Market Impacts of the 2012 Lean Finely Textured Beef Controversy

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Abstract: The impact of the March, 2012 LFTB media event on beef prices was estimated by using the Relative Price of a Substitute Good method applied to 50% and 90% lean beef trim and cull cow prices. Stationarity tests conclude both of the relative prices were cointegrated prior to the LFTB event. Preliminary results suggest the date of the price impact was April 7, 2012 with current estimates suggesting an 11-12% reduction in relative prices of 50% beef trim. Ongoing research is adding more recent data and additional assessments to assess robustness of initial findings.

Key words: ground beef, LFTB, lean finely textured beef, media coverage, price impact, relative price of a substitute good

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March, 2012 brought with it a frenzy of negative media attention to a product called Lean Finely Textured Beef (LFTB). LFTB was named "pink slime" by the news media, a name which may have heightened negative consumer reactions. Prices for 50% lean beef trim (the primary product from which LFTB was made) slumped (Figure 1) as retail customers declined to purchase products containing LFTB. Beef packers began posting financial losses (Gabbett, 2012; Greene, 2012) and LFTB inventor, Beef Products Inc., shut down several plants. Live cattle futures prices "remained on the defensive" (CME Group, 2012; Figure 1) as markets sought to determine the extent of declining demand and its impact on cattle prices.

The purpose of this study is to estimate the impact of the LFTB controversy on beef prices. We hypothesize that prices for 50% lean beef trim will be lower than would have occurred in the absence of the media event while prices for 90% lean beef trim will be higher. Because cutter grade cull cows are a substitute source for lean beef, a second hypothesis is that cull cow prices will be higher than would have been forecasted if the LFTB media scare had not occurred.

Background on Ground Beef and Lean Finely Textured Beef

Lean Finely Textured Beef is a meat product developed by Beef Products Inc. (BPI). BPI invented a process by which 50% lean beef trimmings (approximately 50% lean beef and 50% fat) are heated, the fat is separated from lean in a centrifuge, and the resulting product (LFTB) is of a 94-97% lean composition (Greene, 2012). The fat from the LFTB manufacturing process is typically sent to rendering plants for transformation into other consumable products. Because LFTB has a higher lean percentage than other ground beef products, it is often blended with lower-lean products to create a 90% lean ground beef product.

Approximately 10% of a fabricated beef carcass is processed into 50% lean beef trimmings (CME Group, 2012). Beef processors have lost a significant source of lean with which to blend other beef products. The likely result of this was tightened supplies of 90% lean ground beef, which used LFTB to raise the lean content, leading to higher ground beef prices. In the post-LFTB media event world, packers are mixing higher fat beef with other sources of lean which are often the chuck and other higher value cuts. Additional market effects may be higher cull cow prices (another source of high-lean content beef), and greater imports of ground beef.

Background on the LFTB Media Event

LFTB came to the heightened attention of consumers when ABC News broadcast a story about its use in retail beef products on March 7, 2012 (Greene, 2012). The ABC report referred to LFTB as "pink slime", a name which may have increased concern about the product. In an effort to reassure consumers, food retailers responded by announcing that they would stop buying beef products containing LFTB. Safeway, SuperValu, and Food Lion led the way, and were quickly followed by Kroger, BI-LO/Winn Dixie, and Hy-Vee. Wal-Mart, the world's largest retailer, said that it would give consumers a choice of buying ground beef products with or without LFTB.

On March 15, 2012, the USDA announced that individual school districts would be given the choice of whether or not to purchase ground beef produced with LFTB for use in the National School Lunch Program (Greene, 2012). This decision was driven by mounting consumer pressure even though Secretary of Agriculture Tom Vilsack noted that LFTB was a safe meat product.

The economic impact of the media attention, retailers, and the USDA's decision was swift. Prices for 50% lean beef trim (the primary product from which LFTB was derived) dropped, and the inventor and primary producer or LFTB, Beef Products Inc. (BPI), decreased production and announced on March 26, 2012 that it would lay off 650 employees (Greene, 2012). BPI would later announce the closure of three of its four plants (Garden City, Kansas; Amarillo, Texas; and Waterloo, Iowa) (CBS 2012).

