Factors Affecting Feedlots' Decisions on Cattle Marketing Options: A National Study

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FACTORS AFFECTING FEEDLOTS’ DECISIONS ON CATTLE MARKETING

OPTIONS: A NATIONAL STUDY

BY

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A thesis submitted in partial fulfillment of the requirement for the degree

Master of Science

Major in Economics

South Dakota State University

2017
FACTORS AFFECTING FEEDLOTS' DECISIONS ON CATTLE MARKETING OPTIONS: A NATIONAL STUDY.

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This thesis is approved as a creditable and independent investigation by a candidate for the Master of Science in Economics degree and is acceptable for meeting the thesis requirement for this degree. Acceptance of this thesis does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

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ACKNOWLEDGEMENTS

First, I would like to thank God for how far He has brought me. I also would like to thank my Advisor Scott William Fausti for his enormous support throughout the writing process. My committee members, Dr. David Davis and Dr. Matthew Diersen, have also been of great help.

Special thanks also goes to the Department of Economics for their financial support in my study at SDSU. I would also like thank South Dakota Association of Economics students and NIFA for their financial support towards my work.

Last but not least, I would like to thank all my friends especially Kenneth Kwesi Amoah for making time to edit my work and making constructive suggestions. I am very grateful for the time, encouragement and support.
TABLE OF CONTENTS

LIST OF FIGURES.................................................................................................v

LIST OF TABLES......................................................................................................vi

LIST OF APPENDICES............................................................................................vii

ABSTRACT................................................................................................................ix

CHAPTER 1: INTRODUCTION

1.1 Background .......................................................................................................1

1.11 Alternative Marketing Arrangements ......................................................... 1

1.12 Thinning Cash Market – Causes and Implications ................................. 4

1.2 Problem Statement ........................................................................................... 9

1.3 Research Objectives and Hypothesis ............................................................ 11

1.4 Justification of the study ................................................................................. 13

CHAPTER 2: LITERATURE REVIEW

2.1 Literature on Benefits and Impacts of Captive Supplies ...................... 15

2.2 Literature on Concentration and Market Power ...................................... 19

2.3 Literature on Mandatory Price Reporting ............................................. 22

2.4 Literature on Price Transparency and Price Discovery ....................... 30

CHAPTER 3: DATA DESCRIPTION AND METHODOLOGY

3.1 Data Sources ..................................................................................................... 34

3.2 Theoretical Foundation .................................................................................. 36
3.3 Econometric Model .................................................................39
3.4 Regression Diagnostics .........................................................44
  3.41 Stationarity Test ...............................................................44
  3.42 Serial correlation test ......................................................46
  3.43 Heteroscedasticity .........................................................48
  3.44 Multicollinearity ............................................................48
3.5 Estimation Techniques .........................................................48

CHAPTER 4: RESULTS AND ANALYSIS

  4.1 Summary Statistics ..........................................................51
  4.2 Discussion on Regression Analysis .......................................52
  4.3 Results from Diagnostic Tests ............................................58
    4.31 Results from Residual Correlation Matrix .........................58
    4.32 Results from Endogeneity Test ......................................59
    4.33 Results from stationarity Test .....................................60
    4.34 Results from Serial Correlation Test ..............................60
    4.35 Results from heteroscedasticity Test ..............................60

CHAPTER 5: CONCLUSIONS ...........................................................62

REFERENCES ..............................................................................66
LIST OF FIGURES

Figure 1: Summary of Marketing and Pricing Methods in Cattle market ………… 2

Figure 2: Trends of Market Shares for Fed Cattle ………………………………... 7

Figure 3: Cattle Transactions on Live Basis …………………… 7

Figure 4: Cattle Transactions on Dressed Basis ………………………………… 8
LIST OF TABLES

Table 3.1: Description of Variables ................................................................. 35

Table 4.1: Summary Statistics ................................................................. 52

Table 4.2: SUR for Cash versus Formula Market ................................. 53

Table 4.3: SUR for Cash versus Forward Contract Market ................. 56
LIST OF APPENDICES

Appendix A: Stationarity test for residuals ........................................... 81
Appendix B: Results from residual versus fitted plots ...............................82
Appendix C: Error Correlation Matrix .......................................................84
Appendix D: Results from Augmented Regression Test .............................85
Appendix E: Test for Serial Correlation ....................................................86
Appendix F: Stationarity test for variables ..............................................87
Appendix G: Robust OLS for Forward Contract Market .............................88
Appendix H: Robust OLS for Formula Market .........................................89
This thesis investigates the economic implication of changing slaughter volume patterns across the cash and contract markets in the US cattle industry. Weekly time series data that spans from November 2002 to December 2015 was used in the analysis. Empirical evidence suggests that Mandatory Price Reporting (MPR) played an important role in changing slaughter volumes across the cash and contract markets. Additionally, price of feeder cattle, cattle quality characteristics (Choice-Select spread and the percentage of animals grading choice or better) among others influence feedlots’ decision to use a particular marketing arrangement.

Key words: AMA, MPR, SUR, cattle, cash market, formula market, forward contract market, thinning market, price discovery.
1.0 CHAPTER ONE: BACKGROUND OF STUDY

1.1 ALTERNATIVE MARKETING ARRANGEMENTS

Cash market transactions are transactions that occur immediately or “on the spot”. They may include sales through other buyers, dealers or brokers; direct sales and auction barn sales (Taylor et. al, 2007). All possible alternatives to the cash market are termed Alternative Marketing Arrangements (AMAs). Apart from the fact that AMAs are alternatives to the cash market, they all (except packer ownership) involve delivery of contracted cattle at least 2 weeks after the contract was entered into. AMAs may, however, vary in terms of their ownership method, pricing method or valuation method.

The ownership method defines who owns the cattle at the time of transaction; the pricing method shows how transaction prices were established and the valuation method tells whether or not cattle characteristics were considered in the final transaction price. If cattle characteristics were considered, then grid premiums and or discounts would apply (Taylor et. al).

Forward contracts are similar to cash markets since there is a bid and ask on prices except that cattle are delivered at least two weeks after the agreement was entered into. Formula trades are the most widely used AMAs. Prices used in formula transactions are determined using a base rather than prices dictated by agents involved in the transaction (Koontz, 2013). Sources of base prices used in formula trades of fed cattle may include average regional prices, USDA AMS\textsuperscript{1} regional prices, plant average prices and national average prices. The final formula price for a given transaction is composed of a base price

\textsuperscript{1} United States Department of Agricultural (USDA), Agricultural Marketing Service (AMS).
plus or minus premiums or discounts depending on cattle quality. Until 2004, negotiated grid trades were considered as part of formula trades since they all involved the use of a formula to determine prices. The main difference, however, is that formula trading relies on external market indicators to determine prices while the negotiated grid system sometimes uses these formula prices as a base prices. For the purpose of this discussion, emphasis will be on these three cattle marketing options. Below is a summary of cattle marketing options and pricing methods used in the fed cattle industry.

**FIGURE 1: SUMMARY OF PROCUREMENT AND PRICING METHODS USED IN THE FED CATTLE MARKET.**

Source: Taylor et.al (2007)²

There have been significant changes in the U.S livestock market which includes but is not limited to the increased use of AMAs (as against the cash or spot market) by feedlots to market their livestock (Kim and Zheng; 2015). Over the past few decades, there has been a gradual transition from the use of the cash market to the use of AMAs to sell fed cattle. This is because of the increased advantages AMAs possess and may include: higher and predictable volumes, relatively lower transportation costs as compared to cash markets, higher capacity utilization, and their demand enhancing ability (Koontz, 2013). Also, in the 2007 Grain Inspection, Packers and Stockyards Administration (GIPSA) report, producers and packers were asked the three most important reasons for either using AMAs or cash markets. About 51.6% of producers used AMAs because it allows the sale of higher quality cattle. Again, 16.3% of the respondents also used cash markets because of its higher prices which reflected higher cattle quality.

AMAs that result in captive supplies of livestock by packers (i.e. control or ownership of livestock more than 14 days prior to slaughter) have raised particular concerns for many industry participants. For this reason, in 2003, Congress funded research that was based on the potential costs and benefits that AMAs might have on the meat and livestock industries. The study was completed in early 2007, and the results are being used in discussions about policy changes that are needed to address whether the use of particular methods of procuring livestock by packers had adverse effects on the livestock and beef industries (Taylor et al).

The fact still remains that the use of AMAs is relatively advantageous to both feedlots and packers. This, however, does not justify the displacement of the cash market
(Koontz, 2013). The cash market still plays an important role because, at the very least, it enhances the price discovery\textsuperscript{3} mechanism that aids the determination of prices for most AMAs especially formula-based prices.

1.12 THINNING CASH MARKET- CAUSES AND IMPLICATIONS

Most agricultural markets in the United States have experienced increased concentration over the past two decades. The concentration of the livestock industry has been incentivized by vertical coordination\textsuperscript{4}, change in consumer preferences and technological advancement.

Discussing vertical coordination, firms that use a competitive strategy aim at operating at the lowest average cost as possible (Boland, Barton and Domine, 1999). For this reason, beef packers have increasingly entered into contracts with feedlots to ensure a steady supply of fed cattle so they can operate at full capacity. This makes the livestock industry concentrated as it results in the formation of very large firms.

With reference to changes in consumer preferences, rising incomes, over the years, have led to changes in demand patterns. Even though this has created market for most producers, it has further concentrated the industry since fewer producers “fill each niche” (Adjemian et al, 2016). Historically it has been noted that, the four firm concentration

\textsuperscript{3} Price discovery is the process by which buyers and sellers use available market information to determine the price for a given transaction. It involves two market participants (buyers and sellers) to arrive at a price taking into account the quantity and quality of the commodity being traded (Ward and Schroeder, 2002).

\textsuperscript{4} Vertical coordination is said to have occurred when firms in different stages of production work together to achieve an economic goal (Harkin, 2004).
ration (CR$^4$) for fed cattle increased from 36% to 81% from 1980 to 1993 and has increased marginally since then$^6$. Concentration in the beef industry can be problematic when it results in the exercise of market power by beef packers. Perloff and Rausser (1983) argue that firms that exercise market power are able to control prices and can cause economic losses to other market participants. Below is a chart that shows the trend of the concentration ratio in the US fed cattle industry.

Between 1980 and 2010, concentration in the cattle industry has risen by more than 100% (USDA ERS, 2012). The increase in concentration was sharp between 1980 and 1995, however concentration increased marginally thereafter. The recent thinning$^7$ of the cash market, however, is attributable not only to concentration in the livestock industry but also to the gradual transition from the use of the cash market to contract markets. In packers or processors quest to satisfy downstream demand, they seek better coordination from the sources of their inputs. To further improve the quality of coordination, market participants resort to the use of contracting. According to MacDonald and Korb (2008) the use of contracts offer several advantages to feedlots. Some of which include: serving as a risk management tool, assuring feedlots of a market for their cattle and rewarding (through premiums) feedlots who provide the quality characteristics stated in the contracts. The

$^5$ CR4 simply means four-firm concentration ratio. It measures market concentration by combining the market shares of the four largest firms in the industry. According to Wise and Trist (2010), when CR4 is 20%, the market is concentrated; a CR4 of 40% means that the firm is highly concentrated and 60% and beyond means there is a possibility of firms to exercise market power. A CR4 of 20% means that 20% of the market is being controlled by 4 largest firms.

$^6$ For details on concentration in the livestock industry, see the Concentration in Agriculture report (U.S. Government Accountability Office, 2009).

$^7$ A market can be said to be thin when there is a small number of buying or selling offers. It is usually characterized by high price volatility, low trading volumes, higher searching and bargaining costs (Rostek and Weretka, 2008).
packing industry benefits include the ability to manage their input supply chain and to maintain their plants at full capacity. AMAs are thought to be beneficial to market participants, otherwise, they would not use it. Koontz (2013), however, discussed that a considerable increase in the use of contracts may go a long way to affect the cash market negatively. Koontz argues that the process of price discovery is enhanced by increased transactions in the cash market. Thus, for an effective and efficient price discovery process there should be enough transactions to accurately reflect market activities.

