality. As I know the steers in Chile represents a sub product of the milk farms so is the type of bovine with more movement in the market and also the biggest in number. However the results show that there is no statistically significant monthly market power, so the market has no market power from the firms.

The results are explained because the characteristic of the Chilean Cattle market, especially that the cattle for beef is a byproduct of the diary industry, the increasing role of the supermarkets in the industry and the dramatically increase of beef imports. Also the results are supported based on results of similar studies, but applied to the United States Cattle Industry, like Muth and Wohlgenant (1999), Schroeter (1988) and Azzam and Park (1993).

5.2 Final Recommendations

I do not find market power, however the Chilean Beef-Cattle Industry is decreasing in importance against the imports, so in order to support the producers there are some recommendations for the farmers:

5.2.1 Increase Technical-Marketing Knowledge to Farmers

Like I talk before the Chilean cattle producers, specially the smaller ones, have a lack a technical and commercial knowledge about the cattle production. If they can improve that knowledge the efficiency will increase and the production costs will decrease so they will be better off to confront a market power situation.

Technically speaking the producers need to know how to select the fittest cattle breed for the edaphoclimatic conditions and also for the available resources. For that case Hereford breed is one of the best options for Chilean production based on its hardiness. Also the farmers need to learn how to control the animal productive cycle in order to produce animals in the shortest time and at the smallest cost, this is linked with the correct grassland management which is determinant to decrease the cost of food.

Also the farmers need advice to know which part of the productive process fits better with them: first stage birth, breeding first stages (calves), breeding final stages (heifers or steer), or the whole process. Most of the times the farmers assume the whole process instead of focusing in one so the take most of the time and costs making the process inefficient. Also the farmers must decide among beef, milk or mixed production, and complementary productions, like a silvopastoral system. Even in some cases the cattle production could be non profitable and the producers must produce something more appropriate to their conditions.

Finally the producers must learn how to use the tools and money given by the government and also how to use the available information about prices, for example, in order to have an idea about the opportunities offered by the market.

5.2.2 Increase Technology Transfer

Very related with the previous point, the government spends money in research and development for the beef sector, but the way to transfer this knowledge must improve and also the information must be processed for a better understanding from them, or just the more educated farmers will take advantage of it.

5.2.3 Promote Association between Producers

Like I express before the association, especially between small farmers, is an affordable way to establish an opposite force to the sellers and get better prices but also buy inputs at lower prices, at least among farmers located geographically close. Also could be very convenient to share facilities if they want to process and export beef by themselves.

5.2.4 Explore New Markets: like Export High Quality Beef

A nice option to the producers could be to explore new markets in high income segments in the country or abroad, producing more valuable breeds like: the intense marbling Wagyu, the soft meat Angus, or the leaner meat Limousin; or also another types of production like organic. The main problem with this is that is easier in some way to make it if you sell your own product, more than sell the animal, so the producers needs to integrate vertically the process in order to process the animal and get the beef. Also another problem is to get the certification if they want to export the beef to developed countries or for organic production. The other case if the producers just focus on produce the animal, the processing sector needs to consolidate beef exports, which are very limited in the country. Could be that the government promotes this kind of exports and make with the beef the same than with the fresh fruit, wine and salmon, taking advantage of Chile´s multiple free trade agreements.

5.2.5 Use of Contracts

Just like I mentioned before, the use of contracts for animal sell could help the producers giving them some guaranties about the amount of money earned every season, also ensuring a minimum selling quantity, a stable amount of money, and avoiding imperfect competition effects. Moreover with the use of contracts the producers will need to get a minimal quality, improving their production, generating feedback between firms and producers. Also the contracts could be between firms and groups of farmers, which could be very positive in a sense that together they need to reach a volume, so everyone can produce whatever they can. Anyway in order to reach this requires a joint effort between firms, farmers and government, which is critical because needs to give the first signal that this could be possible.

