The Change in Price Elasticities in the U.S. Beef Cattle Industry and the Impact of Futures Prices in Estimating the Price Elasticities

by

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Practitioner's Abstract

This paper estimates price elasticities in the U.S. beef cattle industry by using the data for the time period during December 1999 and June 2018. In addition to the adaptive model which was used by many previous studies this study also uses rational expectations model by using futures prices to consider the life cycle of growing cattle. The results show that fed cattle supply is more affected by consumption good criteria rather than capital goods criteria in the short term. The long run own price elasticity for fed cattle supply has increased a lot compared to the estimates from previous studies. It implies that producers' low budget situation caused by several droughts has had a considerable impact on the cattle industry. The results for the feeder cattle demand are consistent with profit maximization behavior of the producers.

Key words: fed cattle, feeder cattle, price elasticities, futures price

Introduction

The cattle industry is an important segment of the United States agricultural economy. According to the 2012 Census of Agriculture, the number of farms and ranches specializing in beef cattle was 727,906 and the number of cattle and calf operations was 913,246. In 2015, U.S. beef production was 23.69 billion pounds (carcass weight), and total U.S. beef consumption was 24.81 billion pounds. In addition, the total cash receipts for the beef industry was $78.2 billion in 2015, which represented about 21 percent of the $377 billion total cash receipts from agricultural commodities (USDA, National Agricultural Statistics Service, 2016). The beef industry is economically important and understanding its economic fundamentals is paramount for the design of policies. With that in mind, estimating expected changes in beef cattle supply and demand is especially important.

The estimation of supply response for beef cattle must carefully take into account the dynamics of raising cattle, which depends on expected prices, rather than current price, because of biological and technological factors. There is no agreed upon model of price expectations in empirical studies. Some studies use the Naïve Expectation Model or Adaptive Expectations. Rational expectations and futures prices are also used. Empirically, the evidence for the elasticity of supply in the short run is mixed with some studies showing a positive value (Rosen 1987; Marsh 1994; Sarmiento and Allen 2000) while others find a negative value (Rezitis and Stavropoulos 2010). Some of these differences can be explained by the estimation models, the methods or the data.

The first goal of this study is adopting the empirical approach of Marsh (1994), which builds a partial adjustment model with monthly data from January 1978 to June 1991 for fed supply and feeder placements models, using recent data to see whether their results are robust to the period covered by the data. The U.S beef industry has experienced several changes since 2000, for instance, the discovery of BSE in Canada and the United States, droughts and a major economic recession. However, no study has estimated values for elasticities of demand and supply in the last 18 years.

This study also improves on the method used in prior studies. Specifically, instead of modeling expectations using naïve or adaptive expectations, it also uses futures prices with a proper lag selection to model expected price. Futures prices can be thought of as representing price expectations as formulated in a rational expectations model where market participants use all the information available about the demand and the supply to formulate their expectations. However, many empirical studies in the U.S. cattle industry use previously observed prices to model the expected price without considering the biological life cycle of cattle. In particular, the approach of this paper uses a 6-month lag on the futures prices to reflect the specific amount of time taken to grow cattle. After completion of the "backgrounding" stage, calves are placed on feed, where they are fed high-energy feed rations and gain weight for slaughter about six months later (USDA APHIS, 2012). This known dynamic of cattle production informs which futures price to use to formulate price expectations.

Background Information about the U.S. Cattle Industry

Calves born between January 1 and June 30 are referred to as spring calving or fall-weaned calves and are the most common calving system in the United States (USDA, National Agricultural Statistics Service, 2016). In the first six months of their lives, most male calves are castrated. Calves born in the spring are weaned from their mothers in the fall once their digestive system can process solid feed. Female calves are both a consumption good and a capital good. That is, a cow-calf operator must decide whether to retain a female calf in the breeding stock (capital) or send it to backgrounding (consumption).

Weaned calves go through backgrounding stage for four to six months. In this stage, cattle can be in pens or lots and feed on dry forage, silage, and grain. Once backgrounding is completed, the calves, which are about one year old, are placed on feed, where they are fed high-energy feed rations to gain weight before slaughter. Most cattle spend about six months in a feedlot facility before reaching the optimal weight for slaughter.

U.S. feedlots typically purchase feeder cattle at about 600-800 pounds and feed them for approximately six months, at which point they weigh about 1300-1500 pounds. Most fed cattle are sold for slaughter when they are between 18 and 24 months old.

