Relationships among Prices across Alternative Marketing Arrangements for Fed Cattle and Hogs

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Abstract

Reduced reliance on cash market prices for fed cattle and hogs raise questions about the role of cash prices in price discovery. We use seven years of weekly data from mandatory price reports to determine whether or not cash market prices are cointegrated with other procurement prices and then test for causality among the price series. Cash prices were cointegrated with all but one procurement price series. Cash market prices Granger cause all other procurement prices. Bidirectional causality was found in some but not all cases. Thus, cash market prices remain of central importance in price discovery for fed cattle and hogs.

Keywords

cattle, cointegration, causality, hogs, Johansen, marketing, prices, Stock-Watson, vector error correction

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Introduction

Price discovery has been a thorny issue for fed cattle and a lesser issue for hogs over the past three decades. Depending in part on the group and time period, the focus of the issue has been on various components of price discovery, e.g., buyer competition and its impacts, pricing methods and their impacts, thin markets and adequacy of the cash market, and availability and reliability of market information. Research reported in this article spans these price discovery issues in varying degrees.

Considerable research over the past two decades has targeted the question of captive supply impacts, more recently referred to as alternative marketing arrangements (AMAs). Most research has been on fed cattle and conducted with transaction level data collected by the Grain Inspection, Packers and Stockyards Administration (GIPSA) for special investigations (Ward, Koontz, and Schroeder 1998; Capps et al. 1999; Schroeter and Azzam 2003, 2004; Hunnicutt, Bailey, and Crook 2004; Muth et al. 2008), but research on hogs using transaction data has been conducted as well (Zheng and Vukina 2009). Related research has focused on specific competition and pricing concerns, again mostly for fed cattle (Crespi and Sexton 2004, 2005; Xia and Sexton 2004).

As a result of several price discovery concerns, some which were documented (Koontz 1999; Grunewald, Schroeder, and Ward 2004) and some perceived by various groups, Congress passed the Livestock Mandatory Reporting Act in 1999. Since its implementation in April 2001, most research related to the Act has focused on availability and transparency of data and how it has affected price discovery (Grunewald, Schroeder, and Ward 2004; Perry et al. 2005; Pendell and Schroeder 2006). Passage of mandatory price reporting legislation generated several new data series on both prices and volumes not before available regarding AMAs for both fed cattle and hogs (Koontz and Ward 2008).

One question not directly addressed in research since mandatory price reporting is the continued or changed role of cash prices in price discovery. The mechanics of the pricing process for AMAs implies an important, continuing role for cash market prices. For example, negotiated pricing accounted for 45.5% of fed cattle procurement, though a much smaller percentage for hogs (12.0%) over the 2001-2008 period. Percentages are based on packer procurement excluding packer ownership of livestock. Cash market prices are often the reference prices for formula prices, an estimated 53.8% for hogs and a lesser but substantial percentage (39.4%) for fed cattle. One AMA both for fed cattle and hogs involves forward contracts tied to the futures market price, which in turn has a close relation historically to cash market prices (Koontz, Garcia, and Hudson 1990). Procurement tied to futures market prices was an estimated 13.3% for hogs and 5.4% for fed cattle over 2001-2008.

Research reported here draws from a body of research into the relationships between prices in the marketplace, both horizontally (spatial market integration) as well as vertically (temporal market integration). Specifically, our research relates to previous work on price relationships for livestock and meat, i.e., cointegration and causality, both in regional markets (Bailey and Brorsen 1989; Goodwin and Schroeder 1991) and between market channel levels (Boyd and Brorsen 1985; Schroeder and Hayenga 1987).

In this research, we measured the relationship among prices *within* a spatial and temporal market, i.e., prices paid by meatpackers for fed cattle and slaughter hogs purchased under several AMAs. The specific objective was to determine the relationship between cash market prices and prices from other AMAs for fed cattle and hogs. We determine that these price series are cointegrated and then test for causality among the price series to specify the role of cash market prices in price discovery.