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APPENDICES

Appendix A Instrumental Variables Correlations

Table A.1. Instrumental Variables Correlation with LHS and RHS Variables for Aggregate Model

			Instruments										
			P^{wa}	P^{el}	P^{am}	P^{ch}	P^{i}	P^{co}	P^{mi}	P^{po}	P^{ur}	Q^{i}	t
LHS Variables	D	P^{f}	-0.2	-0.3	-0.2	0.1	-0.2	0.5	0.5	0.6	-0.2	-0.6	-0.8
	S	Q	0.1	0.1	0.2	0.2	0.1	0.3	0.4	0.2	0.3	-0.4	-0.3
		I	0.6	-0.6	-0.3	-0.4	-0.1	-0.3	-0.5	-0.5	-0.5	0.4	0.1
RHS Variables	D	P^{wa}	1.0	-0.7	-0.2	-0.7	-0.1	-0.2	-0.2	-0.6	-0.5	0.1	0.0
		P^{el}	-0.7	1.0	0.6	0.7	0.5	0.0	0.2	0.2	0.8	0.1	0.5
	S	P^{co}	-0.2	0.0	0.2	0.3	-0.2	1.0	0.5	0.4	0.2	-0.5	-0.6
		P^{mi}	-0.2	0.2	0.3	0.2	-0.1	0.5	1.0	0.5	0.3	-0.6	-0.5
		P^{ur}	-0.5	0.8	0.8	0.6	0.5	0.2	0.3	0.3	1.0	0.0	0.3
		t	0.0	0.5	0.3	0.0	0.5	-0.6	-0.5	-0.5	0.3	0.7	1.0

Table A.2. Instrumental Variables Correlation with LHS and RHS Variables for Cow Model

			Instruments										
			P^{wa}	P^{el}	P^{am}	P^{ch}	P^{i}	P^{co}	P^{mi}	P^{po}	P^{ur}	Q^{i}	t
LHS Variables	D	${P^{f}}_{cow}$	-0.2	-0.2	-0.1	0.1	0.5	-0.5	0.6	0.7	-0.1	-0.6	-0.8
	S	Q_{cow}	0.2	0.0	0.4	0.2	0.4	-0.1	0.5	0.2	0.4	-0.4	-0.3
		I_{cow}	-0.6	0.5	-0.6	-0.6	-0.3	0.5	-0.5	-0.5	-0.6	0.4	0.1
RHS Variables	D	P^{wa}	1.0	-0.7	0.6	0.7	0.0	-0.1	0.2	0.2	0.8	0.1	0.5
		P^{el}	-0.7	1.0	-0.2	-0.7	-0.2	0.4	-0.2	-0.6	-0.5	0.1	0.0
	S	P^{co}	0.0	-0.2	0.2	0.3	1.0	-0.3	0.5	0.4	0.2	-0.5	-0.6
		P^{mi}	0.2	-0.2	0.3	0.2	0.5	-0.4	1.0	0.5	0.3	-0.6	-0.5
		P^{ur}	0.8	-0.5	0.8	0.6	0.2	0.0	0.3	0.3	1.0	0.0	0.3
		t	0.5	0.0	0.3	0.0	-0.6	0.5	-0.5	-0.5	0.3	0.7	1.0

Table A.3. Instrumental Variables Correlation with LHS and RHS Variables for Heifer Model

			Instruments										
			P^{wa}	P^{el}	P^{am}	P^{ch}	P^{i}	P^{co}	P^{mi}	P^{po}	P^{ur}	Q^{i}	t
LHS Variables	D	$P^{f}{}_{\square ei}$	-0.3	0.0	-0.2	-0.1	0.4	-0.5	0.5	0.5	-0.3	-0.6	-0.8
	S	Q_{hei}	-0.2	0.6	0.1	-0.3	0.0	0.3	0.0	-0.4	-0.1	-0.1	0.0
		$I_{\square ei}$	-0.9	0.7	-0.6	-0.7	-0.2	0.3	-0.4	-0.5	-0.7	0.1	-0.2
RHS Variables	D	P^{wa}	1.0	-0.7	0.6	0.7	0.0	-0.1	0.2	0.2	0.8	0.1	0.5
		P^{el}	-0.7	1.0	-0.2	-0.7	-0.2	0.4	-0.2	-0.6	-0.5	0.1	0.0
	S	P^{co}	0.0	-0.2	0.2	0.3	1.0	-0.3	0.5	0.4	0.2	-0.5	-0.6
		P^{mi}	0.2	-0.2	0.3	0.2	0.5	-0.4	1.0	0.5	0.3	-0.6	-0.5
		P^{ur}	0.8	-0.5	0.8	0.6	0.2	0.0	0.3	0.3	1.0	0.0	0.3
		t	0.5	0.0	0.3	0.0	-0.6	0.5	-0.5	-0.5	0.3	0.7	1.0

