THE CHANGING STRUCTURE OF THE DETERMINANTS OF CATTLE PRICES IN THE UNITED STATES: AN EMPIRICAL STUDY

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ABSTRACT

This study utilizes a new quarterly data set for the United States cattle markets spanning from 1971-2008 to estimate dynamic price models in three vertically related cattle markets: the models for boxed beef cutouts, slaughter cattle, and feeder cattle. Structural tests are then utilized to test whether the occurrence of Bovine Spongiform Encephalopathy (BSE) in 2003 and the introduction and widespread use of the Atkins diet between 1991 and 2005 lead to structural changes in the determinants of prices in each of the three markets. The results suggest BSE did not cause structural change within any market level, and BSE and Atkins diet events caused structural change within the boxed beef cutout values level. An important contribution of this study is the examination of structural change, suggesting that the market events lead to little or no structural change within the market levels.

CHAPTER 1

INTRODUCTION

Prices for cattle exist at three vertically related market levels: the carcasses/boxed beef cutout values market, the slaughter cattle market, and the feeder cattle market. Schultz and Marsh (1985) investigated the determinants of prices at each of the market levels for steers and heifers from 1971-1982 using information on national prices. While previous studies have investigated cattle prices at one or more market level, no study has estimated price determinant models at these three vertically related market levels using more recent national data. This study attempts to address this gap in the research literature by examining price determinants at each market level as well as testing for structural change within each market. Structural change can be defined as a fundamental change in the supply/demand relationships at each market level. This study therefore estimates price determinant models for steers and heifers as well as model of the determinants of price differences between steers and heifers for four time periods. These time periods are 1971-1982, 1992-2003, 1971-2003, and 1971-2008. Results obtained are compared to the findings reported by Schultz and Marsh as well as other studies.

The data used in this study includes the period 2004-2006, a period in which U.S. cattle prices were believed to be influenced by the December 2003 Bovine Spongiform Encephalopathy (BSE) events in which dairy cattle in Washington were described to be suffering from the mad cow disease. Although this study closely replicates the Schultz and Marsh study, the variables used in this study are not the same variables in the Schultz

and Marsh study. For example, Schultz and Marsh use carcass level data separated into steer and heifer prices but carcass level data stopped being reported in 1990, thus aggregated boxed beef values are used. Schultz and Marsh also used beef carcass-to-retail margins and farm-to-carcass margins in their analysis, but in this study wholesale-to-retail and farm-to-wholesale price spreads are used.[1]

A majority of previous studies focus on cross-sectional feeder auction data. For example, Buccola (1980), Schroeder et al. (1988), and Faminow and Gum (1986) examine certain characteristics such as: feed prices, soil moisture, sex, breed, and presence of horns. Buccola and Jessee (1979) and Schultz and Marsh are the only studies that examine steer and heifer price differences. Buccola and Jessee investigate these differences across time and space using regional market data, and report that differences within steer and heifer feeder prices depend on slaughter prices and the proportion of steers to total cattle on feed. Schultz and Marsh also investigate price differences as well as price determinants within the three market levels: the carcass market, the slaughter market, and the feeder market. Schultz and Marsh use national data and their study is the only one that examines all three markets on the national level.

For steer carcass prices, Schultz and Marsh find the following variables' coefficients statistically significant: the current quantity of steer and heifer carcasses, the lagged quantity of steer and heifer carcasses, the quantity of commercial pork and young chicken supplied, current by-product value of beef carcasses, lagged by-product value of beef carcasses, current disposable income, lagged disposable income, and beef carcass-to-retail margin. For heifer carcass prices, Schultz and Marsh find the following

[1] For an explicit explanation of the different variables utilized see Chapter 4.

variables' coefficients statistically significant: the current quantity of steer and heifer carcasses, the lagged quantity of steer and heifer carcasses, the quantity of commercial pork and young chicken supplied, current by-product value of beef carcasses, lagged by-product value of beef carcasses, current disposable income, lagged disposable income, and beef carcass-to-retail margin.

For slaughter steer prices, Schultz and Marsh find the following variables' coefficients significant: price of steer carcasses, by-product value for slaughter steers, and the quantity of commercial cattle slaughter (nonfed steers and heifers). For slaughter heifer prices, they find the following variables' coefficients significant: price of steer carcasses, by-product value for slaughter steers, and the quantity of commercial cattle slaughter (nonfed steers and heifers). Schultz and Marsh only find the price of steer carcasses to be significant in their slaughter price difference model.

For lighter feeder steer prices, Schultz and Marsh find the following variables' coefficients significant: price of slaughter steers, quantity of feeder heifers, and the farm-to-carcass margin. For heavier feeder steer prices, they find the following variables' coefficients significant: price of slaughter steers, quantity of feeder steers, and the farm-to-carcass margin. For lighter feeder heifer prices, they find the following variables' coefficients significant: price of slaughter steers, quantity of feeder steers, quantity of feeder heifers, price of corn, and the farm-to-carcass margin. For heavier feeder heifer prices, they find the following variables' coefficients significant: price of slaughter steers, quantity of feeder steers, and the farm-to-carcass margin. For lighter feeder price difference model, they find the following variables' coefficients significant: price of

slaughter steers, quantity of feeder steers, and the quantity of feeder heifers. Schultz and Marsh only find the price of slaughter steers coefficient to be significant for the heavier price difference.

Key findings for this study's price determinant models for the period 1971-2008 using one BSE dummy variable for the time period 2004-2006 are as follows. In the boxed beef cutout price model, coefficients for the following variables are statistically significant: the current quantity of slaughter steers and heifers, the lagged quantity of slaughter steers and heifers, current by-product allowances, lagged by-product allowances, wholesale-to-retail price spread, lagged boxed beef cutout values, and the BSE dummy variable.

In the slaughter steer and heifer price models, coefficients for the following variables are statistically significant: quantity of slaughter steers and heifers, by-product allowances, and boxed beef cutout values. In the slaughter price difference models, the following variables' coefficients are significant: the quantity of slaughter cows and boxed beef cutout values.

In the lighter feeder steer price model, coefficients for the following variables are significant: quantity of steers on feed, quantity of heifers on feed, the price of corn, and the price of slaughter steers. In the heavier feeder steer price model, coefficients for the following variables are significant: the quantity of steers on feed, the price of corn, and the price of slaughter steers. In the lighter feeder heifer price model, coefficients for the following variables are significant: the quantity of heifers on feed, the farm-to-wholesale price spread, the price of slaughter heifers, and the price of corn. In heavier feeder heifer

price model, coefficients for the following variables are significant: the quantity of steers on feed, the farm-to-wholesale price spread, the price of slaughter heifers, and the price of corn. In the feeder price difference models, the following variables' coefficients are statistically significant: the farm-to-wholesale price spread, the slaughter steer price, the price of corn, and the slaughter heifer price.

Tests are carried out to explore whether structural change has occurred in price determinant models. Intercept dummy variables are created for the BSE event. BSE is widely believed to have affected U.S. cattle markets and cattle prices in 2004, 2005, and 2006. A second possible source of structural change is an increase in the consumer preferences for red meat. The Atkins diet was introduced in 1989,[2] it is perceived to have positively affected consumer preferences and consumer demand for red meat. Robert Atkins died in 2003 and the company went bankrupt in 2005. Thus slope-intercept dummy variables were used for structural change for the period 1991-2005 at all three market levels.

The key findings for the slope-intercept dummy variables (BSE and Atkins diet) are discussed within the three market levels. For the boxed beef cutout price model, the Atkins diet coefficient is not statistically significant, but the BSE coefficient is positive and significant. The significant BSE coefficient suggests that BSE increases boxed beef values. For the steer slaughter price model, the BSE coefficient is negative and the Atkins diet coefficient is positive, but each coefficient is not significant. For the heifer slaughter price model, the BSE and Atkins diet coefficients are negative and not

[2] This study assumes it took roughly two years to gain in popularity, thus the dummy variable begins in 1991.

significant. The slaughter price difference model reports the BSE coefficient is negative and the Atkins diet coefficient is positive, but neither coefficient is significant. For the feeder price/price difference models, the lighter and heavier steers, the heavier heifers, and the price differences report a BSE coefficient that is negative but not statistically significant. The Atkins diet coefficients are positive for all of the steer/heifer feeder price models, and are negative for the feeder price differences models. The lighter and heavier steer weights, the heavier heifers, and the lighter price differences the Atkins diet coefficients are significant. This study tests for joint significance in which the null hypothesis of structural change is only rejected for the boxed beef cutout value market.

This study proceeds as follows: Chapter 2 discusses the previous literature on price determinant models for cattle prices. The reduced form models, methodology, and estimation issues are discussed in Chapter 3. Chapter 4 discusses the data and variables used in this study. Chapter 5 discusses in detail the empirical results mentioned above, as well as estimation procedures. Chapter 6 summarizes the major findings, and the implications of this study.

CHAPTER 2

LITERATURE REVIEW

This study re-examines the determinants of feeder and slaughter cattle prices and price differences among steers and heifers in the feeder and slaughter markets. The specific objective is to see if structural relationships have changed substantially over time.

The previous research on cattle price differentials incorporates an array of approaches to price evaluation. Price discounts among steer calves and yearlings, price determinants of a particular auction sale, price margins/spreads, and price differences among steers and heifers within different market levels and separate aggregation are examined in the literature.

Though not directly examined in this study, marketing margins/spreads has been the subject of several previous analyses, which have indentified how farm-retail and wholesale-retail margins affect price spreads among separate cattle cohorts (Mathews et. al 1999; Armah and Nelson 2007; Capps et. al 1995; Marsh and Brester 2004).

Price determinants have also been investigated. Marsh (1983) reexamines quarterly live cattle prices using rational lag structure first proposed by Jorgenson (1966). Using quarterly data from 1967 through the first quarter of 1981, Marsh concludes that dynamic stability was achieved with a geometric rational lag structure to describe fed prices cattle and a polynomial rational lag structure to describe feeder cattle prices. Monthly price premiums and discounts between steer calves and yearlings have also been

investigated by Marsh (1985). Using monthly data from January 1972 through December 1982, Marsh applied distributed lags to estimate these short-run price differences; finding that price premiums and discounts are not seasonal, but are affected by changes in slaughter prices and the cost of grain.

The majority of the literature examines the price determinants of feeder cattle in state-specific auction markets (Turner et. al 1991; Faminow and Gum 1986; Schroeder et al 1988; and Buccola 1980). The studies consider different geographic regions, but report similar findings. Buccola uses a breakeven analysis to measure price differences between heifers and steers among different lots of feeder cattle in Virginia auction markets for the period 1958-1977. Faminow and Gum uses a static approach to study price differentials for feeder cattle in Arizona auction markets during the month of May in 1984 and 1985. Schroeder et al. further investigate physical characteristics of feeder cattle in Kansas auction markets, during the fall and spring. Data were collected from October 31, 1986 through December 13, 1986 and from March 19, 1987 through April 15, 1987. Turner et al. also examines feeder cattle market characteristics, using Georgia teleauctions using data from the period 1976 to 1988.

Buccola models on feeder cattle price-weight slopes as a function of expected slaughter price, feed prices, soil moisture conditions, inventory adjustments, sex, and seasonal effects. Faminow and Gum model price as a function of weight, number of head in the sale lot, sex, breed, sale-year, and year. Their model also incorporates nonlinear weight and lot size variables. Schroeder et al. model price as a function of economic and

physical variables,[3] but in addition includes health, presence of horns, fill, lot uniformity, time of sale during the auction, and seasonality differences among the additional variables. Turner et al. estimates a similar model to Schroeder et al., but also accounts for delivery conditions, input prices and nearby cattle prices, and measures of supply and competitive pressure in the auction.

Buccola reports that the variables that affect feeder price levels also affect price differentials among different classes of cattle. Faminow and Gum's statistical results demonstrate the price-weight and price-lot size are consistent with Buccola's finding the price-weight line is convex from below for steers and slightly concave from below for heifers. Schroeder et al. find that most of the physical variables they implement are statistically significant. Turner et al.'s reports results that are similar to those reported by Buccola and Schroeder et al.

Two papers focus solely on price differences between steers and heifers (Buccola and Jessee (1979) and Schultz and Marsh (1985)). Buccola and Jessee investigate feeder price differentials by sex and analyze variations in these differentials across time and space utilizing regional market[4] data from 1964-1976. Schultz and Marsh construct a dynamic model to analyze price differences between steers and heifers at the feeder, slaughter, and carcass levels using quarterly data from 1971-1982. Their study is the only previous analysis to examine price differentials among slaughter cattle. The one

[3] According to Schroeder et al. (1988) the auction variables implemented in previous studies of cattle prices: weight, sex, breed, head per lot, market location (Schwab; Schwab and Rister; Schwab, Rister, and Ritchie); weight-squared, head-squared (Menzie, Gum, and Cable; Faminow and Gum; Davis, Bobst, and Steele); muscling, finish, body size, defects, lot uniformity (Sullivan and Linton); animal appearance (fleshy, full, and gaunt) (Folwell and Rehberg); seasonal factors (Madsen and Liu); and time of sale (Buccola 1982).

[4] Each represented region is a specific state marketing point.

focus on this study is to reexamine their determinants of feeder and slaughter cattle prices and to then analyze where there is evidence of structural change of the determinants of feeder and slaughter prices and price differentials from the period 1971-2008.

Buccola and Jessee model steer-heifer price differences as a function of differences of sex-based backgrounding costs, expected future feeder prices, slaughter prices, feeding costs, and current feedlot inventories. Schultz and Marsh estimates structural models for carcass, slaughter, and feeder prices which these prices are a function of seasonal, economic (price and quantity), and stochastic variables (feed variable, margins, etc.).

Buccola and Jessee report that feeder price sex differences vary among regions, which are partially explained by regional differences in slaughter steer-heifer price spreads and in the proportion of steers to total cattle on feed. Schultz and Marsh find that most of the variables in feeder steer and heifer price can be explained by steer and heifer inventories, slaughter prices, the cost of grain, and beef carcass-to-retail and farm-to-carcass margins.

Summary

The papers discussed above focus on price differences among steer calves and yearlings, price determinants of a particular auction sale, price margins/spreads, and price differences among steers and heifers within different market levels and separate aggregation are each examined in the literature. This study re-examines the price determinants among feeder steers and heifers and slaughter steers and heifers as well as

feeder steer and heifer price differences and slaughter steer and heifer price differences. In this study, the Schultz and Marsh model is re-estimated for the time period 1971-1982 , used in that analysis and is re-estimated using data from the period 1991-2003, 1971-2003, and 1971-2008. Models estimated for the period 1971-2008 incorporate variables accounting for the occurrence of Bovine Spongiform Encephalopathy (BSE). No previous study has re-examined cattle prices using data for these periods nor have the previous studies examined the effect of the 2003 BSE outbreak on slaughter and feeder cattle prices using the models developed by Schultz and Marsh.

CHAPTER 3

MODELS AND METHODOLOGY

Empirical Models

At any level of market aggregation, the price of a given class of cattle is a function of market forces. In a reduced form context, factors that shock supply and demand determine commodity prices. This chapter develops estimation models of the determinants of steer and heifer prices and price differences. Previous studies of cattle markets have included reduced form models of feeder cattle, fed/slaughter cattle, carcass cattle, and the price differences between steer and heifer prices at each level of the cattle marketing chain. This study focuses on three market levels: carcass boxed beef cutouts, feeder cattle, and slaughter cattle. A major focus of this study is to re-estimate the models developed by Schultz and Marsh (SM) for their original time period (1971-1982) and for the periods 1992-2003, 1971-2003, and 1971-2008 to determine whether structural changes have occurred in the livestock industry. To account for events that did not occur during the estimation period of SM, and to address issues of structural change, some additional variables are added to the specification. As discussed above, reduced form estimation models are developed for steer/heifer prices at three stages of the marketing chain. These models are presented in the next three sections. Estimation issues including discussions of appropriate lag issues are then discussed.

Boxed Beef Cutout Values

Schultz and Marsh are the only authors to explore price determinants at the carcass market levels. Their study focused on the determinants of carcass prices and carcass price differences. Slaughter cattle are the live weights of the cattle; carcasses are the primary cuts of meat with little bone and after the trimmings and hides are removed. SM examine the determinants of carcass prices and included the following explanatory variables: total quantities of steer and heifer carcasses, quantities of pork and poultry production, by-product values, disposable income, and carcass-to-retail marketing margins. Carcass values ceased to be reported in 1990. Thus, in this study, the boxed beef cutout values are used as a substitute for carcass values, but boxed beef is not separated into genders and price differences are not examined.

Boxed beef cutout value demand shifters include by-product allowances, disposable income, quantity of pork and poultry production, and the wholesale-to-retail price spread. Factors shifting supply include the quantity of slaughter steers and slaughter heifers, and seasonal (quarterly) dummy variables. This implies that boxed beef cutout values depend on each of these supply and demand variables. Schultz and Marsh maintain that the effects of competitive meat supplies on slaughter steer and heifer prices can be proxied by pork and poultry production. Carcass by-products are sold as both inedible and edible goods. Any changes in by-product values are expected to affect the value of steer and heifer carcasses. Changes in retail demand (proxied by changes in per-captia income) affect the derived demand for carcasses. Schultz and Marsh also argue that the carcass-retail marketing spread is likely to affect carcass prices (boxed beef

cutouts). They argue that changes in the spread serves as proxies for changes in distribution and processing costs. Any increases in distribution processing costs, ceteris paribus, will reduce carcass prices (boxed beef cutouts) as retailers reduce their demand for carcasses.

A reduced form model for boxed beef cutout values is developed. Boxed beef cutout values serve as a proxy for carcass values for which SM estimated. The boxed beef cutout values reduced form estimation model is:

$$BBCV_t = \beta_0 + \sum_{j=2}^{4} \beta_{1,t-j} D_{t-j} + \beta_{2t} QSHC_t + \beta_{3t} QSHS_{t-1} + \beta_{4t} QPKPP_t + \beta_{5t} BPA_t + \beta_{6t} BPA_{t-1} + \beta_{7t} Y_t + \beta_{8t} Y_{t-1} + \beta_{9t} WRS_t + \sum_{j=1}^{4} \beta_{10,t-j} DEP_{t-j} + u_{1t} \quad (1)$$

Boxed beef cutout values (BBCV) are a function (Eq. 1) of seasonal dummies (D), the quantity of slaughter steers and slaughter heifers (QSHS), the quantity of pork and poultry production (QPKPP), by-product allowances (BPA), disposable income (Y), the wholesale-to-retail price spread (WRS), and lagged dependent variables (DEP).

Slaughter Prices and Price Differences

Schultz and Marsh provide the only previous study of slaughter market prices and price differences. SM modeled slaughter steer and heifer prices as a function of the quantity of fed cattle slaughtered, the quantity of nonfed slaughtered, the price of steer carcasses, by-product values, and lagged endogenous variables.