Literature Review

This is the first known study to estimate the market impact of the LFTB event on wholesale beef and cattle prices. As such, the methodology for this study will be adapted from other studies examining similar market shocks. A brief review of this relevant literature follows.

McKenzie and Thomsen (2001) estimated the impact of ground beef recalls on beef and cattle prices. They examined recalls involving *E.*Coli contamination, of which all but two (of 55 total recalls) observations were for ground beef. Their data was obtained from the US Food Safety Inspection Service (FSIS) for all *E.Coli* recalls from October, 1994 to October 2000. The beef and cattle prices examined were the nearby live cattle futures prices, Texas-Oklahoma live cattle cash prices, the CME 90% lean boneless beef price index, and the USDA boxed beef cutout price.

McKenzie and Thomsen examined the influence of *E.Coli* recalls using a standard mean return model. This model analyzes prices reactions over the days preceding and following a recall event by focusing on the daily percentage changes in a price series. Price reactions are analyzed in the following manner: the average normal (before a recall event occurred) returns (daily percentage changes in a commodity or financial instrument) are estimated for each price series and a predicted normal return is generated while abnormal returns (returns to a price series following an event) are estimated for a period of days following the event. The summation of the estimated abnormal returns yields the cumulative abnormal returns (CAR) measure, which can be used to test for negative price reactions. Testing the null hypothesis (CAR > 0) against the alternative hypothesis (CAR < 0) provides insight into the total reaction of a price series to a recall event (McKenzie and Thomsen, 2001).

The results provided by McKenzie and Thomsen showed that the impact of *E.Coli* related beef recalls are largely absorbed at the wholesale level. Their model found significant negative impacts on boneless beef prices and an impact of much smaller magnitude (and of marginal significance) on boxed beef prices. They argue this discrepancy occurs as *E.Coli* is a concern primarily in ground beef products which make up a portion of the boxed beef prices. McKenzie and Thomsen found slight negative impacts on live cattle futures prices but those estimates were not statistically different from zero. Similarly, cash live cattle prices were unaffected by beef recalls. Thus, McKenzie and Thomsen conclude that market shocks are transmitted from the farm level to wholesale but not vice versa.

Carter and Smith (2007) use a relative price of a substitute good (RPS) method to trace the effects of a 2000 food scare where a genetically modified (GM) corn variety, unapproved for human consumption, had entered the human food chain. Due to similar production and consumption characteristics, grain sorghum was chosen as the substitute good for corn in this study. The analysis rests on two factors: showing the stability of relative prices before a market shock and, subsequently, showing a permanent difference in relative prices following the shock. The pre-market shock stability of prices was shown by showing that corn and sorghum prices were cointegrated with a (1, -1) cointegrating vector. This was achieved by showing the presence of a unit root (using the Augmented Dickey-Fuller test) in the log of each price but no unit root in the relative price. Following this, structural break tests were performed using the Bai and Perron (1998) methodology to test the stability of the relative prices in the presence of the market shock.

Their results using daily data from 1989 to 2002 showed a significant structural break in July, 2000. This break was sudden and the price of corn relative to sorghum remained low until slowly regaining two-thirds of its original value by the summer of 2002. Then, using monthly data as a confirmation of their original study, they tested for structural breaks from 1975 to 2002. Only one break in the relative corn: sorghum price was found, in July, 2000 (Carter and Smith, 2007).

Schulz, Schroeder, and Ward (2011) examined *ex post* effects of trade policies on US-Canadian fed cattle markets. Specifically, their model quantified the impact of three different policies:

1. The July 12, 2007 Canadian Food Inspection Agency's rule that cattle tissue capable of transmitting BSE was banned in all animal feed.
2. The US government's November 20, 2007 passing of Rule 2 that allowed Canadian cattle born after March 1, 1999 to be exported to the US.
3. The September 30, 2008 Mandatory of Country of Origin Labeling (MCOOL) regulation which required specific products (including meat) to identified by the country of product origin.