Review of Literature on Elasticities

Several studies of beef supply focus on modeling dynamics and expected prices. The literature employs several models, including the adaptive expectations model from Nerlove (1956). Adaptive expectations, along with the partial adjustment model, are often used in agricultural commodity supply models. While adaptive expectation is commonly used, many studies of beef supply response seek to improve upon that model. The adaptive expectation model assumes that suppliers form their expectations about what will happen in the future based on what has happened in the past. To be specific, it considers that producers revise their notion of "normal price" in proportion to the difference between the current price and their previous idea of a normal price.

Shonkwiler and Hinckley (1985) use adaptive expectations along with a partial adjustment model to estimate the supply responses in the feeder market. In addition, the authors use futures price to model rational expectations of prices.

Marsh (1994) estimates supply and demand elasticities for fed cattle and emphasizes on the dynamics of input and output prices to improve empirical supply estimation using monthly data. Marsh (1994) uses an autoregressive distributed lags model that he estimates by two-stage-least squares. The results found that the output price elasticity of fed cattle supply is negative in the short run, but it changes to positive signs in the intermediate run and the long run. It means that cattle marketing decisions in the short term are considered capital whereas over the longer run, fed cattle are a consumption good and their supply reflect major resource adjustments and technology changes.

Buhr and Kim (1997) investigate the dynamic structure of vertically linked sectors of the U.S. beef industry. They adopt a production theory model relying on the theory of the firm to derive hypotheses to test dynamic adjustment. The authors use quarterly data and assume that live cattle and beef imports are used by U.S. beef firms in response to the inherent fixity in domestic beef production. The result demonstrates that all own-output supply elasticities are positive except for domestic beef production, which is negative in the short run but positive in the long-run.

Sarmiento and Allen (2000) replicate Marsh (1994), and improve the model using an error correction model (ECM). They also evaluated out-of-sample performance both of Marsh's model and the ECM. Sarmiento and Allen (2000) show that the out-of-sample forecast performance from ECM is more accurate than the model from Marsh (1994), hence they argue that the ECM is superior to the model in Marsh (1994). Sarmiento and Allen (2000) find a negative short run supply elasticity as in Marsh (1994).

Marsh (2003) uses an autoregressive distributed lags (ADL) model to determine the effects of declining U.S. retail beef demand on farm-level beef prices and production. The model uses annual data and variables for the U.S. prime interest rate and technology in cattle production are included in the model. He used iterative three-stage least squares (I3SLS) regression with a system of derived demands and primary supplies in the slaughter and feeder cattle sectors.

Rezitis and Stavropoulos (2010) study beef supply response in Greece. The authors use a Generalized Autoregressive Conditional Heteroscedasticity (GARCH) process to estimate expected price and price volatility. In addition, they estimate symmetric, asymmetric and non-linear GARCH models. The specific lag structure of the price equation was selected by using the general-to specific method. The authors also consider the gestation-birth period and the maturation period until slaughtering, which is about 26~27 months, for the lag structure. Rezitis and Stavropoulos (2010) find positive values for the short run and the long run supply price elasticities.

Empirical Models

The theoretical model of this study captures the important features of the U.S. cattle industry. The model assumes that producers maximize profits conditional on output and input prices. Most studies use lags on price variables to model price expectations using an adaptive expectation framework.

In a given month, the short-run profit function for a feedlot i producing only fed cattle is given by

(1) $\pi_i = PF \cdot QF_i \cdot f(I) - C_i[QF_i, INV_i, QP_i, PP, PC, g(I)]; \quad i = 1,2, \ldots, \mathrm{I}.$

where PF is the price of fed cattle and QF_i is the quantity of fed cattle marketed for slaughter. $C_i[\cdot]$ is the cost as a function of the quantity of fed cattle, the number of cattle on feed (INV_i), the feeder cattle placements (QP_i), feeder cattle price (PP) and feed grain price (PC) (Marsh, 1994, Rezitis and Stavropoulos, 2010). The price of beef, the interest rate, and the cost of other inputs are parameters faced by producers to determine the optimum slaughter age and feed input for a steer (Jarvis, 1974).