Packer Procurement Alternatives and Data

GIPSA (2002) distinguished three types of captive supply arrangements and reported annual procurement statistics for them for over two decades; cash market, marketing agreements, and forward contracts. Much of the research on captive supplies used these procurement categories. However, after passage of mandatory price reporting legislation, new pricing method categories were developed by the Agricultural Marketing Service (AMS). AMS collects and reports price and volume data for the following AMAs.

- Fed cattle – AMAs include negotiated cash trades, negotiated grids (with the base price resulting from buyer-seller negotiation), formula priced trades (typically with the base price tied to a cash market quote or plant average cost), and forward contracts (typically with price tied to the futures market or futures market basis).
- For hogs – AMAs include negotiated cash trades, swine market formula priced trades (typically with the base price tied to a cash market quote), other market formula trades (typically with price tied to the futures market), and other purchase methods (which may include window or ledger contracts and cost of production contracts).

Data used in this research were compiled from multiple AMS mandatory price reports, including: fed cattle – LM_CT150, LM_CT151, LM_CT153, LM_CT163, LM_CT164, LM_CT165, LM_CT166, and LM_CT167; hogs – LM_HG200 and can be accessed at http://www.ams.usda.gov/AMSv1.0/ams.fetchTemplateData.do?template=TemplateA&navID=MarketNewsAndTransportationData&leftNav=MarketNewsAndTransportationData&page=MarketNewsAndTransportationData&acct=AMSPW . Weekly data cover the period May 2001, a month after mandatory price reporting began, through May 2008. Therefore, data for this research constitutes seven years of post-mandatory price reporting market activity.

Summary statistics for the price series are shown in Table 1. Note that negotiated grid prices for fed cattle were not reported until April 2004. Thus, the number of weekly negotiated grid prices is considerably fewer and mean prices are not directly comparable to the other fed cattle AMA series.

The dynamics of weekly AMA prices for fed cattle and hogs can be seen over the seven-year period in Figures 1 (fed cattle) and 2 (hogs). Prices for AMAs in fed cattle tend to track each other more closely than for hogs. For fed cattle, negotiated cash prices, negotiated grid prices, and formula prices track each other more closely than forward contracts. For hogs, negotiated cash prices and swine formula prices track each other more closely than either other formula prices or other purchase prices.

From Figures 1 and 2 and knowing how the AMAs are defined, we hypothesize negotiated cash prices are cointegrated with formula prices and negotiated grid prices for fed cattle but not forward contracts; and negotiated prices are cointegrated with swine formula prices for hogs but not other formula prices or other purchase prices. In this article, we report results of tests for cointegration and causality between the cash market and other prices to determine whether the hypothesized importance of the cash market is supported by the data.

Procedures

The methods used in this study are patterned after previous research. First, we determine whether or not each price series has a unit root by using the augmented Dickey-Fuller (ADF) test. Price series in levels are tested first, and in first differences if necessary. If each price series has a unit root, the next step is to determine the existence of a cointegration relationship among AMA prices by the Johansen and Stock-Watson tests. The focus is on the bivariate relationships between negotiated

cash prices and other AMA prices. If prices are integrated of the same order and prices are cointegrated, a vector error correction (VEC) model is employed to test for the long run relationship between price series. Lastly, Granger causality tests are conducted. Throughout this process, our focus is on the relationship between negotiated cash prices and other AMA prices.

Models and Results

Unit Root Tests

An augmented Dickey-Fuller (ADF) test is an augmented version of the Dickey-Fuller test for lagged terms of dependent variables to eliminate autocorrelation. It was used to determine the existence of a unit root (nonstationarity) for each AMA price series for fed cattle and hogs (Dickey and Fuller 1981). The ADF test statistic was obtained from the α_1 parameter in the following regression model

(1) $\Delta x_t = \alpha_0 + \alpha_1 x_{t-1} + \sum_{i=1}^{n} \beta_i \Delta x_{t-i} + \nu_t,$

where Δx_t is the change in price and x_t is the price level. The lag length in each price series is determined by the Akaike Information Criterion. The middle column of Table 2 shows results of the ADF test for levels of each price series, while the last column summarizes the results for first differences. When α_1 =1, there is a unit root (nonstationarity) in each price series. Tests with each price series for fed cattle and hogs failed to reject the null hypothesis of a unit root at the 1% significance level. Therefore, each series was first differenced and tested for nonstationarity. Each price series in first differences was found to be stationary, so prices are integrated of order one, [*I* (1)].