Slaughter market variables which shift the demand for slaughter steers/heifers include the value of boxed beef cutout, by-product allowances, and transportation costs. The 2003 BSE event which occurred well after the period examined by SM also affected

the demand for slaughter cattle. Supply shifters include the quantity of steers/heifers slaughtered, seasonal (quarterly) dummy variables, and the quantity of slaughter cows. The production variable QSC is the quantity of slaughtered cows, where the slaughter cows represent a lower quality grade of beef. An increase in this quantity variable would lower the price of slaughter steers and heifers. In addition, increases in the quantity of steers/heifers slaughtered would lower the price of slaughter steers and heifers. Increases in the value of edible and inedible slaughter by-products are hypothesized to increase slaughter prices as they increase the value of carcasses (Doane 1975). Including carcass prices (boxed beef cutouts), this serves as a proxy for a direct effect of changes in the wholesale market on the live slaughter market. Schultz and Marsh argue that the carcass price represents an output price to packers; thus, an exogenous increase in the carcass price would cause packers to buy slaughter cattle at higher prices. Boxed beef cutout values are likely to be simultaneously determined with the price of slaughter steers/heifers. This potential endogeneity is corrected through an instrumental variables approach. The price of slaughter steers reduced form estimation model is:

$$PSS_t = \beta_0 + \sum_{j=2}^{4} \beta_{1,t-j}\ D_{t-j} + \beta_{2t} QSHS_t + \beta_{3t} QSC_t + \beta_{4t} BBCV_t + \beta_{5t} BPA_t + \beta_{6t} TC_t + \sum_{j=1}^{4} \beta_{7,t-j}\ DEP_{t-j} + u_{2t} \quad (2)$$

Slaughter steer prices (PSS) are a function (Eq. 2) of seasonal dummies (D), the quantity of slaughter steers/heifers (QSHS), the quantity of slaughter cows (QSC), boxed beef cutout values (BBCV), by-product allowances (BPA), transportation costs (TC), and lagged dependent variables (DEP); The price of slaughter heifers reduced form estimation model is:

(3) $$PSH_t = \beta_0 + \sum_{j=2}^{4} \beta_{1,t-j} \; D_{t-j} + \beta_{2t} QSHS_t + \beta_{3t} QSC_t + \beta_{4t} BBCV_t + \beta_{5t} BPA_t + \beta_{6t} TC_t + \sum_{j=1}^{4} \beta_{7,t-j} \; DEP_{t-j} + u_{3t}$$

where m=2,3,4 and n=1,2,3,4

Slaughter heifer prices (PSH) are a function (Eq. 3) of seasonal dummies (D), the quantity of slaughter steers/heifers (QSHS), the quantity of slaughter cows (QSC), boxed beef cutout values (BBCV), by-product allowances (BPA), transportation costs (TC), and lagged dependent variables (DEP); The slaughter price difference reduced form estimation model is:

(4) $$PSS_t - PSH_t = \beta_0 + \sum_{j=2}^{4} \beta_{1,t-j} \; D_{t-j} + \beta_{2t} QSHS_t + \beta_{3t} QSC_t + \beta_{4t} BBCV_t + \beta_{5t} BPA_t + \beta_{6t} TC_t + \sum_{j=1}^{4} \beta_{7,t-j} \; DEP_{t-j} + u_{4t}$$

Differences in slaughter steer and heifer prices (Eq. 4) should, in principle, depend on the same variables that determined individual price levels.

Feeder Prices and Price Differences

Previous studies have included the following variables in reduced form models of feeder cattle prices: weight, sex, breed, head per lot, market location (Schwab; Schwab and Rister; Schwab, Rister, and Ritchie); backgrounding costs, price feeder steers, brood cow inventory, slaughter prices, feeding costs, feedlot inventories, feed efficiency, nonfed costs, (Jessee and Buccola); grade, age, (Buccola 1980); by-product value, quantity of steers and heifers at the feedlot, farm-to-carcass marketing margin, carcass prices (Schultz and Marsh); weight-squared, head-squared (Menzie, Gum, and Cable; Faminow and Gum; Davis, Bobst, and Steele); muscling, finish, body size, defects, lot

uniformity (Sullivan and Linton); animal appearance (fleshy, full, and gaunt) (Folwell and Rehberg); seasonal factors (Madsen and Liu); time of sale (Buccola 1982); health, presence of horns, fill, and lot uniformity (Schroeder et al.). Variables that are likely to shift market demand for feeder cattle include feed prices, transportation costs, farm-to-wholesale price spread, price of slaughter steers/heifers, and BSE events. Feeder cattle supply shifters include the quantity of steers/heifers on feed and seasonal (quarterly) dummy variables. To account for dynamic effects, several studies include lagged dependent variables. Thus, steer/heifer prices are dependent on each of the above supply and demand shift variables. Shultz and Marsh argue that changes in slaughter market prices influence feeder prices by affecting the derived demand for feeder cattle inputs.

Steer and heifer inventories represent feeder cattle supply. A change in the feeder supply of one gender relative to the other is likely to affect the difference between feeder steer and heifer prices. The price of corn, a proxy for feed grain, is likely to influence feeder steer and heifer prices due to the effect on feeder costs. Paired with the fact that feed conversion for heifers is not as efficient as for steers, changes in feed costs may have different effects on feeder steer and feeder heifer prices. Furthermore, each separate weight class may respond differently to feed costs due to the relative weight gain to finishing maturity. Schultz and Marsh also add that the beef carcass-to-retail margin and the farm-to-carcass margin[5] effectively capture the effect of marketing costs on the derived demand for feeders. Higher marketing costs translate into lower feeder cattle prices by reducing the derived demand for feeder cattle. Transportation costs represent

[5] This study uses farm-to-wholesale and wholesale-to-retail price spreads. In order to avoid potential endogeneity between boxed beef cutout values and wholesale marketing costs, food marketing costs could have been used.

the costs of bringing animals to feedlots. An increase in transportation costs will likely decrease the demand for feeder cattle. Slaughter prices are simultaneously determined with feeder prices. Thus the slaughter prices are instrumented to correct for endogeneity in the feeder price equations. The price of feeder steers reduced form estimation models are:

(5) $$PFS665_t = \beta_0 + \sum_{j=2}^{4} \beta_{1,t-j} D_{t-j} + \beta_{2t} PSS_t + \beta_{3t} QFS_t + \beta_{4t} QFH_t + \beta_{5t} FWS_t + \beta_{6t} PC_t + \beta_{7t} TC_t + \sum_{j=1}^{4} \beta_{8,t-j} DEP_{t-j} + u_{5t}$$

and

(6) $$PFS758_t = \beta_0 + \sum_{j=2}^{4} \beta_{1,t-j} D_{t-j} + \beta_{2t} PSS_t + \beta_{3t} QFS_t + \beta_{4t} QFH_t + \beta_{5t} FWS_t + \beta_{6t} PC_t + \beta_{7t} TC_t + \sum_{j=1}^{4} \beta_{8,t-j} DEP_{t-j} + u_{6t}$$

Feeder steer prices (Eq. 5 and Eq. 6) for lighter (600-650 lbs) and heavier (750-800 lbs) weight classes are modeled as function of seasonal dummy variables (D), the price of slaughter steers (PSS), the quantity of steers on feed (QFS), the quantity of heifers on feed (QFH), the farm-to-wholesale price spread (FWS), the price of corn (PC), transportation costs (TC) and to account for dynamic effects, lagged dependent variables (DEP). The price of feeder heifers reduced form estimation models are:

(7) $$PFH455_t = \beta_0 + \sum_{j=2}^{4} \beta_{1,t-j} D_{t-j} + \beta_{2t} PSH_t + \beta_{3t} QFS_t + \beta_{4t} QFH_t + \beta_{5t} FWS_t + \beta_{6t} PC_t + \beta_{7t} TC_t + \sum_{j=1}^{4} \beta_{8,t-j} DEP_{t-j} + u_{7t}$$

and

(8) $$PFH775_t = \beta_0 + \sum_{j=2}^{4} \beta_{1,t-j}\ D_{t-j} + \beta_{2t} PSH_t + \beta_{3t} QFS_t + \beta_{4t} QFH_t + \beta_{5t} FWS_t + \beta_{6t} PC_t + \beta_{7t} TC_t + \sum_{j=1}^{4} \beta_{8,t-j}\ DEP_{t-j} + u_{8t}$$

where m=2,3,4 and n=1,2,3,4

Feeder heifer prices (Eq. 7 and Eq. 8) of the lighter (450-500 lbs) and heavier (700-750 lbs) weight classes are modeled as a function of seasonal dummy variables (D), the price of slaughter heifers (PSH), the quantity of steers on feed (QFS), the quantity of heifers on feed (QFH), the farm-to-wholesale price spread (FWS), the price of corn (PC), transportation costs (TC) and to account for dynamic effects, lagged dependent variables. The feeder price difference reduced form estimation models are:

(9) $$PFS665_t - PFH455_t = \beta_0 + \sum_{j=2}^{4} \beta_{1,t-j}\ D_{t-j} + \beta_{2t} PSS_t + \beta_{3t} PSH_t + \beta_{4t} QFS_t + \beta_{5t} QFH_t + \beta_{6t} FWS_t + \beta_{7t} PC_t + \beta_{8t} TC_t + \sum_{j=1}^{4} \beta_{9,t-j}\ DEP_{t-j} + u_{9t}$$

and

(10) $$PFS758_t - PFH775_t = \beta_0 + \sum_{j=2}^{4} \beta_{1,t-j}\ D_{t-j} + \beta_{2t} PSS_t + \beta_{3t} PSH_t + \beta_{4t} QFS_t + \beta_{5t} QFH_t + \beta_{6t} FWS_t + \beta_{7t} PC_t + \beta_{8t} TC_t + \sum_{j=1}^{4} \beta_{9,t-j}\ DEP_{t-j} + u_{10t}$$

In principle, differences between the prices of feeder steers and heifers (Eq. 9 and Eq. 10) should be a function of the same variables that explain the feeder steer and heifer prices. However, the interpretations of results of the price differences are slightly different than in the individual feeder steer and heifer price equations. A variable that is statistically significant in the price difference model must have different effects on the prices of steers and heifers.

Estimation Issues

Schultz and Marsh derive the reduced form equations they estimate from Jorgenson's (1966) rational lag model. In Jorgenson's model:

(11) $P_t=W(L)Z_t$

and

(12) $W(L) = \frac{\beta(L)}{\lambda(L)}$,

where Z_t is a vector of independent variables and W(L) is a rational lag generating function defined as a ratio of two polynomials (without characteristic roots) $\beta(L)$ and $\lambda(L)$ where $\beta(L)$ is an mth order polynomial in the lag operator L, and $\lambda(L)$ is an nth order polynomial in the lag operator L. W(L) is constrained to apply to all of the variables in Z_t. In SM, the rational lag model is reduced to the following function:

(13) $P_t = \beta_0 + \beta_1 Z_t + \lambda_1 E(P_{t-1}) + \lambda_2 E(P_{t-2}) + u_t$,

which implies then m=1 and n=2.

Equation (13) is a second order difference equation. It is expected that the error term has an autoregressive structure, and to correct for this structure expected price has a two quarter lag. However Shultz and Marsh initially lag expected price two quarters and estimated the error structure as a second order autoregressive process. Based on the t ratios, the higher order β, λ, and p coefficients were removed if not significant. Thus there is variation among the order of lags in the final empirical model. In this study the dependent variables are used instead of expected dependent variables, due to the assumption that the exogenous variables and lagged endogenous variables are not correlated with the error term. Furthermore, Marsh (1985) shows that this procedure of

the lagged expected value allows the systematic portion of each equation to be strictly exogenous with the disturbance term is autocorrelated. In this study the lagged dependent variable is arbitrary chosen as four quarters (one year), hypothesizing that last years price affects this years price using the reduced form models at all levels of market aggregation. As discussed above, endogeneity is corrected for by instrumented variables.

Summary

The reduced form models are created to explain the variation in the dependent variable more sufficiently than an inverse demand model. The reduced form models, which examine the behavior of equilibrium princes, allow various shocks in the supply and demand. In addition, the expected value of the dependent variable is not used in the reduced form models, due to the assumption that exogenous and lagged endogenous variables are not correlated with the error term. Thus, only the lagged dependent variable is used. Structural change is evaluated using F-statistics. The both the SM model and this study's reduced form models are reported in Chapter 5. In the next chapter the data used in this study is described.

CHAPTER 4

DATA

Description of Data

The previous chapter developed the reduced form and structural models estimated in this study. Data are needed to test the reduced form models for structural change over the different time periods. An ideal data set would include the same variables used by Schultz and Marsh (SM) as well as variables that test for the effects of the BSE outbreak in 2003 and the Atkins diet starting in 1991, as well as potential changes in market levels. The data set using the same variables and period modeled by SM is ideal. Such a data set would allow for direct testing of the hypothesis of no structural change in steer/heifer prices and price differences using the SM model for the same time period. However, the data set used by SM could not be extended because reporting and data collection procedures have been changed and/or modified over time. In addition, this study incorporates additional variables not considered by SM. Therefore, the data used in this study are similar, but not identical to the data used by SM. The purpose of this chapter is to describe each of the empirical variables used in this study and, where differences exist between the variables used by SM, to identify and describe those differences. Three types of variables are used in this study: price and value data, quantity data, and dummy variables. One issue is the weights used by SM for the feeder steers and heifers are not exactly the same as this study. A second issue is carcass values reports for steers and heifers ended in 1990. Boxed-beef cutout values are the values of cutouts from the

carcass. As boxed beef values represent direct carcass cuts, these values are used instead of the discontinued carcass value series.

USDA National Agricultural Statistical Service (NASS) reported the number of steers and heifers on feed using data from 23 states during the SM study period. The number of states for which this data set collected was reduced to 13 states in 1982 and then to 7 states in 1994. Although the number of states collecting cattle on feed has changed, this is not a concern due to cattle on feed are concentrated in fewer states. Thus, the number of steers on feed is one variable and heifers on feed is one variable.

In this study, price and other dollar determined variables such as boxed beef cutout values and per capita income variables are converted from nominal to real terms, by each price and income variable is deflated by the Consumer Price Index (1982-1984=100). Quantity variables are expressed in per capita terms dividing each quantity variable by the current period U.S. population to account for population changes over time in relation to the quantity variables used in this study. For example, the quantity of steers and heifers slaughtered in the first quarter of 1971 is divided by the estimated U.S. population in the first quarter of 1971. This study estimates reduced form models for the following periods: 1971-1982, the estimation period used by SM; a second 12 year period that replicates the reduced form model, 1991-2003; the period 1971-2003 which ends prior to the December 2003 BSE event; and entire period 1971-2008.

Price Data

Slaughter steer prices are measured by using Choice 2-4 Nebraska Direct prices for 1100-1300 lbs category, and slaughter heifer prices are measured by using Choice 2-4

Nebraska Direct prices for 1000-1200 lbs category. These data were obtained for various periods from the USDA Red Meats Yearbook. These variables serve as the price of slaughter steers and slaughter heifers. Slaughter price differences for slaughter steers/heifers are complied by subtracting slaughter steer prices from slaughter heifer prices.

Feeder steer prices for the 600-650 lbs category animals are measured by Medium Number 1 Oklahoma City, OK prices. Feeder steer prices for 750-800 lbs category are measured by Medium Number 1 Oklahoma City, OK prices. Feeder heifer prices for 450-500 lbs category are measured by Medium Number 1 Oklahoma City, OK prices. Feeder heifer prices for 700-750 lbs category are measured by Medium Number 1 Oklahoma City, OK prices. These data were obtained from the USDA Red Meats Yearbook.

Price differences for feeder steers and heifers are computed in two ways: for the lighter weights, the difference between 600-650 lbs steer prices and 450-500 lbs heifer prices are calculated; for heavier weights the differences between 750-800 lbs steer prices 700-750 lbs heifer prices are calculated.

Per-capita income is measured as per-capita income in United States dollars deflated by the CPI. These data were obtained from the Livestock Marketing Information Center (LMIC).

The price of Number 2 yellow corn Central Illinois is used to represent the price of corn. These data were obtained from the USDA Red Meats Yearbook, except for the

period 1971 to 1974. Data for these years were collected by Darrel Good,[6] and are measures of the loaded rail car corn price in Central Illinois.

By-product allowances indicate the value of edible and non-edible by-products as reported by LMIC. SM had separate by-product values for carcasses and slaughter cattle; however only the aggregated data is reported for the entire 1971-2008 period.

The farm-to-wholesale price spread is measured by the difference between the beef wholesale value and the net farm value of the animal as reported by LMIC. This variable represents the farm-to-wholesale price spread, and is similar to the farm-to-carcass marketing margin utilized by SM. The wholesale-to-retail price spread equals the difference between the Choice beef retail value and the wholesale value as reported by LMIC.

Wholesale boxed beef cut-out values which are only available for all animals (and not separately for steers and heifers) for Choice 1-3 Central U.S. 600-750 lbs animals are obtained from the USDA Red Meats Yearbook. Boxed beef cutout values were not available for 1971-1973. To address this issue, an OLS regression of the boxed beef cutout value on the choice retail beef value was estimated and used to back-cast estimates of boxed beef cutout values for the missing years.[7]

Transportation costs are represented by the price of Unleaded Regular Gasoline (U.S. City average) reported by the Energy Information Administration. These data are available only for the period 1976-2008. Data for this variable were not available for the period 1971-1976. Thus, the available Unleaded Regular Gasoline prices were regressed

[6]Agricultural Economics Professor at the University of Illinois

[7] The estimated model is as follows: Cutout = 36.95 + .2682 (choice retail beef value). The t-value for the model is 57.58 and the R^2 is .8769

on the fuel price index reported by the U.S. Bureau of Economic Analysis. The estimated model was used to obtain back-cast estimates of the Unleaded Regular Gasoline prices for the period 1971-1976.[8]

Quantity Data

Commercial (non-federally inspected plus federally inspected) steer, heifer, and cow slaughters are the amounts of steers, heifers, and cows slaughtered, as reported in USDA Red Meats Yearbook.

Commercial pork and poultry production is measured by the sum of the amount of pork produced and commercial poultry production measured by the amount of young and mature poultry produced for sale. Pork production is reported in the USDA Red Meats Yearbook. Poultry production is reported by LMIC.

The number of steers, heifers, and cows on feed as reported by the USDA NASS does not include placements, marketing, or other disappearance. For the period 1970-1981, the data are reported by NASS for 23 states; from 1982-1993, the data are based on 13 states reported by NASS; from 1994-2008 the data are reported for feedlots with 1000 or more head in 7 states as reported by LMIC.

Dummy Variables

Intercept dummy variables are used for BSE starting in 2004 and continuing through 2006, implying by 2007 most of the effects of the December 2003 BSE outbreak

[8] The estimated model is as follows: Gasoline = 2.26 + 1.50 (Fuel Price Index). The t-value for the model is 93.64 and the R^2 is .9853

disappeared. Individual year dummy variables and one total time period dummy variable were created to test the yearly and total effects of BSE.

In addition to the BSE intercept dummy variables, a slope-intercept variable was included and interacted with quantity variables to test for structural change over time.

Finally, a slope-intercept dummy variable was formed to estimate if whether the Atkins diet structurally changed steer/heifer prices. The company started in 1989 and filed for bankruptcy in 2005. This variable spans from 1991-2005 and is interacted with quantity variables among the different steer/heifer markets.

Summary

The data described in this chapter are used to estimate the parameters of the reduced form model developed in Chapter 3. A primary objective of this study is to replicate the models and estimations by SM for the period 1971-1982. The SM model is then estimated for the period of 1971-2008. Ideally identical measures of the models used by SM would be utilized in this study if they had been available. However, because of changes in data reporting practices, this study uses similar, but not identical, variables used by SM (for example, retail, wholesale, and carcass margins, and carcass values). In addition, dummy variables are utilized to account for the potential effects of the 2003 BSE event and other potential causes of structural change. The variables for this study are defined in Table 1. The next chapter identifies the empirical results.

Table 1: Variable Definitions.