Taking the partial derivatives of (1) with respect to QF_i and QP_i, the feedlot maximizes profit with respect to the quantity of fed cattle marketings (fed cattle supply) and feeder cattle placements (feeder cattle demand). The short-run supply function for fed cattle is

(2) $QF_i^S = \phi_i(PF, PP, PC, INV_i, I),$

and demand function for feeder cattle is

(3) $QP_i^D = \varphi_i(PF, PP, PC,\ INV_i, I).$

Equation (2) shows that fed cattle supply depends on the price of fed cattle, the price of feeder cattle, the corn price, the number of cattle on feed, and interest rate. Equation (3) shows that feeder placement demand also depends upon the same exogenous factors.

The market supply function for fed cattle is obtained by summing individual supply functions of all producers, and the market demand for feeder cattle placements is obtained by summing all producers' demand functions.

(4) $QF^S = \theta(\boldsymbol{PF}, \boldsymbol{PP}, \boldsymbol{PC}, \boldsymbol{INV}, \boldsymbol{I}, \boldsymbol{GDP}, \boldsymbol{Dum}).$

(5) $QP^D = \vartheta(\boldsymbol{PF}, \boldsymbol{PP}, \boldsymbol{PC}, \boldsymbol{INV}, \boldsymbol{I}, \boldsymbol{GDP}, \boldsymbol{Dum}),$

, where $\boldsymbol{Dum}$ represents monthly binary variables for seasonality, and $\boldsymbol{GDP}$ represents GDP of the USA.

Data

I use monthly time series data for the period of December 1999 through June 2018. Similar data were used in Marsh (1994) and Sarmiento and Allen (2000). I obtained quantities and prices from the United States Department of Agriculture (USDA), where data were assembled by the Livestock Marketing Information Center (LMIC). The six-month treasury bill rate was obtained from the Federal Reserve Bank of ST. Louis (FRED) and the monthly GDP index was obtained from macroeconomic advisers by HIS Markit. I deflated all price variables by the consumer price index (Dec, 2017=100), which I obtained from the Bureau of Labor Statistic (BLS).

Table 1 summarizes the definitions of the variables, and Figure 1 summarizes the data. There are downward trends for both the quantities of fed and feeder cattle. Some explanations for the downward trends are high feed costs, high operating cost, age of the producer, prolonged drought, and withholding heifers and cows in order to rebuild herds (Paterson, 2015).

A few events have impacted U.S. cattle production including a drought in 2000, recession in 2008 and 2009 and drought events between 2012 and 2014. The drought is one of primary reasons for the decreased cattle supply and high price of beef. Kansas, Oklahoma, and Texas, important producing states, have been affected by the droughts. The surge in the price of corn was also caused by the severe drought of 2012.

The inventory of cattle on feed is relatively stable. It peaks during the winter (December through January) and hits a low level during the months of August or September.

I begin by testing the stationarity of the data. Spurious regression occurs with non-stationary time series data that follow trends. It is important to test for the presence of unit roots to avoid spurious regressions. If there is evidence of unit roots, we must stabilize the data by expressing them in first difference or exploit cointegration relationships between variables that indicate a stable long run equilibrium

Table 2 shows the results of the Augmented Dickey-Fuller tests on each series. The table reports p-value for the tests, where the alternative hypothesis is a variable stationary. The result shows that price variables for fed cattle, feeder cattle, and corn are not stationary in levels. However, the variables are stationary in first difference, indicating that they are $I(1)$ variables. This is the same result as in Sarmiento and Allen (2000). From the results, the price variables and interest variable are used as first difference.

Results

The empirical models are estimated by a two-stage least squares procedure because of the endogeneity of fed cattle price in equation (4) and the endogeneity of feeder cattle price in equation (5). As mentioned earlier, biological considerations govern cattle production. Moreover, farmers' expectations of prices must be considered in empirical models of demand and supply. When we consider the adaptive expectation model, where people form their expectations about the future based on what has happened previously, past use of inputs and outputs influences the current decision making. Therefore, the fed cattle supply and feeder cattle demand are modeled as autoregressive distributed lags (ADL).