Johansen Cointegration Test

Based on the existence of a unit root (nonstationarity) for each price series, the cointegration relationship among prices is determined by testing pairs of AMAs prices: for fed cattle – (1) negotiated cash prices versus forward contract prices, (2) negotiated cash prices versus negotiated grid prices, and (3) negotiated cash prices versus formula prices; for hogs – (1) negotiated cash prices versus other formula prices, (2) negotiated cash prices versus swine market formula prices, and (3) negotiated cash prices versus other purchase prices.

Johansen's cointegration test determines whether or not the variables are cointegrated and the number of cointegrating vectors in the case of a multivariate model (Engle and Granger 1987). There can be up to n-1 cointegrating vectors (r) when there are n variables in the model. For each bivariate model, the null hypothesis is that the cointegration rank (r) is at most 1. Following past research, we report both the trace and max eigenvalue statistics even though the difference between the two tests is small with a bivariate model.

Fed Cattle – Johansen's cointegration test statistics are reported in Table 3. The null hypothesis of cointegration corresponds to the null hypothesis that r=1. In the first and third models (negotiated cash prices vs. forward contract prices, and negotiated cash prices vs. formula prices), the null hypothesis that r=1 cannot be rejected at the 5% significance level. In the second model (negotiated cash prices vs. negotiated grid prices), the null hypothesis that r=1 is rejected at the 5% level although not at the 1% level. Therefore, both negotiated cash prices and forward contract prices, and negotiated cash prices and formula prices are cointegrated. But negotiated cash prices and negotiated grid prices are not cointegrated.

Hogs – Table 3 also contains cointegration tests for hogs. In each model, the null hypothesis that r=1 cannot be rejected. Therefore, negotiated cash prices for hogs are cointegrated with each of the other AMA series with a cointegration rank of r=1.

Stock-Watson Common Trends Test

To support the evidence of a cointegrated relationship from the Johansen test between all but one price series, we also conducted an alternative cointegration test. Stock and Watson (1988) view cointegrated variables as sharing common stochastic trends. In general, for a model with n variables and r cointegrating vectors, there are n-r=m common trends. If there exists a unitary long-run relationship between nonstationary price series Y_t and X_t, the cointegrated prices will contain a common trend that links them together. When the test statistic is less than the critical value, the test rejects the null hypothesis that there are m common trends.

Fed Cattle – Stock-Watson test results for fed cattle are presented in Table 4. For the first and third bivariate models (negotiated cash prices vs. forward contract prices, and negotiated cash prices vs. formula prices), results failed to reject the first null hypothesis at the 5% significance level of one common trend, but the second null hypothesis of two common trends was rejected. In the second model (negotiated cash price vs. negotiated grid price), the null hypotheses that m=1 and m=2 are rejected at the 5% significance level. Thus, we found a common trend in two of the three models for fed cattle.

Hogs – Table 4 also shows results from the Stock-Watson test for hogs. In each bivariate model, the results failed to reject the first null hypothesis that there is 1 common trend at the 5%

significance level, but the test for *m*=2 common trends was rejected. Therefore, we conclude there exists one common trend in all models for hogs.

Comparison of Johansen and Stock-Watson Results

Earlier, we stated our expectation based on visual depiction of the data over time that negotiated cash prices for fed cattle would be cointegrated with negotiated grid prices and formula prices, but not forward contract prices. Similarly, we hypothesized negotiated cash prices for hogs would be cointegrated only with swine formula contracts, but not other formula prices and other purchases prices. Results differed from our hypotheses but were consistent for the two cointegration tests.