By regressing the two countries' fed cattle price difference on dependent variables accounting for cattle characteristics, feedlot and packer differences, and US-Canadian political policy dummy variables, Schultz, Schroeder, and Ward (2011) were able to examine the impact of each legislative action. They found the expected positive impact on Canadian fed cattle price from Rule 2 and a negative impact for MCOOL.

Methodology

Following Carter and Smith (2007), the RPS model was chosen for this study. Thus, the impact of media attention directed at LFTB will be analyzed by comparing the price of 50% lean beef trim to other, similar products intended to increase the lean content of ground beef. The 50% lean beef prices will be compared against 90% lean beef trimmings and cull cow prices. The 90% lean trimmings price series, the leanest reported prices, are the next highest lean content product for ground beef manufacturers to use. "Cutter" grade cull cows, yield significant portions of lean beef and offer a substitute for LFTB. Accordingly, the two relative price series analyzed in this paper are the price of 50% lean beef trim relative to 90% lean beef trim and the price of 50% lean beef trim relative to cutter grade cull cows.

Relative Price of a Substitute Good Method

Carter and Smith (2007) argue that the relationship between two goods' prices can be written as a function of quantities of supply and demand shifters (income, input prices, and prices of other goods), that is,

1. $log\left(\frac{P_{1t}}{P_{2t}}\right) = g(Q_{1t}, Q_{2t}, Z_t)$

Where P_{it} and Q_{it} are the prices and quantities of good *i* in time *t*, g(*) is an unspecified function, and Z_t denotes supply and demand shifters.

They further argue that the function g(*) in equation (1) does not need to be specified at all if log (Q_{1t}/Q_{2t}) varies over time but returns to a constant mean. This supposes that technologies influencing the relative use of each good suffer temporary shocks but are mean reverting in the long run. The temporary shocks induce serial correlation in log (P_{1t}/P_{2t}), which allows one to test for changes in preferences or relative technologies by testing for changes in the mean of log (P_{1t}/P_{2t}) while allowing for serial correlation.

Broadly, if supply and demand shifters (consumer income, production technologies, etc.) only have a temporary impact on relative prices, then a shift in the mean of relative prices indicates a change in preferences or relative technologies. However, if these shifters have a permanent effect of the relative price series, then this series contains a unit root and changes in preferences or technologies cannot be differentiated from shocks from other explanatory variables.

To account for this, a cointegrating relationship between the relative prices must be found. Cointegration can be shown through a number of different statistical tests, including the popular augmented Dickey-Fuller Unit Root test. Carter and Smith note that "This cointegrating relationship provides a stable conditional mean function for the relative price, and therefore a parameter shift in the cointegrating relationship indicates a change in preferences or technology" (pg. 526). Accordingly, the RPS method must be used in the context of a stable pre-event price relationship of,

2. $$\log\left(\frac{P_{1t}}{P_{2t}}\right) = \mu + \beta' Z_t + u_t$$

Where u_t, the error term, is a stationary random variable, and Z_t denotes all relevant supply and demand shifters. Carter and Smith (2007) maintain that the Z variables are stationary and are only needed if the log of relative prices is not stationary. Thus, to test the hypothesis that an event had a significant impact on the relative prices, one should first test for the stationarity of each individual variable and the relative price, and then test for changes in the specified parameter.

Testing for changes in parameters, or structural breaks, is easily accomplished via the Chow (1960) *F*-test. When the break point in known and easily identified, the test is easily conducted for one specific point. However, when the break point is unknown structural break tests become more complicated. Bai and Perron (1998) proposed the sup-*F* test, which is the maximum *F*-test value over all possible break points.

Data

Weekly prices for 50% and 90% lean beef trimmings, and cutter-grade cull cows were available from the Livestock Marketing Information Center (LMIC, 2012). The data used in this analysis are from July 26, 2008 to October 20, 2012. This yielded 222 observations in total and 33 observations after the March 7, 2012 LFTB news event. Summary statistics for the log of 90% and 50% lean beef trimmings, the log of cull cow prices, and the log of both relative prices are reported before and after the LFTB media event in Table 1 and

Table 2, respectively.