VARIABLE	VARIABLE DEFINITIONS
D	Seasonal Dummy Variables for quarters two, three, and four
PSS	Real Price of Choice 2-4 Nebraska Direct slaughter steers, 1100-1300 lbs ($/cwt)
PSH	Real Price of Choice 2-4 Nebraska Direct slaughter heifers, 1000-1200 lbs ($/cwt)
PSS - PSH	The real price difference between slaughter steers and slaughter heifers ($/cwt)
PFS6-65	Real Price of Medium #1 Oklahoma City feeder steers, 600-650 lbs ($/cwt)
PFS75-8	Real Price of Medium #1 Oklahoma City feeder steers, 750-800 lbs ($/cwt)
PFH45-5	Real Price of Medium #1 Oklahoma City feeder heifers, 450-500 lbs ($/cwt)
PFH7-75	Real Price of Medium #1 Oklahoma City feeder heifers, 700-750 lbs ($/cwt)
PFS6-65-PFH45-5	The real price difference between 600-650 lbs feeder steers and 450-500 lbs feeder heifers ($/cwt)
PFS75-8-PFH7-75	The real price difference between 750-800 lbs feeder steers and 700-750 lbs feeder heifers ($/cwt)
Y	Real Per-Capita Income (1982-1984=100) ($)
PC	Real Price of Yellow #2 Corn Central Illinois ($/bu.)
SBM	Real Price of 48% Solvent Decatur Illinois ($/ton)
BPA	Real By-product Allowance (cents/lb)
BBCV	Real Wholesale Boxed Beef cut-out value Choice 1-3 Central U.S., 600-750 lbs ($/cwt)
FWS	Farm-to-Wholesale real price spread (cents/lb)
WRS	Wholesale-to-Retail real price spread (cents/lb)
QSHS	Quantity of Commercial Steers + Heifers Slaughtered (millions of head)
QCS	Quantity of Commercial Cows Slaughtered (head)
QPPKP	Quantity of Commercial Pork + Poultry Production (millions of pounds)
TC	Real Gasoline prices ($/gal.)
QFS	Quantity of Steers on Feed (millions of head)
QFH	Quantity of Heifers on Feed (millions of head)
MAD04	2004 BSE Dummy variable
MAD05	2005 BSE Dummy variable
MAD06	2006 BSE Dummy variable
MAD	2004-2006 BSE Dummy variable
STATE 23	23 State Cattle on Feed Dummy variable
STATE 13	13 State Cattle on Feed Dummy variable
STATE 7	7 State Cattle on Feed Dummy variable
ATKINS	Slope-Intercept interaction term for the Atkins diet 1991-2005
MAD1	Slope-Intercept interaction term for BSE 2003-2006

CHAPTER 5

EMPIRICAL RESULTS

Results of Estimation

Empirical results are presented in this chapter for models estimated at the following three market levels: boxed beef cutout value, slaughter prices, and feeder prices. A primary focus of this study is to re-estimate reduced form models of the determinants of these prices developed by Schultz and Marsh (SM) using more extensive data. Thus, this study uses the data described in Chapter 4 to estimate the reduced form model presented in Chapter 3. Each model is estimated for four time periods; 1971-1982, 1992-2003, 1971-2003, and 1971-2008. For the period 1971-2008, the effects of the 2003 BSE event are accounted for in two ways. The first uses individual dummy variables for the years 2004, 2005, and 2006. The second uses a single dummy variable for the period 2004-2006. To specifically test for structural change slope-intercept variables are constructed.

Carcass and Boxed Beef Cutout Values

As described in the previous chapter, carcass prices ceased to be reported in 1990. However, boxed-beef cutout values are closely related and, therefore, are used in place of carcass values.

The SM model, in which boxed beef cutout values are used to represent the dependent variable, was re-estimated for the period 1971-1982. Results are presented in

Table 2. The coefficient on the pork and poultry production variable is positive and statistically significant, but not as large as in the SM study. This result seems contrary to economic theory since a negative effect would be expected with competitive meat supplies. Freebairn and Rausser (1975) and Hayenga and Hacklander (1970) attribute the positive sign to consumer preferences for variety in diet menu. The quantity of slaughter steers and heifers[9] is included to measure the effects of wholesale beef production on boxed beef cut-out values. As in the SM study, the coefficient is negative for both the current and lagged period of the quantity of slaughter steers and heifers, but, in contrast to the SM study, the coefficients are not statistically significance. The by-product allowance coefficient is significant and positive; indicating that as the value of by-products increases the per-unit values of steer and heifer carcasses will also increase. Using the SM model with this study's data, current and lagged values of the coefficient for by-product allowances are positive, but only the coefficient for lagged by-product allows is statistically significant at the 10% level. Real disposable income is a demand shifter, reflecting changes in consumer purchasing power. Change in purchasing power affects initial beef demand and demand for boxed beef. SM's study reports a statistically significant positive effect of per capita income on carcass values. Here, in contrast, the coefficient of the current and one period lagged values of per capita income are negative, but only significant for current period per capita income. The wholesale-to-retail marketing spread[10] is designed to capture the effect of changes in per-unit processing and distribution costs on boxed beef cutout values. Results obtained for this variable are

[9] Schultz and Marsh use steer and heifer carcass production.
[10] This study assumes perfect competition on the retail market.

similar to those reported in the SM study. The coefficient is negative and significant at the 1% level.

Table 2: Boxed Beef Cutout Values vs. SM Boxed Beef Cutout Values (1971-1982).

Dependent Variable: Boxed Beef Cutout Values			
Reduced Form VARIABLES	**(a)**	**SM Model VARIABLES**	
D1	-0.0279	D1	-0.247**
	(-1.244)		(-2.574)
D2	-0.0269	D2	0.0436
	(-1.375)		(0.530)
D3	-0.0360	D3	-0.0351
	(-1.537)		(-0.332)
Q of Slaughter Str/Hef	-6.801	Q of Slaughter Str/Hef	-7.021
	(-0.971)		(-0.371)
Lagged Q of Slaughter Str/Hef	4.166	Lagged Q of Slaughter Str/Hef	-5.005
	(0.560)		(-0.266)
Q of Pork/Poultry Prod.	0.00256	Q of Pork/Poultry Prod.	0.0723**
	(0.770)		(2.520)
By-product allowance	1.624***	By-product allowance	0.900
	(4.089)		(0.796)
Lagged of by-product allowance	-0.762**	Lagged of by-product allowance	1.876*
	(-2.287)		(1.721)
Disposable Income	0.00626	Disposable Income	-0.0411*
	(0.832)		(-1.994)
Lagged Disposable Income	-0.00509	Lagged Disposable Income	-0.0314
	(-0.758)		(-1.520)
Whole-to-Retail price spread	-0.828***	Whole-to-Retail price spread	-2.090***
	(-6.836)		(-6.419)
Lagged Boxed Beef Cutout	0.708***	Lagged Boxed Beef Cutout	1.352**
	(7.444)		(2.398)
Constant	0.715	Constant	2.931***
	(1.249)		(11.39)

Table 2: Boxed Beef Cutout Values vs. SM Boxed Beef Cutout Values (1971-1982) (continued).

Dependent Variable: Boxed Beef Cutout Values			
Reduced Form VARIABLES	**(a)**	**SM Model VARIABLES**	
Observations	47	Observations	46
Adjusted R-squared	0.960	Adjusted R-squared	0.497
t-statistics in parentheses		t-statistics in parentheses	
*** p<0.01, ** p<0.05, * p<0.1		*** p<0.01, ** p<0.05, * p<0.1	
DW	2.02	DW	0.9321
HET		HET	0.9824
(a) Corrects for first-order autocorrelation using PRAIS			

Boxed beef cutout values are not differentiated into separate genders, however, the SM study examines steer and heifer carcass price differences, and the only significant variable is the quantity of steer and heifer carcasses. The SM study reports a R^2 of .074, for their carcass price difference model, indicating the effects of seasonality and production have minimal effects on steer/heifer carcass price differences, and that changes in this variable are attributed to variables omitted from their model. One factor may be variation in quality; heifer carcasses do not marble as well as steers. A second factor maybe the higher per-unit processing costs of heifers, since on average heifers are lighter than steers.

With this study's data and employing the SM model for the period 1971-1982, the estimation reports an adjusted R^2 of .497 and a Durbin-Watson (1951) (DW) of .9321, indicating positive first-order autocorrelation using the SM model (Table 3). Thus an error correction model was implemented to more accurately explain the variation among

the updated data set. This approach appears to correct for serial correlation and produces a DW of 2.02 and an adjusted R^2 of .96 (Table 3).

The results obtained using their estimation procedures are as follows. The quantity of pork and poultry production coefficient is small in magnitude, positive, and not statistically significant. Quantity of slaughter heifers and slaughter steers coefficients are negative for the current period and positive for the lagged period, but not statistically significant for either period. By-product allowances coefficients are significant for both the current period and the lagged period, with a positive sign for the current period and a negative sign for the lagged period. The negative coefficient is contrary to the SM model, but increases in the by-product allowances from the quarter before could lead to decreases in per-unit boxed beef cutout values in the current period due to demand shifts for by-product allowances this period. The coefficient for disposable income is positive for the current period and negative for the lagged period. The expected sign is shown for the current period; increases in income would lead to an increase of demand for boxed beef. No coefficients for disposable income are statistically significant. The wholesale-to-retail marketing spread coefficient is negative for both this study's reduced form model and the SM model. Boxed beef cutout value coefficient of the lagged variable is statistically significant and positive. The results imply a $10 increase of the cutout value last period increases the boxed beef cutout value of $7.08 for the current period.

The reduced form model is also estimated for the remaining periods of 1992-2003, 1971-2003, and 1971-2008. The reduced form model corrects for autocorrelation for the period 1992-2003 (Table 3). The pork and poultry production coefficient has the

negative expected sign, but is not statistically significant. The quantity of slaughter heifers and steers coefficient is negative for the current period and positive for the lagged period. The current period coefficient is statistically significant. The by-product allowance coefficients are not statistically significant for the current and lagged period; these coefficients are negative for the current period and positive in the lagged period. The negative coefficient for by-product allowance in the current period is different from the coefficient for the earlier time period of 1971-1982. Disposable income coefficients are negative for the current period and positive for the lagged period, but not significant for either period. The wholesale-to-retail spread coefficient is negative and significant with at the 1% level. The lagged boxed beef cutout values coefficient is positive and significant, implying the lagged boxed beef price increases in price lead to increases in the current periods boxed beef price.

Table 3: Boxed Beef Cutout Values.

Dependent Variable: Boxed Beef Cutout Values			
Time Periods VARIABLES	**1971-1982-prais(a)**	**1992-2003-prais (a)**	**1971-2003-prais(a)**
D1	-0.0279	0.0692***	0.0236*
	(-1.244)	(5.880)	(1.959)
D2	-0.0269	0.0503**	-0.0148
	(-1.375)	(2.524)	(-1.308)
D3	-0.0360	0.0143	-0.0333***
	(-1.537)	(0.908)	(-2.650)
Q of Str/Hef Slaughter	-6.801	-25.77***	-14.50***
	(-0.971)	(-5.148)	(-3.767)
Lagged Q of Str/Hef Slaughter	4.166	3.625	16.00***
	(0.560)	(0.560)	(4.050)
Q of Pork/Poutry Prod.	0.00256	-0.00300	0.000612
	(0.770)	(-0.568)	(0.383)
By-product allowance	1.624***	-0.0997	1.347***
	(4.089)	(-0.206)	(5.087)

Table 3: Boxed Beef Cutout Values (continued).

Dependent Variable: Boxed Beef Cutout Values			
Time Periods	**1971-1982-prais(a)**	**1992-2003-prais (a)**	**1971-2003-prais(a)**
VARIABLES			
Lagged of by-product allowance	-0.762**	0.598	-1.038***
	(-2.287)	(1.233)	(-3.984)
Disposable Income	0.00626	-0.00133	0.000269
	(0.832)	(-0.588)	(0.0829)
Lagged Disposable Income	-0.00509	0.00381	-0.000182
	(-0.758)	(1.548)	(-0.0560)
Whole-to-Retail price spread	-0.828***	-0.500***	-0.407***
	(-6.836)	(-4.727)	(-6.247)
Lagged Boxed Beef Cutout	0.708***	0.511***	0.894***
	(7.444)	(3.823)	(26.27)
Constant	0.715	1.020*	0.281*
	(1.249)	(1.816)	(1.817)
Observations	47	47	131
Adjusted R-squared	0.960	0.843	0.982
t-statistics in parentheses			
*** p<0.01, ** p<0.05, * p<0.1			
DW	2.02	2.1	1.95
Dwalt			
HET			
(a) Corrects for first-order autocorrelation using PRAIS			

Table 3: Boxed Beef Cutout Values (continued).

Dependent Variable: Boxed Beef Cutout Values		
Time Periods	**1971-2008-prais (a)**	**1971-2008m1-prais (a)**
VARIABLES		
D1	0.0341***	0.0331***
	(2.729)	(2.682)
D2	-0.0183*	-0.0182*
	(-1.723)	(-1.749)
D3	-0.0307**	-0.0291**
	(-2.399)	(-2.301)
Q of Str/Hef Slaughter	-15.97***	-15.48***
	(-4.339)	(-4.290)
Lagged Q of Str/Hef Slaughter	17.32***	16.71***
	(4.544)	(4.470)
Q of Pork/Poultry Prod.	0.000123	0.000324
	(0.0885)	(0.243)

Table 3: Boxed Beef Cutout Values (continued).

Dependent Variable: Boxed Beef Cutout Values		
Time Periods	**1971-2008-prais (a)**	**1971-2008m1-prais (a)**
VARIABLES		
By-product allowance	1.291***	1.325***
	(5.162)	(5.445)
Lagged of by-product allowance	-1.064***	-1.043***
	(-4.336)	(-4.371)
Disposable Income	0.000243	-0.00135
	(0.0832)	(-0.470)
Lagged Disposable Income	0.000663	0.00179
	(0.226)	(0.624)
Whole-to-Retail price spread	-0.337***	-0.329***
	(-6.021)	(-6.420)
Lagged Boxed Beef Cutout	0.939***	0.920***
	(35.92)	(35.96)
mad04	0.0369	
	(1.525)	
mad05	0.0574**	
	(2.544)	
mad06	0.000848	
	(0.0380)	
mad		0.0464***
		(3.347)
Constant	0.116	0.173
	(0.930)	(1.418)
Observations	151	151
Adjusted R-squared	0.985	0.986
t-statistics in parentheses		
*** p<0.01, ** p<0.05, * p<0.1		
DW	2.01	2.02
Dwalt		
HET		
(a) Corrects for first-order autocorrelation using PRAIS		

This study's reduced form model corrects for first-order autocorrelation for the period 1971-2003 (Table 3). The pork and poultry production coefficient is positive but not significant. The quantity of slaughter steers and heifers coefficient is negative for the current period and positive for the lagged period. Both coefficients are statistically significant at the 1% level. The negative coefficient for the lagged values implies that

increases in the supply of slaughter steers and heifers in one period lead to a decreasing of price in the next period. The by-product allowances coefficient is positive for the current value and negative for the lagged value, and significant in both cases. Disposable income coefficients are positive for the current period and negative for the lagged period, but not statistically significant in either case. The wholesale-to-retail spread coefficient is positive and significant and lagged cutout boxed beef is negative with statistical significant.

The estimated reduced form models include estimates for first-order autocorrelation for the period 1971-2008 period (Table 3). In the model that includes separate BSE dummy variables for 2004, 2005, and 2006, the pork and poultry production coefficient is positive and not significant. Quantity of slaughter steers and heifers coefficients are negative for the current period variable and positive for the lagged variable, and both are statistically significant at the 1% level. An increase supply of slaughter steers and heifers in one period leads to a decrease in boxed beef cutout value in the next period. The by-product allowances coefficients are positive and significant for the current period and negative and significant for the lagged period. Disposable income coefficients are positive for the lagged and current period, but not statistically significant. Wholesale-to-retail spread coefficient is negative and significance, and the lagged boxed beef cutout value coefficient is positive and statistical significant. The BSE dummy coefficient that is positive and statistically significant for 2005. The coefficient implies that the BSE outbreak in 2003 increases the boxed beef cutout values by $.05.

In the reduced form model for the period 1971-2008 period (Table 3) which includes one BSE dummy for the period 2004-2006, the pork and poultry production coefficient is positive but not significant. Quantity of slaughter steers and heifers coefficients are negative for the current period and positive for the lagged period. Both periods are statistically significant at 1% level. By-product allowances coefficients are positive and significant for the current period and negative and significant for the lagged period. Disposable income coefficients for the current period are negative and positive for the lagged period, but not statistically significant. Wholesale-to-retail spread coefficient and lagged boxed beef values coefficient report negative and positive signs with statistical significance. The combined BSE dummy variable coefficient is positive and statistically significant at the 1% level, implying that BSE increased boxed beef values of $.04. A possible explanation for the positive coefficient is as follows. Even though there was an initial decrease in demand for beef, negative supply shocks were larger than the demand shock and, as a result, boxed beef cutout values increased. The supply shocks consist of a decrease of Canadian imports, and older cull cows being retained by U.S. producers. Instead of selling cull cows, because the low price, ranchers could have decided to keep the cattle to try to receive higher prices in the future.

F-statistics were calculated for boxed beef cutout values price estimated models for the periods 1971-2003 and 1971-2008 to test for structural change during the BSE event. The resulting test statistics did not indicate rejection of the null hypothesis of a BSE outbreak changes the market structure over the time periods of 1971-2003 to 1971-2008. In the estimated reduced form equation incorporating the BSE outbreak, the

estimated coefficients on the BSE variables are positive, suggesting that the 2003 BSE outbreak lead to higher boxed beef cutout values.

Slaughter Cattle

The SM models for steer and heifer prices are re-estimated using the data set described in Chapter 4 for the time period of 1971-1982. Results are presented in Table 4 and Table 5. According to SM, by-product allowances (meat packer output) reflect the prices of edible and non-edible products. It is hypothesized that as by-product values increase the overall value of the live animal increases. In the estimated SM models, by-product allowances coefficients for both slaughter steers and heifers are positive and significant. The results imply that a $10 increase in by-product allowances leads to an $8.90 increase in the price per cut of steers and an $8.80 increase for in the price per cut heifers. The estimated coefficients for the value of boxed beef are positive and significant in both of the slaughter steers and slaughter heifers models. The results imply that a $10 increase in boxed beef values would lead to almost a $4 increase in the price per cut for both slaughter steers and heifers. Quantity of slaughter steers and heifers represents the supplies of steers and heifers marketed from ranches and feedlots. The estimated coefficients for this variable are negative and significant in both slaughter steers and slaughter heifers models. Quantity of slaughter cattle represent the cows marketed by ranches and feedlots. This variable's coefficients are positive and statistical significant for both slaughter steers and heifers. Osprina and Shumway (1979) state that slaughter cattle are considered lower quality compared to slaughter steers/heifers. Increases in number of the slaughter cows potentially leads to increases in slaughter steer

and heifer prices because of the market becomes saturated with lower quality meat; there is a higher demand for higher quality meat (i.e. steers and heifers).

Using this study's data set to estimate the SM model, a DW value of 1.32 for the slaughter steer price model and a DW of 1.29 for the slaughter heifer price model were obtained. In addition the .0341 test statistic for heteroskedasticity indicates that the null hypothesis of no heteroskedasticity is rejected. Thus the SM model is re-estimated and compared to the reduced form models used in this study. The results are reported in Table 4 and Table 5. The reduced form models are estimated using the Prais-Winsten (1954) procedure to correct for first-order autocorrelation, or estimated using robust standard errors correcting for heteroskedasticity, and then both first-order autocorrelation and heteroskedasticity ARCH procedures are utilized.

Table 4: Slaughter Str Prices vs. SM Slaughter Str Prices (1971-1982).

Dependent Variable: Price of Slaughter Steers			
Reduced Form VARIABLES		**SM Model VARIABLES**	
D1	0.0179	D1	0.0139
	(1.249)		(1.265)
D2	0.0244	D2	0.0104
	(1.537)		(0.944)
D3	-0.0197	D3	-0.0242**
	(-1.353)		(-2.135)
Q of Slaughter Str/Hef	-19.79***	Q of Slaughter Str/Hef	-14.49***
	(-4.910)		(-7.396)
By-product allowance	0.860***	Q of Slaughter Cows	7.783***
	(5.701)		(3.877)
Q of Slaughter Cows	7.992***	Boxed Beef Cutout	0.401***
	(3.118)		(17.36)
Boxed Beef Cutout	0.358***	By-product allowance	0.889***
	(6.137)		(9.362)
Transportation Costs	-0.0895	Constant	0.478***
	(-1.638)		(7.787)

Table 4: Slaughter Str Prices vs. SM Slaughter Str Prices (1971-1982) (continued).