Figure 2 shows trends of markets shares under the four major marketing options. It confirms that the fed cattle market, over the years, has experienced an enormous shift from the use of conventional cash markets to the use of contracts – formula trade and forward contracts. Negotiated grid sales, however, have seen little or no changes in volume shares over the course of time. These trends slightly differ for both the live and dressed-weight market. For this reason, figure 2 was further broken down into transaction on live and dressed basis for the various marketing arrangements. Figure 2 indicates that there has been a steady decline in cash market sales over the past few decades. Most of the shift in market shares favored formula trade. There has also been a slight increase in forward contract shares over time. The decline in the cash market is also evident in figure 4. It is, however, slightly different from what was seen in figure 2.
FIGURE 2: TRENDS OF MARKET SHARES FOR FED CATTLE

Source: Livestock Marketing Information Center (LMIC)

FIGURE 3: CATTLE TRANSACTIONS ON LIVE BASIS

Source: Livestock Marketing Information Center (LMIC)
Figure 3 shows that, even though cash transactions for the live market are declining over the years; the cash market still remains dominant relative to the other AMAs as far as the live market is concerned. Schroder et. al (2009) argued that the live market is mostly used by those producers who are not sure of the quality characteristics of their cattle. They further explained that if producers expect the quality of their cattle to be lower than average, they are motivated to sell on the live rather than the dressed market.

Fausti and Qasmi (2002) also explained that producers who are risk averse and do not meet the minimum quality characteristics prefer to sell on an average price basis rather than on a grid. In the same light, most producers who use the cash market are not concerned about quality characteristics. This further explains why the cash market is dominant when selling cattle on live basis.

**FIGURE 4: CATTLE TRANSACTIONS ON DRESSED BASIS**

*Source: Livestock Marketing Information Center (LMIC)*
Dressed weight pricing was not more popular relative to live weight pricing. Feuz et al (1993) asserted that this was because there is a time lag between the sale and procurement of animals under the dressed weight marketing option. Most dressed weight prices are similar to live prices in the sense they all start off with a base price and are further adjusted for weight premiums and discounts, yield and quality grades, slaughter cost and so on (Schroder et al). Dressed-weight prices can be compared to live-weight prices after adjusting for dressing percentage. However, dressed weight cattle sold by the pen will receive the same price per hundredweight.

According to Feuz et al, dressed weight system (except for cattle sold by the pen\textsuperscript{8}) is value based and it rewards quality cattle. It is, therefore, expected marketing option that takes into account quality measures will dominate the dressed-weight market. Figure 4 shows that formula trade transactions are dominant with the dressed weight pricing option.

1.2 PROBLEM STATEMENT

A market is said to be transparent when all market information deemed relevant is made available to market participants. In an economic sense, relevant information may include information on both price and quantities traded to determine the market price for a given commodity. Price transparency, therefore, is making transaction prices available to all market participants. This has the advantage of resulting in efficiency in price discovery, reducing the incidence of arbitrage opportunities and increasing integration between spatial markets (Pendell & Schroeder, 2006).

\textsuperscript{8}Cattle sold by the pen will receive the same price per hundredweight.
Prior to the Mandatory Price Reporting Act of 1999, the Voluntary Price Reporting (VPR) system was the primary source of public information on livestock market activity. This system allowed producers, feedlot operators and packers to voluntarily report prices and respective quantities for the various sale/procurement methods they used. Over time, both feeders and packers began to resort to the use of alternatives to the cash market. These other methods, however, did not have prices and volumes reported. In other words, a framework had not been established to report these prices. Also, given the heterogeneous nature of the pricing and valuation methods that were in use, it was not possible for market reporters to collect price information for the variety of sales through the informal survey methods they were using (Ward and Schroeder, 2002). This made the accuracy of the prices used on the cash market questionable since it did not reflect all on-going cattle transactions.

There were various criticisms regarding the use of the VPR system as prices and quantities reported did not reflect what was happening in reality. Market transparency was degraded and market agents behaved strategically when they voluntarily reported prices (Fausti and Diersen, 2003). Without price information there will be no historical basis upon which risk management policies will be formulated (Koontz, 2015). In an attempt to increase competition, make prices reflect all cattle trade, and more importantly, improve price discovery; Congress passed the Livestock Mandatory Price Reporting (LMR) Act of 1999. The LMR policy proposal was strongly contested by packing industries but was supported by producers. The system, however, took effect from April 2001 and mandated meatpackers to report daily transactions of their livestock to the Agricultural Marketing Services (AMS).
Various studies (Schroeder, Grunewald & Ward 2004; Koontz 2013; Ward, Vestal and Lee 2014) have observed downward trends in the use of the cash market since the implementation of the MPR. Increased transparency has led to renewed interest and focus on thin markets (Ward, Vestal and Lee 2014). The thinning of the cash market has raised concerns regarding the accuracy of prices reported on the cash market. Another concern that Ward (2008) raised is that prices in thin markets are subject to greater potential manipulation than in more heavily traded markets. Are these prices representative of the interaction between market forces? How thin can the cash market be so that the prices discovered are still accurate? How thin can the cash market get so that the price discovery mechanism is still efficient? Most parts of literature on this subject matter have looked at the trends of the cash market and AMAs before and after the inception of MPR (Wachenheim and DeVuyst (2001); Koontz (2013); Ward (2014); Ward, Vestal and Lee 2014).

In addition, concentration in the fed cattle industry has led to decreased competition among packers. A reduction in competitive activities also serves as breeding grounds for certain market participants to exercise power. In the case of the fed cattle industry, packers who exercise market power may increase their profits by reducing the prices they pay to feedlots. The issue of thin cash markets results in insufficient data for market participants to analyze the accuracy of information on the market. Feedlots, for this reason, doubt whether they receive fair prices in the face the thinning cash market (Adjemian et al., 2016).

In an effort to add to existing knowledge, this study attempts to explore the potential causes of the shift from the use of the cash market to contract markets. Specifically, it seeks
to find out the possible factors that encourage or prompts market participants to use contracts instead of the conventional cash market beyond rational provided in the current literature.  

1.3 RESEARCH OBJECTIVES AND HYPOTHESES

This study generally seeks to examine factors responsible for the shift from the use of cash markets to the use of AMAs. Economic factors suggested in the literature are empirically tested. One controversial casual factor being tested is whether or not MPR played a role in the decline of cash market volume over the period under study. The influence of MPR is of interest because it is a major policy change that occurred in the US livestock industry since 2001. There is a branch of the MPR literature that argues that MPR could result in a change in marketing behavior in the fed cattle market. Anecdotal evidence in support of this view is that use of cash market also occurred around the same time. This provides a basis to the believe that MPR might partly be responsible for the gradual shifts to the use of AMAs. To account for this in the analysis, MPR is defined as a dummy variable that takes on the value of one in periods when MPR was enforced and zero in periods when MPR was not active.

The strawman assumption behind the MPR dummy variable is that the introduction of MPR did not affect volumes shares of marketing arrangements in any way. Or, even if it did, the effect was insignificant. The reverse is true for the alternative hypothesis.

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9 Recent studies show that market participants use AMAs instead of the cash market because of the many advantage AMAs provide. [Ward and Schroeder (2004); Franken et al (2009); Koontz (2007)] argue that some reasons why feedlots and packers use AMAs include: lower transaction costs, higher and predictable volumes and reduction of potential risk.
Rejection of the null hypothesis will mean that the introduction of MPR had a significant effect on volumes shares. A rejection of the null hypothesis will imply that volume shares in the contract market increased in periods when MPR was enforced.

1.4 JUSTIFICATION OF THE STUDY

Agricultural commodities experience relatively higher price variations than other non-farm goods (Tomek & Robinson, 2003). These variations can be attributed to market forces coupled with the production process. Economists and other financial stakeholders have recognized price fluctuations as an important economic phenomenon that affects most decision-making on prices. This complicates price discovery and implies risk to many economic agents.

The AMA literature has shown that most AMA prices are related to cash market prices. For instance, the base prices used in formula prices are frequently tied to last week’s cash market in some way (Ward, Vestal & Lee, 2014). In this regard, prices dictated by the cash market should be as accurate as possible since there is a spillover to other markets. The recent concern regarding the thinning of the cash market and the accuracy of cash prices have necessitated studies that seek to find out the causes of this problem.

Results from this study will provide information relevant to policy making in the fed cattle industry. Policy officials working on policies geared towards tackling specific problems may find insight on how price discovery and market transparency can be improved once the questions to these objectives are answered. Specifically, results from this study will give insight as to how MPR has affected volume shares of the cattle marketing options under consideration.
This thesis was divided into five chapters. Chapter 1 covers the introduction, research objectives and the justification of the study. Chapter 2 is a review of previous literature related to cash market thinning. Chapter 3 describes the datasets and the research methodology used. Analysis of empirical results corresponding to the research objectives is presented in Chapter 4. Conclusions from the study and necessary recommendations are provided in Chapter 5.
2.0 CHAPTER 2: LITERATURE REVIEW

This section provides literature on the main tenets of this paper. It covers literature on Alternative Marketing Arrangements, Mandatory Price Reporting, Concentration in the livestock industry, market transparency and price discovery.

2.1 LITERATURE ON BENEFITS AND IMPACTS OF CAPTIVE SUPPLIES

GIPSA defines captive supply as livestock that is procured by packers for more than two weeks before slaughter. In other words, captive supply can be referred to as livestock that are procured through a contract, which was entered into at least 14 days before slaughter. The rising concern about the use of captive supplies resulted in a legislation proposed as part of the 2002 Farm Bill to ban packer procurement of cattle through captive supplies. In the fall of 2007, the Senate Agriculture Committee passed an amendment that would have prevented packers from owning cattle for more than two weeks before slaughter. The share of livestock procured through captive supplies is on the increase and has raised concerns about thinning cash markets and its unexpected consequences. In the case of cattle, cash transactions declined from more than 60% in 2004 to less than 30% in 2014 (Adjemian et. al, 2016). About 36% of hogs were transacted on the cash market in 1999, however, this share had decreased to 24% by 2004 and 2005 (Grimes and Plains, 2009). These trends do not only show producer-packer preference for non-cash transactions but also draws attention to the potential to erode price transparency and price discovery in the cash market.

There are two Congressionally-mandated studies on captive supplies. The first study was done by Ward, Koontz and Schroeder in 1996 and the second study was Taylor
et. al (2007). Both studies were focused on evaluating the cost and benefits from the use of AMAs. Using data from April 1992 to April 1993, the 1996 study found that the use of AMAs reduces cash prices by at most 1.2%. The 2007 study found that the use of AMAs reduced cash prices by at most 0.3%. Authors of the 2007 paper also found that the cost of using AMAs was about $4.50 per head while gains from the use of AMAs were estimated to be $6.50 per head. They concluded that the overall benefits from the use of AMAs outweighed costs.

Schroeter and Azzam (1996) used data on cattle procurement for the four largest packing firms in Texas, Panhandle from February 1995 to May 1996 to assess the effect of AMAs on cash prices. They found that when packers anticipate large deliveries of AMA cattle, they are motivated to pay lower prices in the cash market. Schroeter and Azzam found that a 10% increase in AMA deliveries is associated with a $0.021/cwt lower cash price. They explained further that if the source of the base price is USDA reported prices, it will be nearly impossible for packers to manipulate cash prices. However, if the source of the base price is from the plant average cost, then it would be easier to manipulate prices paid for formula-priced cattle. They argued that whether or not AMA deliveries affected cash prices depended on the type of base price used in formula pricing. Crespi and Sexton (2004) also used transaction data on Texas Panhandle region to examine market competitiveness with reference to the procurement of captive supplies. They found that captive supplies allow packers to reduce cash bids by 5-10%.

Hayenga and O’Brien (1991) used a 15-month period data from October 1988 to December 1989 to examine the effect of captive supply deliveries on weekly fed cattle
prices. They found no evidence to support the claim that forward contracts negatively affected fed cattle prices. Elam (1993) also used monthly average fed cattle data from October 1988 to May 1991. The main aim of the study was to examine the effects of captive supply deliveries on fed cattle price in Kansas, Colorado, Texas, Nebraska and the United States as a whole. Elam found an inverse relationship between fed cattle prices and captive supplies. Results from Elam’s time series analysis suggested that impacts of captive supplies on fed cattle price differed from state to state. Elam found that the impact of captive supplies on cattle prices ranged from no significant impact to about $0.37/cwt. Ward et al (1998) found rather mixed but interesting results. They found that the relationship between total inventory of captive supply was generally negative for the period they examined. These results, however, differed based on the marketing arrangement under consideration. Captive supplies associated with the forward market had a positive impact on cash prices while marketing arrangement inventory constantly showed a negative relationship with cash prices.