Definition of Variables

The relevant variables used in this analysis are defined as follows:

- l90 = the log price (in $/lb.) of fresh 90% lean beef trim
- l50 = the log price (in $/lb.) of fresh 50% lean beef trim
- div9050 = (l90 / l50) is the relative price of 90% to 50% lean beef trim
- lCut = the log price of cutter grade cull cows ($/cwt)
- divC50 = (lCut / l50) is the relative price of cull cows to 50% lean beef trim

Results

Market Cointegration

Stationarity tests were conducted for the natural logarithm of 90% and 50% lean beef trim prices and of the relative price. Stationarity tests point to the long-term stability of the relative price by showing that 90% and 50% lean beef trim prices are integrated with a (1, -1) cointegrating vector. As Carter and Smith (2007) noted, this can be accomplished by showing that the logarithm of each price series contained a unit root while the price ratio does not contain a unit root. The augmented Dickey-Fuller test (ADF) was applied to the following equation (adapted from Carter and Smith, 2007):

3. $(l90/l50) = \mu + z_t$

Where *l90* and *l50* are the log prices of 90% and 50% lean beef trim, μ is the intercept, and z_t is the error term. Results for the ADF tests are presented in Table 3. These results suggest that, prior to the LFTB media attention in March, 2012, both 90% lean and 50% lean beef trim prices contained a unit root. The null hypothesis of a unit root in the relative prices was rejected at the 5% level of significance. The results further suggest that both prices series were cointegrated prior to the market shock.

The same analysis was conducted for the relative price of cutter cows divided by 50% beef trim (divC50). The results again indicate that the cutter cow price series contained a unit root prior to the LFTB market shock while the hypothesis of a unit root in divC50 was rejected at the 10%

level of significance (Table 3). Thus, the conclusion is that the prices of cutter grade cull cows and 50% lean beef trim are cointegrated.

Structural Break Tests

Following the cointegration tests, the relative price series was tested for structural breaks. The parameter μ in equation (3) was examined for structural breaks using the Bai and Perron (1998) test procedure to finding the maximal F-statistic value.   To avoid degrees of freedom complications, the first and last twenty observations were omitted from the Chow tests.

Results from the Chow tests indicate a strongly significant structural break occurred in both relative price series. For both the div9050 and divC50 variables, the most significant F-test valued occurred on April 7, 2012, exactly one month after ABC news first aired the LFTB story. As seen in Figure 4 and Figure 5, F-test values for div9050 and divC50 had been increasing over time but both price series' experienced their highest levels of significance following the LFTB media event.

That F-test values were increasing prior to the media event would indicate the presence of some pre-event shocks to the relative price series. Figure 2 confirms this as it shows that the relative price of 90% / 50% lean beef trim was increasing from an all-time low in late 2011. Figure 3 illustrates the same story for the relative price of cull cows and 50% lean beef trim. While the exact reason for these pre-event changes is unknown, it is likely that shortened cattle supplies and changing global supply and demand may have influenced the relative price. Regardless, the most significant structural breaks in the relative prices variables div9050 and divC50 occur after the LFTB media event.

The results of the structural breaks tests are consistent with Figure 2 and Figure 3. Both figures show a moderately stable relative price until April, 2012, then the relative prices spike to a new, higher level. This spike in the graph corresponds to April 7, 2012 when the relative price of 90% and 50% lean beef trim experienced a 6.7% change from the week prior, the highest percent change in the data set. Similarly, the relative price of cull cows to 50% lean beef trim jumped 6.9% higher from the week prior on March 31, 2012 (the last pre-shock date).

Price Impact Estimations

The final step in the RPS method, as outlined by Cater and Smith (2007) is to estimate the price impacts of a shock on the relevant markets. Cater and Smith used an error-correction model (ECM) which, as Engle and Granger (1987) note, exists whenever there is cointegration in a time series model.