Dependent Variable: Price of Slaughter Steers			
Reduced Form VARIABLES		**SM Model VARIABLES**	
Price of Slaughter Str in t-1	-0.106		
	(-1.344)	Observations	48
Price of Slaughter Str in t-2	0.0240	Adjusted R-squared	0.946
	(0.321)	t-statistics in parentheses	
		*** p<0.01, ** p<0.05, *	
Price of Slaughter Str in t-3	0.131	p<0.1	
	(1.651)		
Price of Slaughter Str in t-4	0.0172		
	(0.263)	DW	1.32
Constant	0.755***	HET	0.0341
	(3.354)		
Observations	44		
Adjusted R-squared	0.938		
t-statistics in parentheses			
*** p<0.01, ** p<0.05, * p<0.1			
DW	1.48		
Dwalt	0.114		
HET	0.5077		

Table 5: Slaughter Hef Prices vs. SM Slaughter Hef Prices (1971-1982).

Dependent Variable: Price of Slaughter Heifers			
Reduced Form VARIABLES		**SM Model VARIABLES**	
D1	0.0186	D1	0.0127
	(1.404)		(1.161)
D2	0.0137	D2	0.000171
	(0.933)		(0.0156)
D3	-0.0214	D3	-0.0232**
	(-1.600)		(-2.051)
Q of Slaughter Str/Hef	-18.13***	Q of Slaughter Str/Hef	-12.74***
	(-4.907)		(-6.534)
By-product allowance	0.853***	Q of Slaughter Cows	5.417***
	(6.102)		(2.712)
Q of Slaughter Cows	5.593**	Boxed Beef Cutout	0.383***
	(2.372)		(16.68)

Table 5: Slaughter Hef Prices vs. SM Slaughter Hef Prices (1971-1982) (continued).

Dependent Variable: Price of Slaughter Heifers			
Reduced Form VARIABLES		**SM Model VARIABLES**	
Boxed Beef Cutout	0.315***	By-product allowance	0.881***
	(5.897)		(9.332)
Transportation Costs	-0.102*	Constant	0.444***
	(-2.034)		(7.275)
Price of Slaughter Hef in t-1	-0.0880		
	(-1.150)	Observations	48
Price of Slaughter Hef in t-2	0.0461	Adjusted R-squared	0.944
	(0.629)	t-statistics in parentheses	
		*** p<0.01, ** p<0.05, * p<0.1	
Price of Slaughter Hef in t-3	0.123		
	(1.580)		
Price of Slaughter Hef in t-4	0.0428		
	(0.661)	DW	1.29
Constant	0.730***	HET	0.016
	(3.537)		
Observations	44		
Adjusted R-squared	0.945		
t-statistics in parentheses			
*** p<0.01, ** p<0.05, * p<0.1			
DW	1.66		
Dwalt	0.3434		
HET	0.4674		

The reduced form model for the original time period of 1971-1982 reports sufficient DW and heteroskedasticity (.5077) test statistics, thus an error correction model is not needed. The by-product allowances coefficient and the boxed beef value coefficient are positive and significant in the re-estimated heifers and steers slaughter price models. The results implies a $10 increase in the by-product allowance results in an $8.60 increase in the price of slaughter steers and an $8.53 increase in slaughter heifers. A $10 increase in boxed beef values leads to a $3.15 increase in the price per cut of slaughter heifers and a $3.58 increase in the price per cut of slaughter steers. The

coefficients for quantity of slaughter steers and heifers are negative and statistically significant in both the steers and heifers slaughter price reduced form models. Lagged price and transportation costs coefficients are not statistically significant for slaughter steers. The sign on transportation costs is negative as expected. The first lagged price coefficient is negative, the other lagged price coefficients are positive for slaughter steers. In the heifer price model, the coefficient for transportation costs is negative and significant at the 10% level. This result implies increases in transportation costs causes the demand for heifers to decrease, thus the price of heifers decreases. Lagged price coefficients are positive but not statistically significant in the slaughter heifer model.

For the period 1992-2003, first-order autocorrelation exists for heifer and steer slaughter prices. Thus the reduced form models for this period are estimated using the Prais-Winsten procedure to correct for first-order autocorrelation. Results are shown in Table 6 and Table 7. In these models, by-product allowances and boxed beef cutout coefficients are positive and significant for both slaughter heifers and steers. Increases in by-product allowances result in larger increases in heifer price than steers price. A $10 increase in boxed beef values lead to increase in the prices of slaughter steers and slaughter heifers of more than $6. Quantities of slaughter steer and heifer coefficients are positive and not statistically significant for both slaughter steers and slaughter heifers. The coefficient for the quantity of slaughter cattle cows is negative but not statistically significant. Transportation costs coefficients are significant and negative in the steer and heifer models. Intuitively, an increase in costs would decrease slaughter prices. Lagged price coefficients are not statistically significant for slaughter steers or for slaughter

heifers. The coefficient is negative for the t-1 lagged price variable. The coefficients of the other lagged prices are positive for both slaughter steers and slaughter heifers.

Table 6: Price of Slaughter Steers.

Dependent Variable: Price of Slaughter Steers			
Time Periods	**1971-1982**	**1992-2003-prais (a)**	**1971-2003-arch(b)**
VARIABLES			
D1	0.0179	-0.0101	0.0198***
	(1.249)	(-0.954)	(2.858)
D2	0.0244	-0.0165*	0.0131*
	(1.537)	(-1.750)	(1.674)
D3	-0.0197	-0.0138**	-0.0202**
	(-1.353)	(-2.253)	(-2.510)
Q of Slaughter Str/Hef	-19.79***	1.777	-11.26***
	(-4.910)	(0.416)	(-8.725)
By-product allowance	0.860***	0.958***	0.822***
	(5.701)	(3.427)	(10.38)
Q of Slaughter Cows	7.992***	-2.361	8.884***
	(3.118)	(-0.303)	(6.832)
Boxed Beef Cutout	0.358***	0.666***	0.441***
	(6.137)	(5.795)	(14.84)
Transportation Costs	-0.0895	-0.103*	0.0433**
	(-1.638)	(-1.989)	(2.221)
Price of Slaughter Str in t-1	-0.106	-0.129	-0.0782
	(-1.344)	(-1.337)	(-1.228)
Price of Slaughter Str in t-2	0.0240	0.146	0.0737
	(0.321)	(1.533)	(1.254)
Price of Slaughter Str in t-3	0.131	0.105	0.121***
	(1.651)	(1.088)	(2.791)
Price of Slaughter Str in t-4	0.0172	0.0221	-0.0224
	(0.263)	(0.227)	(-0.615)
Constant	0.755***	-0.157	0.198***
	(3.354)	(-0.835)	(6.203)
Observations	44	44	128
Adjusted R-squared	0.938	0.895	
t-statistics in parentheses			
*** p<0.01, ** p<0.05, * p<0.1			
DW	1.48	1.98	
Dwalt	0.114		
HET	0.5077		
(a) Corrects for first-order autocorrelation using PRAIS			
(b) Corrects for eteroscedasticity and first-order autocorrelation using ARCH			

Table 6: Price of Slaughter Steers (continued).

Dependent Variable: Price of Slaughter Steers		
Time Periods **VARIABLES**	**1971-2008-arch (b)**	**1971-2008m1-arch (b)**
D1	0.0174***	0.0175***
	(2.620)	(2.605)
D2	0.0110	0.0110
	(1.491)	(1.500)
D3	-0.0163**	-0.0164**
	(-2.126)	(-2.191)
Q of Slaughter Str/Hef	-9.165***	-9.038***
	(-7.331)	(-7.419)
By-product allowance	0.867***	0.888***
	(10.98)	(11.14)
Q of Slaughter Cows	8.544***	8.652***
	(6.472)	(6.480)
Boxed Beef Cutout	0.396***	
	(15.09)	
Transportation Costs	0.000940	-0.00258
	(0.0728)	(-0.201)
Price of Slaughter Str in t-1	-0.0661	-0.0689
	(-1.338)	(-1.439)
Price of Slaughter Str in t-2	0.0856*	0.0862*
	(1.747)	(1.759)
Price of Slaughter Str in t-3	0.115***	0.116***
	(2.807)	(2.860)
Price of Slaughter Str in t-4	0.0447	0.0463
	(1.253)	(1.275)
mad04	-0.0161	
	(-1.205)	
mad05	-0.0101	
	(-0.456)	
mad06	-0.0206	
	(-0.467)	
mad		-0.00813
		(-0.815)
Boxed Beef Cutout Total MAD Dummy		0.393***
		(14.77)
Constant	0.163***	0.162***
	(5.295)	(5.289)
Observations	148	148
Adjusted R-squared		
t-statistics in parentheses		
*** p<0.01, ** p<0.05, * p<0.1		

Table 6: Price of Slaughter Steers (continued).

Dependent Variable: Price of Slaughter Steers		
Time Periods **VARIABLES**	**1971-2008-arch (b)**	**1971-2008m1-arch (b)**
DW		
Dwalt		
HET		
(a) Corrects for first-order autocorrelation using PRAIS (b) Corrects for heteroskedasticity and first-order autocorrelation using ARCH		

Table 7: Price of Slaughter Heifers.

Dependent Variable: Price of Slaughter Heifers			
Time Periods **VARIABLES**	**1971-1982**	**1992-2003-prais (a)**	**1971-2003-arch (b)**
D1	0.0186	-0.0115	0.0190***
	(1.404)	(-1.125)	(2.882)
D2	0.0137	-0.0174*	0.00950
	(0.933)	(-1.918)	(1.308)
D3	-0.0214	-0.0131**	-0.0189***
	(-1.600)	(-2.210)	(-2.672)
Q of Slaughter Str/Hef	-18.13***	2.319	-11.08***
	(-4.907)	(0.562)	(-8.892)
By-product allowance	0.853***	1.031***	0.794***
	(6.102)	(3.815)	(10.49)
Q of Slaughter Cows	5.593**	-4.040	6.739***
	(2.372)	(-0.537)	(5.252)
Boxed Beef Cutout	0.315***	0.645***	0.410***
	(5.897)	(5.759)	(14.42)
Transportation Costs	-0.102*	-0.105**	0.0241
	(-2.034)	(-2.078)	(1.349)
Price of Slaughter Hef in t-1	-0.0880	-0.144	-0.0837
	(-1.150)	(-1.510)	(-1.309)
Price of Slaughter Hef in t-2	0.0461	0.131	0.0910
	(0.629)	(1.400)	(1.482)
Price of Slaughter Hef in t-3	0.123	0.118	0.140***
	(1.580)	(1.235)	(3.047)
Price of Slaughter Hef in t-4	0.0428	0.0317	-0.0188
	(0.661)	(0.329)	(-0.519)
Constant	0.730***	-0.150	0.231***
	(3.537)	(-0.816)	(8.011)

Table 7: Price of Slaughter Heifers (continued).

Dependent Variable: Price of Slaughter Heifers			
Time Periods **VARIABLES**	**1971-1982**	**1992-2003-prais (a)**	**1971-2003-arch (b)**
Observations	44	44	128
Adjusted R-squared	0.945	0.895	
t-statistics in parentheses			
*** p<0.01, ** p<0.05, * p<0.1			
DW	1.66	1.9	
Dwalt	0.3434		
HET	0.4674		

(a) Corrects for first-order autocorrelation using PRAIS
(b) Corrects for heteroskedasticity and first-order autocorrelation using ARCH

Table 7: Price of Slaughter Heifers (continued).

Dependent Variable: Price of Slaughter Heifers		
Time Periods **VARIABLES**	**1971-2008 arch (b)**	**1971-2008 m1-arch (b)**
D1	0.0166***	0.0166***
	(2.712)	(2.702)
D2	0.00813	0.00807
	(1.192)	(1.211)
D3	-0.0151**	-0.0152**
	(-2.327)	(-2.403)
Q of Slaughter Str/Hef	-9.166***	-9.034***
	(-7.768)	(-7.848)
By-product allowance	0.848***	0.868***
	(11.47)	(11.60)
Q of Slaughter Cows	6.413***	6.492***
	(4.924)	(4.902)
Boxed Beef Cutout	0.376***	
	(15.14)	
Transportation Costs	-0.00719	-0.0102
	(-0.611)	(-0.875)
Price of Slaughter Hef in t-1	-0.0830*	-0.0866*
	(-1.653)	(-1.789)
Price of Slaughter Hef in t-2	0.0973*	0.0975*
	(1.873)	(1.863)
Price of Slaughter Hef in t-3	0.131***	0.132***
	(3.113)	(3.183)

Table 7: Price of Slaughter Heifers (continued).

Dependent Variable: Price of Slaughter Heifers		
Time Periods **VARIABLES**	**1971-2008-arch (b)**	**1971-2008m1-arch (b)**
Price of Slaughter Hef in t-4	0.0430	0.0451
	(1.204)	(1.223)
mad04	-0.0162	
	(-1.404)	
mad05	-0.00885	
	(-0.471)	
mad06	-0.0177	
	(-0.445)	
mad		-0.00738
		(-0.830)
Boxed Beef Cutout Total MAD Dummy		0.373***
		(14.84)
Constant	0.195***	0.193***
	(7.139)	(7.075)
Observations	148	148
Adjusted R-squared		
t-statistics in parentheses		
*** p<0.01, ** p<0.05, * p<0.1		
DW		
Dwalt		
HET		
(a) Corrects for first-order autocorrelation using PRAIS		
(b) Corrects for heteroskedasticity and first-order autocorrelation using ARCH		

The reduced form model corrects for both first-order autocorrelation and heteroskedasticity for the time period of 1971-2003 (Table 6 and Table 7). By-product allowances and boxed beef cutout coefficients are positive and significant for both slaughter heifers and slaughter steers. A $10 increase in the by-product allowances results in an $8.22 increase in the price of slaughter steers and a $7.94 increase in the price of slaughter heifers. A $10 increase in boxed beef values leads to almost a $4 increase in the both price of slaughter heifers and in the price of slaughter steers. The

magnitude on the coefficient for the quantity of slaughter steers and heifers is large and negative, and each coefficient is statistically significant. As in the 1971-1982 period, the coefficient for the quantity of slaughter cattle is positive and significant. Transportation cost coefficients are positive for both slaughter steers and slaughter heifers, but only significant for the steer slaughter price model. Lagged price coefficients for the three quarter lag are statistically significant in both the steer and heifer slaughter price models.

For the time period of 1971-2008, the estimated reduced form model corrects for first-order autocorrelation and heteroskedasticity, and includes individual BSE dummy variables for 2004, 2005, 2006 (Table 6 and Table 7). By-product allowance and boxed beef values coefficients are positive and significant for both slaughter heifers and steers. Quantity of slaughter steers and heifers coefficients are negative and statistically significant for both slaughter steers and slaughter heifers. Transportation costs coefficients are positive for slaughter steers, but negative for slaughter heifers providing support the hypothesis that packers prefer steers over heifers when costs increase. However, neither coefficient is statistically significant. In both slaughter price models, the dependent variable lagged two quarters coefficients are positive. The coefficients for the dependent variable lagged three quarters are positive and significant in both models. BSE individual dummy variable coefficients have the expected negative sign, but the coefficients are small in magnitude and not statistically significant.

For the time period 1971-2008 the estimated reduced form model includes one BSE dummy variable for the 2004-2006 outbreak, corrects for first-order autocorrelation and heteroskedasticity using an ARCH procedure with one dummy variable (Table 6 and

Table 7). By-product allowances and boxed beef values coefficients are positive and significant for both slaughter heifers and steers. Quantity of slaughter steers and heifers coefficients are negative and statistically significant in both slaughter price models. Transportation costs coefficients are negative and not significant for the steer and heifer price slaughter price models. In the heifer slaughter price model, the dependent variable lagged one quarter is negative and significant. In both slaughter price models, the dependent variable coefficient lagged three quarters is positive and significant. The BSE series (2004-2006) dummy variable coefficient has the expected negative sign, but as in the model with separate BSE dummy variables, for 2003, 2004, and 2006, the coefficient is small in magnitude and not statistically significant.

F-statistics were calculated for slaughter price estimated models for the periods 1971-2003 and 1971-2008 to test for structural change during the BSE event. The resulting test statistics did not indicate rejection of the null hypothesis of a BSE outbreak changes the market structure over the time periods of 1971-2003 to 1971-2008.

The reduced form model estimation equation for the price differences of slaughter steers and heifers (PSS-PSH) as the dependent variable, include the same set of variables as do the individual equations (Table 8). SM study reports that steer carcass prices (boxed beef for this study) are the only significant variable. However, in this study using the SM model, coefficients for the boxed beef values, the quantity of slaughter steers and heifers, and the quantity of slaughter cattle are significant. SM state the reason for the positive coefficient on carcass prices is based on the relationship between the carcass and live slaughter markets. To meat packers, variables that influence the output market

directly affect the input market since profit margins are affected as heifers cost more to process on a per animal basis. SM suggest, for example, that if retailers were bidding higher for steer carcasses, to meet that demand, packers would demand more live steers relative to heifers for slaughter. The SM model estimated using this study's data results in significant negative coefficients on the quantity of slaughter steers and heifers. Increases in the quantity of slaughter steers and heifers increase slaughter steer prices relative to slaughter heifer prices an increase in the quantity of slaughter cows decreases the price difference between slaughter steers and heifers. Using the SM price difference model an adjusted R^2 of .406 is reported. Omitted factors that contribute to the relatively low adjusted R^2 may include packer's preference for steers versus heifers, changes in beef grades, and variations in judging quality differences between steers and heifers when they are purchased from the feedlots and ranches. Using the SM model with this study's data set, a DW of 1.35 is reported for the slaughter steers minus slaughter heifers. In addition a rejection of the null of no heteroskedasticity is reported. The reduced form models are estimated using the Prais-Winsten (1954) procedure to correct for first-order autocorrelation, or estimated using robust standard errors correcting for heteroskedasticity, and/or in cases with both first-order autocorrelation and heteroskedasticity ARCH procedures are utilized.

Table 8: Slaughter Price Difference vs. SM Slaughter Price Difference (1971-1982).

Dependent Variable: Slaughter Price Differences			
Reduced Form VARIABLES		**SM Model VARIABLES**	
D1	-0.00356	D1	0.00123
	(-0.901)		(0.406)
D2	0.0101**	D2	0.0102***
	(2.651)		(3.369)
D3	-0.00639	D3	-0.00110
	(-1.614)		(-0.350)
Q of Slaughter Str/Hef	-1.004	Q of Slaughter Str/Hef	-1.755***
	(-1.080)		(-3.245)
By-product allowance	0.0376	Q of Slaughter Cows	2.372***
	(1.013)		(4.282)
Q of Slaughter Cows	1.900**	Boxed Beef Cutout	0.0176***
	(2.621)		(2.768)
Boxed Beef Cutout	0.00754	By-product allowance	0.00735
	(0.654)		(0.281)
Transportation Costs	0.00466	Constant	0.0338*
	(0.375)		(1.995)
Price Difference in t-1	0.385**		
	(2.246)	Observations	48
Price Difference in t-2	-0.403**	Adjusted R-squared	0.406
	(-2.404)	t-statistics in parentheses	
Price Difference in t-3	0.313*	*** p<0.01, ** p<0.05, * p<0.1	
	(1.857)		
Price Difference in t-4	-0.414**		
	(-2.701)	DW	1.35
Constant	0.0215	HET	0.0199
	(0.410)		
Observations	44		
Adjusted R-squared	0.474		
t-statistics in parentheses			
*** p<0.01, ** p<0.05, * p<0.1			
DW	1.94		
Dwalt	0.8415		
HET	0.442		

The reduced form model for slaughter steers and slaughter heifers price difference estimation equation reports a slightly higher adjusted R^2 (.474) for the 1971-1982 time period than the SM model (Table 8). In this study, only the coefficients for the quantity

of slaughter cows and lagged prices are statistically significant. The quantity of steers and heifers slaughter coefficient is negative, but not statistically significant. Boxed beef values and by-product allowances coefficients are positive but not significant. However, the quantity of slaughter cows coefficient is positive and significant. An increase in the number of cows slaughtered increases the difference between slaughter steers and slaughter heifers. A higher demand for higher quality meat from the packer, which is usually obtained from steers, could potentially be the reason for the increase in the price difference. The transportation cost coefficient is positive but not statistically significant. The lagged price differences coefficients are statistically significant. The one quarter lagged difference and the three quarter lag have positive coefficients. The coefficients for the lagged dependent variable at two and four quarters are negative and statistically significant.