Ward and Schroeder (2004) concluded that AMAs are beneficial to both cattle producers and packers or else they would not use them. The concern of most market participants in the industry is how AMAs might affect suppliers who prefer to deal on cash basis. Procuring cattle through AMAs effectively reduces the supply of cattle on the cash market that can be purchased by other buyers. Also, packers without captive supplies need to bid more aggressively on the cash market for the limited supply of cattle (Ward and Schroeder, 2004). Both of these scenarios should push the prices of fed cattle up. However, it also means that packers who have met most of their supply needs through captive
supplies need not bid aggressively on the cash market and this may cause a decline in the market price of fed cattle.

Research by USDA GIPSA (1996) and Schroeter and Azzam (2003) have also confirmed that the net effects of the increased use of captive supplies on short run prices paid for cattle on the cash market is negative but small. Kim and Zheng (2015) specified a model which defines two ways through which captive supplies may affect the spot price in livestock markets. They found that increases in the number of hogs procured through AMAs increases cash price volatility and the cash price level. They further decomposed the effect on the price level into direct effects and indirect effects. The direct effect, according to their model, results from the increase in the number of hogs procured through AMAs. This causes packers to bid less aggressively in the cash market thus causing a reduction in demand rather than supply in the cash market. Kim and Zheng concluded that this represented a structural change that favored packers. Wang and Jaenicke (2006), however, argued that the reason for low cash prices is that captive supplies divert livestock of good quality away from the cash market. If that is the case, then the issue of low cash prices is less problematic as it simply reflects that fact that low quality livestock commands low prices.

Another branch of the AMA literature discusses the benefits and potential motivations involved in the use of captive supplies. Franken et. al (2008) stated that both risk preferences and transaction costs are important in determining a packer’s choice of procurement method. Other papers show that efficiencies exist where packers with more captive supplies operate at higher volumes, have less variability in slaughter volumes,
lower average cost and higher average margins per head. For example, Key and McBride (2003) specifically show that one of the main reasons why packers use captive supplies is that they can reduce transaction costs by contracting with fewer and larger feedlots. Ward and Schroeder (2004) also identified potential motivations behind why cattle feeders use contract markets. Risk management, obtaining favorable financial terms and securing a buyer(s) for their cattle were some of the reason they stated. On the other hand, the cash market exhibits economies of scale and as the cash market thins, producers may incur higher transaction costs that may make the use of cash markets less attractive. Koontz (2007) also stated that higher predictable volumes and lower average costs are some of the reasons why packers would want to use captive supplies. Whitley (2002) also found that, on average, a greater percentage of cattle procured through AMAs is positively related to a higher beef quality. However, a relationship between beef quality and the use of certain marketing channels has not been established.

2.2 LITERATURE ON CONCENTRATION AND MARKET POWER

As discussed in Chapter one, one of the structural changes that the US livestock industry has undergone over the past few decades is increased firm concentration. A major concern with regards to concentration in the beef industry is the inadequacy of competition among buyers and its effects on fed cattle prices.

Ward and Schroeder (2004) defined concentration as a measure of the market dominance by few large firms. High concentration levels are usually associated with lower prices paid for inputs and higher prices charged for outputs. Impacts of high concentration are difficult to measure. Cattle suppliers raise concerns about not having a market for cattle
when they reach market weight, receiving lower prices for livestock and inadequate competition among buyers.

Azzam and Schroeter (1995) assessed the tradeoffs in gains from efficiency and loss from market power that results from concentration in the beef packing industry. They found that cost savings of at most 2.4% from efficiency gains can offset a 50% increase in concentration that results in market power. They, therefore, concluded that the net effect will be positive as efficiency gains outweighed losses from market power. Azzam (1997) extended the work of Appelbaum (1982) and clearly distinguished market power effects that are due to concentration from effects due to cost efficiency. He also found that concentration of packers is associated with both costs and benefits, which yielded positive net effects. He concluded that his analysis provided empirical confirmation of the trade-off between cost efficiency and market power that results from packer concentration. Paul (2001) also used monthly plant-level cost and revenue data from 1992 to 1993 to estimate Oligopsony and Oligopoly power for beef packing plants. This study found significant evidence of economies of size and little evidence in support of market price distortions.

Several studies have also used different approaches and varying sources of data to test whether there is evidence that beef packers exercise market power. The overall conclusions with regards to the extent and impacts of market power on the cattle industry as a whole is, however, mixed.

Schroeter (1988) used the conduct parameter approach to assess the degree of market power in the beef packing industry. He found that monopoly and monopsony price
distortions\textsuperscript{10} were small but statistically significant. Koontz, Garcia and Hudson (1993) modified the conduct parameter approach by featuring a dynamic pricing game. They found that market power is found in daily fed cattle prices and price distortion ranges between 0.5\% and 0.8\%. They, therefore, concluded that cooperative price behavior among meatpackers in procuring cattle is indicative of oligopsonistic power. Stiegart, Azzam and Brorsen (1993), however, stated that reducing concentration in the cattle industry is unlikely to increase fed cattle prices. Koontz and Garcia (1997) extend the 1993 paper to include multiple regional markets. Oligopsony behavior was found across multiple geographic (regional) fed cattle markets.

Zhang and Sexton (2000) used a spatial model and a noncooperative game approach to show how meatpackers use captive supplies to strategically influence cash prices. They find that captive supplies can create geographic buffers that reduce competition among processors. Xia and Sexton (2004) also examine the competitive implications of the contract arrangements on the cash market. They focused on “top-of-the-market-pricing” (TOMP) which is commonly related to AMAs. They found that buyers who purchase cattle on contract also compete to procure cattle in the cash market. They, however, noted that the use of captive supplies reduces packers’ incentive to compete in the cash market.

For the purposes of testing the existence of market power on the cash market and whether the source of that market power could be related to the use of captive supplies, Vukina and Zheng (2009) modelled market power as a function of packers’ stock of captive supplies.

\textsuperscript{10}Monopoly price distortions refer to observing prices that are higher than competitive prices for wholesale meat sold by packers. Monopsony price distortions, on the other hand, refer to observing prices that are lower than competitive prices for livestock purchased for slaughter by packers.
supplies. They found a statistically significant presence of market power in the procurement of live hogs on the cash market. They, however, concluded that the source of market power could not result from captive supplies only; it could also stem from the concentration of meat packers in the industry. Ji (2011), in one of his three essays on market power, used a New Empirical Industry Organization (NEIO) model. He extended the work of Azzam (1997) by including the effects of captive supplies on market power. He estimated the conjectural variation elasticity, which measures how market power responded to changes in concentration, captive supplies and their corresponding cost-efficiencies. He concluded that captive supplies and packers’ concentration were sources of market power in the beef industry; however, their benefits exceeded costs and hence improved social welfare.

2.3 LITERATURE ON MANDATORY PRICE REPORTING

The voluntary pricing system was used to report prices and volumes before 2001. This system allowed buyers and sellers to report market prices willingly. Confirmations were required by both buyers and sellers by Agricultural Marketing Service (AMS) reporters before transactions were included in market summaries. It was basically a communication between reporters and market participants to provide market summaries on prices and volumes. The Livestock Mandatory Report Act (LMR) was passed in 1999 and allowed the USDA AMS to implement a mandatory price reporting system which took effect in April 2001. The main goal of the Act was to facilitate marketing by providing information about what transpired in the market and to ensure transparent price discovery.
According to the US Senate report in 1999, the Act required packers that slaughter greater than 125,000 cattle yearly to give reports on transactions twice daily. Prices paid for cattle and the marketing arrangement(s) under which they were sold were also supposed to be part of the reports. The passage of MPR was accompanied by new reports and an increase in the amount of information available to market participants. The Act was reauthorized in 2010 and expired in September 30, 2015. According to Scott Shearer of the Bockony Group in Washington D.C., the Act has currently being reauthorized and is set to expire on September 30, 2020.

Proponents of the mandatory system argued that the voluntary price system was no longer reliable due to the decline of terminal livestock markets and an increase in concentration in the livestock industry (Keimig et. al, 2002). Feeders and packers also had rapidly adopted the use of AMAs to market cattle, a portion of on-going transactions that were not included in market summaries under the voluntary system. The transition from the use of cash markets to the use of contracts reduced the amount and quality of information that were available to both feedlots and packers (Perry, 2005). These raised concerns among cattle producers about the advantages meat packers could be enjoying to their detriment.

There is a considerable amount of literature that discusses the implications of MPR\textsuperscript{11} and its effects on the livestock industry. A large component of this literature addresses the issue of the potential costs and benefits associated with its implementation. Specifically, previous literature discusses: price and volume differentials associated with

\textsuperscript{11} See Ward and Koontz 2011 for an excellent discussion of the MPR literature.
the introduction of MPR and how the change in the quality of information (if any) has caused market shares to change over time.

To examine the adequacy of the voluntary price reporting system, Fausti and Diersen (2005) used a 19-month period data on South Dakota’s MPR that was collected prior to the federal MPR. They addressed the question of whether there were similarities in the content of information provided by the voluntary system and MPR. The results from their Cointegration and Error Correction model suggested no difference in the content of information both systems provided, in the case of South Dakota. The content of information provided by these two systems is debatable as it depends on whether “content” is defined as “quality” or “quantity” of information provided. Reports from the USDA in 2002 indicated that about 35% to 40% of negotiated cattle transactions were not reported.

In this same light, Wachenheim and DeVuyst (2001) also mentioned that there was the need for MPR because of the incomplete nature of the information provided by the voluntary system and its inability to ensure market transparency. They stated that transparent markets provide useful information on volumes, prices and quality of commodities traded for the purpose of decision making in production and marketing. Koontz and Ward (2011), however, disagreed with the idea of “incomplete information” and argued that even statisticians work with samples; not the whole population. Instead, they suggested that the most efficient way to assess MPR was to first find out the percentage of prices and volumes that were needed for price accuracy. One of the major conclusions in Wachenheim and DeVuyst’s 2001 paper was that reports from MPR at the

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12 Market transparency is a situation where market participants have equal accessibility to information on prices and respective quantities traded at those prices to aid decision making.
national level were likely to be of little importance to producers. They explained that, even if reports from MPR shows that another packer is paying a higher price for livestock; it does not tell producers where to redirect their cattle – due to confidentiality reasons. Wilson et. al (1999) also had similar conclusions even though their arguments were based on empirical observations of industries rather than a formal model. Wilson et. al again noted that meatpackers already had accurate information about other firms’ bids so it wasn’t clear whether the introduction of MPR added more information to what was already available. Their observation was, however, based on industries such as the railroad industry which use a posted price system, so it is uncertain whether all these arguments relates to livestock markets.

One of the key reasons behind the introduction of MPR was to increase market information on prices and volumes traded in order to enhance the efficiency of price discovery through transparency. Parcell et. al (2009) argued that the introduction of the MPR could reduce missing data that usually occurred under the voluntary price reporting system. They also argued that the lack of trust in the voluntary price reporting system raised costs to firms since they had to spend additional money to collect data on prices. Njoroge, Giannakas and Azzam (2007) also developed a theoretical model to account for both risk and collusive effects from improved transparency associated with MPR. They argued that increased information enhances social benefits by reducing the cost of uncertainty for packers but could, as well, lead to collusive behaviors and thus create social costs.
Matthews et. al (2015), used an error correction model (ECM)\textsuperscript{13} to examine how markets changed given that there is new information available. They found that market efficiency improved in MPR periods regardless of the continuous reduction in cash market transactions. They further argued that despite the declining nature of cash market transactions during MPR periods, there are similarities in the pre and post MPR cash prices. This further implied the content of information provided in both periods were also similar. They finally concluded that, even though the content of information in both periods remained the same, MPR ensured an increase in the flow of information and fastened the price discovery process in all of the markets they examined.

Another major objective of MPR was to provide information to all market participants to ensure a fair distribution of potential benefits from trading. However, a major criticism against MPR was that it resulted in increased price transparency which had the tendency to increase Oligopsony power\textsuperscript{14} exercised by meatpackers. The relatively high concentration in the meatpacking industry has lead livestock producers to believe that meatpackers may exercise market power. However, the high level of concentration in the meatpacking industry allows these firms to handle high livestock volumes efficiency due to economies of scale. This gives rise to circumstances under which meatpackers will have a relative advantage in bargaining over a fragmented livestock production sector. Several studies have hypothesized that despite the numerous advantages that MPR may possess, it

\textsuperscript{13} The Error Correction Model measures the speed with which a dependent variable returns to equilibrium after a change in the independent variable.

\textsuperscript{14} Oligopsony is a market structure in which there are small number of buyers and a relatively large number of sellers.
may induce meatpackers to adopt strategic behaviors which includes merging and collusion to their advantage.