Table A.4. Instrumental Variables Correlation with LHS and RHS Variables for Oxen Model

			Instruments										
			P^{wa}	P^{el}	P^{am}	P^{ch}	P^{i}	P^{co}	P^{mi}	P^{po}	P^{ur}	Q^{i}	t
LHS Variables	D	$P^{f}{}_{ox}$	-0.4	-0.1	-0.3	0.0	0.4	-0.4	0.4	0.6	-0.3	-0.6	-0.8
	S	Q_{ox}	-0.1	-0.1	0.0	0.0	0.3	-0.2	0.6	0.4	0.1	-0.4	-0.6
		I_{ox}	-0.9	0.6	-0.6	-0.6	-0.1	0.2	-0.3	-0.3	-0.8	0.0	-0.4
RHS Variables	D	P^{wa}	1.0	-0.7	0.6	0.7	0.0	-0.1	0.2	0.2	0.8	0.1	0.5
		P^{el}	-0.7	1.0	-0.2	-0.7	-0.2	0.4	-0.2	-0.6	-0.5	0.1	0.0
	S	P^{co}	0.0	-0.2	0.2	0.3	1.0	-0.3	0.5	0.4	0.2	-0.5	-0.6
		P^{mi}	0.2	-0.2	0.3	0.2	0.5	-0.4	1.0	0.5	0.3	-0.6	-0.5
		P^{ur}	0.8	-0.5	0.8	0.6	0.2	0.0	0.3	0.3	1.0	0.0	0.3
		t	0.5	0.0	0.3	0.0	-0.6	0.5	-0.5	-0.5	0.3	0.7	1.0

Table A.5. Instrumental Variables Correlation with LHS and RHS Variables for Steer Model

			Instruments										
			P^{wa}	P^{el}	P^{am}	P^{ch}	P^{i}	P^{co}	P^{mi}	P^{po}	P^{ur}	Q^{i}	t
LHS Variables	D	${P^f}_{ste}$	-0.3	-0.1	-0.1	0.0	0.5	-0.5	0.6	0.6	-0.1	-0.6	-0.9
	S	Q_{ste}	0.2	-0.1	0.1	0.2	0.3	0.0	0.3	0.3	0.2	-0.2	-0.2
		I_{ste}	-0.9	0.5	-0.7	-0.6	0.1	0.0	-0.1	-0.1	-0.7	-0.2	-0.6
RHS Variables	D	P^{wa}	1.0	-0.7	0.6	0.7	0.0	-0.1	0.2	0.2	0.8	0.1	0.5
		P^{el}	-0.7	1.0	-0.2	-0.7	-0.2	0.4	-0.2	-0.6	-0.5	0.1	0.0
	S	P^{co}	0.0	-0.2	0.2	0.3	1.0	-0.3	0.5	0.4	0.2	-0.5	-0.6
		P^{mi}	0.2	-0.2	0.3	0.2	0.5	-0.4	1.0	0.5	0.3	-0.6	-0.5
		P^{ur}	0.8	-0.5	0.8	0.6	0.2	0.0	0.3	0.3	1.0	0.0	0.3
		t	0.5	0.0	0.3	0.0	-0.6	0.5	-0.5	-0.5	0.3	0.7	1.0