The reduced form model corrects for heteroskedasticity using robust standard errors for the period 1992-2003 (Table 9). The lowest adjusted R^2 of .205 is reported. The quantity of steers and heifers slaughter coefficient is negative, but not statistically significant. The boxed beef values, by-product allowances, quantity of slaughter cows, and transportation cost coefficients are positive but not significant. The lagged price difference coefficient of two quarters is statistically significant. Other lagged price coefficients are not significant.

Table 9: Slaughter Price Difference.

Dependent Variable: Slaughter Price Differences			
Time Periods	**1971-1982**	**1992-2003-robust (a)**	**1971-2003-arch (b)**
VARIABLES			
D1	-0.00356	0.00171	0.000837
	(-0.901)	(1.164)	(0.448)
D2	0.0101**	0.00116	0.00311**
	(2.651)	(0.799)	(2.001)
D3	-0.00639	0.000138	-0.00326*
	(-1.614)	(0.170)	(-1.693)
Q of Slaughter Str/Hef	-1.004	-0.266	-0.306
	(-1.080)	(-0.495)	(-1.068)
By-product allowance	0.0376	0.00521	0.0231
	(1.013)	(0.254)	(0.965)
Q of Slaughter Cows	1.900**	1.019	1.835***
	(2.621)	(1.443)	(4.941)
Boxed Beef Cutout	0.00754	0.0126	0.0134***
	(0.654)	(1.646)	(3.351)
Transportation Costs	0.00466	0.00368	0.0113***
	(0.375)	(1.181)	(3.189)
Price Difference in t-1	0.385**	-0.225	0.371***
	(2.246)	(-0.954)	(4.649)
Price Difference in t-2	-0.403**	-0.251*	-0.230***
	(-2.404)	(-1.932)	(-3.004)
Price Difference in t-3	0.313*	0.00867	0.197**
	(1.857)	(0.0589)	(2.290)
Price Difference in t-4	-0.414**	-0.191	-0.0785
	(-2.701)	(-1.100)	(-1.059)
Constant	0.0215	-0.0119	-0.0233**
	(0.410)	(-0.709)	(-2.395)
Observations	44	44	128
Adjusted R-squared	0.474	0.205	
t-statistics in parentheses			
*** p<0.01, ** p<0.05, * p<0.1			
DW	1.94		
Dwalt	0.8415		
HET	0.442		
(a) Corrects for heteroskedasticity using robust se			
(b) Corrects for heteroskedasticity and first-order autocorrelation using ARCH			

Table 9: Slaughter Price Difference (continued)

Dependent Variable: Slaughter Price Differences		
Time Periods **VARIABLES**	**1971-2008-arch (b)**	**1971-2008m1-arch (b)**
D1	0.00103	0.00101
	(0.592)	(0.582)
D2	0.00283*	0.00279*
	(1.832)	(1.802)
D3	-0.00273	-0.00274
	(-1.379)	(-1.374)
Q of Slaughter Str/Hef	-0.273	-0.247
	(-1.014)	(-0.886)
By-product allowance	0.0140	0.0166
	(0.637)	(0.754)
Q of Slaughter Cows	1.591***	1.604***
	(5.014)	(4.987)
Boxed Beef Cutout	0.0118***	
	(3.278)	
Transportation Costs	0.00379	0.00350
	(1.409)	(1.259)
Price Difference in t-1	0.419***	0.420***
	(5.889)	(5.891)
Price Difference in t-2	-0.176**	-0.176**
	(-2.476)	(-2.473)
Price Difference in t-3	0.219***	0.221***
	(3.045)	(3.070)
Price Difference in t-4	-0.00255	-0.00381
	(-0.0389)	(-0.0572)
mad04	-0.00101	
	(-0.255)	
mad05	-0.00110	
	(-0.0260)	
mad06	-0.00168	
	(-0.148)	
mad		-0.000315
		(-0.105)
Boxed Beef Cutout Total MAD Dummy		0.0114***
		(3.096)
Constant	-0.0152*	-0.0158*
	(-1.704)	(-1.706)
Observations	148	148
Adjusted R-squared		
t-statistics in parentheses		
*** p<0.01, ** p<0.05, * p<0.1		

Table 9: Slaughter Price Difference (continued).

Dependent Variable: Slaughter Price Differences		
Time Periods **VARIABLES**	**1971-2008-arch (b)**	**1971-2008m1-arch (b)**
DW		
Dwalt		
HET		

(a) Corrects for heteroskedasticity using robust se
(b) Corrects for heteroskedasticity and first-order autocorrelation using ARCH

The reduced form price difference model corrects for first-order autocorrelation and heteroskedasticity for the period 1971-2003 (Table 9). The adjusted R^2 of .829 is significantly higher than previous time periods. For this time period, the quantity of slaughter cows, boxed beef cutout value, transportation costs, and lagged prices yielded statistically significant coefficients. The quantity of steers and heifers slaughter coefficient is negative, but not statistically significant. The by-product allowance coefficient is positive and not significant. However, the boxed beef values coefficient is significant and positive, and this implies a $10 increase in cutout values increases the difference in slaughter steer and heifer prices by $.13. The quantity of slaughter cows coefficient is statistically significant and positive, implying, increases in the number of cows slaughter increases the difference between slaughter steers and slaughter heifers. The transportation costs coefficient is positive and statistically significant. The results imply an increase in transportation costs lead to a larger decline in slaughter heifer prices than slaughter steer prices. Dependent variable lagged value coefficients are statistically significant for one, two, and three quarters.

For the time period 1971-2008, the estimated reduced form price difference model corrects for first-order autocorrelation and heteroskedasticity. Individual BSE dummy variables for each of the years 2004, 2005, and 2006 are included in this model (Table 9). The quantity of slaughter cows, boxed beef cutout value, and lagged prices have statistically significant coefficients. The quantity of steers and heifers slaughter coefficient is negative, but not statistically significant, and the by-product allowances coefficient is positive and not significant. The boxed beef cutout values coefficient is significant and positive, and implies that a $10 increase in cutout values increase the difference in slaughter steer and heifer prices by $.11. Quantity of slaughter cow coefficient is positive and significant. The transportation cost coefficient is positive but not statistically significant. Lagged price differences coefficients are statistically significant for one, two, and three quarter lags. The individual dummy variables coefficients are small in magnitude, negative, and not statistically significant.

The reduced form price difference model corrects for first-order autocorrelation and heteroskedasticity for the period 1971-2008 with one dummy variable for the BSE outbreak from 2004-2006 (Table 9). The quantity of slaughter cows, boxed beef cutout value, and lagged dependent variables coefficients are statistically significant coefficients. The quantity of steers and heifers slaughter coefficient is negative, but not statistically significant. By-product allowance coefficient is positive and not significant. The boxed beef values coefficient and quantity of slaughter cows coefficient are positive and significant. The transportation cost coefficient is positive, but is not statistically significant. The combined dummy variable coefficient is not statistically significant.

F-statistics were calculated for slaughter price difference estimated models for the periods 1971-2003 and 1971-2008 to test for structural change during the BSE event. The resulting test statistics did not indicate rejection of the null hypothesis of a BSE event changes the market structure over the time periods of 1971-2003 to 1971-2008.

The slaughter estimated reduced form section examined, slaughter steers, slaughter heifers, and the slaughter price difference models. The BSE outbreak coefficients are not statistically significant. The estimated reduced form models constructed in this study sufficiently explain the variation (adjusted R^2) when compared to the SM models.

Feeder Cattle

The SM model is re-estimated using the expanded data set described in Chapter 4 for the period 1971-1982. Results are presented in Table 10 and Table 11. According to the SM study, the price of slaughter steers is crucial in determining feeder steer and heifer prices for all weight categories. The price of slaughter steers represents the value of output for the feedlots. In principle, the price of lighter cattle increases relatively more than does the price of heavier cattle (Buccola 1980); this increase in price of lighter cattle can be attributed to the feedlot trying to minimize purchasing costs. When slaughter prices increase it becomes more economical for feedlots to buy relatively lighter cattle, ceteris paribus. However, using the re-estimated SM model, the slaughter steers price coefficients do not indicate relatively higher increases in price for the lighter feeder cattle compared to heavier feeder cattle, ceteris paribus, which are positive but not statistically significant.

The price of corn serves as a proxy for feed costs. Previous studies (Buccola and Jessee 1979 and Marsh 1983) suggest that the price of corn significantly influences derived demand for feeder cattle. For the re-estimated SM model, the price of corn coefficient, the farm-to-wholesale price spread coefficient, and the quantity of feeder steers coefficient are all positive. The quantity of feeder heifers coefficient is negative. All coefficients are not statistically significant.

The re-estimated SM model reports a Durbin-Watson (DW) test statistic for all feeder weights close to 1, see Table 10 and Table 11. In addition the highest adjusted R^2 is .255. Thus the reduced form models are estimated using the Prais-Winsten (1954) procedure to correct for first-order autocorrelation, or estimated using robust standard errors correcting for heteroskedasticity, and then both first-order autocorrelation and heteroskedasticity ARCH procedures are utilized.

Table 10: Price of Feeder Steers vs. SM Price of Feeder Steers (1971-1982).

Dependent Variable: Price of Feeder Steers			
The Reduced Form Model VARIABLES	**600-650**	**The Reduced Form Model VARIABLES**	**750-800**
D1	-0.0642***	D1	-0.0599***
	(-3.023)		(-2.893)
D2	-0.0356	D2	-0.0320
	(-1.514)		(-1.394)
D3	0.00178	D3	0.00253
	(0.0659)		(0.0955)
Transportation Costs	-0.0278	Transportation Costs	-0.0102
	(-0.384)		(-0.141)
Q of Feeder Steers	-1.785	Q of Feeder Steers	-1.640
	(-0.540)		(-0.518)
Q of Feeder Heifers	18.77***	Q of Feeder Heifers	17.17***
	(3.071)		(2.887)

Table 10: Price of Feeder Steers vs. SM Price of Feeder Steers (1971-19820 (continued).

Dependent Variable: Price of Feeder Steers			
The Reduced Form Model VARIABLES	**600-650**	**The Reduced Form Model VARIABLES**	**750-800**
Farm-Wholesale Spead	-1.111***	Farm-Wholesale Spead	-0.941***
	(-3.876)		(-3.344)
Price of Corn	-1.622*	Price of Corn	-1.487*
	(-1.991)		(-1.820)
Price of Slaughter Str	1.059***	Price of Slaughter Str	0.993***
	(9.420)		(9.010)
Price Feeder Str in t-1	0.609***	Price Feeder Str in t-1	0.552***
	(6.050)		(5.285)
Price Feeder Str in t-2	-0.173	Price Feeder Str in t-2	-0.124
	(-1.365)		(-0.970)
Price Feeder Str in t-3	0.119	Price Feeder Str in t-3	0.112
	(0.902)		(0.856)
Price Feeder Str in t-4	-0.0240	Price Feeder Str in t-4	-0.0444
	(-0.243)		(-0.435)
Constant	-0.227	Constant	-0.217
	(-1.204)		(-1.189)
Observations	44	Observations	44
Adjusted R-squared	0.961	Adjusted R-squared	0.954
t-statistics in parentheses		t-statistics in parentheses	
*** p<0.01, ** p<0.05, * p<0.1		*** p<0.01, ** p<0.05, * p<0.1	
DW	1.96	DW	1.94
Dwalt	0.9992	Dwalt	0.9431
HET	0.1582	HET	0.1896

(a) Corrects for first-order autocorrelation using PRAIS

Table 10: Price of Feeder Steers vs. SM Price of Feeder Steers (1971-19820 (continued).

Dependent Variable: Price of Feeder Steers		
SM Model	**Prais(a)**	**Prais(a)**
VARIABLES	**600-650**	**750-800**
D1	0.00980	0.00801
	(0.199)	(0.177)
D2	0.0405	0.0374
	(0.864)	(0.866)
D3	0.00104	0.00315
	(0.0256)	(0.0844)
Q of Feeder Steers	7.384	6.539
	(1.143)	(1.098)
Q of Feeder Heifers	-8.589	-6.660
	(-0.744)	(-0.626)
Farm-Wholesale Spread	0.0450	0.0666
	(0.107)	(0.171)
Price of Corn	0.841	0.845
	(0.391)	(0.426)
Price of Slaughter Str	0.137	0.135
	(1.034)	(1.068)
Price in t-1	0.234	
	(1.445)	
Price in t-1		0.258
		(1.550)
Constant	0.802***	0.772***
	(6.110)	(6.667)
Observations	47	47
Adjusted R-squared	0.217	0.247
t-statistics in parentheses		
*** p<0.01, ** p<0.05, * p<0.1		
DW	1.06	1.09
HET		

(a) Corrects for first-order autocorrelation using PRAIS

Table 11: Price of Feeder Heifers vs. SM Price of Feeder Heifers (1971-1982).

Dependent Variable: Price of Feeder Heifers			
The Reduced Form Model		**The Reduced Form Model**	
VARIABLES	**450-500**	**VARIABLES**	**700-750**
D1	-0.0451*	D1	-0.0455**
	(-1.958)		(-2.215)
D2	-0.0391	D2	-0.0234
	(-1.508)		(-1.028)
D3	-0.0130	D3	-0.00920
	(-0.460)		(-0.357)
Transportation Costs	-0.0580	Transportation Costs	-0.00945
	(-0.765)		(-0.142)
Q of Feeder Steers	-3.967	Q of Feeder Steers	-2.179
	(-1.148)		(-0.719)
Q of Feeder Heifers	22.35***	Q of Feeder Heifers	17.98***
	(3.223)		(2.939)
Farm-Wholesale Spread	-1.290***	Farm-Wholesale Spead	-0.949***
	(-4.206)		(-3.542)
Price of Corn	-1.551*	Price of Corn	-1.568**
	(-1.763)		(-2.048)
Price of Slaughter Str	1.074***	Price of Slaughter Str	0.934***
	(8.182)		(8.186)
Price Feeder Hef in t-1	0.729***	Price Feeder Hef in t-1	0.635***
	(6.948)		(5.693)
Price Feeder Hef in t-2	-0.252*	Price Feeder Hef in t-2	-0.170
	(-1.781)		(-1.200)
Price Feeder Hef in t-3	0.208	Price Feeder Hef in t-3	0.113
	(1.420)		(0.777)
Price Feeder Hef in t-4	-0.0573	Price Feeder Hef in t-4	-0.0342
	(-0.545)		(-0.309)
Constant	-0.208	Constant	-0.212
	(-1.023)		(-1.201)
Observations	44	Observations	44
Adjusted R-squared	0.966	Adjusted R-squared	0.958
t-statistics in parentheses		t-statistics in parentheses	
*** p<0.01, ** p<0.05, * p<0.1		*** p<0.01, ** p<0.05, * p<0.1	
DW	1.65	DW	1.83
Dwalt	0.4052	Dwalt	0.7481
HET	0.1874	HET	0.2366
(a) Corrects for first-order autocorrelation using PRAIS			

Table 11: Price of Feeder Heifers vs. SM Price of Feeder Heifers (1971-1982) (continued).

Dependent Variable: Price of Feeder Heifers		
SM Model	**Prais(a)**	**Prais(a)**
VARIABLES	**450-500**	**700-750**
D1	0.0132	0.0114
	(0.248)	(0.264)
D2	0.0310	0.0367
	(0.613)	(0.902)
D3	-0.0253	-0.0157
	(-0.580)	(-0.448)
Q of Feeder Steers	5.860	6.414
	(0.841)	(1.143)
Q of Feeder Heifers	-11.95	-10.92
	(-0.961)	(-1.090)
Farm-Wholesale Spread	0.0352	0.0811
	(0.0773)	(0.221)
Price of Corn	1.673	1.044
	(0.725)	(0.561)
Price of Slaughter Str	0.0559	0.128
	(0.405)	(1.141)
Price in t-1	0.213	
	(1.413)	
Price in t-1		0.199
		(1.274)
Constant	0.756***	0.710***
	(4.773)	(5.894)
Observations	47	47
Adjusted R-squared	0.179	0.255
t-statistics in parentheses		
*** p<0.01, ** p<0.05, * p<0.1		
DW	1.08	1
HET		
(a) Corrects for first-order autocorrelation using PRAIS		

For the period of 1971-1982, concentrating on the 600-650 lb and 750-800 lb feeder steers, the estimated reduced form model reports an R^2 of .96 and a DW of 1.96 (slightly lower values are obtained for heavier steers). The coefficients for the 600-650 lb feeder steers model are slightly higher then the 750-800 lb feeder steers model, and are

consistent with the previous study's finding that the prices of lighter feeder steers increase relatively more than heavier feeder steers when slaughter prices increase. Transportation cost coefficients are negative for both steer weights, but not statistically significant. The quantity of steers on feed coefficients are negative for both weights, but not statistically significant. The quantity of heifers on feed coefficients are positive and significant for both steer weights. The farm-to-wholesale price spread coefficients are negative and statistically significant for both steer weights. The results implies increases in the farm-to-wholesale price spread of $10 decreases the price of 600-650 lbs feeder steers by $11.10. The price of corn coefficients are negative and statistically significant for both steer weights. The price of slaughter steers coefficients are positive and significant for both feeder steers. Only the one quarter lagged dependent variable coefficients are statistically significant for both steer weights.

For the period of 1971-1982, concentrating on the 400-450 lb and 700-750 lb feeder heifers, the estimated reduced form model reports an adjusted R^2 of .96 for the lighter heifer weight class. Like the feeder steers, most of the coefficients for lighter feeder heifers are slightly higher compared to heavier heifers. Transportation cost coefficients are negative but not significant for both heifer weights. The quantity of steers on feed coefficients are negative, but not statistically significant for both heifer weights. The quantity of heifers on feed coefficients are positive and significant for both heifer weights. The farm-to-wholesale price spread coefficients are statistically significant and negative for both heifer weights. The results imply than an increase in the farm-to-wholesale price spread of $10 decreases the price of the lighter feeder heifers by

$12.90 and decreases the price of heavier feeder heifers by $9.49. Price of corn coefficients are negative and statistically significant for both heifer weight groups. The price of slaughter heifers[11] coefficient is positive and significant. One quarter lagged price coefficients are statistically significant for both weight groups.

The estimated reduced form model for the period 1992-2003 using the 600-650 lbs and 750-800 lbs feeder steers reports an R^2 of .925 and a DW of 1.88 for lighter feeder steers (Table 12 and Table 13). Transportation cost coefficients are positive, but not statistically significant for both steer weight groups. The quantity of steers on feed coefficients are negative, but not statistically significant for both steer weights. Quantity of heifers on feed coefficient is positive, but not statistically significant for both weight groups. The farm-to-wholesale price spread coefficients are positive and significant for both weight groups. The price of corn coefficients are negative for both weights, but only significant for the lighter weight steers. The price of slaughter steers coefficients are positive and significant for both weights. Only one quarter lagged price coefficients are statistically significant for both steer weights.