Two different ECM's were estimated and their specification is as follows:

Model 1: ECM 90% and 50% Lean Beef Trim prices

$$\Delta l50_t = \alpha_{50} Z_t 9050 + \gamma_{50}(L)\Delta l50_{t-1} + \delta_{50}(L)\Delta l90_{t-1} + \epsilon_{(50)t}$$

$$\Delta l90_t = \alpha_{90} Z_t 9050 + \gamma_{90}(L)\Delta l50_{t-1} + \delta_{90}(L)\Delta l90_{t-1} + \epsilon_{90_t}$$

Model 2: ECM Cutter cow and 50% Lean Beef Trim prices

$$\Delta lcut_t = \alpha_c Z_t cut50 + \gamma_c(L)\Delta l50_{t-1} + \delta_c(L)\Delta l90_{t-1} + \epsilon_{ct}$$

$$\Delta l50_t = \alpha_{c50} Z_t cut50 + \gamma_{c50}(L)\Delta l50_{t-1} + \delta_{c50}(L)\Delta l90_{t-1} + \epsilon_{c50t},$$

Where $\gamma_i(L)$, and $\delta_i(L)$ are polynomials in the lag operator, i = {50, 90, c, and c50} (representing unique subscripts for each of the regressions), $Z_t9050 = (l90 / l50 - \mu)$ is the error-correction term for Model 1 as defined in equation (3), and $Z_tcut50 = (lcut / l50 - \mu)$ is the similarly-defined error-correction term for Model 2. Each ECM was analyzed for the July 26, 2008 to April 7, 2012 (the LFTB market shock point identified earlier) period, providing pre-market shock coefficient estimates.

Results for the ECMs are presented in Table 4 and

Table 5. For Model 1, the error-correction terms for 50% and 90% beef trim are 0.49594 and 0.0017, respectively. This indicates that the weekly price of 50% and 90% beef trim adjust 49.6% and 0.17%, respectively, to correct any deviation from the long run trend. For Model 2, the error-correction terms are 0.42552 and -0.03819, for 50% beef trim and cull cow prices, respectively. Again, this indicates a 42% and -3.8% weekly corrections for these two respective markets from any long term trend. While significant at the 1% level, the error-correction terms for 50% beef trim seem inflated. This initial finding is the subject of ongoing expansion of preliminary assessments.

Following the ECM analysis, in-sample forecasts were made for each ECM and were compared to the observed post-LFTB market shock values. Forecast errors for the 50% and 90% lean beef trim and cull cow prices were obtained by subtracting the observed values multiplied by the ECM coefficients from the observed values. Forecast errors for the relative price series were obtained by the negative of the sum of the absolute values of each contributing forecast error (i.e., 50% and 90% lean beef trim for the relative forecast error of Model 1). In so doing, the relative error also represents the total forecast error for the model (Carter and Smith, 2007). Errors for each model were collected and are graphed in Figure 6 and Figure 7. Summary statistics of the forecast errors are presented in Table 6.

Results from Model 1 indicate mean forecast errors of -0.09938, -0.00225, and -0.12151 for the 50%, 90%, and relative prices of lean beef trim, respectively. Therefore, the post-LFTB 50% beef trim prices was 9.9% lower on average than what was expected in the absence of the market shock. Furthermore, we note that the LFTB media event created a 0.225% drop in 90% lean beef trim prices. A possible reason for the near-zero value of this mean is that the post-LFTB market for 90% lean beef trim may be torn between conflicting effects of tighter lean beef supplies and declining consumer demand. Finally, the forecast error for the relative price of 90% and 50% lean beef trim suggests that the LFTB market shock caused on average a 12.51% increase in the relative price. This estimate is somewhat lower than expected but still reasonable as the ECM attempt to estimate only the impact created by the LFTB event and ignore other market shocks. For instance, imports of Australian beef were likely to increase even in the absence of the LFTB event due to higher US prices and favorable exchange rates. This would have increased the relative price (by decreasing demand for 50% lean beef) even without the LFTB event and the market event only served to increase the relative price further.

The second ECM, Model 2, had mean forecast errors of 0.00945, -0.08936, and -0.10925 for cull cow, 50% lean beef trim, and the relative prices, respectively. This would indicate that cull cow prices (as measured by the price of cutter grade animals) were 0.95% higher than would have been expected in the absence of a market shock. The 50% lean beef trim prices were 8.9% lower, on average, than were forecasted. The forecast error for the relative prices suggested the market shock raised the relative price by 10.9%, on average.