Both the Johansen cointegration test and Stock-Watson common trends test indicated negotiated cash prices for fed cattle were cointegrated with forward contract prices and formula prices but not negotiated grid prices. For hogs, negotiated cash prices were found to be cointegrated with each of the three other AMA series.

Vector Error Correction Model

Based on cointegration among AMA prices for fed cattle and hogs, excluding negotiated grid prices for fed cattle, we estimated a vector error correction (VEC) model to determine the long run behavioral relationship among AMA prices. The VEC model contains short-run effects as well as long-run, but we focus on the long-run effects (Saghaian, Hasan, and Reed 2002). The regression model can be expressed as

(2) $\Delta Z_t = \Pi Z_{t-k} + \sum_{i=1}^{k-1} \Phi^*_i \, \Delta Z_{t-1} + \epsilon_t,$

where $Z_t = (y_t, x_t)'$, $\Pi = \alpha\beta'$. Π reflects the long-run relationship between cointegrated prices. The Π matrix can be decomposed into α and β matrices. The α matrix (adjustment coefficients) provides information about the speed of adjustment at which each price moves back to its underlying long-run equilibrium. The β matrix includes the cointegrating vectors that represent the underlying long-run relationship. From the Johansen cointegration test, we found one cointegration vector (r=1) for fed cattle and hogs, meaning there exists a stationary long-run equilibrium between cointegrated prices. When unitary equilibrium holds, then α estimates the speed at which prices return to their equilibrium level. From the adjustment coefficient (α), we determine the stability of cointegrated prices in the long run.

Fed Cattle – Cointegration tests for fed cattle revealed a long-run relationship in two models (negotiated cash prices vs. forward contract prices, and negotiated cash prices vs. formula prices). In VEC model results for fed cattle (Table 5), the absolute value of the adjustment coefficient (α) for negotiated cash prices is less than for forward contract prices; and similarly for negotiated cash prices vs. formula prices. Thus, the model gives the expected result that forward contract prices and formula cash prices are adjusting toward the negotiated cash price.

Hogs – A long-run relationship was found in all three models for hogs (Table 5). In the VEC model results for hogs, the dominance of the negotiated cash price is not as well established as it is for fed cattle. The absolute value of the adjustment coefficient (α) for negotiated cash prices is greater than the value for other formula prices and other purchase prices. However, in the second model (negotiated cash prices vs. swine formula prices), the absolute value of negotiated cash prices is less than the value for swine formula prices, meaning swine formula prices are doing more of the adjusting.

Causality Tests

When economic variables x_t and y_t affect each other with distributed lags, the causal relationship can be captured in a VAR model (Enders 2003). Alternatively, we determine the causal relationship between pairs of AMAs prices in a VEC model. In this paper, we test whether y_t causes lagged x_t and whether x_t causes lagged y_t. If both are found, we can conclude there is bidirectional feedback, or x_t and y_t are independent under the chosen lags. Our Granger causality tests are based on a VEC model with (p) lags using the full information maximum likelihood method

(3) $x_t = a_0 - \alpha_1 x_{t-1} + \alpha_1 \gamma y_{t-1} + a_{11}\Delta x_{t-1} + a_{12}\Delta x_{t-2} + a_{21}\Delta y_{t-1} + a_{22}\Delta y_{t-2}$,

(4) $y_t = b_0 - \alpha_2 x_{t-1} + \alpha_2 \gamma y_{t-1} + b_{11}\Delta x_{t-1} + b_{12}\Delta x_{t-2} + b_{21}\Delta y_{t-1} + b_{22}\Delta y_{t-2}$.

We tested the hypothesis that a_{21}=0 with one lag or $a_{21} = a_{22} = 0$ with 2 lags. Lag lengths were chosen by the Akaike Information Criterion.