[11] The price of slaughter heifers are included in the feeder heifer price model, instead of the price of slaughter steers.

Table 12: Price of 600-650 Feeder Steers.

Dependent Variable: Price of 600-650 Feeder Steers			
Time Periods	**1971-1982**	**1992-2003**	**1971-2003-robust (a)**
VARIABLES			
D1	-0.0642***	-0.00402	-0.0171
	(-3.023)	(-0.368)	(-1.407)
D2	-0.0356	-0.00797	0.00338
	(-1.514)	(-0.732)	(0.275)
D3	0.00178	-0.0357***	-0.0128
	(0.0659)	(-3.890)	(-1.029)
Transportation Costs	-0.0278	0.0150	-0.0128
	(-0.384)	(0.293)	(-0.585)
Q of Feeder Steers	-1.785	-0.998	2.571*
	(-0.540)	(-0.0867)	(1.960)
Q of Feeder Heifers	18.77***	3.971	3.154*
	(3.071)	(0.181)	(1.734)
Farm-Wholesale Spread	-1.111***	0.158	-0.179
	(-3.876)	(1.153)	(-1.458)
Price of Corn	-1.622*	-2.501**	-3.582***
	(-1.991)	(-2.234)	(-5.130)
Price of Slaughter Str	1.059***	0.420***	0.626***
	(9.420)	(3.058)	(7.246)
Price Feeder Str in t-1	0.609***	0.816***	0.646***
	(6.050)	(4.321)	(7.193)
Price Feeder Str in t-2	-0.173	-0.417*	-0.0210
	(-1.365)	(-1.856)	(-0.181)
Price Feeder Str in t-3	0.119	0.733***	0.0718
	(0.902)	(3.298)	(0.451)
Price Feeder Str in t-4	-0.0240	-0.617***	-0.157
	(-0.243)	(-4.340)	(-1.500)
Constant	-0.227	0.0725	-0.0424
	(-1.204)	(1.338)	(-0.843)
Observations	44	44	128
Adjusted R-squared	0.961	0.925	0.957
t-statistics in parentheses			
*** p<0.01, ** p<0.05, * p<0.1			
DW	1.96	1.88	
Dwalt	0.9992	0.6536	
HET	0.1582	0.1701	

(a) Corrects for heteroskedasticity using robust se

Table 12: Price of 600-650 Feeder Steers (continued).

Dependent Variable: Price of 600-650 Feeder Steers		
Time Periods	**1971-2008-robust (a)**	**1971-2008m1-robust (a)**
VARIABLES		
D1	-0.00990	-0.00980
	(-0.858)	(-0.857)
D2	0.00574	0.00563
	(0.494)	(0.484)
D3	-0.0175*	-0.0175*
	(-1.686)	(-1.674)
Transportation Costs	0.00610	0.00737
	(0.417)	(0.517)
Q of Feeder Steers	2.406*	2.406*
	(1.804)	(1.823)
Q of Feeder Heifers	2.797*	2.786*
	(1.694)	(1.702)
Farm-Wholesale Spread	-0.116	-0.124
	(-1.140)	(-1.198)
Price of Corn	-4.062***	-4.051***
	(-5.440)	(-5.372)
Price of Slaughter Str	0.634***	
	(7.167)	
Price Feeder Str in t-1	0.613***	0.613***
	(6.909)	(7.019)
Price Feeder Str in t-2	-0.0183	-0.0148
	(-0.157)	(-0.127)
Price Feeder Str in t-3	0.112	0.109
	(0.706)	(0.693)
Price Feeder Str in t-4	-0.187*	-0.186*
	(-1.880)	(-1.888)
mad04	0.0119	
	(0.436)	
mad05	0.00532	
	(0.344)	
mad06	0.00429	
	(0.345)	
mad		0.00263
		(0.236)
Price of Slaughter Str Total MAD		0.634***
		(7.252)
Constant	-0.0450	-0.0443
	(-0.977)	(-0.979)

Table 12: Price of 600-650 Feeder Steers (continued).

Dependent Variable: Price of 600-650 Feeder Steers		
Time Periods	**1971-2008-robust (a)**	**1971-2008m1-robust (a)**
VARIABLES		
Observations	148	148
Adjusted R-squared	0.953	0.954
t-statistics in parentheses		
*** p<0.01, ** p<0.05, * p<0.1		
DW		
Dwalt		
HET		
(a) Corrects for heteroskedasticity using robust se		

Table 13: Price of 750-800 Feeder Steers.

Dependent Variable: Price of 750-800 Feeder Steers			
Time Periods	**1971-1982**	**1992-2003**	**1971-2003-robust (a)**
VARIABLES			
D1	-0.0599***	-0.00430	-0.0195
	(-2.893)	(-0.474)	(-1.581)
D2	-0.0320	0.0167*	0.0179
	(-1.394)	(1.719)	(1.437)
D3	0.00253	0.0153*	0.00656
	(0.0955)	(1.818)	(0.536)
Transportation Costs	-0.0102	0.00872	-0.00452
	(-0.141)	(0.183)	(-0.214)
Q of Feeder Steers	-1.640	-0.131	2.593*
	(-0.518)	(-0.0131)	(1.941)
Q of Feeder Heifers	17.17***	1.795	1.987
	(2.887)	(0.0939)	(1.213)
Farm-Wholesale Spread	-0.941***	0.185	-0.123
	(-3.344)	(1.515)	(-1.126)
Price of Corn	-1.487*	-1.537	-3.628***
	(-1.820)	(-1.677)	(-5.865)
Price of Slaughter Str	0.993***	0.468***	0.648***
	(9.010)	(3.705)	(7.836)
Price Feeder Str in t-1	0.552***	0.740***	0.518***
	(5.285)	(4.022)	(6.417)
Price Feeder Str in t-2	-0.124	-0.251	0.0398
	(-0.970)	(-1.129)	(0.364)
Price Feeder Str in t-3	0.112	0.542**	0.116
	(0.856)	(2.474)	(0.804)

Table 13: Price of 750-800 Feeder Steers (continued).

Dependent Variable: Price of 750-800 Feeder Steers			
Time Periods **VARIABLES**	**1971-1982**	**1992-2003**	**1971-2003-robust (a)**
Price Feeder Str in t-4	-0.0444	-0.527***	-0.192**
	(-0.435)	(-3.775)	(-2.014)
Constant	-0.217	0.00928	-0.0401
	(-1.189)	(0.185)	(-0.860)
Observations	44	44	128
Adjusted R-squared	0.954	0.913	0.957
t-statistics in parentheses			
*** p<0.01, ** p<0.05, * p<0.1			
DW	1.94	1.98	
Dwalt	0.9431	0.9916	
HET	0.1896	0.1979	

(a) Corrects for heteroskedasticity using robust se

Table 13: Price of 750-800 Feeder Steers (continued).

Dependent Variable: Price of 750-800 Feeder Steers		
Time Periods **VARIABLES**	**1971-2008-robust (a)**	**1971-2008m1-robust (a)**
D1	-0.00819	-0.00826
	(-0.694)	(-0.708)
D2	0.0278**	0.0274**
	(2.293)	(2.275)
D3	0.0116	0.0112
	(1.042)	(1.006)
Transportation Costs	0.0185	0.0185
	(1.267)	(1.293)
Q of Feeder Steers	2.915**	2.836**
	(2.154)	(2.139)
Q of Feeder Heifers	1.982	1.870
	(1.294)	(1.232)
Farm-Wholesale Spread	-0.106	-0.109
	(-1.149)	(-1.152)
Price of Corn	-4.255***	-4.222***
	(-6.455)	(-6.321)
Price of Slaughter Str	0.681***	
	(7.709)	
Price Feeder Str in t-1	0.458***	0.460***
	(5.661)	(5.678)

Table 13: Price of 750-800 Feeder Steers (continued).

Dependent Variable: Price of 750-800 Feeder Steers		
Time Periods	**1971-2008-robust (a)**	**1971-2008m1-robust (a)**
VARIABLES		
Price Feeder Str in t-2	0.0407	0.0447
	(0.386)	(0.418)
Price Feeder Str in t-3	0.141	0.136
	(1.073)	(1.043)
Price Feeder Str in t-4	-0.194**	-0.196**
	(-2.263)	(-2.291)
mad04	0.0133	
	(0.416)	
mad05	-0.00143	
	(-0.0773)	
mad06	-0.00431	
	(-0.298)	
mad		-0.000637
		(-0.0506)
Price of Slaughter Str Total MAD		0.681***
		(7.784)
Constant	-0.0618	-0.0572
	(-1.403)	(-1.324)
Observations	148	148
Adjusted R-squared	0.951	0.951
t-statistics in parentheses		
*** p<0.01, ** p<0.05, * p<0.1		
DW		
Dwalt		
HET		
(a) Corrects for heteroskedasticity using robust se		

For the period 1992-2003, the lighter heifers estimated reduced form model corrects for heteroskedasticity using robust standard errors (Table 14). For the heavier heifers the estimated reduced form model reports DW and heteroskedasticity test statistics that indicates an error correction model is not required (Table 15). The coefficients for transportation costs are positive for both heifer weights, but not statistically significant. The quantity of steers coefficients are negative, but not statistically significant for both weights. Quantity of heifers on feed coefficients are

positive and significant for both weights. The farm-to-wholesale price spread coefficients are positive and not statistically significant. Price of corn coefficients are negative and statistically significant for both weights. The price of slaughter heifers coefficients are positive and significant for both weight groups. One, three, and four quarter lagged dependent variable coefficients are statistically significant for both weight classes of feeder heifers.

The estimated reduced form model corrects for heteroskedasticity using robust standard errors for the lighter and heavier steer classes for the period 1971-2003 (Table 12 and Table 13). Transportation cost coefficients are negative but not statistically significant for both steer weights. The quantity of steers on feed coefficients are positive and significant for both weights at the ten percent level. Quantity of heifers on feed coefficients are positive for both weights. The farm-to-wholesale price spread coefficients are negative, but not statistically significant for both weights. The price of corn coefficients are negative and significant for both steer weights. These results imply that a $10 increase in the price of corn decreases lighter steers by $35.82. The price of slaughter steers coefficients is positive and significant for both steer weights. One quarter lagged price coefficient is statistically significant for the lighter weight. The heavier feeder steers four quarter lagged coefficient is negative and statistically significant.

For the period 1971-2003, the estimated reduced form model for the lighter heifer weights corrects for first-order autocorrelation and heteroskedasticity, while for the heavier heifers the estimated reduced form model corrects for only heteroskedasticity

(Table 14 and Table 15). Transportation cost coefficients are negative for both heifer weights, but not statistically significant. The quantity of steers on feed coefficients are positive, and only significant for the heavier cattle. Quantity of heifers on feed coefficients are positive but not significance for both weights. The farm-to-wholesale price spread coefficients are negative, and only significant for the lighter heifer weight class. Price of corn coefficients are negative and statistically significant for both the lighter and heavier heifers. The price of slaughter heifers coefficients are positive and significant for both weights.

The estimated reduced form model corrects for heteroskedasticity in both steer weight groups for the period 1971-2008 with individual BSE dummy variables for 2004, 2005, and 2006 (Table 12 and Table 13). Transportation cost coefficients are a positive, and not statistically significant for either weight. Quantity of steers on feed coefficients are positive and significant for both weights. Quantity of heifers on feed coefficients are positive, and statistically significant only for the lighter weight. Farm-to-wholesale price spread coefficients are negative and not statistically significant. Price of corn coefficients are negative and statistically significant for both steer weight groups. These results imply that a $1 increase in the price of corn will decrease lighter steers by $4.62. The price of slaughter steers coefficients are positive and significant. One quarter and four quarter lagged prices coefficients are statistically significant for both weights. The individual dummy BSE variables coefficients, similar to the slaughter level, are positive and not significant for both weights. The 2005 BSE dummy variable coefficient for the heavier steers is consistent economic logic, negative, but is not significant.

For the time period 1971-2008 when individual dummy variables for the BSE outbreak for 2004, 2005, and 2006 are included, the estimated reduced form model corrects for first-order autocorrelation and heteroskedasticity for only the lighter heifers, while the estimated reduced form model corrects for heteroskedasticity for the heavier heifers (Table 14 and Table 15). The transportation cost coefficient is negative for the lighter weight and positive for the heavier heifer weight but is not statistically significant in either market. The quantity of steers on feed coefficients are positive, but only significant for the heavier cattle. Quantity of heifers on feed coefficients are positive, and only significant for the lighter heifer weight. The farm-to-wholesale price spread coefficients are negative and significant for both heifer weight classes. The price of corn coefficients are negative and statistically significant for both weights. Price of slaughter heifers coefficients are positive and significant. The BSE dummy variables coefficients for 2005 and 2006 are negative for the heavier heifers. No BSE coefficients are statistically significant. The magnitudes on all of the coefficients are small. This result indicates that the BSE event did not significantly affect the quarterly feeder heifer prices.

The estimated reduced form model corrects for heteroskedasticity for both steer weight groups for the period 1971-2008 with one total BSE dummy variable for the years of 2004, 2005, and 2006 (Table 12 and Table 13). The transportation cost coefficients are positive, but not statistically significant for both weights. The quantity of steers on feed coefficients are positive and statistically significant for both weights. Quantity of heifers on feed coefficients are positive, but only statistically significant for the lighter weight. The farm-to-wholesale price spread coefficients and the price of corn coefficients

are negative and significant. The price of slaughter steer coefficients are positive and significant for both weight groups. One quarter and four quarter lagged price coefficients are statistically significant for both weights. The BSE variable coefficient for the lighter feeder steer weight is positive but not statistically significant. The BSE dummy coefficient for the heavier steers is negative but not statistically significant.

Table 14: Price of 450-500 Feeder Heifers.

Dependent Variable: Price of 450-500 Feeder Heifers			
Time Periods **VARIABLES**	**1971-1982**	**1992-2003-robust(a)**	**1971-2003-arch (b)**
D1	-0.0451*	-0.0130	-0.0114
	(-1.958)	(-0.945)	(-1.063)
D2	-0.0391	-0.0343**	-0.0143
	(-1.508)	(-2.465)	(-0.945)
D3	-0.0130	-0.0521***	-0.0317**
	(-0.460)	(-3.950)	(-2.226)
Transportation Costs	-0.0580	0.0676	-0.0193
	(-0.765)	(1.065)	(-0.901)
Q of Feeder Steers	-3.967	-5.380	1.622
	(-1.148)	(-0.491)	(1.182)
Q of Feeder Heifers	22.35***	12.57	2.985
	(3.223)	(0.598)	(1.542)
Farm-Wholesale Spread	-1.290***	0.0376	-0.257**
	(-4.206)	(0.277)	(-2.391)
Price of Corn	-1.551*	-4.135***	-3.729***
	(-1.763)	(-2.859)	(-6.279)
Price of Slaughter Hef	1.074***	0.413**	0.631***
	(8.182)	(2.518)	(8.520)
Price Feeder Hef in t-1	0.729***	0.679***	0.779***
	(6.948)	(2.811)	(10.91)
Price Feeder Hef in t-2	-0.252*	-0.133	-0.0981
	(-1.781)	(-0.611)	(-0.934)
Price Feeder Hef in t-3	0.208	0.487*	0.162*
	(1.420)	(1.919)	(1.756)
Price Feeder Hef in t-4	-0.0573	-0.501***	-0.229***
	(-0.545)	(-3.105)	(-3.833)

Table 14: Price of 450-500 Feeder Heifers (continued).

Dependent Variable: Price of 450-500 Feeder Heifers			
Time Periods **VARIABLES**	**1971-1982**	**1992-2003-robust(a)**	**1971-2003-arch (b)**
Constant	-0.208	0.0795	-0.0347
	(-1.023)	(1.145)	(-0.705)
Observations	44	44	128
Adjusted R-squared	0.966	0.918	
t-statistics in parentheses			
*** p<0.01, ** p<0.05, * p<0.1			
DW	1.65		
Dwalt	0.4052		
HET	0.1874		

(a) Corrects for heteroskedasticity using robust se
(b) Corrects for heteroskedasticity and first-order autocorrelation using ARCH

Table 14: Price of 450-500 Feeder Heifers (continued).

Dependent Variable: Price of 450-500 Feeder Heifers		
Time Periods **VARIABLES**	**1971-2008-arch (b)**	**1971-2008m1-arch (b)**
D1	-0.00766	-0.00722
	(-0.801)	(-0.753)
D2	-0.0113	-0.0107
	(-0.838)	(-0.811)
D3	-0.0357***	-0.0352***
	(-2.802)	(-2.861)
Transportation Costs	-0.00239	-0.000577
	(-0.131)	(-0.0324)
Q of Feeder Steers	1.420	1.536
	(1.126)	(1.228)
Q of Feeder Heifers	2.943*	2.932*
	(1.662)	(1.688)
Farm-Wholesale Spread	-0.236**	-0.256**
	(-2.409)	(-2.523)
Price of Corn	-4.061***	-4.030***
	(-7.251)	(-7.182)
Price of Slaughter Hef	0.644***	
	(8.954)	
Price Feeder Hef in t-1	0.752***	0.750***
	(11.24)	(11.14)

Table 14: Price of 450-500 Feeder Heifers (continued).

Dependent Variable: Price of 450-500 Feeder Heifers		
Time Periods **VARIABLES**	**1971-2008-arch (b)**	**1971-2008m1-arch (b)**
Price Feeder Hef in t-2	-0.0800	-0.0790
	(-0.848)	(-0.825)
Price Feeder Hef in t-3	0.176**	0.177**
	(2.140)	(2.126)
Price Feeder Hef in t-4	-0.246***	-0.245***
	(-4.685)	(-4.669)
mad04	0.0135	
	(0.793)	
mad05	0.0107	
	(0.113)	
mad06	0.0144	
	(0.123)	
mad		0.0106
		(0.668)
Price of Slaughter Hef Total MAD		0.645***
		(8.664)
Constant	-0.0413	-0.0432
	(-0.920)	(-0.987)
Observations	148	148
Adjusted R-squared		
t-statistics in parentheses		
*** p<0.01, ** p<0.05, * p<0.1		
DW		
Dwalt		
HET		
(a) Corrects for heteroskedasticity using robust se		
(b) Corrects for heteroskedasticity and first-order autocorrelation using ARCH		

Table 15: Price of 700-750 Feeder Heifers.

Dependent Variable: Price of 700-750 Feeder Heifers			
Time Periods **VARIABLES**	**1971-1982**	**1992-2003**	**1971-2003-robust (a)**
D1	-0.0455**	-0.0126	-0.0146
	(-2.215)	(-1.331)	(-1.304)
D2	-0.0234	0.0155	0.0182*
	(-1.028)	(1.651)	(1.735)

Table 15: Price of 700-750 Feeder Heifers (continued).