All signs provided by the ECMs matched *a priori* expectations; however, the LFTB event was expected to have a larger price impact than indicated in these results. These results may still be reasonable as the ECMs attempt to estimate only the impact created by the LFTB event and ignore other market shocks. For instance, imports of Australian beef were likely to increase even in the absence of the LFTB event due to higher US prices and favorable exchange rates. This would have increased the relative prices (by decreasing demand for 50% lean beef) even without the LFTB event. Thus, the price changes seen in the data are the cumulative effect of this (and other) market changes, and the LFTB event. Because ECMs solely estimate the impact of LFTB, the impact found by these models will likely be smaller than what is observed in the data. As noted earlier, ongoing expansions of this assessment are exploring these potential explanations. Moreover, the addition of more recent observations (e.g. current estimates reflect data only thru October of 2012) may well add robustness to estimates.

It is also important to note that the analysis conducted on the impact of the LFTB media event on prices does not infer any statistical significance to the values. Therefore, while mean forecast error estimates are unbiased, neither significance nor confidence intervals can be directly inferred.

Conclusions

The March, 2012 media attention given to Lean Finely Textured Beef caused a significant decline in the demand for ground beef products, in particular, 50% lean beef trim. This trim product was the primary ingredient for LFTB and its demand has fallen along with that for LFTB. This decline in value for a beef product has likely had significant economic impacts.

The Relative Price of a Substitute Good method, proposed originally by Carter and Smith (2007) was adapted for this analysis. Two substitute goods were analyzed; 90% lean beef trim and cutter grade cull cows. Stationarity tests concluded that each price series contained a unit root but that each relative price series (i.e., *90% trim / 50% trim* and *cull cows / 50% trim*) rejected the presence of a unit root, pointing to a cointegrated price series. Structural break tests were conducted which indicated that a fundamental change in each of the relative prices occurred on April 7, 2012, one month after the initial LFTB media attention.

Error-correction models were then used to estimate the extent of the price impact. Preliminary results suggest that 50% lean beef trim suffered a 9-10% decrease in value while 90% beef trim and cutter grade cull cows slightly increased in value. The relative price of 90% to 50% lean beef trim increased by 12% following the LFTB shock while the relative price of cull cows to 50% lean beef trim increase by nearly 11%. It is important to note that these values do not imply statistical significance.

Significant room exists for future research on this subject. For starters, methods should be applied to estimate the magnitude and significance of price changes stemming from the LFTB media event. Secondly, more recent observations and consideration of alternative "substitute goods" should be added to explore robustness of preliminary findings offered herein.

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Figure 1- Prices of 90% and 50% Lean Beef Trim and Live Cattle Futures