Appendix B Additional Tests for the models

Table B.1. Jarque-Bera Normality Test Results

Model	Equation	p-value				
		M&W	Cow	Heifer	Ox	Steer
zeroar1ar2	Inv. Dem	0.2780	0.8854	0.7407	0.0000***	0.3223
	Supply	0.0000***	0.0000***	0.0000***	0.0000***	0.0000***
	Joint	0.0000***	0.0000***	0.0000***	0.0000***	0.0000***
constar1ar2	Inv. Dem	0.0000***	0.0012***	0.7420	0.0000***	0.0694*
	Supply	0.0000***	0.0000***	0.0000***	0.0000***	0.0000***
	Joint	0.0000***	0.0000***	0.0000***	0.0000***	0.0000***
varar1ar2	Inv. Dem	0.0000***	0.0013***	0.9164	0.0000***	0.7182
	Supply	0.0000***	0.0000***	0.0000***	0.0000***	0.0000***
	Joint	0.0000***	0.0000***	0.0000***	0.0000***	0.0000***
dumar1ar2	Inv. Dem	0.0764*	0.7796	0.4275	0.0000***	0.0000***
	Supply	0.0000***	0.0000***	0.0000***	0.0000***	0.0000***
	Joint	0.0000***	0.0000***	0.0000***	0.0000***	0.0000***
zeroar1	Inv. Dem	0.0993*	0.3132	0.5002	0.0000***	0.3513
	Supply	0.0000***	0.0000***	0.0000***	0.0000***	0.0000***
	Joint	0.0000***	0.0000***	0.0000***	0.0000***	0.0000***
constar1	Inv. Dem	0.0000***	0.9352	0.0034***	0.0000***	0.5207
	Supply	0.0000***	0.0000***	0.0000***	0.0000***	0.0000***
	Joint	0.0000***	0.0000***	0.0000***	0.0000***	0.0000***
varar1	Inv. Dem	0.0342**	0.5742	0.0047***	0.0000***	0.3928
	Supply	0.0000***	0.0000***	0.0000***	0.0000***	0.0000***
	Joint	0.0000***	0.0000***	0.0000***	0.0000***	0.0000***
dumar1	Inv. Dem	0.0055***	0.7178	0.3047	0.0000***	0.8679
	Supply	0.6359	0.0000***	0.0000***	0.0024***	0.0000***
	Joint	0.0232**	0.0000***	0.0000***	0.0000***	0.0000***

Statistical Significance: ***1%, **5%, *10% for rejecting Null Hypothesis of normality of the residues

Appendix C Model Results with OLS and 2SLS

Table C.1. OLS and 2SLS Results from the M&W Model for the Chilean Cattle Market with AR(1) Terms

	OLS				2SLS			
Coef	$\theta = 0$	Const θ	$\theta_0 + \theta_1 T$	Mont. Dum	$\theta = 0$	Const θ	$\theta_0 + \theta_1 T$	Mont. Dum
θ_0		0.00	0.03	-0.01		-0.14	0.40	0.01
θ_1			-0.00	-0.00			-0.00	0.00
θ_2				0.01				0.00
θ_3				0.00				0.00
θ_4				0.00				0.00
θ_5				0.00				0.00
θ_6				0.01*				0.00
θ_7				0.02**				0.01
θ_8				0.04**				0.01
θ_9				0.03**				0.01
θ_{10}				0.02**				0.00
θ_{11}				0.01				0.00
δ_1		-0.05	-0.05	-0.16**		0.09	0.09	-0.03
α_1	0.00**	-0.00	-0.00	0.00	0.00	-0.00	0.00	-0.00
α_2	0.00***	-0.00	0.00***	0.00***	-0.00	-0.00	-0.00	0.00
α_3	-0.01	-0.02	0.01	-0.00	-0.01	-0.04	-0.08	-0.03**
α_4	0.23***	0.18***	0.27***	0.17***	0.44***	0.32**	0.35**	0.32***
$AR(1)$	0.86***	0.99***	0.67***	0.91***	0.56***	0.98***	0.98***	0.61***
δ_1	-0.05	-0.05	-0.05	-0.16**	0.09	0.09	0.09	-0.03
δ_2	0.23*	0.22*	0.22*	4.40***	0.25*	0.25*	0.25	4.79***
δ_3	0.94***	0.94**	0.94***	0.47	0.52	0.52	0.52	0.51
δ_4	1.39***	1.38***	1.38***	1.13***	0.89**	0.89**	0.89*	1.17***
δ_5	0.01	0.01	0.01	-0.09	0.04	0.04	0.04	-0.27**
δ_6	0.00	0.00	0.00	-0.00**	0.00	0.00	0.00	-0.00**
$AR(1)$	0.58***	0.58***	0.58***	0.55***	0.55***	0.55***	0.55***	0.56***