For fed cattle supply, through current-period (t) to three-period (t-3) lags on the dependent variable are used, and the lag order 2 is used for other explanatory variables. Considering the finds that only price variables have unit roots I can reformulate the model to take into account the stationarity properties of the data:

(6) $QF_t^S = a_1 + \sum_{i=1}^{3} \alpha_{1i} QF_{t-i}^S + \sum_{j=0}^{1} b_{1j} \Delta PF_{t-j} + \sum_{k=0}^{1} c_{1k} \Delta PP_{t-k} + \sum_{l=0}^{1} d_{1l} \Delta PC_{t-l} + \sum_{m=0}^{1} \beta_{1m} INV_{t-m} + \sum_{n=0}^{1} \gamma_{1n} \Delta I_{t-n} + \sum_{p=0}^{1} \delta_{1p} \Delta GDP_{t-p} + \sum_{q=2}^{12} \lambda_{1q} Dum_q + \nu_t$.

Similarly, the modified ADL for feeder cattle demand is as follow

(7) $QP_t^D = a_2 + \sum_{i=1}^{2} \alpha_{2i} QP_{t-i}^D + b_2 \Delta PF_t + c_2 \Delta PP_t + d_2 \Delta PC_t + \sum_{m=0}^{1} \beta_{2m} INV_{t-m} + \gamma_2 \Delta I_t + \delta_2 \Delta GDP_t + \sum_{q=2}^{12} \lambda_{2q} Dum_q + \omega_t$.

The lag order 2 is used for the feeder cattle demand, and lag order 1 is used for other explanatory variables. For the two-stage least squares procedure, real price of diesel is used as an additional instrumental variable. One additional lag order on fed cattle price and feeder cattle price are also used as instrument variables for fed supply and feeder placement, respectively.

Table 3 shows the regression results for the 2SLS. Observe first that an increase in the current fed cattle price (ΔPP_t) leads to an increase in fed supply. The positive coefficient implies that fed cattle marketing decisions in the short term are affected more by consumption good criteria rather than capital goods criteria. An increase in current feeder cattle price (ΔPP_t) leads to a decrease in fed supply, which is consistent with profit maximization behavior.

The current fed cattle price (ΔPF_t) has positive effect on feeder cattle demand. It reflects a profit maximization behavior of fed cattle producers, where an increase in fed cattle price leads to an increase in cattle feeding returns.

From the results in Table 3, we can calculate price elasticities. The short-run price elasticity can be estimated as $\frac{\partial Q}{\partial P_i} \times \frac{\sum P_i}{\sum Q}$, where the coefficient of ΔP_{it} is $\frac{\partial Q}{\partial P_i}$ and $\frac{\sum P_i}{\sum Q}$ is the ratio of the average price over the average quantity. I estimate the long-run price elasticity as $\sum_{r=0}^{n} \frac{\partial Q_t}{\partial \Delta P_{it-r}} \times \frac{\sum P_i}{\sum Q} \times [1/(1 - \alpha_1 - \alpha_2 - \cdots - \alpha_l)]$, where the summation of the coefficients of ΔP_{it} is divided by the cumulative supply effects. I use delta method for the price elasticities.

Table 4 shows the price elasticities for fed cattle supply and feeder cattle demand from the regression results in Table 3. From the previous literature, there have been conflicts in estimating short run elasticity for fed cattle supply with respect to fed cattle price. There are several studies which estimate negative supply elasticities with respect to fed cattle price. The negative elasticity is consistent with an expected increase in the asset value of cattle (Jarvis), but the table 4 reports that the short run elasticity for fed cattle supply is positive with respect to fed cattle price.

Previous literature agrees that the long run supply elasticity of fed cattle is positive, reflecting profit maximization behavior. Sarmiento and Allen (2000) estimate the long run fed cattle elasticity with respect to the fed price is 0.33, and Marsh (1994) estimate it is 3.24. The estimated long run supply elasticity of fed cattle from Table 4 is 4.13, which is larger than the estimates from previous literature.

For feeder cattle demand, the estimated elasticities in Table 4 shows that fed cattle price increases feeder cattle demand in both short run and long run. However, the effects of feeder cattle price and corn price on feeder cattle demand are insignificant.

Using Futures Price for Price Expectation

I use futures price in this part to model price expectations specifically considering the biological cycle of growing cattle. As mentioned earlier, after completion of the backgrounding stage, calves that are about one year old are placed on feed, where they are fed high-energy feed rations and gain weight for slaughter about six months later. This known dynamic of cattle production informs about which futures price to use to formulate price expectations.