Fed Cattle - Table 6 presents results of Granger causality tests for fed cattle. A lag of 2 was selected for all fed cattle models. Negotiated cash prices Granger cause all other price series. There is feedback from negotiated grid prices, weaker feedback from forward contract prices, and no significant feedback from formula prices. Thus, these results provide further support that the negotiated cash market is the center for discovery of fed cattle prices.

Hogs - Table 6 also presents results of Granger causality tests for hogs. For the hog models, the VEC model chose different lag lengths, either 1 or 2. Results also support negotiated cash prices being the center for price discovery for hog prices. Negotiated cash prices unidirectionally cause both other formula prices and other purchases prices. However, there is relatively strong feedback from swine formula prices.

Implications and Conclusions

Cash prices have traditionally played a significant role in price discovery for fed cattle and hogs. First, as noted earlier, a considerable percentage of fed cattle continue to be sold on the basis of a negotiated cash price. While that percentage is much lower for hogs, cash market prices remain important for another reason.

Cash market prices serve as a reference market for many formula priced contracts and marketing agreements, both for fed cattle (formula prices) and hogs (swine market formula prices). If negotiated cash prices thinned to near zero or disappeared, transaction prices for a significant percentage of fed cattle and a higher percentage of hogs would have to be discovered in another manner. Maybe prices would be tied to wholesale or retail prices or maybe more would be tied to the futures market.

Many concerns have been raised regarding price discovery amid structural and behavioral changes among buyers and sellers of fed cattle and hogs. The overarching objective of this research was to ascertain whether or not cash market prices remained important in price discovery for fed cattle and hogs. We determined which AMA price series were cointegrated and then tested for causality among the price series to specify the role of cash market prices in price discovery.

Results confirm the importance of negotiated cash prices both for fed cattle and hogs. Negotiated cash prices were cointegrated with formula prices and forward contract prices for fed cattle; and with swine market formula prices, other formula prices, and other purchase prices for hog.

VEC results suggest negotiated cash market prices in the long run are more stable than formula prices and forward contract prices for fed cattle. Negotiated cash prices also were found to be more stable than swine market formula prices for hogs.

Given it was hypothesized the cash market remained important for price discovery, the causality test results could be argued to be reassuring. Negotiated cash market prices Granger cause prices for each of the other series: fed cattle – negotiated grid prices, formula prices, and forward contract prices; hogs – swine market formula prices, other formula prices, and other purchase prices. Bidirectional causality was found between negotiated cash prices, negotiated grid prices, and forward contract prices for fed cattle but not for formula prices. For hogs, bidirectional causality was found between negotiated cash prices and swine market formula prices but not for other formula prices and other purchase prices.

While results point to a continued positive and significant role for negotiated cash prices in price discovery, other questions remain. The percentage of negotiated cash market prices continues to decline slowly, begging the question, "how thin is too thin?" What percentage of prices is needed to ensure cash market prices accurately represent supply-demand conditions? As markets thin, what are acceptable and effective formula pricing alternatives to the cash market? Formula prices tied to futures market prices have existed for years for fed cattle and hogs as an alternative to formula pricing to the cash market, but the percentage of transactions tied to the future market remains relatively small compared with formula purchases.

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Table 1. Summary Statistics for Fed Cattle and Hog Procurement Prices and First Differences ($/cwt) by AMA, May 2001- May 2008

Procurement Method	N	Mean	Standard deviation	Min	Max
Fed cattle – prices					
Negotiated cash price	364	131.16	15.90	97.90	177.97
Forward contract price	351	132.01	15.34	15.34	161.82
Negotiated grid price	213	139.79	7.14	7.14	157.95
Formula price	364	131.72	15.72	15.61	166.39
Fed cattle – differences					
Negotiated cash price	363	0.08	3.74	-19.75	23.96
Forward contract price	350	0.11	3.79	-24.04	20.33
Negotiated grid price	212	0.07	2.16	-6.94	4.88
Formula price	363	0.09	3.22	-18.48	15.20
Hogs – prices					
Negotiated cash price	364	59.35	10.75	28.88	80.59
Other formula price	364	58.91	6.10	39.70	71.80
Swine formula price	364	59.17	10.34	29.56	80.28
Other purchase price	364	60.81	6.27	49.79	74.28
Hogs – differences					
Negotiated cash price	363	-0.02	2.79	-10.50	7.77
Other formula price	363	0.02	1.54	-4.50	6.21
Swine formula price	363	-0.02	2.47	-11.29	6.93
Other purchase price	363	0.01	1.61	-6.29	4.30