Statistical Significance: ***1%, **5%, *10%

Table C.2. Weighted OLS and 2SLS Results from the Cow Model for the Chilean Cattle Market with AR(1) Terms

	Weighted OLS				Weighted 2SLS			
Coef	$\theta = 0$	Const θ	$\theta_0 + \theta_1 T$	Mont. Dum	$\theta = 0$	Const θ	$\theta_0 + \theta_1 T$	Mont. Dum
θ_0		-0.09	-0.10	-0.10*		0.05	0.21	0.03
θ_1			0.00	0.00			-0.00	0.00
θ_2				0.01				0.00
θ_3				0.00				-0.00
θ_4				0.00				0.00
θ_5				-0.00				-0.00
θ_6				0.01*				0.00
θ_7				0.03**				0.01
θ_8				0.05***				0.01
θ_9				0.05***				0.02
θ_{10}				0.03***				0.01
θ_{11}				0.01**				0.00
δ_1		-0.00***	-0.00***	-0.00***		-0.00	-0.00	-0.00
α_1	-0.00***	0.00	0.00	0.00	-0.00	-0.00	-0.00	-0.00
α_2	0.00***	0.00***	-0.00	0.00***	-0.00	-0.00	-0.00	-0.00
α_3	0.00	0.00	-0.01	0.00	0.00	-0.08	-0.07	-0.04
α_4	0.20***	0.19***	0.16***	0.11***	0.42***	0.27	0.20	0.18
$AR(1)$	0.87***	0.89***	0.99***	0.92***	0.55***	1.00***	1.00***	0.99***
δ_1	-0.00***	-0.00***	-0.00***	-0.00***	-0.00	-0.00	-0.00	-0.00
δ_2	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***
δ_3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
δ_4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.00
δ_5	0.00***	0.00***	0.00***	0.00***	0.00**	0.00**	0.00***	0.00***
δ_6	0.00*	0.00*	0.00*	0.00*	0.00	0.00	0.00	0.00*
$AR(1)$	0.66***	0.66***	0.66***	0.66***	0.67***	0.67***	0.67***	0.60***

Statistical Significance: ***1%, **5%, *10%

Table C.3. Weighted OLS and 2SLS Results for Heifer Model for the Chilean Cattle Market with AR(1) Terms

	Weighted OLS				Weighted 2SLS			
Coef	$\theta = 0$	Const θ	$\theta_0 + \theta_1 T$	Mont. Dum	$\theta = 0$	Const θ	$\theta_0 + \theta_1 T$	Mont. Dum
θ_0		0.00	0.04	0.00		0.12	0.15	-0.07
θ_1			-0.00	-0.00			-0.00	0.00
θ_2				0.00				0.01
θ_3				0.00				0.00
θ_4				0.00				0.01
θ_5				0.00				0.01
θ_6				0.00				0.03
θ_7				0.01				0.05
θ_8				0.02				0.07
θ_9				0.02				0.09
θ_{10}				0.00				0.06
θ_{11}				0.00				0.03
δ_1		-0.00	-0.00	-0.00		-0.00	-0.00	-0.00
α_1	-0.00***	-0.00	-0.00	-0.00	-0.00***	-0.00	-0.00	0.00
α_2	0.00***	0.00***	0.00***	0.00***	0.00**	-0.00	-0.00	-0.00
α_3	-0.01*	-0.02	-0.01	-0.01	-0.02**	-0.09	-0.09	0.00
α_4	0.31***	0.31***	0.29***	0.24***	0.40***	0.29	0.29	0.19
$AR(1)$	0.72***	0.72***	0.67***	0.80***	0.61***	1.00***	1.00***	0.97***
δ_1	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00
δ_2	0.00**	0.00**	0.00**	0.00**	0.00***	0.00***	0.00***	0.00***
δ_3	0.00	0.00	0.00	0.00	-0.00	-0.00	-0.00	-0.00
δ_4	0.00*	0.00*	0.00*	0.00*	0.00	0.00	0.00	0.00
δ_5	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***
δ_6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00*
$AR(1)$	0.58***	0.58***	0.58***	0.58***	0.54***	0.54***	0.54***	0.48***