Koontz (1999); Wachenheim and DeVuyst (2001) and Njorage (2003), in their studies, find evidence to support the claim that the introduction of MPR could increase the ability of meat packers to exercise market power and collude at the detriment of cattle producers. Wachenheim and DeVuyst (2001) specifically noted that greater transparency due to MPR could assist firms to behave non-competitively by speeding the flow of information among the few firms. Njorage, Yiannaka, Giannakas and Azzam (2007) also included in their model the tendency of packers to collude given new market information and they discussed two possible instances. The first instance they considered was the possibility of risk effects from increased transparency to exceed collusive effects - resulting in an increase in livestock procurement. They added that this will improve the welfare of packers, feeders and consumers. The second instance they considered had to do with collusive effects outweighing risk effects – this had the possibility of reducing quantity procured and increasing packers’ market power. In both instances, they concluded that social benefits outweighed social costs.

Cai, Stiegert and Koontz (2011) developed a Markov chain model that tested a regime switching behavior among packing firms that moved between cooperative and non-cooperative systems. They examined beef pricing margins using periods before and after the implementation of the Act. They found that market power of meatpackers increased after MPR. Post MPR periods (after 2001) showed economic profits of $2.59 per head which means that cattle prices were reduced by 0.2 to 0.3 cents due to Oligopsony power.
Their results are consistent with the fact that even though MPR encouraged transparency, it also has the tendency to facilitate market power among meatpackers. An earlier research article by Anderson et al. (1998), however, argues that increased transparency could also favor feedlots. They simulated interactions between meatpackers and livestock sellers using experimental data from Oklahoma State University’s Packer-Feeder game. They found that an increase in public information to meatpackers increased market prices paid to feedlots.

Azzam and Salvador (2004), however, came to the opposite conclusion reported by Anderson et al. They developed a theoretical model assuming risk averse Cournot firms to measure the change in market power of meatpackers with the introduction of MPR. They found that the introduction of the policy did not increase market power of meat packers in all the regional markets under consideration. They concluded that MPR would not lead to collusive behaviors among packers.

Discussing MPR and its effects on price volatility: Njorage (2003), following Koontz (2003), considered a conceptual model that sought to analyze the potential impacts of market transparency under MPR. The results from this analysis predicted that MPR would reduce price volatility of slaughter livestock and thus reduce the associated cost of uncertainty. Empirical evidence contradicting to this argument was found by Perry et al (2005) who examined the volatility of prices before and after MPR. They concluded that prices were twice as volatile under the mandatory system. Perry et al explained that, one of the possible reasons for the increased price volatility was that the AMS may have observed less week-to-week variations with the voluntary price system. This, therefore,
resulted in more a consistent animal quality and hence prices. Koontz and Ward (2011) also noted and gave a plausible reason to this conclusion to be the result of the reduced filtering role of reporters under the mandatory system. The mandatory system allowed the inclusion of the full price range of all transactions and thus increased price variability.

Koontz (2007) also examined the vertical relationship between national fed cattle prices and boxed beef cutout values. He modelled cattle prices as a function of boxed beef prices, byproduct values, and live cattle futures prices. The results from his analysis suggested that, on average, there is a stronger relation between fed cattle prices and live cattle futures prices. However, the confidence interval around the expected price was larger with the MPR. These results are consistent with findings that support the claim that MPR ensured increased transparency but also increased price volatility.

As stated earlier, MPR allowed the prices and volumes of non-cash market transactions to be also reported. Using different econometric techniques, many authors in their attempt to assess the implications of the MPR, have written extensively on the market trends in the post-MPR era. Most proponents of the MPR were livestock producers because they believed the voluntary system did not reflect all market transactions. They asserted that higher prices are paid for cattle sold in the contract market and that if these higher prices were reported; it will help them obtain higher prices from packers. They were, therefore, speculating large price differences existed between cash and non-cash transactions.

Ward (2004) used MPR data from April 2001 to March 2004 to compare the current week’s formula prices to the previous week’s cash prices. He found an insignificant
difference between the two prices and thus rejected the concept of large price differentials between cash and formula prices as livestock producers speculated. Perry (2005) also found evidence against the producers’ assertion and explained that it might be the reason for the initial producer dissatisfaction with the MPR. Grunewald, Schroeder and Ward (2004) also empirically verified whether or not cattle feeders were satisfied with the mandatory system. They administered a survey that asked for feedback on MPR report usage. As early as 2002, their results indicated that MPR had not enhanced negotiations between cattle feeders and beef packers. Schroder et. al (2002) also surveyed feedlot operators in Kansas, Nebraska, Texas and Iowa about their views on MPR. About 76% of the respondents expressed dissatisfaction with the mandatory system.

Some aspects of literature have looked at how cattle prices have changed with regards to the availability of new information as required by MPR. Other papers have looked at the role MPR has played in empowering packers at the detriment of producers. Through it all, the results are rather mixed. This paper focuses mainly on whether the introduction of MPR has affected volume shares of the various marketing arrangement over the past few decades.

2.4 LITERATURE ON PRICE TRANSPARENCY AND PRICE DISCOVERY

Price transparency is an important component of market transparency. A market is said to be transparent if all relevant information on prevailing market conditions is made available to all market participants. According to the Council of Security Regulators of the Americas (COSRA, 1993), transparency can also be defined as the degree to which information on prices and volumes is made publicly available. Market transparency is an
important factor in ensuring efficient price discovery and increase traders confidence that they are trading efficiently (International Organization of Securities Commissions (IOSCO), 2001). O’Hara (1995) also notes that price transparency enables market participants to extract market information necessary for achieving the goal of price discovery. There are several studies on financial markets regarding market transparency and how it affects prices and trade volumes.

Barclay and Hendershott (2003) examined the effects of trading after hours on the amount and timing of price discovery over a 24 – hour period. They found that higher volumes of liquidity trade enhanced price discovery in the US stock exchange market. Barclay and Hendershott also found that lower trading volumes resulted in significant although inefficient price discovery. Similarly, Ward (1987) noted the importance of accurate and timely reports on market prices and concluded that it was necessary for the promotion of market efficiency and adequate price discovery.

Flood et al (1999) examined the effect of price disclosure on market performance. Their experiment was on a multi-dealer market where seven markets trade a single security. Public prices were compared to bilateral quoting. They concluded that higher cost of searching induces aggressive pricing strategies which enhances price discovery in opaque markets.

Pagano and Roell (1996), also investigated whether greater market transparency reduces the possibility of taking advantage of uninformed market participants. They compared auction and dealer market prices with different degrees of transparency. They
concluded that, on average, increased information from market transparency reduces transaction cost for uninformed traders.

Bloomfield and O’Hara (1999) used laboratory experiments to determine how market efficiency is affected by trade and quote disclosure. They found that transparency of trade improves information efficiency of transaction prices. They noted, however, that trade disclosure also had the tendency to reduce competition among market participants. Though their study was on financial markets, their conclusion is in line with Wachenheim and DeVuyst (2001) who concluded that firms may behave non-competitively with increased transparency resulting from MPR.

Anderson (1998) used experimental simulations to examine the impacts of reduced market information on price discovery and production efficiency. Results from their analysis showed that reducing market information increased variation in prices and decreased market efficiency. Bastian, Koontz and Menkhaus (2007) also performed an experimental simulation to assess the impact of increased information of forward contract volumes. They found that when MPR-like information was provided, forward contract volumes improved. They concluded that MPR-like information caused forward contract volumes to increase and improved market efficiency.

Fausti, Qasmi and Diersen (2010) used data on national slaughter cattle grid premiums and discounts to evaluate the increased market transparency following the implementation MPR. They found that the variations in premiums and discounts were higher after the implementation of MPR. They concluded that the passage of the Act was necessary with regards to public reports on grid premiums and discounts.
Conclusions from this section suggest that market transparency has the overall effect of increasing market efficiency. The literature reviewed on MPR also suggests that the policy increased market transparency. For this reason, MPR was included in the analysis to verify whether or not it impacted the volume shares of the marketing channels under consideration.
CHAPTER THREE: DATA DESCRIPTION AND METHODOLOGY

3.0 INTRODUCTION

This chapter introduces the theoretical framework upon which a series of hypotheses associated with AMA volume patterns can be derived. An econometric model is developed based on the underlying theoretical framework. Estimation of the econometric model and diagnostic tests employed in the analysis were conducted using Stata 12.1 statistical software. Data sources and the description of variables were also provided in this section. Data used in this study were collected from secondary sources.

3.1 DATA SOURCES

The datasets used for analysis in this paper were compiled from two main sources: Livestock Marketing Information Center (LMIC) and the Bureau of Labor Statistics (BLS) of the United States Department of Labor (USDL). A weekly data series were compiled from Nov 24th, 2002 to December 27th, 2015 for all variables used in the empirical analysis.

National slaughter cattle, both live and dressed for all steers, heifers, cows and bulls, were used as the total supply of fed cattle in the market (LM_CT106). Both live prices and dressed prices were used for the analysis. Weekly live prices (steers) and dressed prices (all heifers and steers) were compiled from LMIC for all three marketing options (LM_CT151 and LM_CT 154). Cattle on feed, placements, choice-select spread (LM_CT155), percentage of animals grading choice or better, packer-owned cattle for both formula and forward contract (LM_CT153) were also used as explanatory variables in the two contract markets. Both corn and feeder cattle prices were also obtained from LMIC.
The producer price index for farm products was derived from BLS and was used as the price deflator for the prices in all 8 equations. All prices are in 2015 dollars. See full definition of variables in table 1.

### TABLE 3.1: DESCRIPTION OF VARIABLES

<table>
<thead>
<tr>
<th>Variables</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$p_1$ ($/\text{cwt}$)</td>
<td>Average price paid to feedlot operators for cattle (both live and dressed) sold on the cash market.</td>
</tr>
<tr>
<td>$p_2$ ($/\text{cwt}$)</td>
<td>Average price paid to feedlot operators for cattle (both live and dressed) sold by forward contract.</td>
</tr>
<tr>
<td>$p_3$ ($/\text{cwt}$)</td>
<td>Average price paid to feedlot operators for cattle (both live and dressed) sold by formula trade.</td>
</tr>
<tr>
<td>$p_C$ ($/\text{bushel}$)</td>
<td>Price of corn (input) used in feeding cattle in dollars per bushel. $p_C$ was lagged 8 weeks.</td>
</tr>
<tr>
<td>$p_f$ ($/\text{cwt}$)</td>
<td>Price of feeder cattle used in feeding cattle. This is used as an input by feedlot operators. $p_f$ was lagged 16 weeks.</td>
</tr>
<tr>
<td>$mpr$</td>
<td>Dummy variable representing periods when mpr was active and periods when it had expired. 1 represents periods when mpr was active and 0 if otherwise.</td>
</tr>
<tr>
<td>$\text{Neg}$</td>
<td>Proportion of cattle (both live and dressed) sold on the cash market.</td>
</tr>
<tr>
<td>$\text{forw}$</td>
<td>Proportion of cattle (both live and dressed) sold by forward contract. Agreement is entered into at least two weeks before cattle is delivered to packer.</td>
</tr>
<tr>
<td>$\text{form}$</td>
<td>Proportion of cattle (both live and dressed) sold on formula.</td>
</tr>
<tr>
<td>$\text{spread ($/\text{cwt}$)}$</td>
<td>Choice-select spread is the spread between the price of USDA choice beef and USDA select beef.</td>
</tr>
<tr>
<td>$\text{choice (%)}$</td>
<td>Percentage of animals grading choice or better. This is equivalent total number of cattle grading prime and choice.</td>
</tr>
<tr>
<td>$\text{onfeed (1000/head)}$</td>
<td>Cattle on feed to gain weight before slaughter. Onfeed was lagged 8 weeks. It can also be defined as the stock of cattle in a feedlot.</td>
</tr>
<tr>
<td>$\text{Plc (1000/head)}$</td>
<td>Cattle being put in feedlots to attain required weight. It usually takes a period of an average of 16 weeks. This variable was lagged 16 weeks. It can also be defined as the flow of cattle to a feedlot.</td>
</tr>
</tbody>
</table>
3.2 THEORETICAL FOUNDATION

The theoretical framework is based upon Hoteling’s lemma (Hoteling, 1932). Hoteling’s lemma demonstrates the relationship that exists between profit that a firm earns and its output supply and input demand functions. It is assumed here that the firm operates in a competitive market.\(^\text{15}\) Thus the following conditions hold:

i. There are \(n\) identical firms that sell undifferentiated goods
ii. There are no barriers to entry and exit into the market
iii. There is perfect information about prices
iv. Firms are price takers
v. There are many buyers and sellers

Varian (1992) discusses the concept of an equilibrium profit function and the use of Hoteling’s lemma in creating output supply functions.