Table 2. Augmented Dickey-Fuller (ADF) Tests for Fed Cattle and Hog Prices with Weekly Data, May 2001-May 2008

Procurement Methods	Levels	First Differences
Fed cattle		
Negotiated cash price	-1.92(3)	-11.43*(2)
Forward contract price	-1.45(2)	-16.40*(1)
Negotiated grid price	-3.09(5)	-5.51*(4)
Formula trade price	-1.80(3)	-11.53*(2)
Hogs		
Negotiated cash price	-2.69(3)	-12.03*(2)
Other formula price	-1.79(1)	-21.30*(0)
Swine market formula price	-2.66(3)	-11.54*(2)
Other purchase price	-3.07(3)	-14.98*(0)

Notes: One (*) indicates that the rejection of the null hypothesis that there is a unit root at the 1% significance level. The critical value at the 1% is -3.43. The numbers inside parenthesis ( ) are the chosen lag length.

Table 3. Johansen's Cointegration Tests for Fed Cattle and Hogs

		Trace Statistic			Max Statistic	
Variables		λ_{trace}	Critical Value		λ_{max}	Critical Value
Fed cattle						
Negotiated cash price	r=0	35.98**	19.99	r=0	32.45**	15.67
Forward contract price	r=1	3.53	9.13	r=1	3.53	9.24
Negotiated cash price	r=0	94.16**	19.99	r=0	84.40**	15.67
Negotiated grid price	r=1	9.75**	9.13	r=1	9.75**	9.24
Negotiated cash price	r=0	107.74**	19.99	r=0	104.01**	15.67
Formula price	r=1	3.72	9.13	r=1	3.73	9.24
Hogs						
Negotiated cash price	r=0	19.62**	19.99	r=0	15.97**	15.67
Other formula price	r=1	3.65	9.13	r=1	3.44	9.24
Negotiated cash price	r=0	49.50**	19.99	r=0	41.21**	15.67
Swine formula price	r=1	8.23	9.13	r=1	8.22	9.24
Negotiated cash price	r=0	21.81**	19.99	r=0	14.49**	15.67
Other purchase price	r=1	7.10	9.13	r=1	7.06	9.24

Notes: Double (**) indicates the rejection of null hypotheses that there are r cointegrating vectors at the 5% significance level. Failure to reject r=1 is a failure to reject the null hypothesis of cointegration. Rejection of r=0 is confirmation of the existence of a common unit root.

Table 4. Stock-Watson's Common Trends for Fed Cattle and Hogs

Variables	$H_0(n\text{-}r)$	Test results	Critical value	Lag
Fed cattle				
Negotiated cash price	1	-7.04	-14.10	4
Forward contract price	2	-99.46*	-23.00	
Negotiated cash price	1	-15.22*	-14.10	3
Negotiated grid price	2	-95.04*	-23.00	
Negotiated cash price	1	-7.92	-14.10	4
Formula price	2	-203.63*	-23.00	
Hogs				
Negotiated cash price	1	-11.31	-14.10	4
Other formula price	2	-28.44*	-23.00	
Negotiated cash price	1	-12.51	-14.10	4
Swine market formula price	2	-183.32*	-23.00	
Negotiated cash price	1	-11.91	-14.10	4
Other purchase price	2	-33.39*	-23.00	

Note: Single (*) indicates the rejection of the null hypothesis of *m* common trends at the 5% significance level. *m* is *n-k.*