Given the dynamic of cattle production, I can formulate a simple regression model for fed cattle supply as follows

(8) $QF_t^S = \alpha_1 + \beta_1 PF_t + \beta_2 PP6_t + \beta_3 PC_{t-6,T} + \beta_4 INV_t + \beta_5 I_t + \beta_6 GDP_t + \lambda_1 Dum_t + \nu_t$,

where $PP6_t$ is a six- month lag on the feeder cattle price, and $PC_{t-6,T}$ is the price of corn expected six months ago from today. For feeder cattle demand, I can specify the following model:

(9) $QP_t^D = \alpha_2 + \gamma_1 PF_{t,T} + \gamma_2 PP_t + \gamma_3 PC_{t,T} + \gamma_4 INV_t + \gamma_5 I_t + \gamma_6 GDP_t + \lambda_2 Dum_t + \omega_t$,

where $PF_{t,T}$ is the current expectation of the price of fed cattle in six months and $PC_{t,T}$ is the current expectation of the price of corn in six months.

For the equations (8) and (9), I will use futures prices to model expectations for the prices for fed cattle such that $PF_{t,T} = FPF_t$ and for corn such that $PC_{t,T} = FPC_t$ and $PC_{t-6,T} = FPC6_t$.

I obtained futures prices of fed cattle and corn from the USDA. To consider the dynamic of the cattle cycle, I adjust the futures price data to obtain price expectations based on the futures contract that expires soon after the six months period required.

Before estimating the regression models, I use the ADF test to check the stationarity of the new price variables. The ADF tests show that the futures price of fed cattle (FPF_t) and the futures price of corn (FPC_t and $FPC6_t$) are $I(1)$ variables.

As in the previous chapter, I stabilize the variables by expressing them in first difference. I use the same lag structure as in equation (6) for fed supply, and the equations are as follows

(10) $QF_t^S = a_1 + \sum_{i=1}^{3} \alpha_{1i} QF_{t-i}^S + \sum_{j=0}^{1} b_{1j} \Delta PF_{t-j} + \sum_{k=0}^{1} c_{1k} \Delta PP6_{t-k} + d_1 \Delta FPC6_t + \sum_{m=0}^{1} \beta_{1m} INV_{t-m} + \sum_{n=0}^{1} \gamma_{1n} \Delta I_{t-n} + \sum_{p=0}^{1} \delta_{1p} \Delta GDP_{t-p} + \sum_{q=2}^{12} \lambda_{1q} Dum_q + \nu_t$

For the demand for feeder cattle placement, using the same lag structure as in equation (7).

(11) $QP_t^D = a_2 + \sum_{i=1}^{2} \alpha_{2i} QP_{t-i}^D + b_2 \Delta FPF_t + c_2 \Delta PP_t + d_2 \Delta FPC_t + \sum_{m=0}^{1} \beta_{2m} INV_{t-m} + \gamma_2 \Delta I_t + \delta_2 \Delta GDP_t + \sum_{q=2}^{12} \lambda_{2q} Dum_q + \omega_t$

I use once again the general to specific approach. Table 5 shows the regression results. It says that coefficients for the 6-month lagged feeder cattle price ($\Delta PP6_t$) is negative and statistically significant in the fed cattle supply regression.

The current expectation of the price of fed cattle in six months (ΔFPF_t) has a significant effect on feeder cattle demand in 10% level, while the current feeder price (ΔPP_t) and the current expectation of the price of corn in six months (ΔFPC_t) do not have significant effect on feeder cattle demand.

The estimated price elasticities are reported in Table 6. For the fed cattle supply, the short and long run price elasticities with respect to fed cattle price are positive, and they are larger than the estimates from most previous studies. For feeder cattle demand model, only short run price elasticity with respect to fed cattle price is significant and consistent with profit maximization behavior.

Conclusion

This study estimates elasticities for fed cattle supply and feeder cattle placement demand in the United States. I use recent monthly data from December 1999 to June 2018. I estimate models previously used in the literature and estimate models using futures price that incorporate the biological dynamic in growing beef cattle.