Dependent Variable: Price of 700-750 Feeder Heifers			
Time Periods	**1971-1982**	**1992-2003**	**1971-2003-robust (a)**
VARIABLES			
D3	-0.00920	-0.00433	-0.0121
	(-0.357)	(-0.462)	(-1.058)
Transportation Costs	-0.00945	0.0324	-0.000258
	(-0.142)	(0.642)	(-0.0129)
Q of Feeder Steers	-2.179	1.534	2.124*
	(-0.719)	(0.147)	(1.663)
Q of Feeder Heifers	17.98***	-1.013	1.623
	(2.939)	(-0.0508)	(1.081)
Farm-Wholesale Spread	-0.949***	0.143	-0.169
	(-3.542)	(1.106)	(-1.627)
Price of Corn	-1.568**	-1.748*	-3.568***
	(-2.048)	(-1.770)	(-5.950)
Price of Slaughter Hef	0.934***	0.405***	0.611***
	(8.186)	(3.046)	(6.889)
Price Feeder Hef in t-1	0.635***	0.738***	0.624***
	(5.693)	(3.982)	(6.446)
Price Feeder Hef in t-2	-0.170	-0.285	-0.0482
	(-1.200)	(-1.318)	(-0.383)
Price Feeder Hef in t-3	0.113	0.589***	0.191
	(0.777)	(2.795)	(1.343)
Price Feeder Hef in t-4	-0.0342	-0.516***	-0.245***
	(-0.309)	(-3.788)	(-2.643)
Constant	-0.212	0.0134	-0.0312
	(-1.201)	(0.257)	(-0.720)
Observations	44	44	128
Adjusted R-squared	0.958	0.904	0.955
t-statistics in parentheses			
*** p<0.01, ** p<0.05, * p<0.1			
DW	1.83	2.08	
Dwalt	0.7481	0.6275	
HET	0.2366	0.2952	
(a) Corrects for heteroskedasticity using robust se			

Table 15: Price of 700-750 Feeder Heifers (continued).

Dependent Variable: Price of 700-750 Feeder Heifers		
Time Periods	**1971-2008-robust (a)**	**1971-2008m1-robust (a)**
VARIABLES		
D1	-0.00413	-0.00405
	(-0.380)	(-0.374)
D2	0.0276**	0.0273**
	(2.613)	(2.604)
D3	-0.00646	-0.00670
	(-0.609)	(-0.631)
Transportation Costs	0.0166	0.0164
	(1.283)	(1.303)
Q of Feeder Steers	2.380*	2.331*
	(1.887)	(1.894)
Q of Feeder Heifers	1.504	1.407
	(1.127)	(1.066)
Farm-Wholesale Spread	-0.155*	-0.161*
	(-1.808)	(-1.862)
Price of Corn	-4.051***	-4.022***
	(-6.494)	(-6.425)
Price of Slaughter Hef	0.633***	
	(6.790)	
Price Feeder Hef in t-1	0.567***	0.566***
	(5.927)	(5.966)
Price Feeder Hef in t-2	-0.0307	-0.0256
	(-0.257)	(-0.214)
Price Feeder Hef in t-3	0.210	0.206
	(1.639)	(1.620)
Price Feeder Hef in t-4	-0.252***	-0.253***
	(-3.018)	(-3.058)
mad04	0.0112	
	(0.380)	
mad05	-0.000687	
	(-0.0406)	
mad06	-0.00336	
	(-0.224)	
mad		0.000809
		(0.0701)
Price of Slaughter Hef Total MAD		0.635***
		(6.918)
Constant	-0.0466	-0.0431
	(-1.202)	(-1.140)

Table 15: Price of 700-750 Feeder Heifers (continued).

Dependent Variable: Price of 700-750 Feeder Heifers		
Time Periods	**1971-2008-robust (a)**	**1971-2008m1-robust (a)**
VARIABLES		
Observations	148	148
Adjusted R-squared	0.949	0.949
t-statistics in parentheses		
*** p<0.01, ** p<0.05, * p<0.1		
DW		
Dwalt		
HET		
(a) Corrects for heteroskedasticity using robust se		

For the period 1971-2008 using one total BSE dummy variable for 2004-2006, the estimated reduced form model corrects for first-order autocorrelation and heteroskedasticity for the lighter heifers, while the estimated reduced form model for the heavier heifers corrects for heteroskedasticity (Table 14 and Table 15). The transportation cost coefficient is negative for the lighter weight, but not statistically significant. The transportation cost coefficient is positive for the heavier heifer weight but not statistically significant. The quantity of steers on feed coefficient is positive, but only significant for the heavier heifers. Quantity of heifers on feed coefficient is positive and only significant for the lighter heifer weight. The farm-to-wholesale price spread coefficients and the price of corn coefficients are negative and statistically significant for both weights. The price of slaughter heifers coefficients are positive and significant. The BSE dummy variable coefficients are positive, and not statistically significant for both weight groups. The coefficient is greater in magnitude for the lighter weight than the heavier heifer weight; the magnitude suggests the lighter heifers are more sensitive to a BSE outbreak when compared to heavier heifers.

F-statistics were calculated for feeder prices estimated models for the periods 1971-2003 and 1971-2008 to test for structural change during the BSE event. The resulting test statistics did not indicate rejection of the null hypothesis of BSE changes the market structure over the time periods of 1971-2003 to 1971-2008.

The estimated SM price differences model for the period 1971-1982 reports an adjusted R^2 of .305 for the lighter price difference (Table 16). The price of slaughter steers coefficients is positive and significant for the light price difference, but negative and insignificant for the heavier price difference. SM suggest that the positive coefficient on the price of slaughter steers for the lighter price difference could lead to increases derived demand for feeder steers and heifers. If packers demand relatively more slaughter steers than slaughter heifers, this yields a pricing signal to cattle feeders, thus widening the difference between steers and heifers feeder prices. All quantity variables coefficients are positive and insignificant, which is inconsistent with the inverse relationship found among quantity and price variables reported in previous studies (Schultz and Marsh, Buccola and Jessee). The price of corn coefficients are negative and not statistically significant. These results agree with SM who suggest that feedlots may not be sensitive to the steer-heifer feed conversion differences when the cost of grain changes. SM further suggests that when feed costs increase the price reductions for both steers and heifers are very similar. One reason for this could be that heifers require more feed per pound of gain resulting in the finishing weights being lighter; feeder heifers are on feed a smaller number of days. A second reason (according to the Subcommittee on Beef Cattle Nutrition (1984)) that the feed conversion differences are not large is that,

depending on weight and grades, the conversion difference is 7 to 10 percent. The farm-to-wholesale price spread coefficients are positive and not significant for both weight differences.

Table 16: Price Differences vs. SM Differences (1971-1982).

Dependent Variable: Price of Differences			
The Reduced Form Model		**The Reduced Form Model**	
VARIABLES	**600/650-450/500**	**VARIABLES**	**750/800-700/750(a)**
D1	-0.0263*	D1	-0.0142
	(-2.004)		(-1.474)
D2	-0.0316**	D2	-0.0133*
	(-2.146)		(-1.818)
D3	-0.0100	D3	0.00286
	(-0.760)		(0.298)
Transportation Costs	-0.0215	Transportation Costs	-0.00948
	(-0.775)		(-1.077)
Q of Feeder Steers	2.193	Q of Feeder Steers	0.567
	(1.258)		(0.955)
Q of Feeder Heifers	-7.133**	Q of Feeder Heifers	-2.086*
	(-2.293)		(-1.839)
Farm-Wholesale Spread	0.0468	Farm-Wholesale Spread	-0.0739
	(0.291)		(-1.087)
Price of Corn	0.469	Price of Corn	0.511*
	(0.946)		(1.997)
Price of Slaughter Str	3.241***	Price of Slaughter Str	1.557***
	(3.040)		(4.260)
Price of Slaughter Hef	-3.460***	Price of Slaughter Hef	-1.564***
	(-3.051)		(-4.157)
Price Difference in t-1	0.518***	Price Difference in t-1	0.801***
	(3.188)		(5.675)
Price Difference in t-2	-0.161	Price Difference in t-2	-0.477**
	(-0.915)		(-2.637)
Price Difference in t-3	0.190	Price Difference in t-3	0.224
	(1.042)		(1.261)
Price Difference in t-4	-0.119	Price Difference in t-4	-0.123
	(-0.810)		(-0.954)
Constant	0.166*	Constant	0.0434
	(1.917)		(1.536)

Table 16: Price Difference vs. SM Differences (1971-1982) (continued).

Dependent Variable: Price of Differences			
The Reduced Form Model		**The Reduced Form Model**	
VARIABLES	**600/650-450/500**	**VARIABLES**	**750/800-700/750(a)**
Observations	44	Observations	44
Adjusted R-squared	0.781	Adjusted R-squared	0.881
t-statistics in parentheses		t-statistics in parentheses	
*** p<0.01, ** p<0.05, * p<0.1		*** p<0.01, ** p<0.05, * p<0.1	
DW	2.29	DW	2.19
Dwalt	0.1235	Dwalt	
HET	0.5287	HET	
(a) Corrects for first-order autocorrelation using PRAIS			

Table 16: Price Differences vs. SM Differences (1971-1982) (continued).

Dependent Variable: Price of Differences		
SM Model		
VARIABLES	**600/650-450/500 (a)**	**750/800-700/750 (a)**
D1	-0.000509	0.00495
	(-0.0307)	(0.480)
D2	0.00810	-0.00296
	(0.535)	(-0.318)
D3	0.0264**	0.0174**
	(2.045)	(2.177)
Q of Feeder Steers	1.565	0.624
	(0.750)	(0.483)
Q of Feeder Heifers	3.360	3.461
	(0.908)	(1.531)
Farm-Wholesale Spread	0.0153	0.0304
	(0.112)	(0.354)
Price of Corn	-0.793	-0.0838
	(-1.181)	(-0.202)
Price of Slaughter Str	0.0862**	-0.0165
	(2.181)	(-0.433)
Price in t-1	0.295	
	(1.044)	
Price in t-1		0.630**
		(2.081)
Constant	0.0447*	0.0647***
	(1.980)	(5.804)

Table 16: Price Differences vs. SM Differences (1971-1982) (continued).

Dependent Variable: Price of Differences		
SM Model		
VARIABLES	**600/650-450/500 (a)**	**750/800-700/750 (a)**
Observations	47	47
Adjusted R-squared	0.305	0.330
t-statistics in parentheses		
*** p<0.01, ** p<0.05, * p<0.1		
DW	1.91	1.6
HET		
(a) Corrects for first-order autocorrelation using PRAIS		

The re-estimated SM price difference model reports a Durbin-Watson (DW) test statistic of 1.91 for the lighter price difference and 1.6 for the heavier price difference (Table 16). The adjusted R^2 is around .30 for both weight differences. Thus the reduced form models are estimated using the Prais-Winsten procedure to correct for first-order autocorrelation, or estimated using robust standard errors correcting for heteroskedasticity, and then both first-order autocorrelation and heteroskedasticity ARCH procedures are utilized.

For the period 1971-1982, the estimated reduced form model for the lighter price differences report sufficient DW and heteroskedasticity test statistics; thus, an error correction model is not needed. The estimated reduced form model for the heavier price differences, however, corrects for first-order autocorrelation. Transportation costs coefficients are negative but not statistically significant for both weight groups. The quantity of feeder steers coefficients are positive, but not significant for either weight group. Quantity of feeder heifers coefficients are negative and significant for both

weights. The farm-to-wholesale price spread coefficient is positive for the lighter price difference and is negative for the heavier price difference, but not significant for either price difference. The price of corn coefficients are positive and are not statistically significant for the lighter price difference, but is statistically significant at the 10% level for the heavier price difference. The price of slaughter steers coefficients are positive and significant for both price differences. The price slaughter heifers coefficients are negative and statistically significant for both price differences. Only the one quarter lag is statistically significant for both price differences.

For the period 1992-2003, the estimated reduced form model corrects for first-order autocorrelation and heteroskedasticity for the lighter for feeder cattle price differences, and the estimated reduced form model corrects for heteroskedasticity for the heavier price differences (Table 17 and Table 18). This time period's adjusted R^2 is the lowest reported. The transportation costs coefficients are negative and significant only for the lighter weight difference. The quantity of steers on feed coefficient is positive for the lighter price differences and the quantity of heifers on feed coefficient is negative for the light price differences, and neither are significant. The quantity of steers on feed coefficient is negative and the quantity of heifers on feed coefficient is positive for the heavier price difference model, but both are not statistically significant. The farm-to-wholesale price spread coefficients are positive for the lighter and heavier price difference, but not statistically significant. The price of corn coefficients are positive and statistically significant for the both weight groups. For the heavier price difference, the price of slaughter steers coefficient is positive, slaughter heifers coefficients is negative,

and both are statistically significant. For the lighter price difference, the price of slaughter steers coefficient is negative, the slaughter heifers coefficient is positive, and neither are statistically significant. No quarter price lags coefficients are statistically significant for the lighter price difference and one and four quarter lags coefficients are significant for the heavier cattle.

Table 17: Feeder Price Differences of 600/650-450/500 Str/Hef.

Dependent Variable: Feeder Price Differences of 600/650-450/500 Str/Hef		
Time Periods **VARIABLES**	**1971-1982**	**1992-2003-arch(a)**
D1	-0.0263*	0.00627
	(-2.004)	(0.782)
D2	-0.0316**	0.0146
	(-2.146)	(1.381)
D3	-0.0100	0.00716
	(-0.760)	(0.884)
Transportation Costs	-0.0215	-0.0201
	(-0.775)	(-0.460)
Q of Feeder Steers	2.193	6.812
	(1.258)	(0.896)
Q of Feeder Heifers	-7.133**	-12.43
	(-2.293)	(-0.862)
Farm-Wholesale Spread	0.0468	0.159
	(0.291)	(1.120)
Price of Corn	0.469	1.902**
	(0.946)	(2.281)
Price of Slaughter Str	3.241***	-1.118
	(3.040)	(-0.530)
Price of Slaughter Hef	-3.460***	1.101
	(-3.051)	(0.511)
Price Difference in t-1	0.518***	0.427
	(3.188)	(1.626)
Price Difference in t-2	-0.161	0.0714
	(-0.915)	(0.272)
Price Difference in t-3	0.190	0.0343
	(1.042)	(0.119)
Price Difference in t-4	-0.119	0.113
	(-0.810)	(0.594)
Constant	0.166*	-0.0386
	(1.917)	(-0.756)

Table 17: Feeder Price Difference of 600/650-450/500 Str/Hef (continued).

Dependent Variable: Feeder Price Differences of 600/650-450/500 Str/Hef		
Time Periods	**1971-1982**	**1992-2003-arch(a)**
VARIABLES		
Observations	44	44
Adjusted R-squared	0.781	
t-statistics in parentheses		
*** p<0.01, ** p<0.05, * p<0.1		
DW	2.29	
Dwalt	0.1235	
HET	0.5287	
(a) Corrects for heteroskedasticity and first-order autocorrelation using ARCH		

Table 17: Feeder Price Difference of 600/650-450/500 Str/Hef (continued).

Dependent Variable: Feeder Price Differences of 600/650-450/500 Str/Hef			
Time Periods	**1971-2003-arch (a)**	**1971-2008**	**1971-2008m1**
VARIABLES			
D1	-0.0125**	-0.00739	-0.00763
	(-2.320)	(-1.582)	(-1.648)
D2	0.00235	0.00347	0.00338
	(0.306)	(0.657)	(0.646)
D3	0.00509	0.00684	0.00645
	(0.735)	(1.392)	(1.328)
Transportation Costs	-0.00996	-0.000778	-0.000846
	(-0.886)	(-0.103)	(-0.118)
Q of Feeder Steers	0.162	0.0827	-0.0275
	(0.259)	(0.145)	(-0.0494)
Q of Feeder Heifers	-0.644	-0.626	-0.648
	(-0.742)	(-0.964)	(-1.014)
Farm-Wholesale Spread	0.0946	0.125***	0.138***
	(1.389)	(2.758)	(3.009)
Price of Corn	0.923**	0.817***	0.784***
	(2.392)	(3.218)	(3.096)
Price of Slaughter Str	1.709**	1.652***	
	(2.273)	(2.640)	
Price of Slaughter Hef	-1.864**	-1.813***	
	(-2.324)	(-2.754)	
Price Difference in t-1	0.697***	0.650***	0.652***
	(6.912)	(7.908)	(8.016)

Table 17: Feeder Price Difference of 600/650-450/500 Str/Hef (continued).

Dependent Variable: Feeder Price Differences of 600/650-450/500 Str/Hef			
Time Periods	**1971-2003-arch (a)**	**1971-2008**	**1971-2008m1**
VARIABLES			
Price Difference in t-2	-0.256**	-0.211**	-0.205**
	(-2.006)	(-2.157)	(-2.128)
Price Difference in t-3	0.269**	0.199**	0.202**
	(2.210)	(2.018)	(2.059)
Price Difference in t-4	-0.212***	-0.148*	-0.145*
	(-2.764)	(-1.885)	(-1.872)
mad04		-0.00458	
		(-0.480)	
mad05		-0.00174	
		(-0.175)	
mad06		-0.00912	
		(-0.888)	
mad			-0.00646
			(-1.129)
Price of Slaughter Str Total MAD			1.537**
			(2.524)
Price of Slaughter Hef Total MAD			-1.693***
			(-2.643)
Constant	0.0568**	0.0489**	0.0481**
	(2.061)	(2.397)	(2.428)
Observations	128	148	148
Adjusted R-squared		0.804	0.807
t-statistics in parentheses			
*** p<0.01, ** p<0.05, * p<0.1			
DW		1.96	1.97
Dwalt		0.4814	0.4666
HET		0.3202	0.384
(a) Corrects for heteroskedasticity and first-order autocorrelation using ARCH			

Table 18: Feeder Price Differences of 750/800-700/750 Str/Hef.

Dependent Variable: Feeder Price Differences of 750/800-700/750 Str/Hef			
Time Periods	**1971-1982-prais (a)**	**1992-2003-robust (b)**	**1971-2003-robust (b)**
VARIABLES			
D1	-0.0142	0.000920	-0.00850***
	(-1.474)	(0.261)	(-2.656)
D2	-0.0133*	0.00266	-0.00481
	(-1.818)	(0.846)	(-1.301)
D3	0.00286	0.00800**	0.0103***
	(0.298)	(2.275)	(3.662)
Transportation Costs	-0.00948	-0.0311**	-0.0105
	(-1.077)	(-2.484)	(-1.409)
Q of Feeder Steers	0.567	-1.263	0.0231
	(0.955)	(-0.803)	(0.0668)
Q of Feeder Heifers	-2.086*	1.925	-0.109
	(-1.839)	(0.636)	(-0.288)
Farm-Wholesale Spread	-0.0739	0.0425	0.0799***
	(-1.087)	(0.957)	(2.906)
Price of Corn	0.511*	0.466**	0.393**
	(1.997)	(2.257)	(2.595)
Price of Slaughter Str	1.557***	1.700**	1.040***
	(4.260)	(2.265)	(3.283)
Price of Slaughter Hef	-1.564***	-1.661**	-1.065***
	(-4.157)	(-2.197)	(-3.217)
Price Difference in t-1	0.801***	0.298**	0.386***
	(5.675)	(2.052)	(3.579)
Price Difference in t-2	-0.477**	0.00488	-0.0133
	(-2.637)	(0.0263)	(-0.131)
Price Difference in t-3	0.224	0.0172	0.00398
	(1.261)	(0.115)	(0.0350)
Price Difference in t-4	-0.123	0.350*	-0.0446
	(-0.954)	(2.028)	(-0.480)
Constant	0.0434	5.70e-05	0.0168
	(1.536)	(0.00354)	(1.156)
Observations	44	44	128
Adjusted R-squared	0.881	0.504	0.890
t-statistics in parentheses			
*** p<0.01, ** p<0.05, * p<0.1			
DW	2.19		
Dwalt			
HET			
(a) Corrects for first-order autocorrelation using PRAIS			
(b) Corrects for heteroskedasticity using robust se			

Table 18: Feeder Price Differences of 750/800-700/750 Str/Hef (continued).