There are two main market participants: feedlot operators (on the supply side) and packers (demand side). The focus of this investigation is feedlot marketing behavior with respect to AMA options. The \(i^{th}\) feedlot firm’s goal is to maximize profit. If it is assumed that \(\pi\) denotes profit, \(s_i\) denotes the firm’s output (fed cattle) that will be sold using an AMA\(^\text{16}\), \(p\) denotes the vector of AMA prices, \(x\) denotes vector of inputs into the production of cattle \(s_i\) and \(w\) denotes the vector of input prices. Then an individual firm’s goal is to:

\(^{15}\) Firms are assumed to be competitive for simplicity of analysis. The beef industry is, however, not considered competitive as there is evidence of the existence of market power – even though it causes up to 3% of price distortions on average (Schroeter, 1988). The possibility of the existence of market power in the beef industry is therefore relaxed. However, the focus of this study is on the beef feedlot industry and feedlot firm behavior. Thus, assuming competitive behavior in the feedlot industry is less problematic than if this study was modeling the packing industry.

\(^{16}\) For estimating purposes and ease of discussion the cash market is considered to be a component of the AMA set of alternatives in this chapter.
Max $\pi_i = ps_i - wx$

Accordingly, the general form of the profit function can be specified as follows (Varian 1992);

$$\pi^* = \pi^*(p_i, w_i)$$  \hspace{1cm} (1)

The profit function is stated the way it is because it is assumed that the individual firm is in equilibrium. Comparative static analysis requires differentiating with respect to input and output prices to derive the general functional form of the input demand and output supply functions for the firm. They are defined as follows;

$$\frac{\partial \pi^*(p, w)}{\partial p} = s(p, w) \geq 0$$  \hspace{1cm} (2)

$$\frac{\partial \pi^*(p, w)}{\partial w} = x(p, w) \leq 0$$  \hspace{1cm} (3)

Hoteling’s lemma assumes that the profit function increases with $p$ (output price) and decreases with $w$ (input price). The profit function is also homogenous of degree one in $p$ and $w$. This means that profit changes one-for-one with input and output prices. It is assumed that the conditions of hoteling’s lemma are met in this analysis. It is assumed in the fed cattle market an individual feedlot can sell cattle through one or all marketing arrangements. In this analysis three market outlets are considered for cattle produced by each firm: the cash market, forward contract market and the formula market\textsuperscript{17}. An individual firm produces $s_i$ number of cattle using $x_i$ inputs in a given market period. Given that $w_i$ and $p_i$ are input and output prices respectively and all inputs are used in the

\textsuperscript{17} Before 2004, negotiated grid trades were considered as part of formula trades since they all involved the use of some formula to determine prices. The negotiated grid market was not included in our discussion because there has been relatively little or no changes compared to the rest of the marketing options.
production of total output; an individual firm maximizes profits based on input and output prices:

$$\pi^* = \pi^* \left( p_1, p_2, p_3, \sum_{i=1}^{\infty} w_i \right)$$

Equation (4) is the general profit maximizing function given that there are three different market outlets for fed cattle. Equations (5), (6) and (7) are supply equations for negotiated cash market, forward contract market and formula based market respectively for an individual firm. $p_1, p_2, p_3$ are prices received by an individual feedlot operator from the cash market, forward contract market and formula based market, respectively.

Since there are $n$ identical firms, a linear aggregation of individual input and output functions was used to construct the industry’s input demand and output supply functions. The total cattle produced by industry in a given market period is thus given by $\sum_{i=1}^{n} s_i = S$. Where, $\sum_{k=1}^{n} x_k$ is a vector of factor inputs needed to produce total output, $S$. Feedlot operators choose to maximize their profits in equation (8) by choosing output prices. Equations (9), (10) and (11) give the industry’s supply functions for the three market outlets.

$$\pi^* = \pi^* \left( P_1, P_2, P_3, \sum_{i=1}^{\infty} W_i \right)$$

$$\frac{\partial \pi^*(p_i, w_i)}{\partial p_1} = S_1(p_i, w_i)$$

$$\frac{\partial \pi^*(p_i, w_i)}{\partial p_2} = S_2(p_i, w_i)$$

$$\frac{\partial \pi^*(p_i, w_i)}{\partial p_3} = S_3(p_i, w_i)$$
\[ \frac{\partial \pi^*(P_i, W_i)}{\partial P_2} = S_2(P_i, W_i) \]  

(10)

\[ \frac{\partial \pi^*(P_i, W_i)}{\partial P_3} = S_3(P_i, W_i) \]  

(11)

\( P_1, P_2, P_3 \) are prices received by all feedlot operators from the cash market, forward contract market and formula based market respectively.

### 3.3 ECONOMETRIC MODEL

The supply equations were specified in terms of input prices, output prices and other variables that may affect the volume shares of the cattle marketing channels. Two fed cattle marketing channels are considered: live and dressed weight. Separate OLS regressions were estimated for live and dressed delivery options. The assumed model structure upon which this analysis is based is due to following observations:

- the live market and dressed weight market behave differently,
- there is a high correlation between the cash and the two contract markets under consideration and;
- the forward contract market and formula market are independent of each other (evidence from correlation matrix of their residuals and endogeneity test).

From the observations above, two SUR (Seeming Unrelated Regressions) were estimated between the negotiated market and each of the two contract markets. Individual OLS regressions were estimated for forward contract and the formula markets in the live and dressed weight delivery options (since they acted independent of each other).\(^\text{18}\)

\(^{18}\) The individual OLS regression results for the forward and formula markets are considered unbiased and consistent but inefficient. SUR provides more efficient estimates.
The two sets of SUR equations were structured for the live market as follows:

\[ \text{Neg}_t = \alpha_0 + \alpha_1(p_{1t} - p_{2t}) + \alpha_2 \text{mpr} + \alpha_3 pc_8 + \alpha_4 \text{trend} + \sum_{i=5}^7 \alpha_i D_i + \varepsilon_{1t} \]

(12a)

\[ \text{Forw}_t = \beta_0 + \beta_1 \text{forw}_{t-1} + \beta_2(p_{1t} - p_{2t}) + \beta_3 \text{mpr} + \beta_4 p_{f16} + \beta_5 \text{plc}_{16} + \beta_6 \text{onfeed}_8 + \beta_7 \text{trend} + \sum_{i=8}^{10} \beta_i D_i + \varepsilon_{2t} \]

(12b)

The two sets of SUR equations were structured for the dressed-weight market as follows:

\[ \text{Neg}_t = \delta_0 + \delta_1 \text{neg}_{t-1} + \delta_2 \text{neg}_{t-2} + \delta_3(p_{1t} - p_{3t}) + \delta_4 \text{mpr} + \delta_5 pc_8 + \delta_6 \text{trend} + \sum_{i=7}^9 \delta_i D_i + \varepsilon_{3t} \]

(13a)

\[ \text{Form}_t = \gamma_0 + \gamma_1 \text{form}_{t-1} + \gamma_2 \text{form}_{t-2} + \gamma_3(p_{1t} - p_{3t}) + \gamma_4 \text{mpr} + \gamma_5 p_{f16} + \gamma_6 \text{plc}_{16} + \gamma_7 \text{onfeed}_8 + \gamma_8 \text{trend} + \gamma_9 \text{choice} + \gamma_{10} \text{spread} + \sum_{i=11}^{13} \gamma_i D_i + \varepsilon_{4t} \]

(13b)

The two sets of SUR equations were structured for the dressed-weight market as follows:

\[ \text{Neg}_t = \sigma_0 + \sigma_1 \text{neg}_{t-1} + \sigma_2(p_{1t} - p_{3t}) + \sigma_3 \text{mpr} + \sigma_4 pc_8 + \sigma_5 \text{trend} + \sum_{i=6}^8 \sigma_i D_i + \varepsilon_{5t} \]

(14a)

\[ \text{Forw}_t = \theta_0 + \theta_1 \text{forw}_{t-1} + \theta_2(p_{1t} - p_{2t}) + \theta_3 \text{mpr} + \theta_4 p_{f16} + \theta_5 \text{plc}_{16} + \theta_6 \text{onfeed}_8 + \theta_7 \text{trend} + \theta_8 \text{choice} + \theta_{10} \text{spread} + \sum_{i=11}^{13} \theta_i D_i + \varepsilon_{6t} \]

(14b)
Where: $Neg_t$, $Forw_t$, $Form_t$ are market shares for negotiated, forward and formula markets respectively. $p_{1t}, p_{2t}, p_{3t}$ are prices received by feedlot operators at time $t$. The coefficients of these prices provide an estimate of how volume shares in each market change when prices in other markets change. Own prices were, however, not included in the models because the focus is on how shares in the two contract markets change when the price in the cash market changes.

Instead, price differentials were included in all the equations to capture a price change and its effect on a feedlot’s motivation to supply fed cattle to a given market. For instance, if an increase in the own price of a particular supply outlet, say $p_1$ (negotiated cash price), increases $q_1$ (negotiated market share); then it is expected that if $p_1 - p_2 > 0$, then $q_1$ should increase relative to $q_2$. In effect, an increase in the own price of market 1 relative to market 2’s price should cause volumes to increase in market 1.

Input prices, $p_f$ and $p_c$ are prices of feeder cattle and corn; the two main inputs firms use in the production of cattle (Feuz, 2011). The price of corn relates differently to all three markets. As corn prices become cheaper during the feeding period, there is a tendency for producers to feed cattle longer, and this will lead to an increase in quality rather than yield (Diersen and Fausti, 2012). This gives a greater incentive to sell on contract rather than the cash market. The coefficient of corn in the negotiated cash market is, therefore, expected to be less than zero since producers prefer to sell higher quality cattle on contract instead of the cash market. Producers are rewarded if they meet the quality requirements stated in the agreement they entered into. Again, since contracting is used as a risk management tool, when feedlot operators expect an increase in the price of corn;
they are likely to lock-in current corn prices. It is, therefore, expected that as the price of corn increase, volumes in formula and forward markets will also increase.

\(D_i\) represents three quarterly dummies that were included in all three models to account for seasonal variations. The first quarter was used as the base quarter to which comparisons were made. A linear time trend was also included to control for unobservable factors associated with market shares.

The variable “Cattle on Feed” denotes cattle on feed in feed yards to gain weight prior to slaughter. It was lagged 8 weeks because that is the average time cattle are fed prior to slaughter. This was used as an explanatory variable in both formula and forward contract markets as it has the tendency to affect the volume shares in both markets.

Cattle placed on feed is directly related with future cattle on feed inventory (Mark and Small, 2007). It is expected an increase in placements will lead to an increase in future cattle supplies. Placement was lagged 16 weeks because on average, cattle spend about three to six months in a feedlot.

Periods when MPR active include: April, 2001 to September, 2005; October, 2006 to September, 2010 and September, 2010 to September, 2015. All periods beside these were considered as periods when MPR was inactive. The explanatory variable MPR (a dummy variable) was also included in all the equations to capture the influence of the introduction of the mandatory price reporting system on feedlot and packer behavior during periods when mandatory reporting was enforced and periods when it had expired. As discussed earlier, Matthews et. al (2015), claimed that the introduction of MPR occurred at the same time as a decline in cash market volumes. In the light of this argument, it is
expected that negotiated market volumes decline while contract market volumes increase in periods when MPR was enforced.

Quality traits such as choice-select spread (“spread”) and animals grading choice or better (choice) were included as covariates in equations with formula volumes as dependent variables. According to Whitley (2002), AMA are directly related with higher quality cattle. Even though he did not find a causal relationship, it is expected that as these quality traits increase, formula volumes will also increase.

The variables, $\varepsilon_{1t}$ through $\varepsilon_{8t}$ represent the error terms associated with the supply equations. These error terms are assumed to be normally distributed and have an expected value of zero.

3.4 REGRESSION DIAGNOSTICS

Four standard regression diagnostic tests were conducted. The essence of these tests is to assess the validity of the model in several ways. Due to the time-series nature of the data, the following tests were carried out: test for stationarity, serial correlation, heteroskedasticity, and multicollinearity.