Statistical Significance: ***1%, **5%, *10%

Table C.4. Weighted OLS and 2SLS Results for Ox Model for the Chilean Cattle Market with AR(1) Terms

	Weighted OLS				Weighted 2SLS			
Coef	$\theta = 0$	Const θ	$\theta_0 + \theta_1 T$	Mont. Dum	$\theta = 0$	Const θ	$\theta_0 + \theta_1 T$	Mont. Dum
θ_0		0.03	-0.04	0.07		0.02	-0.09	0.10
θ_1			0.00**	-0.02*			0.00	-0.01
θ_2				-0.02				-0.00
θ_3				-0.00				0.00
θ_4				-0.00				0.00
θ_5				-0.01				-0.00
θ_6				-0.03*				-0.01
θ_7				-0.01				-0.00
θ_8				-0.02				-0.02
θ_9				-0.00				-0.01
θ_{10}				-0.02				-0.03
θ_{11}				-0.00				-0.01
δ_1		0.00***	0.00***	0.00***		0.00	0.00	0.00
α_1	0.00***	0.00**	0.00	0.00**	0.00	0.00	-0.00	0.00
α_2	0.00***	0.000*	0.00***	0.00	0.00	-0.00	-0.00	0.00
α_3	-0.02***	-0.02	-0.01	-0.01	-0.03***	0.01	-0.07	0.02
α_4	0.33***	0.33***	0.26***	0.35***	0.42***	0.17	0.06	-0.02
$AR(1)$	0.47***	0.46***	0.42***	0.49***	0.43***	0.99***	1.00***	0.97***
δ_1	0.00***	0.00***	0.00***	0.00***	0.00	0.00	0.00	0.00
δ_2	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***
δ_3	-0.00***	-0.00***	-0.00***	-0.00***	-0.00***	-0.00***	-0.00***	-0.00***
δ_4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.00
δ_5	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***
δ_6	0.00***	0.00***	0.00***	0.00***	0.00**	0.00***	0.00***	0.00
$AR(1)$	0.68***	0.68***	0.68***	0.68***	0.68***	0.68***	0.68***	0.70***

Statistical Significance: ***1%, **5%, *10%

Table C.5. Weighted OLS and 2SLS Results for Steer Model for the Chilean Cattle Market with AR(1) Terms

	Weighted OLS				Weighted 2SLS			
Coef	$\theta = 0$	Const θ	$\theta_0 + \theta_1 T$	Mont. Dum	$\theta = 0$	Const θ	$\theta_0 + \theta_1 T$	Mont. Dum
θ_0		0.00	0.08	-0.01		0.61	-0.28	-0.22
θ_1			-0.00**	-0.00			0.00	0.03*
θ_2				0.01**				0.04**
θ_3				0.00				0.02*
θ_4				0.01*				0.06**
θ_5				0.01*				0.04**
θ_6				0.02***				0.06**
θ_7				0.02***				0.06**
θ_8				0.03***				0.06**
θ_9				0.03***				0.06**
θ_{10}				0.02***				0.04**
θ_{11}				0.00*				0.04*
δ_1		-0.00***	-0.00***	-0.00***		-0.00**	-0.00**	-0.00***
α_1	0.00*	-0.00	-0.00	0.00	0.00	-0.00	-0.00	0.00
α_2	0.00***	0.00***	0.00***	0.00***	-0.00	-0.00	-0.00	-0.00
α_3	-0.00	-0.01	0.00	-0.00	-0.00	-0.14	-0.08	-0.00
α_4	0.34***	0.34***	0.37***	0.30***	0.49***	0.48***	0.39*	0.42***
$AR(1)$	0.86***	0.86***	0.68***	0.90***	0.58***	0.99***	0.99***	0.87***
δ_1	-0.00***	-0.00***	-0.00***	-0.00***	-0.00**	-0.00**	-0.00**	-0.00***
δ_2	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*
δ_3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
δ_4	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.0***
δ_5	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***
δ_6	0.00***	0.00***	0.00***	0.00***	0.00**	0.00**	0.00**	0.00
$AR(1)$	0.52***	0.52***	0.52***	0.52***	0.51***	0.51***	0.51***	0.49***

Statistical Significance: ***1%, **5%, *10%