Dependent Variable: Feeder Price Differences of 750/800-700/750 Str/Hef		
Time Periods	**1971-2008-robust (b)**	**1971-2008m1-robust (b)**
VARIABLES		
D1	-0.00652**	-0.00656**
	(-2.290)	(-2.339)
D2	-0.00325	-0.00316
	(-1.073)	(-1.054)
D3	0.0110***	0.0110***
	(4.755)	(4.748)
Transportation Costs	-0.00194	-0.00109
	(-0.465)	(-0.281)
Q of Feeder Steers	-0.000640	-0.0205
	(-0.00179)	(-0.0577)
Q of Feeder Heifers	0.0978	0.130
	(0.277)	(0.370)
Farm-Wholesale Spread	0.0825***	0.0867***
	(3.609)	(3.629)
Price of Corn	0.324**	0.309**
	(2.165)	(2.062)
Price of Slaughter Str	1.139***	
	(3.256)	
Price of Slaughter Hef	-1.166***	
	(-3.221)	
Price Difference in t-1	0.375***	0.378***
	(3.805)	(3.831)
Price Difference in t-2	-0.0438	-0.0432
	(-0.453)	(-0.446)
Price Difference in t-3	-0.0150	-0.0163
	(-0.134)	(-0.146)
Price Difference in t-4	-0.0369	-0.0366
	(-0.428)	(-0.429)
mad04	0.000653	
	(0.137)	
mad05	0.00158	
	(0.395)	
mad06	0.00136	
	(0.363)	
mad		-0.00134
		(-0.540)
Price of Slaughter Str Total MAD		1.101***
		(3.216)
Price of Slaughter Hef Total MAD		-1.128***
		(-3.183)
Constant	0.00932	0.00792
	(0.719)	(0.637)

Table 18: Feeder Price Differences of 750/800-700/750 Str/Hef (continued)

Dependent Variable: Feeder Price Differences of 750/800-700/750 Str/Hef		
Time Periods **VARIABLES**	**1971-2008-robust (b)**	**1971-2008m1-robust (b)**
Observations	148	148
Adjusted R-squared	0.887	0.888
t-statistics in parentheses		
*** p<0.01, ** p<0.05, * p<0.1		
DW		
Dwalt		
HET		
(a) Corrects for first-order autocorrelation using PRAIS		
(b) Corrects for heteroskedasticity using robust se		

The estimated reduced form price difference model corrects for first-order autocorrelation and heteroskedasticity for the lighter price difference, and the estimated reduced form model corrects for heteroskedasticity for the heavier weight price difference for the period 1971-2003 (Table 17 and Table 18). The transportation costs coefficients are negative and not statistically significant. For both price differences, the quantity of steers on feed coefficient is positive and the quantity of heifers on feed coefficient is negative, but neither are statistically significant. The farm-to-wholesale price spread coefficients are positive for the lighter and heavier price difference, but significant only for the heavier weight difference. The price of corn coefficients are positive and statistically significant for both weight groups. The price of slaughter steers coefficient is positive, slaughter heifers coefficient is negative, and both are statistically significant. All quarter lagged dependent variable coefficients are statistically significant for the lighter weight, and only the one quarter lagged dependent variable coefficient is statistically significant for the heavier cattle.

For the period 1971-2008 with individual BSE dummy variables for the years of 2004, 2005, and 2006, the estimated reduced form model for the lighter price difference reports DW and heteroskedasticity test statistics that indicate an error correction model is not needed. However, the estimated reduced form model for the heavier price difference corrects for heteroskedasticity (Table 17 and Table 18). The transportation cost coefficients is negative and not statistically significant for either difference. For the lighter price difference the quantity of steers on feed coefficient is positive but not statistically significant, and the quantity of heifers on feed coefficient is negative but not statistically significant. For the heavier price difference the quantity of steers on feed coefficient is negative and the quantity of heifers on feed is positive, but both are not statistically significant. The farm-to-wholesale price spread coefficients and the price of corn coefficients are positive and statistically significant for both weight differences. The price of slaughter steers coefficient is positive and slaughter heifers coefficients is negative and both are statistically significant. The individual dummy BSE variables coefficients are negative for the lighter price difference, but not statistically significant. For the heavier price difference the coefficients for the BSE outbreak are positive and not significant.

For the period 1971-2008 with one BSE dummy variable for 2004-2006, the estimated reduced form model for the lighter price difference reports sufficient DW and heteroskedasticity test statistics, thus this is not an error correction model. However, the estimated reduced form model for the heavier price difference corrects for heteroskedasticity (Table 17 and Table 18). The transportation costs coefficient is

negative and not statistically significant for both differences. For the lighter price difference the quantity of steers on feed coefficient is negative but not statistically significant, and the quantity of heifers on feed coefficient is negative but not statistically significant. For the heavier price difference the quantity of steers on feed coefficient is negative and the quantity of heifers on feed coefficient is positive, but neither are statistically significant. The farm-to-wholesale price spread coefficients and price of corn coefficients are positive and significant for either difference. The price of slaughter steers coefficient is positive and slaughter heifers coefficient is negative and both are statistically significant. The BSE dummy variable coefficient is negative but not statistically significant for either price difference.

F-statistics are calculated for the feeder price difference estimated models for the periods 1971-2003 and 1971-2008, testing for structural change during the BSE event. The resulting test statistics did not indicate rejection of the null hypothesis of BSE changes the market structure over the time periods of 1971-2003 to 1971-2008.

This feeder price model section examined feeder steer, feeder heifer, and feeder price differences. A key finding is each form of BSE variable constructed did not result in statistical significance, suggesting that the BSE outbreak did not have an effect on the feeder cattle price market. The estimated reduced form models with the additional variables explain the variation more sufficiently (higher R^2) than the SM model. A majority of the variable's coefficients report the expected signs. Additional tests for structural change suggest no significant structural change from 1971-2008.

Additional Structural Change

The final objective of this study is to test for structural change within each market sector. Two slope-intercept variables (Atkins diet and BSE dummy variables are multiplied by quantity variables) are added: one for the Atkins diet and one for the BSE dummy variable. The reduced form models are estimated with these two additional variables. On the boxed beef cutout value level, the Atkins diet coefficient is not statistically significant thus no structural change is indicated (Table 19). The BSE coefficient is statistically significant but positive. At the slaughter steer level coefficients are negative for the BSE event and positive for the Atkins diet, but are not statistically significant (Table 20). The slaughter heifer level, both coefficients are negative but not significant. The slaughter price difference coefficients are negative for BSE and positive for Atkins, but neither are significant. Each of the BSE coefficients on the feeder level, including the price differences, are negative except for the 400-450 lbs heifers, but not significant (Table 21). Each of the Atkins diet coefficients are positive, except for the price differences. Both of the steer weights, the heavier heifers, and the lighter price differences coefficients for Atkins diet are statistically significant. This suggests that when the Atkins diet becomes popular, it increases the price of feeder cattle. Testing for joint significance, the F-statistic fails to reject the null (of joint significance greater than 0 for all market levels except boxed beef cutout values). The Atkins diet and BSE outbreak lead to structural change in the boxed beef cutout values coefficient.

Table 19: Boxed Beef Cutout Values-Structural.

Dependent Variable: Boxed Beef Cutout Values	
Time Periods	**1971-2008-prais(a)**
VARIABLES	
D1	0.0327***
	(2.640)
D2	-0.0189*
	(-1.807)
D3	-0.0301**
	(-2.349)
Q of Str/Hef Slaughter	-15.65***
	(-4.317)
Lagged Q of Str/Hef Slaughter	17.09***
	(4.536)
Q of Pork/Poultry Prod.	0.000498
	(0.341)
By-product allowance	1.312***
	(5.334)
Lagged of by-product allowance	-1.035***
	(-4.297)
Disposable Income	-0.00131
	(-0.455)
Lagged Disposable Income	0.00175
	(0.607)
Whole-to-Retail price spread	-0.328***
	(-6.371)
Lagged Boxed Beef Cutout	0.920***
	(35.98)
Q of Str/Hef Slaughter MAD	2.003***
	(3.360)
Q of Str/Hef Slaughter ADKINS	-0.136
	(-0.343)
Constant	0.163
	(1.285)
Observations	151
Adjusted R-squared	0.986
t-statistics in parentheses	
*** p<0.01, ** p<0.05, * p<0.1	

(a) Corrects for first-order autocorrelation using PRAIS

Table 20: Prices and Price Difference-Structural.

Dependent Variable: Slaughter Prices and Price Differences			
Time Periods	**1971-2008-arch (a)**	**1971-2008-arch (a)**	**1971-2008-arch (a)**
VARIABLES	**Slaughter Str**	**Slaughter Hef**	**Difference**
D1	0.0177***	0.0166***	0.00102
	(2.632)	(2.683)	(0.600)
D2	0.0111	0.00805	0.00277*
	(1.514)	(1.200)	(1.830)
D3	-0.0165**	-0.0151**	-0.00287
	(-2.200)	(-2.389)	(-1.440)
Q of Slaughter Str/Hef	-9.109***	-8.974***	-0.287
	(-7.503)	(-7.829)	(-1.028)
By-product allowance	0.897***	0.867***	0.0249
	(11.29)	(11.57)	(1.199)
Q of Slaughter Str/Hef MAD	-0.355	-0.286	-0.0491
	(-0.740)	(-0.670)	(-0.331)
Q of Slaughter Str/Hef ADKINS	0.109	-0.0171	0.0923
	(0.256)	(-0.0471)	(0.852)
Q of Slaughter Cows	8.818***	6.444***	1.822***
	(6.565)	(4.821)	(5.770)
Boxed Beef Cutout	0.390***	0.373***	0.0123***
	(14.61)	(14.86)	(3.359)
Transportation Costs	-0.00262	-0.0110	0.00499*
	(-0.192)	(-0.903)	(1.684)
Price of Slaughter in t-1	-0.0653	-0.0843*	0.388***
	(-1.372)	(-1.740)	(5.418)
Price of Slaughter in t-2	0.0857*	0.0971*	-0.177**
	(1.747)	(1.851)	(-2.548)
Price of Slaughter in t-3	0.117***	0.131***	0.211***
	(2.877)	(3.133)	(2.966)
Price of Slaughter in t-4	0.0482	0.0450	-0.00258
	(1.318)	(1.215)	(-0.0391)
Constant	0.160***	0.193***	-0.0198**
	(4.943)	(6.811)	(-1.968)
Observations	148	148	148
Adjusted R-squared			
t-statistics in parentheses			
*** p<0.01, ** p<0.05, * p<0.1			

(a) Corrects for heteroskedasticity and first-order autocorrelation using ARCH

Table 21: Price of Feeder Str/Hef and Price Differences-Structural.

Dependent Variable: Price of Feeder Str/Hef and Price Differences			
Time Periods	**1971-2008-robust (a)**	**1971-2008-robust (a)**	**1971-2003-arch (b)**
VARIABLES	**Str 600-650**	**Str 750-800**	**Hef 450-500**
D1	-0.00899	-0.00779	-0.00646
	(-0.779)	(-0.663)	(-0.679)
D2	0.00751	0.0285**	-0.00886
	(0.634)	(2.325)	(-0.658)
D3	-0.0158	0.0125	-0.0336***
	(-1.495)	(1.105)	(-2.637)
Transportation Costs	0.0184	0.0286*	0.0121
	(1.273)	(1.958)	(0.622)
Q of Feeder Steers	2.855**	3.214**	1.948
	(2.160)	(2.354)	(1.506)
Q of Feeder Heifers	2.245	1.394	2.254
	(1.441)	(0.945)	(1.187)
Farm-Wholesale Spread	-0.199*	-0.174	-0.337***
	(-1.701)	(-1.622)	(-3.217)
Price of Corn	-4.050***	-4.222***	-3.979***
	(-5.472)	(-6.342)	(-6.916)
Price of Slaughter Str	0.671***	0.715***	
	(7.528)	(8.028)	
Price of Slaughter Hef			0.684***
			(8.899)
Feeder Price in t-1	0.598***	0.444***	0.739***
	(7.052)	(5.455)	(10.70)
Feeder Price in t-2	-0.0217	0.0427	-0.0838
	(-0.193)	(0.406)	(-0.860)
Feeder Price in t-3	0.113	0.139	0.179**
	(0.723)	(1.074)	(2.123)
Feeder Price in t-4	-0.183*	-0.194**	-0.242***
	(-1.832)	(-2.264)	(-4.586)
Q of Feeder Str MAD	-0.0712	-0.257	
	(-0.134)	(-0.434)	
Q of Feeder Str ADKINS	0.937**	0.814*	
	(2.086)	(1.825)	
Q of Feeder Hef MAD			0.268
			(0.312)
Q of Feeder Hef ADKINS			1.155
			(1.359)
Constant	-0.0595	-0.0700	-0.0609
	(-1.275)	(-1.590)	(-1.405)
Observations	148	148	148
Adjusted R-squared	0.954	0.952	

Table 21: Price of Feeder Str/Hef and Price Differences-Structural (continued).

Dependent Variable: Price of Feeder Str/Hef and Price Differences			
Time Periods	**1971-2008-robust (a)**	**1971-2008-robust (a)**	**1971-2003-arch (b)**
VARIABLES	**Str 600-650**	**Str 750-800**	**Hef 450-500**
t-statistics in parentheses			
*** p<0.01, ** p<0.05, * p<0.1			
(a) Corrects for heteroskedasticity using robust se			
(b) Corrects for heteroskedasticity and first-order autocorrelation using ARCH			

Table 21: Price of Feeder Str/Hef and Price Differences-Structural (continued).

Dependent Variable: Price of Feeder Str/Hef and Price Differences			
Time Periods	**1971-2008-robust (a)**	**1971-2008 600/650-450/500**	**1971-2008-robust (a) 750/800-700/750**
VARIABLES	**Hef 700-750**		
D1	-0.00366	-0.00758	-0.00655**
	(-0.337)	(-1.634)	(-2.316)
D2	0.0283***	0.00379	-0.00325
	(2.652)	(0.728)	(-1.085)
D3	-0.00568	0.00631	0.0112***
	(-0.526)	(1.296)	(4.899)
Transportation Costs	0.0256*	-0.00447	-0.00104
	(1.938)	(-0.575)	(-0.246)
Q of Feeder Steers	2.603**	-0.0722	0.0859
	(2.074)	(-0.125)	(0.251)
Q of Feeder Heifers	0.978	-0.474	0.0704
	(0.752)	(-0.718)	(0.200)
Farm-Wholesale Spread	-0.216**	0.164***	0.0821***
	(-2.201)	(3.247)	(3.253)
Price of Corn	-3.995***	0.705***	0.315**
	(-6.395)	(2.760)	(2.029)
Price of Slaughter Str		1.362**	1.179***
		(2.172)	(3.300)
Price of Slaughter Hef	0.663***	-1.521**	-1.211***
	(7.097)	(-2.303)	(-3.276)
Feeder Price in t-1	0.555***	0.657***	0.368***
	(5.830)	(8.077)	(3.709)
Feeder Price in t-2	-0.0268	-0.198**	-0.0457
	(-0.226)	(-2.042)	(-0.474)
Feeder Price in t-3	0.207	0.206**	-0.0260
	(1.636)	(2.098)	(-0.233)
Feeder Price in t-4	-0.251***	-0.144*	-0.0480
	(-3.036)	(-1.838)	(-0.554)
Q of Feeder Str MAD		-0.204	-0.0201
		(-0.698)	(-0.159)

Table 21: Price of Feeder Str/Hef and Price Differences-Structural (continued).

Dependent Variable: Price of Feeder Str/Hef and Price Differences			
Time Periods	**1971-2008-robust (a)**	**1971-2008**	**1971-2008-robust (a)**
VARIABLES	**Hef 700-750**	**600/650-450/500**	**750/800-700/750**
Q of Feeder Str ADKINS		-0.488*	-0.0687
		(-1.773)	(-0.641)
Q of Feeder Hef MAD	-0.194		
	(-0.352)		
Q of Feeder Hef ADKINS	0.780*		
	(1.805)		
Constant	-0.0555	0.0514**	0.0112
	(-1.435)	(2.456)	(0.852)
Observations	148	148	148
Adjusted R-squared	0.950	0.807	0.888
t-statistics in parentheses			
*** p<0.01, ** p<0.05, * p<0.1			
(a) Corrects for heteroskedasticity using robust se			
(b) Corrects for heteroskedasticity and first-order autocorrelation using ARCH			

Summary

This chapter discussed each market level: boxed beef, slaughter, and feeder, in detail. Each vertically related market level is estimated using the reduced form price determinant models presented in Chapter 3, as well as SM models. The estimated reduced form models are estimated for the time periods of 1971-1982, 1992-2003, 1971-2003, and 1971-2008. F-tests are constructed to determine whether structural change has occurred. In addition, specific structural variables (BSE events, and Atkins diet slope-intercept dummy variables) are included test for structural change from 1971-2008. This chapter reports that BSE had a relatively small effect on each market level and did not result in drastic structural changes. Chapter 6 concludes this study.

CHAPTER 6

CONCLUSIONS

This study has re-examined the price determinants of three vertically related price markets focusing on the boxed beef values market, the slaughter market, and the feeder market. No previous study has estimated all three market levels using national data since the 1985 Schultz and Marsh study who examined the price determinants for the period 1971-1982. This re-estimation was one objective of this study. Since 1982 structural changes may have occurred in the beef cattle markets. For example, shifts in tastes and preferences within retail demand, increases in the size of feedlots, and increases in geographic concentration of cattle on feed in smaller numbers of states. Further in 2003 dairy cows were discovered to suffer from BSE or "mad cow". All events may have caused structural changes in the determinants of prices for cattle. Thus, a second objective was to test for structural change. Therefore, this study estimates the price determinant models from 1971-2003, and the data period 1971-2008 was used to estimate models to test for structural change.

Estimation models assume rational lags following Schultz and Marsh models. Initially, the estimation procedures by Schultz and Marsh are utilized in this study. The results for this study are different from the results reported by Schultz and Marsh. Some reasons for this difference may be: changes in data collection procedures, variables changing over time, and key variables being measured differently. In addition, for the period 1971-1982 diagnostic statistics for serial correlation and heteroskedasticity were

estimated for each price model. These statistics resulted in the estimation procedures to account for serial correlation, and heteroskedasticity through Prais-Winsten correction for first-order serial correlation, robust standard errors for heteroskedasticity, or ARCH procedures for both first-order serial correlation and heteroskedasticity.

Due to the nature of these price determinant models incorporating three market levels, packers, feedlots, ranches, and consumers may be interested in this study. Packers, feedlots, and ranches may be have been concerned that the BSE events have had substantial effects on the cattle market and cattle prices. This study reports that the feedlots and packers acted as is after the outbreak. The analysis of boxed beef cutout values indicated that the BSE outbreak increased feeder and slaughter cattle price because negative supply shifts outweighed the decrease in demand for beef.

Red meat consumption has declined since 1971. Much of this decline is due to the demographic changes over the past 37 years. One factor is the changing racial composition of the U.S. population. Hispanics who on average consume less red meat have become a much larger proportion of the U.S. population, thus decreasing the overall demand for beef. A second factor in the decline of the demand for beef is the age structure of the Caucasian population. As the “baby-boomer” and other generation aged, they tended to eat less red meat. These factors are not accounted for within this study. Another factor is trade. In May 2003 a beef cow in Canada tested positive for BSE. This led the United States to stop importing Canadian cattle, which decreased the supply of cattle. In addition, the December 2003 BSE case in the United States led Japan and

South Korea to stop importing United States cattle. This decreased demand for beef. These imports and exports components are not explicitly considered in this study.

This study concludes the Schultz and Marsh re-estimated models were not used. The reduced form models were used in place due to the higher adjusted R^2, and the expected coefficient signs. Using the updated reduced form models, the results reported statistically significant price determinants for each market level. Whether or not BSE affected the cattle markets was tested. The models indicated that at each market level the intercept BSE coefficients were not significant, suggesting that BSE did not cause structural change. In addition, the Atkins diet and BSE slope-intercept variables were created. After testing for joint significance, structural change only occurred in the boxed beef cutout values market. This suggests there was not structural change in the slaughter and feeder markets, but Atkins and BSE occurrences changed consumer's tastes and preferences in the boxed beef cutout values market.

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