The results show that the short run price elasticities for fed cattle supply were estimated as 1.813 and -0.877 with respect to fed cattle price and feeder cattle price, respectively. The positive short run own price elasticity for fed cattle supply implies that the cattle marketing decisions in the short term are affected more by consumption goods criteria. The long run price elasticities for fed cattle supply were estimated as 4.107 and -2.07 with respect to the fed cattle price and the feeder cattle price, respectively. These results imply that fed cattle supply responds positively to an increase in its price and negatively to input prices, which goes consistent with expectations. While, the long run price elasticity with respect to fed cattle price is higher than the estimates from the previous studies (0.33-3.24). The larger value of the long run own price elasticity for fed cattle supply might reflect budget impacts on producers. According to the U.S. drought monitor in August 2018, approximately 30% of cattle inventory in within an area experiencing drought. High feed and operating costs caused by droughts caused cattlemen to down-sized their herds so they have been in low budget situation. The low budget of the producers may drove the higher supply elasticities.

In alternative models, I use futures prices to model price expectations. Although using futures prices is a more sensible way of modeling price expectation, it does not provide improvement over the estimated values of the price elasticities with several of them being of the insignificance. In particular, only short run price elasticity for feeder cattle demand with respect to fed cattle price is significant when calculating by using delta method. The regression results from using futures prices were similar with the results from the adaptive models.

This study shows that estimates of supply and demand elasticities for cattle have changed since 2000 even though applying rational expectations using futures price does not seem to provide improvement. One possible consideration of using futures price can be risk aversion of producers. Producers would like to avoid production loss due to the expected price volatility of beef price, and Rezitis and Stavropoulos (2010) show that price volatility is an important risk factor in the supply response function of the Greek beef market. For future work, I would like to incorporate the price volatility into the rational expectations model and to allow for price uncertainty and risk aversion.

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Table 1. Data used in analysis

QF^S	Quantity of fed steers and heifers marketed for slaughter, thousand head
QP^D	Quantity of cattle paced on feed, U.S total, thousand head
INV	Inventory of cattle on feed, U.S total, thousand head
PF	Price of choice slaughter steers, Nebraska direct, 1100-1300 pounds, dollars per hundredweight
PP	Price of feeder steers, Oklahoma city, 600-700 pounds, medium #1 frame, dollars per hundredweight
PC	Price of #2 yellow corn, Omaha, dollars per bushel
I	Six-month treasury bill
GDP	Monthly GDP index
Dum	Monthly binary variables for seasonality

Table 2. Augmented Dickey-Fuller test results

Variables	Level (p-value)	First difference (p-value)
QF^S	0.00	-
QP^D	0.00	-
INV	0.01	-
PF	0.32	0.00
PP	0.59	0.00
PC	0.46	0.00
I	0.21	0.00
GDP	0.95	0.00

Table 3. Estimated coefficients

Fed cattle supply			Feeder cattle demand		
	Coefficient	Standard error		Coefficient	Standard error
Lagged dependent variable:					
QF^S_{t-1}	-0.012	(0.101)	QP^D_{t-1}	0.654***	(0.088)
QF^S_{t-2}	0.304***	(0.086)	QP^D_{t-2}	0.155**	(0.068)
QF^S_{t-3}	0.449***	(0.090)			
Fed cattle price:					
ΔPF_t	36.085***	(13.368)	ΔPF_t	12.258**	(5.340)
ΔPF_{t-1}	-14.755***	(3.812)			
Feeder cattle price:					
ΔPP_t	-13.456**	(5.866)	ΔPP_t	-6.915	(6.408)
ΔPP_{t-1}	4.837*	(2.518)			
Corn price:					
ΔPC_t	-17.620	(38.492)	ΔPC_t	26.019	(42.861)
ΔPC_{t-1}	1.291	(36.818)			
INV_t	0.031	(0.088)	INV_t	-0.394***	(0.098)
INV_{t-1}	0.051	(0.078)	INV_{t-1}	0.347***	(0.092)
ΔI_t	5.856	(75.318)	ΔI_t	-59.626	(56.896)
ΔI_{t-1}	-64.743	(82.199)			
ΔGDP_t	0.151	(0.132)	ΔGDP_t	0.177	(0.132)
ΔGDP_{t-1}	0.027	(0.130)			
$Const$	-539.340	(333.192)	$Const$	978.886***	(271.778)

Note: I do not report results for the inventories and monthly dummies for conciseness. They are available upon request.
*p<0.1, ** p<0.05, *** p<0.01