3.41 STATIONARITY TEST

In order to avoid spurious estimates in the regression analysis, Augmented Dickey Fuller and Phillips-Perron unit root tests were applied on the time series data used in the regression analysis. The ADF test, as proposed by Said and Dickey (1984), is an improvement on the Dickey-Fuller (DF) test to allow for series to be autocorrelated at higher order lags (Dickey and Fuller, 1979). Both tests were used to determine whether or not the variables under consideration were stationary.
The ADF statistic was obtained from the parameter $\delta$ by using the following equation;

$$
\Delta z_t = \delta z_{t-1} + \sum_{i=1}^{P} \gamma_i \Delta z_{t-i} + \beta t + \mu_t
$$

(16)

The null hypothesis for the ADF test is that the variable in question is non-stationary or has a unit root ($\delta = 0$). The alternative hypothesis is that the null hypothesis is false ($\delta \neq 0$). In other words, if the test statistic is less than the critical value, we fail to reject the null hypothesis of unit root and vice versa. These null and alternative hypotheses also hold for the Phillips-Perron test.

The Phillips-Perron (PP) test rectifies serial correlation and heteroskedasticity by using the Newey-West heteroskedasticity and autocorrelation-consistent covariance matrix (Philips, 1987). It also has the merit of not having to specify the lag lengths for the test regression. According to Philips and Perron (1988, p.343), the PP unit root test also derives it test statistic from the following equation;

$$
\Delta y_t = \pi z_{t-1} + \sum_{i=1}^{P} \gamma_i \Delta z_{t-i} + \beta t + \mu_t
$$

(17)

The null hypothesis for the PP test is that $\pi = 0$ (presence of unit root) and the alternative hypothesis is that the null is false.

There are three possible cases with regards to stationarity of variables in a given regression. First, both the independent and dependent variable may be stationary. Second, both the independent ($x$) and the dependent ($y$) variables may be integrated of order one. The last condition is that $y$ may be stationary and $x$ may be integrated of order one. In the last two cases, if the returned error terms are I (1), then the regressions are spurious. However, if the error terms turn out to be I (0), it means that $x$ and $y$ are cointegrated. In
other words, the models eliminate the stochastic trends to produce stationary error terms (Nielsen, 2005).

The stationarity tests showed that negotiated and formula market shares were I (1) and the forward contract market share is I (0). According to Baffes (1997), the minimum criterion for an appropriate model is to have an I (0) error term. The condition to achieve an I (0) error term with an I (1) dependent variable, is to have at least two independent variables that are I (1). He stressed that, if this is not the case, the growth in the dependent variable will be explained by the error term. Also, explanatory variables will just explain the variation in the growth of the dependent variable in question.

Even though the error term is expected to be I (0) to prove a satisfactory model, it should not be as a result of inheriting the stationarity properties of the dependent variable in question. For this reason, the coefficients of the explanatory variables in the forward contract market equation were tested to see if they are significantly different than zero. Different than zero coefficients implied that the stationary error term was not as a result of the stationary dependent variable. This same principle was applied in the case of our regression analysis. Both stationary and non-stationary variables were included in the regression equation without detrending or first differencing. The stationarity of the error terms in all equations was checked prior to all estimations. The error terms for all equations, both in the live and dressed weight markets, were I (0). See Appendix A for results from stationarity test of the error terms of the equations under consideration.
3.42 SERIAL CORRELATION

Serial correlation is frequently a problem with time-series data. It occurs when errors from a one-time period say, t, is correlated with another time period say, t+1. Even though the presence of serial correlation does not affect consistency; some efficiency might be lost.

The Durbin-Watson (DW) test was used to test the presence of serial correlation. The null hypothesis is that there is no serial correlation in the time series. The alternative hypothesis for this test is that the errors are positively autocorrelated (Montgomery et. al, 2008 p.136). The DW statistics is given by:

\[
d = \frac{\sum_{t=2}^{T}(e_t - e_{t-1})^2}{\sum_{t=1}^{T} e_t^2}
\]  (18)

Lagged dependent variables were included as covariates in most of the equations. For this reason, the DW test would not be appropriate to check for autocorrelation. The Durbin h test was used for this purpose. According to Durbin (1970, p.419), the Durbin h statistic is given by:

\[
h = (1 - 0.5d) \sqrt{\frac{T}{1 - \text{Var}(\hat{\beta}_1)}}
\]  (19)

where:

\[d\] is the DW statistic; \(\text{Var}(\hat{\beta}_1)\) is the estimated variance of the coefficient of the lagged dependent variable. The same null and alternative hypotheses apply for both the DW and the Durbin h tests.
In instances when serial correlation was detected, lagged dependent variables were included as covariates to resolve this issue (Verbeek, 2008). However, equations 12b and 14b exhibited serial correlation which could not be corrected with the addition of lagged dependent variables as covariates.

3.43 HETEROSKEDASTICITY

Heteroskedasticity is rarely an issue when analyzing time series data. However, this problem can occur. It occurs when the variances of regression disturbances are not constant across observations (Greene, 2003 p.215). In this paper, the Breusch-Pagan test was used to detect the presence of heteroskedasticity in the models. The Breusch-Pagan test is a Lagrange multiplier that tests the hypothesis that $\sigma_i^2 = \sigma^2 f(a_0 + a'x_i)$; where $x_i$ is a vector of covariates. If $\alpha = 0$ then the model is homoskedastic. The null hypothesis is that the errors are homoscedastic and the reverse is true for the alternative hypothesis.

3.44 MULTICOLLINEARITY

As part of the model diagnostics, a multicollinearity test was also carried out. Mere correlations among a pair of predictors may understate multicollinearity in a given equation. The variance inflation factor (VIF), which measures the how much the variance of an estimated regression coefficient is inflated due to collinearity, was used to detect multicollinearity in all equations. Farrar and Glauber (1967, p.98) explain that the rule of thumb for unacceptable collinearity is correlations between covariates $\geq 0.8$. In our case, lagged dependent variables were also covariates in most equations. Some degree of multicollinearity was, therefore, expected.
3.5 ESTIMATION TECHNIQUES

Ordinary Least Square (OLS) is a method for estimating unknown parameters of a linear regression model with the aim of minimizing the sum of squared approximation errors. According to (Verbeek, 2008. p.15) OLS follows these four Gauss-Markov assumptions:

- The expected value of the error term should be equal to zero;
- Explanatory variables should be independent of error terms;
- Constant variance of the error terms and;
- Independence of error terms from different time periods.

A SUR (Seemingly Unrelated Regressions) estimation was used to estimate equations whose error terms were related. A Seemingly Unrelated Regression is a system of equations that is composed of several individual seemingly unrelated equations that are linked because their error terms are correlated (Moon and Perron, 2006). This paper considered four (two by two) SUR estimations instead of a three by three SUR. This was because of the idea to capture the unique relationship between the cash market and the formula and forward contract market.

The four SUR equations comprised of the negotiated with formula market and the negotiated with the forward contract market. These estimations were done for both the live and dressed markets. The correlation matrix of the residuals between the forward and the formula markets suggested that they were independent of each other. However, OLS estimations for the forward and formula market were not carried out. This is because performing OLS estimations for these two markets will suggest that they do not have any
relationship with the cash market – which is not the case. Besides, the OLS estimations for the forward and formula markets did not provide any additional information to what the SUR estimations between the cash and each of the two contract markets provided. See Appendix E and Appendix F for SUR and OLS estimations respectively.

The Augmented regression test (Durbin-Wu Hausman test) which was suggested by Davidson and MacKinnon (1993, p.237) showed that there was no endogeneity between the two contract markets. See Appendix C and Appendix D for error correlation matrices and results for the endogeneity test respectively. All diagnostics tests discussed in this chapter are relevant in ensuring that the estimated results are valid.
4.0 CHAPTER 4: RESULTS AND ANALYSIS

This chapter provides the empirical findings associated with the primary objective of this thesis; to identify the economic factors that have resulted in the shift in market volume shares in the fed cattle market across the cash and contract markets. This chapter reports the following statistical results; a. summary statistics for all the variables used in this research, b. diagnostic test results discussed in Chapter three, and c. parameter estimates produced by the SUR empirical model and the implications of those results.

4.1 SUMMARY STATISTICS

Weekly data series that spans from November 24, 2002 to December 27, 2015 was used. This thesis examines the economic factors responsible for changes in market shares between cash and contract markets. Variables or factors under consideration were selected from the literature addressing pricing discovery and market structure issues in the fed cattle. Descriptive statistics of the variables of interest are presented in table 4.1.

Table 4.1 shows that, on average, the percentage of market shares going to the cash, forward contracts and formula trade markets is 40.1%, 9.4% and 43.5% respectively. Their sum does not add up to 100% because negotiated grid transactions were not reported until 2004. Of the three markets, forward market volumes were the most volatile while formula volumes were the least volatile. Prices of the three markets are very close to each other in both the live and dressed markets. Also, the coefficient of variation shows that the variability of these prices are almost the same.
### Table 4.1: Summary Statistics (For live and dressed markets)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Obs(^19)</th>
<th>Mean</th>
<th>Std. Dev</th>
<th>COV(^20)</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>(p_1) (dressed)</td>
<td>680</td>
<td>174.082</td>
<td>21.641</td>
<td>0.124</td>
<td>132.294</td>
<td>241.614</td>
</tr>
<tr>
<td>(p_2) (dressed)</td>
<td>680</td>
<td>173.112</td>
<td>21.479</td>
<td>0.124</td>
<td>133.411</td>
<td>241.166</td>
</tr>
<tr>
<td>(p_3) (dressed)</td>
<td>680</td>
<td>174.697</td>
<td>21.903</td>
<td>0.124</td>
<td>131.696</td>
<td>239.420</td>
</tr>
<tr>
<td>(p_1p_2) (dressed)</td>
<td>680</td>
<td>.970224</td>
<td>11.784</td>
<td>12.146</td>
<td>-39.628</td>
<td>47.253</td>
</tr>
<tr>
<td>(p_1p_3) (dressed)</td>
<td>680</td>
<td>-.614</td>
<td>5.62241</td>
<td>9.157</td>
<td>38.082</td>
<td>37.274</td>
</tr>
<tr>
<td>(p_1) (live)</td>
<td>680</td>
<td>109.883</td>
<td>13.854</td>
<td>0.126</td>
<td>84.193</td>
<td>151.867</td>
</tr>
<tr>
<td>(p_2) (live)</td>
<td>680</td>
<td>110.888</td>
<td>13.959</td>
<td>0.126</td>
<td>84.959</td>
<td>152.181</td>
</tr>
<tr>
<td>(p_3) (live)</td>
<td>680</td>
<td>110.858</td>
<td>13.97</td>
<td>0.126</td>
<td>83.119</td>
<td>153.575</td>
</tr>
<tr>
<td>(p_1p_2) (live)</td>
<td>680</td>
<td>-1.005</td>
<td>6.669</td>
<td>6.636</td>
<td>-25.561</td>
<td>23.049</td>
</tr>
<tr>
<td>(p_1p_3) (live)</td>
<td>680</td>
<td>-.975</td>
<td>3.162</td>
<td>3.243</td>
<td>-22.828</td>
<td>23.505</td>
</tr>
<tr>
<td>(p_c)</td>
<td>680</td>
<td>3.972</td>
<td>1.0637</td>
<td>0.268</td>
<td>2.152</td>
<td>6.787</td>
</tr>
<tr>
<td>(p_f)</td>
<td>680</td>
<td>127.524</td>
<td>24.115</td>
<td>0.189</td>
<td>87.747</td>
<td>198.862</td>
</tr>
<tr>
<td>Neg</td>
<td>680</td>
<td>.4014</td>
<td>.1335</td>
<td>0.333</td>
<td>.135</td>
<td>.687</td>
</tr>
<tr>
<td>Forw</td>
<td>680</td>
<td>.0942</td>
<td>.0437</td>
<td>.0464</td>
<td>.0171</td>
<td>.266</td>
</tr>
<tr>
<td>Form</td>
<td>680</td>
<td>.435</td>
<td>.1157</td>
<td>.266</td>
<td>.2094</td>
<td>.6704</td>
</tr>
<tr>
<td>Choice</td>
<td>680</td>
<td>61.812</td>
<td>6.42256</td>
<td>0.104</td>
<td>50.72</td>
<td>75.68</td>
</tr>
<tr>
<td>Spread</td>
<td>680</td>
<td>-9.161</td>
<td>4.572935</td>
<td>0.499</td>
<td>-24.87</td>
<td>-1.22</td>
</tr>
<tr>
<td>Plc</td>
<td>680</td>
<td>1894.56</td>
<td>303.025</td>
<td>0.160</td>
<td>1391</td>
<td>2788</td>
</tr>
<tr>
<td>mpr</td>
<td>680</td>
<td>0.904</td>
<td>0.295</td>
<td>0.326</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

**NB:** All prices are in 2015 dollars.

Cattle grading choice or better (choice) were 61.8% on average; depicting that more than half of cattle slaughtered graded prime or choice. Choice-Select spread\(^21\) also averages -9.2. A wider spread (Choice-Select Spread), means that there is an increase in the demand (or lower supply of) for high quality cattle relative to low quality cattle. The number of cattle placed on feed was denoted by “place”. The summary statistics showed that, on

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\(^{19}\) Number of observations used to calculate the above estimates.