Table 5. Results from the Adjustment Coefficient Estimates for Fed Cattle and Hogs

Cointegrated Prices	Adjustment Coefficient (α)
Fed Cattle	
Negotiated cash price	-0.03
Forward contract price	0.16
Negotiated cash price	-0.01
Formula price	0.51
Hogs	
Negotiated cash price	-0.08
Other formula price	-0.01
Negotiated cash price	0.18
Swine formula price	0.40
Negotiated cash price	-0.07
Other purchase price	0.01

Table 6. Granger Causality for Fed Cattle and Hogs in VEC model

Independent Variables	Direction	Dependent Variables	Test results
Fed Cattle			
NegCash (2)	→	FwdCon	79.73*
FwdCon (2)	→	NegCash	8.31*
NegCash (2)	→	NegGrid	484.35*
NegGrid (2)	→	NegCash	5.58*
NegCash (2)	→	Formula	137.33*
Formula (2)	×	NegCash	2.05
Hogs			
NegCash (1)	→	OthrForm	4.47*
OthrForm (1)	×	NegCash	0.06
NegCash (1)	→	SwneForm	17.21*
SwneForm (1)	→	NegCash	10.63*
NegCash (2)	→	OthrPurch	7.18*
OthrPurch (2)	×	NegCash	0.60

Notes: Single (*) indicates the rejection of the null hypothesis of no causality at the 5% significant level. The number in parenthesis is lag length. The pair, negotiated cash and negotiated grid prices for fed cattle, is estimated by VAR in first differences.