Table 4. Estimated price elasticities

		Fed cattle price	Feeder cattle price	Corn price
Fed cattle supply	SR	1.813***	-0.877**	-0.031
		(0.672)	(0.383)	(0.067)
	LR	4.13***	-2.166**	-0.110
		(1.530)	(1.026)	(0.337)
Feeder cattle demand	SR	0.707**	-0.518	0.052
		(0.308)	(0.480)	(0.086)
	LR	2.045**	-1.497	0.151
		(0.981)	(1.448)	(0.250)

Standard Errors in parenthesis
*p<0.1, ** p<0.05, *** p<0.01

Table 5. Estimated coefficients using futures prices

	Fed cattle supply			Feeder cattle demand	
	Coefficient	Standard error		Coefficient	Standard error
Lagged dependent variable:					
QF_{t-1}^{S}	-0.051	(0.107)	QP_{t-1}^{D}	0.734***	(0.090)
QF_{t-2}^{S}	0.341***	(0.085)	QP_{t-2}^{D}	0.140*	(0.065)
QF_{t-3}^{S}	0.441***	(0.087)			
Fed cattle price:					
ΔPF_{t}	30.351***	(11.203)	ΔFPF_{t}	23.765*	(11.726)
ΔPF_{t-1}	-14.830***	(3.806)			
Feeder cattle price:					
$\Delta PP6_{t}$	-3.611**	(1.692)	ΔPP_{t}	-8.685	(7.581)
$\Delta PP6_{t-1}$	2.408	(1.640)			
Corn price:					
$\Delta FPC6_{t}$	-15.637	(29.461)	ΔFPC_{t}	-36.582	(60.203)
INV_{t}	0.043	(0.088)	INV_{t}	-0.425***	(0.095)
INV_{t-1}	0.039	(0.077)	INV_{t-1}	0.354***	(0.090)
ΔI_{t}	-32.564	(74.592)	ΔI_{t}	-68.879	(56.380)
ΔI_{t-1}	-27.582	(77.929)			
ΔGDP_{t}	0.045	(0.128)	ΔGDP_{t}	0.139	(0.124)
ΔGDP_{t-1}	0.022	(0.127)			
$Const$	-491.292	(301.610)	$Const$	1168.143***	(265.237)

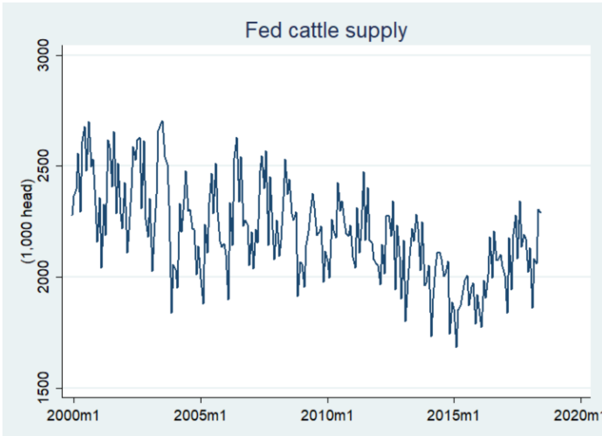
Note: I do not report results for the inventories and monthly dummies for conciseness. They are available upon request.
*p<0.1, ** p<0.05, *** p<0.01

Table 6. Estimated price elasticities using futures prices

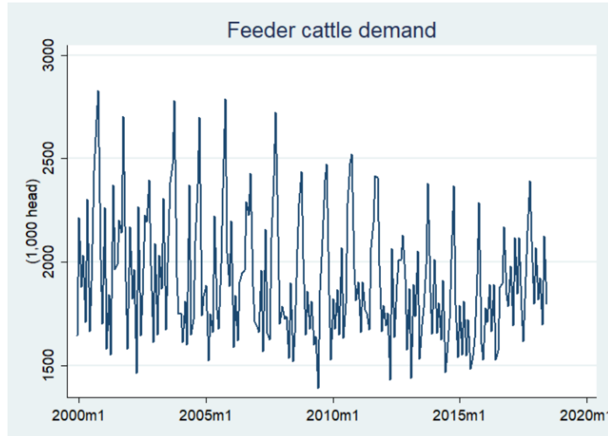
		Fed cattle price	Feeder cattle price	Corn price
Fed cattle supply	SR	1.525***	-0.232**	-0.029
		(0.563)	(0.109)	(0.055)
	LR	2.901***	-0.287	-0.108
		(1.025)	(0.441)	(0.207)
Feeder cattle demand	SR	1.366**	-0.651	-0.079
		(0.674)	(0.568)	(0.130)
	LR	10.895	-5.188	-0.630
		(11.347)	(7.105)	(1.281)