\(^{20}\) The coefficient of variation (COV) is the ratio of the standard deviation to the absolute mean value. It shows the variability of an object in relation to the mean of the population. The COV will be used as a measure of variation in this discussion.

\(^{21}\) The choice-select spread was calculated by LMIC as the difference in the price of select cattle and choice cattle. This is why it returns a negative value. It is sometimes referred to as choice-select discount.
average, 1895\textsuperscript{22} head of cattle are placed on feed in a given market period. Also, about 90.4\% of the observations represents periods when MPR was active.

4.2 DISCUSSION ON REGRESSION ANALYSIS

Table 4.2 gives SUR regression estimates between the cash and formula markets. About 93\% of the variation in cash volumes was explained by the covariates considered for both the live and dressed markets. Covariates included in the live and dressed markets for formula trade also explained about 94\% of the variation in formula volumes.

For the live market, every dollar increase in cash prices over formula prices increased volume in the cash market by 0.35\%\textsuperscript{23}. This is consistent with economic theory because producers are induced to sell in markets that offer relatively higher prices. This was also the case in the dressed weight market except that volume shares in the cash market increased by 0.234\%, on average.

Every dollar increase in cash prices over formula prices had an adverse effect on the formula market. On average, volume shares for formula trade reduced by 0.4\% and 0.2\% for the live and dressed markets respectively; with a dollar increase in cash prices. In both instances, relative price differential had a greater impact on the live than the dressed weight market. All price differential estimates were significant at 5\%.

\textsuperscript{22} In thousands.
\textsuperscript{23} All interpretations are based on Multiple Linear regressions. As such, it is assumed that all other covariates are held constant per the effect of variation in the covariates under consideration.
As mentioned earlier, MPR is a dummy variable that takes on the value of 1 for periods when MPR was active and 0 if otherwise. On average, in periods when MPR was active, volume shares for the cash market reduced by 0.8% and 0.9% in the live and dressed markets, respectively.

24 *, **, *** indicates rejection of the $H_0$ at 10%, 5%, 1% significance level. A significance level is the probability of rejecting the null hypothesis given that it is true. For instance, a 95% significance level shows that we are 95% confident that the estimates from the regression analysis are true.
markets respectively. However, this effect was not statistically significant for the live market. Even though the reduction in cash volumes was relatively small, it is at least significant at 10% for the dressed-weight market. It further confirmed Wachenheim and DeVuyst’s (2001) theoretical conclusions on MPR and its relation to packer competitiveness. They argued that MPR could decrease competitiveness among packers and consequently result in the thinning of the cash market. The reverse is true for the formula market. MPR had a positive impact on formula trade as far as volume shares were concerned. On average, in periods when MPR was active, formula volumes increased by 0.9% and 1% in the live and dressed market respectively. MPR estimates, for both live and dressed markets were significant at 5%.

The price of corn was lagged eight weeks and was included as an explanatory variable in the cash market. An increase in corn prices had a negative impact on both the live and dressed cash market - reducing volume shares by 0.024 and 0.021 respectively; per dollar increase in corn prices. These estimates were significant for live market but not for the dressed market. This is expected because corn is an input used in feeding cattle. It is, therefore, expected that as corn prices increase, cash volumes will decrease. The result is in line with the adage regarding changes in corn prices and its tendency to influence feeding practices. As corn price become cheaper, cattle are fed for more days, dressing percentage falls and yield increases relative to quality. When this happens feedlots are more likely to sell their cattle on a live weight basis.

Price of feeder cattle was also lagged 16 weeks and was used as an explanatory variable in the formula trade market. It was significant for the dressed market but not the live market. An increase in the price of feeder cattle by a dollar decreases formula volumes
by 0.008%. Though trivial, this is expected because feeder cattle is an input used in feeding cattle. Cattle placement and cattle on feed were insignificant in explaining changes in formula market volumes.

The choice select-spread (discount) is a negative value because it was computed by LMIC as the difference between the select discount and the choice premium. It is the current price differential between carcass with higher intramuscular fat and carcass of low quality (Fausti et al., 2012). Empirical evidence from table 4.3 indicates that, for every dollar increase in the choice-select spread, formula volumes increase by 0.07% for both live and dressed markets. This is consistent with the conclusions Fausti et al (2012) found in this study on pricing fed cattle on a grid. They concluded that an increase in the choice premium by a dollar will reduce carcass quality price risk and thus increase the incentive to use a pricing method that rewards cattle quality (in their case grid pricing).

The choice variable also depicts the percentage of cattle grading choice or better. The results from table 4.3 suggests that an increase in the percentage of animals grading choice or better by 1,000 head increases formula volumes by 0.08% for both live and dressed markets. This implies that as the percentage of cattle grading choice or better increases, feedlots will prefer to sell on formula than the cash market.

Trend and quarterly dummies were included to control for seasonality. All quarterly dummies were not significant except in the second quarter for the cash market. The reasoning behind this could be that as summer approaches, the demand for high quality beef is likely to increase. Also as mentioned earlier, feedlots would rather sell higher quality cattle on a formula because they will be rewarded for cattle quality. It is, therefore, expected that as the demand for higher quality cattle increases, cash volumes will fall in
favor of AMA volumes; all things being equal. The trend coefficients for the cash market further confirms the declining nature of the cash market over the past few decades. Conversely, the trend for formula trade was positive for both the live and dressed markets; further confirming the gradual replacement of the cash market with AMAs. All trend coefficients were significant at 5%.

Table 4.3: SUR for Cash versus Forward Contract Market

<table>
<thead>
<tr>
<th>Markets</th>
<th>Observations</th>
<th>R-squared</th>
<th>R-squared</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neg</td>
<td>664</td>
<td>0.8925</td>
<td>0.9272</td>
</tr>
<tr>
<td>Forw</td>
<td>664</td>
<td>0.6955</td>
<td>0.6976</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>LIVE</th>
<th>DRESSED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neg</td>
<td>Coefficient</td>
</tr>
<tr>
<td>neg1</td>
<td>N/A</td>
</tr>
<tr>
<td>p1p2</td>
<td>0.0006</td>
</tr>
<tr>
<td>mpr</td>
<td>-0.020</td>
</tr>
<tr>
<td>pc8</td>
<td>-0.0033</td>
</tr>
<tr>
<td>trend</td>
<td>-0.0006</td>
</tr>
<tr>
<td>q2</td>
<td>-0.02018</td>
</tr>
<tr>
<td>q3</td>
<td>-0.0075</td>
</tr>
<tr>
<td>q4</td>
<td>0.0033</td>
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<tr>
<td>constant</td>
<td>0.6624</td>
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</table>

<table>
<thead>
<tr>
<th>Forw</th>
<th>Coefficient</th>
<th>Std. Err</th>
<th>P value</th>
<th>Coefficient</th>
<th>Std. Err</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>forw1</td>
<td>0.5197</td>
<td>0.0288</td>
<td>0.000***</td>
<td>0.6364</td>
<td>0.0264</td>
<td>0.000***</td>
</tr>
<tr>
<td>p1p2</td>
<td>-0.00012</td>
<td>0.0001</td>
<td>0.323</td>
<td>-0.00008</td>
<td>0.0008</td>
<td>0.331</td>
</tr>
<tr>
<td>mpr</td>
<td>0.0065</td>
<td>0.0038</td>
<td>0.086*</td>
<td>0.0035</td>
<td>0.0023</td>
<td>0.335</td>
</tr>
<tr>
<td>pf16</td>
<td>0.0001</td>
<td>0.000059</td>
<td>0.052*</td>
<td>0.0001</td>
<td>0.00004</td>
<td>0.008***</td>
</tr>
<tr>
<td>plc16</td>
<td>2.42e-07</td>
<td>3.71e-06</td>
<td>0.948</td>
<td>3.60e-07</td>
<td>3.30e-06</td>
<td>0.913</td>
</tr>
<tr>
<td>onfeed8</td>
<td>3.41e-06</td>
<td>2.30e-06</td>
<td>0.139</td>
<td>9.75e-07</td>
<td>1.91e-06</td>
<td>0.610</td>
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<td>trend</td>
<td>0.00007</td>
<td>7.72e-06</td>
<td>0.000***</td>
<td>0.000053</td>
<td>6.40e-06</td>
<td>0.000***</td>
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<td>0.028*</td>
<td>-0.0052</td>
<td>0.0031</td>
<td>0.087*</td>
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<td>-0.0120</td>
<td>0.0234</td>
<td>0.607</td>
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</table>
Table 4.3 gives SUR regression estimates between the cash and forward contract markets. Covariates considered under live and dressed markets explained 89.3% and 92.87% of the variations in cash volume shares respectively. Also, covariates considered under live and dressed weights explained about 70% of the variations in forward contract volume shares.

For cattle priced by live weight, every dollar increase in cash prices over forward contract prices increases volume shares of the cash market by 0.06%. This is consistent with economic theory because producers are induced to sell in markets that offer relatively higher prices. This is also the case in the dressed weight market except that volume shares in the cash market increases by 0.03% on the average. Also, every dollar increase in cash price over formula prices conversely affected volume shares in the forward contract market. Forward volume shares are, however, irresponsible to changes in cash prices.

On average, in periods when MPR was active, volume shares for the cash market reduced by 2% for the live market. Even though the reduction in cash volumes was relatively small, it was significant at 5%. It further confirms the fact that there might be a relationship between MPR and the thinning cash market. On the other hand, MPR had a positive impact on forward contract volumes at least for the live market. On average, in periods when MPR was active, volume shares for the forward contract market increased by 0.65% for the live market.

Price of corn was lagged eight weeks and was included as an explanatory variable in the cash market. It had a negative impact in both the live and dressed weight markets - reducing volume shares by 0.033% and 0.15% per increase in the price of corn by a dollar. These estimates were significant for live weight in the cash market but not for the dressed
weight. These findings are similar to results from the SUR between the cash and formula markets. The economic implication of this can also be explained by how changes in corn prices affect feeding practices and impact the quality and yield grades of cattle.

Price of feeder cattle was also lagged 16 weeks and was used as an explanatory variable in the forward contract market. A dollar increase in the price of feeder cattle increased volume shares by 0.01% for both live and dressed markets. These coefficients were statistically significant at 5%. This may explain why feedlots choose to forward contract. Feedlots are able to lock in prices of inputs so that changes in market conditions do not affect their profit margins. Cattle on feed placement and cattle on feed variables were insignificant in explaining changes in volumes for forward contracts.

Trend and quarterly dummies were included to control for seasonality. All quarterly dummies were not significant at 5% except in the second quarter for the cash market and the third quarter for the forward contract market. The trend coefficients for the cash market further confirms the declining nature of the cash market over the past few decades. The trend coefficients for forward contracts were, however, positive and statistically significant; further confirming the gradual replacement of the cash market with contracts. Trend coefficients were all significant at 5%.

4.3 RESULT FROM DIAGNOSTIC TESTS

4.3.1 RESULTS FROM RESIDUAL CORRELATION MATRIX

The Breusch – Pagan test for independence was used to obtain the correlation matrix for the residuals in all four SUR equations. The null hypothesis for the Breusch – Pagan test was that the equations under consideration are independent of each other and
the alternative hypothesis was that the equations are not independent of each. A failure to reject the null hypothesis will mean that OLS can be used to obtain estimates for parameters without danger. A failure to reject the alternative hypothesis will permit the use of SUR (Seeming Uncorrelated Regressions) to obtain estimates for parameters.

Appendix C gives cross model correlations for the marketing options under consideration (for the dressed and live markets). Results for both live and dressed markets are similar in every sense. Cash-forward and cash-formula models (for both live and dressed markets) seem to be correlated. Some efficiency will be lost when OLS is used.