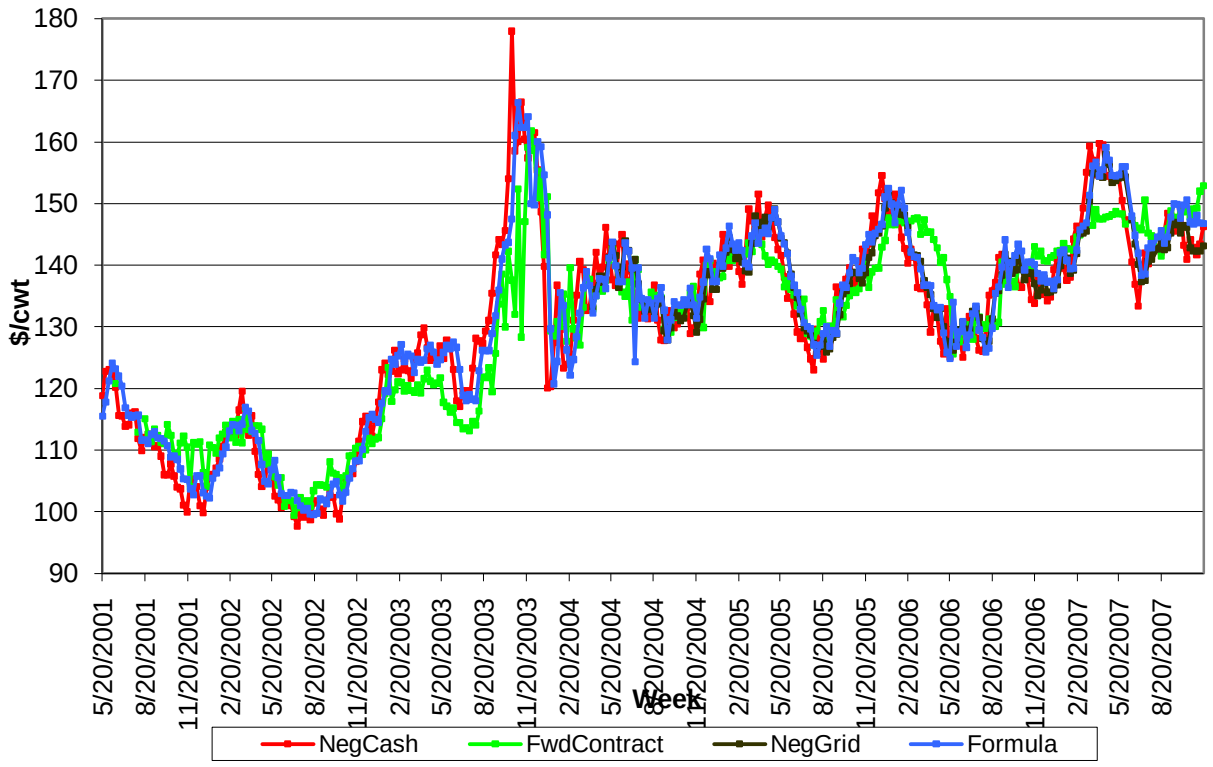

Figure 1. Weekly Fed Cattle AMA Prices, May 2001 to May 2008.

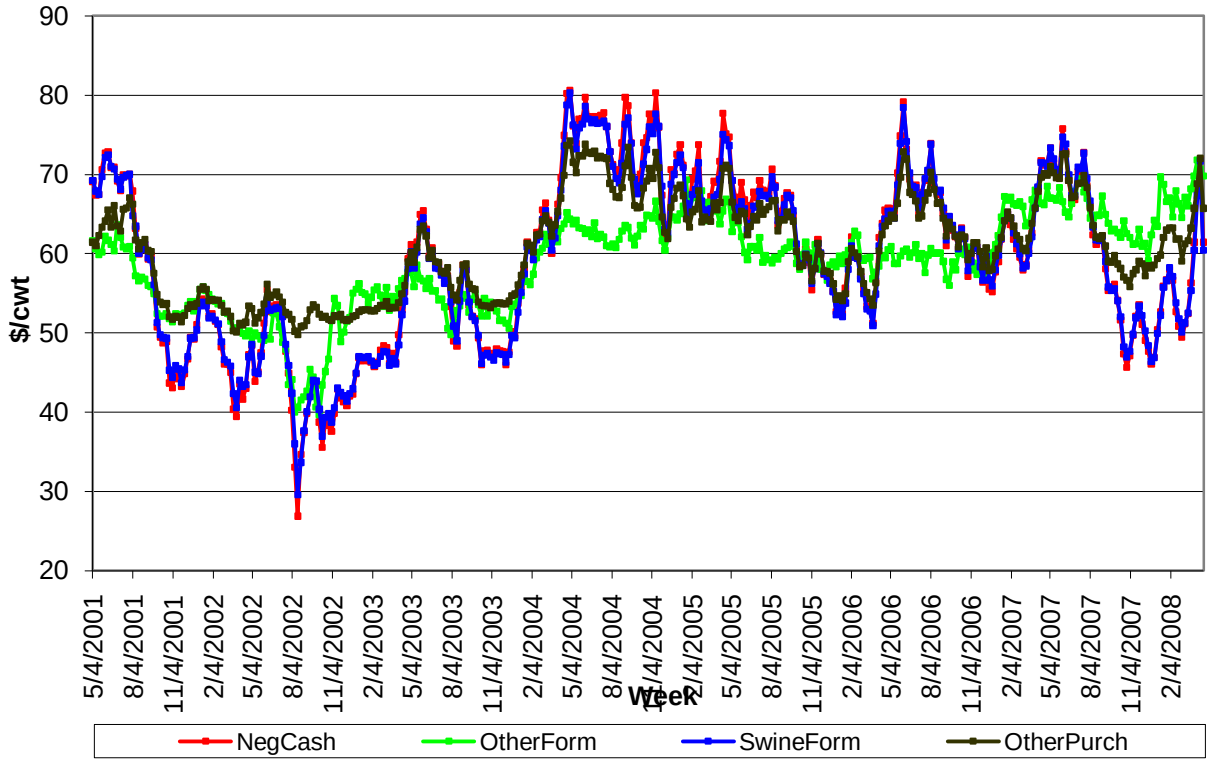

Figure 2. Weekly Slaughter Hog AMA Prices, May 2001 to May 2008.