Standard Errors in parenthesis
*p<0.1, ** p<0.05, *** p<0.001

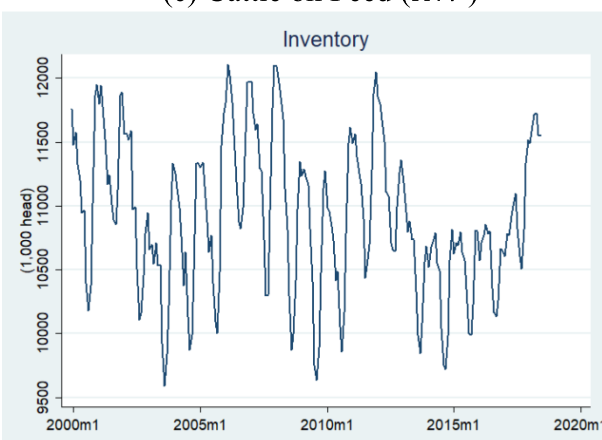
(a) Fed cattle (QF^S)



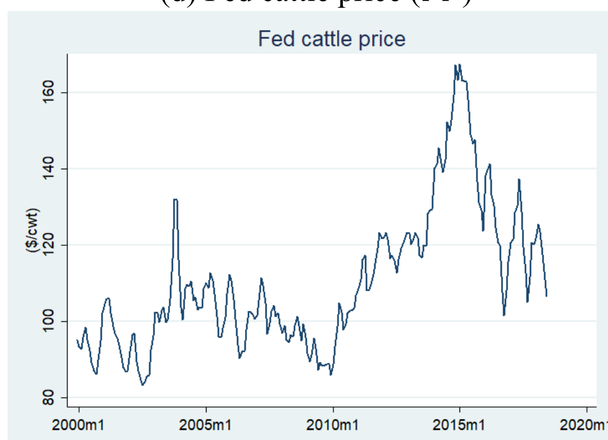
(b) Feeder cattle (QP^D)



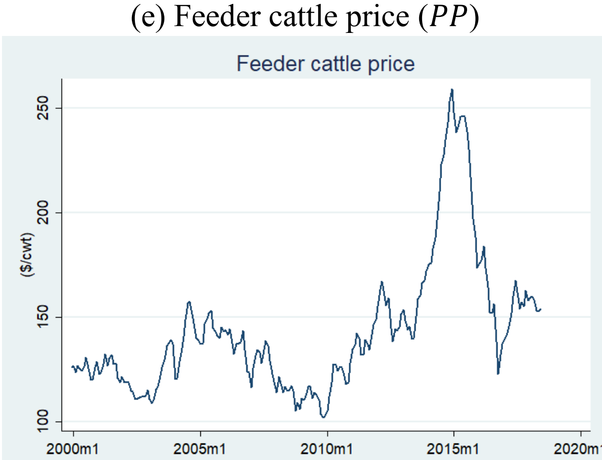
(c) Cattle on Feed (INV)



(d) Fed cattle price (PF)



(e) Feeder cattle price (PP)



(f) Corn price (PC)

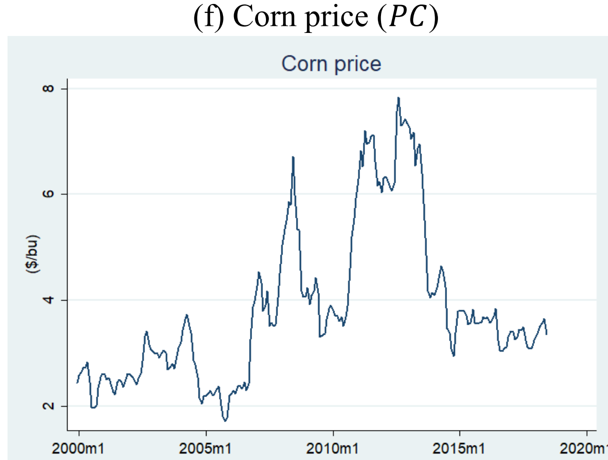


Figure 1. Graphs of data