4.32 RESULTS FROM ENDOGENEITY TEST

It was hypothesized that the forward and formula markets might be related since they are all AMAs. The Augmented regression test as suggested by Davidson and Mackinnon was used to test for endogeneity between the forward contract and formula trade markets. First, the formula trade market was set as a function of the forward contract market. An OLS regression was estimated and the residual (e13) was obtained. Finally, an OLS regression was estimated for the forward contract market with the obtained residual as one of the covariates.

The basis for the decision on endogeneity lied in the significance of the error term. If the error term was statistically different than zero, then there was an issue of endogeneity. Put differently, if the error term was significant, then driving forces in the formula market were the same forces affecting the forward contract market. The endogeneity test between the forward contract and the formula markets was carried out for both live and dressed weight pricing options. Results from the test suggested that the forward contract and
formula trade markets were not related. In other words, even though they were all AMAs, they acted independently of each other. This was the case for both live and dressed weight markets. See Appendix D for endogeneity test results.

4.33 RESULTS FROM STATIONARITY TEST

ADF and PP tests were used to test for the stationarity of all the variables under consideration. Some variables were integrated of order zero, I (0) and others were integrated of order one, I (1). Following Baffes, regardless of the stationarity of the variables under consideration, a stationary error term is enough to show that the model is satisfactory. The stationarity of error terms in all equations under consideration were tested before regression analysis was carried out. All the error terms were I (0) – stationary. See Appendix A for stationarity test results.

4.34 RESULTS FROM SERIAL CORRELATION

The Durbin Watson test was used to check for serial correlation in the models. The test showed that serial correlation was present in all models. Lagged dependent variables were included to cater for the presence of multicollinearity. The Durbin h test was used to check for the presence of serial correlation after the lagged dependent variables were included. All but equations for the forward contract market (both live and dressed weights) had no serial correlation. See Appendix E for results from serial correlation.
4.35 RESULTS FOR HETEROSCEDASTICITY

The Breusch-Pagan test statistics revealed that most of the models were heteroskedastic in nature. Fitted values were plotted against the residuals to visually confirm the results from the Breusch-Pagan test. All 8 plots seemed fairly homoscedastic (See Appendix B for plots).
CHAPTER 5: SUMMARY AND CONCLUSION

This study sought to provide insight into factors responsible for the shift in the pattern of slaughter volumes across marketing channels. To provide a better understanding of how the cattle market works, the linkages between the marketing channels under consideration were examined. Also, it had been hypothesized in the literature that the introduction of MPR provided additional information that gave packers a competitive advantage over feedlots. In addition, the introduction of MPR occurred side-by-side with the dramatic change in the flow of slaughter volumes across cattle marketing channels. The specific objective of this study sought to access the role of MPR with regards to changes in volume shares in the cattle market.

For the purpose of this analysis, MPR together with other factors thought to influence volume shares were included in the equations to be estimated. The theoretical framework was based on the assumptions of Hoteling’s lemma. In that, the cattle market was assumed to be perfectly competitive and in equilibrium. The output supply assumption of the lemma was used to structure all regression equations used in this paper.

Appropriate correlation tests revealed that there was a relationship between the cash and the two contract markets – formula and forward contract markets. However, forward contract and formula markets had no relationship. Based on the discovery of this relationship, eight SUR equations were estimated – four for negotiated versus formula markets (for live and dressed prices) and the other four for negotiated versus forward contract markets (for live and dressed prices).
From the regression analysis, driving forces identified to cause changes in volume shares in the two contract markets included: MPR, cattle price differentials, price of feeder cattle, quality characteristics (i.e. choice-select spread and animals grading choice or better). Overall, as consistent with economic theory\textsuperscript{25}, feedlots were induced to sell their cattle in a market that offered a relatively higher price.

As mentioned earlier, the transition from voluntary price reporting to MPR changed the informational structure of the cattle market. In that, there was a sudden release of information on prices and volumes on cattle transactions. As hypothesized in the literature, packers could use the available information to the detriment of feedlot operators. Overall, MPR had a significant effect on volume shares for all marketing channels but for live cash market\textsuperscript{26} and dressed forward market. Generally speaking, MPR had a positive impact on forward contract and formula markets – for both live and dressed prices. Mandatory Price Reporting (MPR), however, had a negative impact on the cash market.

Cattle quality characteristics coefficients also provided evidence that producers are motivated to sell high quality cattle on formula when they are given the choice between the cash and formula market. This is in line with theory because unlike live weight and dressed weight pricing where a single average price can be used for the entire lot, formula pricing allows higher quality cattle to receive relatively higher prices (Feuz, Schroeder and Ward, 1998).

\textsuperscript{25} The law of supply states that more is supplied at a higher price. Producers are induced to sell in markets that gives the highest prices – this is because they are rational beings.

\textsuperscript{26} The MPR coefficient for the SUR between cash versus formula trade for the live market was insignificant.
Also, since forward contract is used as a risk management tool, it is very distinct in explaining volume shares (Diersen and Fausti, 2012). It allows feedlots to lock in feeder cattle prices when they expect the market to change. We observe from the results that an increase in feeder cattle prices increases forward contract volumes. This explains why feedlots might want to forward contract.

Evidence from the coefficients of the trend component in all equations estimated confirmed the shift from the use of the conventional cash markets to the use of contract markets. The seasonality coefficient also showed that cash volumes reduced by 1.3% and 0.8% in the second quarter\textsuperscript{27} for live and dressed markets respectively. The reasoning behind this could be that as summer approaches, demand for high quality beef is likely to increase. Also as mentioned earlier, feedlots would rather sell higher quality cattle on a formula because they will be rewarded for cattle quality. It is, therefore, expected that as the demand for higher quality cattle increases, cash volumes will fall in favor of AMA volumes; all things being equal.

Due to time constraint and insufficient and or unavailability of data, some factors that could have provided more insights to the objective of the study could not be included in the models estimated. Following Cai et al (2011) and Fausti et al (2015)\textsuperscript{28}; market power (cooperative\textsuperscript{29} and non-cooperative periods) could be included in the model to assess packer behavior and its possible effects on volume shares. Packer margins could also be

\textsuperscript{27} This reduction is relative to the first quarter. The first quarter was used as the benchmark to which other quarters were compared to.

\textsuperscript{28} Fausti et al (2015) argued that during cooperative periods, discounts paid on cattle increased. This made it difficult for producers who were not sure about the quality of their cattle to adopt the grid pricing system.

\textsuperscript{29} Cooperative periods are used interchangeably with non-competitive periods on the part of the packers.
useful in the variation in cattle volumes. Further studies can include these factors as they may throw more light on what is going on in the cattle market. While this study is not conclusive, it provides useful explanations regarding possible factors that are responsible for changes in volume shares across cattle marketing channels.
REFERENCES


Fausti, S. W., & Qasmi, B. A. (2002). Does the producer have an incentive to sell fed cattle on a grid?. *The International Food and Agribusiness Management Review, 5*(1), 23-39.


Mark, D.R. and Small, R.M. (2007), Interpretation of the USDA Cattle on Feed Report, Extension Report No. 850, Extension Division of the Institute of Agriculture and Natural Resources, University of Nebraska, Lincoln, NE.


Industries. *Report prepared for USDA, Grain Inspection, Packers and Stockyards Administration, Washington, DC.*


APPENDIX

APPENDIX A: STATIONARITY TEST FOR RESIDUALS.

<table>
<thead>
<tr>
<th>Residuals</th>
<th>PP test statistic</th>
<th>Results</th>
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<tr>
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<td>-20.542***</td>
<td>I(0)</td>
</tr>
<tr>
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<tr>
<td>$\varepsilon_4$</td>
<td>-25.861***</td>
<td>I(0)</td>
</tr>
<tr>
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<td>I(0)</td>
</tr>
<tr>
<td>$\varepsilon_6$</td>
<td>-25.861***</td>
<td>I(0)</td>
</tr>
<tr>
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<td>I(0)</td>
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<td>$\varepsilon_{12}$</td>
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</table>

NB: *, **, *** indicates a rejection of the $H_0$ at 10%, 5%, 1% significance level. The critical value at 1%, 5%, 10% significance level for both tests are -3.43, -2.86 and -2.57 respectively.
APPENDIX B: RESULTS FOR RESIDUAL VS. FITTED PLOTS

Equation 12a

Equation 12b

Equation 13a

Equation 13b
APPENDIX C: ERROR CORRELATION MATRIX

i. SUR Correlation matrix of residuals (For live prices)

<table>
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<th>$\Delta Neg$</th>
<th>$\Delta Forw$</th>
<th>$\Delta Form$</th>
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<tr>
<td>$\Delta Form$</td>
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ii. SUR Correlation matrix of residuals (For dressed prices)

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<td>$\Delta Form$</td>
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APPENDIX D: RESULTS FOR ENDOGENEITY TEST FOR LIVE AND DRESSED MARKETS.

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<th>Root MSE</th>
<th>R-squared</th>
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PART TWO OF THE ENDOGENEITY TEST FOR LIVE AND DRESSED MARKETS.

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**Forw**

<table>
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<tr>
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</table>

**APPENDIX E: TEST FOR SERIAL CORRELATION**

<table>
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<tr>
<th>Fitted against Residuals</th>
<th>Chi-square statistic</th>
<th>Prob &gt; Chi-square</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>$y_1, \epsilon_1$</td>
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</tr>
<tr>
<td>$y_2, \epsilon_2$</td>
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<td>0.8041</td>
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<td>$y_5, \epsilon_5$</td>
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<td>0.6483</td>
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<tr>
<td>$y_6, \epsilon_6$</td>
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<td>$y_7, \epsilon_7$</td>
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<td>0.2011</td>
<td>No serial correlation</td>
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<td>$y_8, \epsilon_8$</td>
<td>64.253</td>
<td>0.000</td>
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<table>
<thead>
<tr>
<th>Variables</th>
<th>PP test</th>
<th>ADF</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>$p_1$ (live)</td>
<td>-2.156</td>
<td>-2.669*</td>
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<tr>
<td>$p_2$ (live)</td>
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<td>-1.861</td>
<td>I(1)</td>
</tr>
<tr>
<td>$p_3$ (live)</td>
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<td>-2.311</td>
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</tr>
<tr>
<td>$p_1$ (dressed)</td>
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<td>-2.685*</td>
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</tr>
<tr>
<td>$p_2$ (dressed)</td>
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<td>-2.349</td>
<td>I(1)</td>
</tr>
<tr>
<td>$p_3$ (dressed)</td>
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<td>-2.287</td>
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</tr>
<tr>
<td>Place_16</td>
<td>-26.252***</td>
<td>-26.017***</td>
<td>I(0)</td>
</tr>
<tr>
<td>Onfeed_8</td>
<td>-26.052***</td>
<td>-25.689**</td>
<td>I(0)</td>
</tr>
<tr>
<td>spread</td>
<td>-5.504***</td>
<td>-3.153**</td>
<td>I(0)</td>
</tr>
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<td>choice</td>
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<td>-1.458</td>
<td>I(1)</td>
</tr>
<tr>
<td>Pc_8</td>
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<td>-27.788***</td>
<td>I(0)</td>
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<td>Pf_16</td>
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<td>-37.073***</td>
<td>I(0)</td>
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<td>Neg</td>
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<td>-4.160***</td>
<td>I(1)</td>
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<td>Forw</td>
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<td>-8.317***</td>
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<tr>
<td>Form</td>
<td>-2.492</td>
<td>-3.854***</td>
<td>I(1)</td>
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NB: *, **, *** indicates a rejection of the $H_0$ at 10%, 5%, 1% significance level. The critical value at 1%, 5%, 10% significance level for both tests are -3.43, -2.86 and -2.57 respectively.
### APPENDIX G: ROBUST OLS FOR FORWARD MARKET

<table>
<thead>
<tr>
<th>Observations</th>
<th>Root MSE</th>
<th>R-squared</th>
</tr>
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<tr>
<td>Live</td>
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<td>Dressed</td>
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<td>0.02414</td>
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<table>
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<tr>
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<th>Coefficient</th>
<th>Std. Err</th>
<th>P value</th>
<th>Coefficient</th>
<th>Std. Err</th>
<th>P value</th>
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<tr>
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<td>0.031**</td>
<td>0.0072083</td>
<td>0.0033733</td>
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<tr>
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APPENDIX H: ROBUST OLS FOR FORMULA MARKET

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<tr>
<th></th>
<th>Observations</th>
<th>Root MSE</th>
<th>R-squared</th>
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<tr>
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<table>
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<th>P value</th>
<th>Coefficient</th>
<th>Std. Err</th>
<th>P value</th>
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