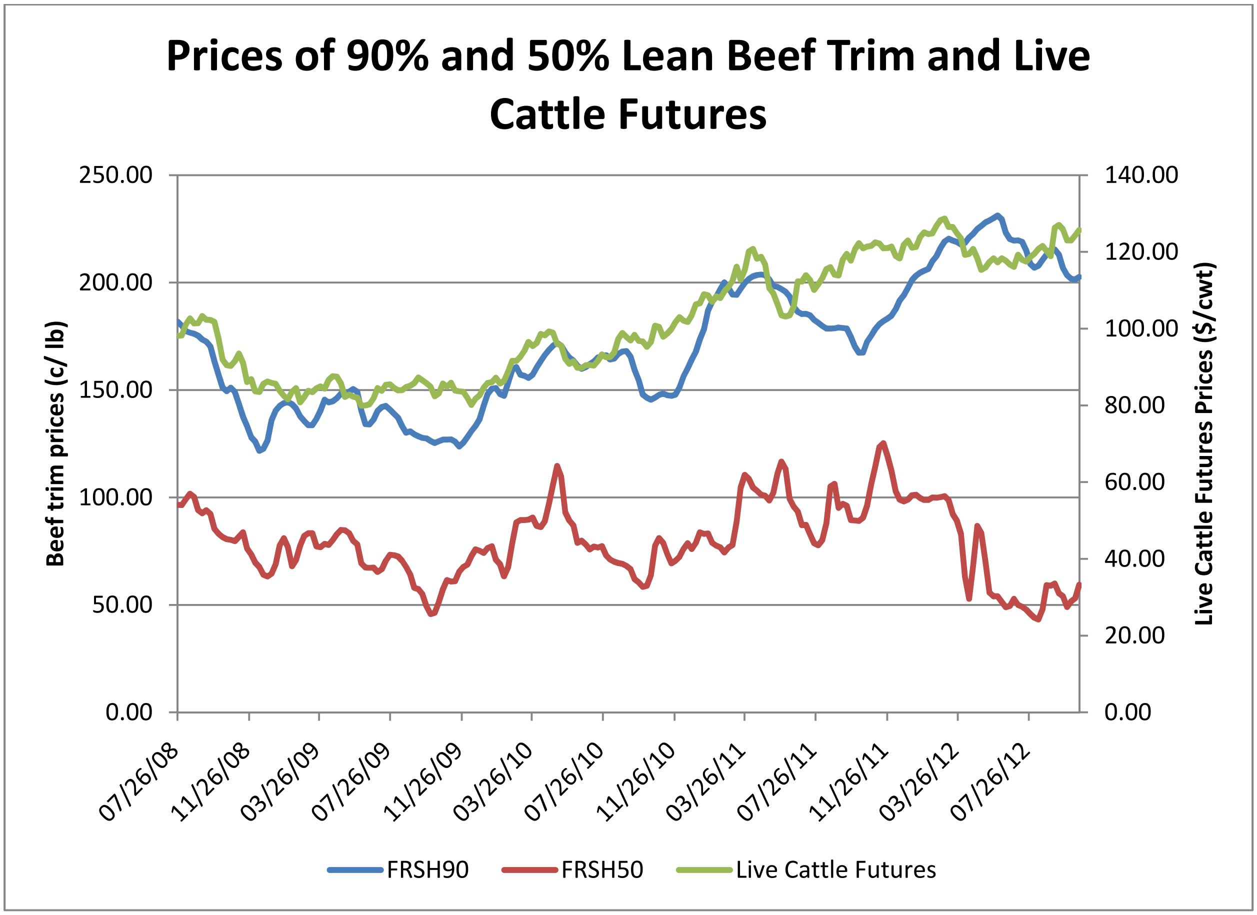

Figure 2 – Log Relative Price of 90% / 50% lean beef trim

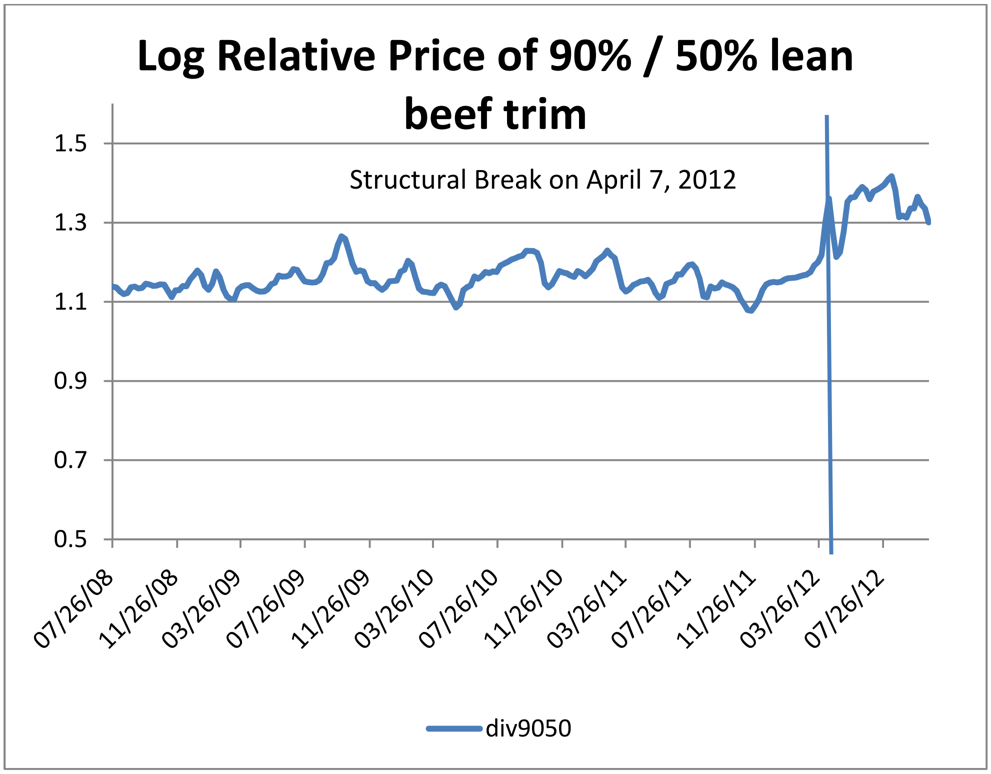

Figure 3 – Log Relative Price of cutter cows to 50% lean beef trim

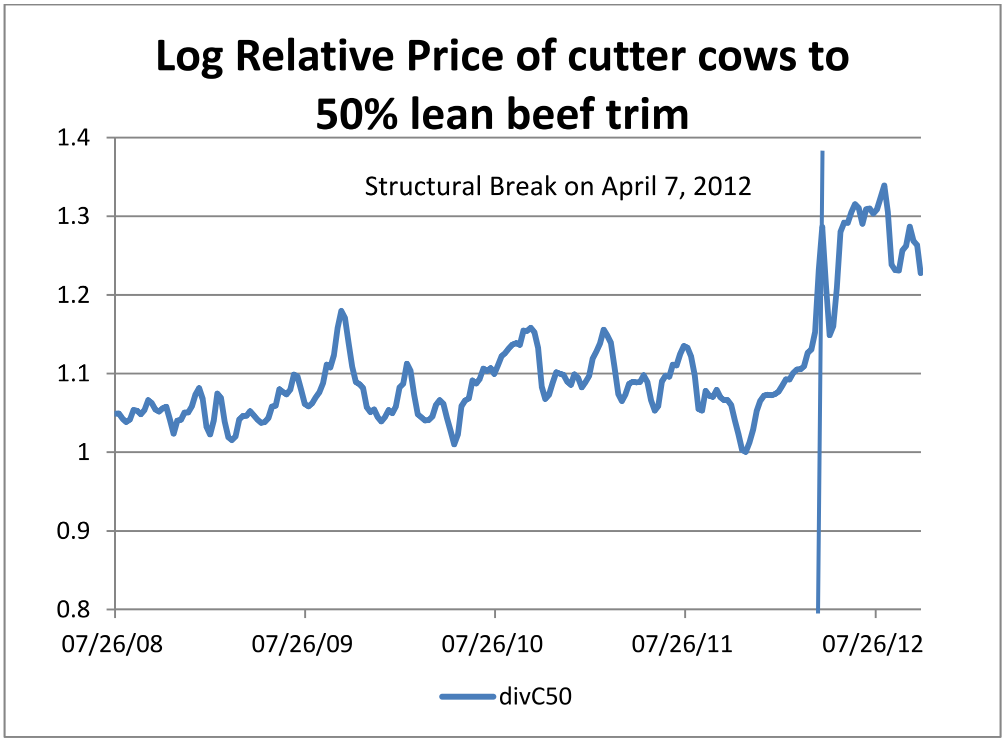

Table 1 - Summary Statistics Pre-Media Event

Variable	Units	N	Mean	Std Dev	Minimum	Maximum
l90	$/lb.	188	5.0763694	0.1486138	4.8015590	5.3757875
l50	$/lb.	188	4.3963165	0.1918291	3.8236289	4.8306311
div9050	$/lb.	188	1.1557779	0.0335585	1.0774071	1.2655249
lcut	$/lb.	188	4.7304216	0.1797808	4.4025643	5.0911087
divC50	$/lb.	188	1.0768236	0.0353283	1.0003797	1.1797038

Table 2 - Summary Statistics Post-Media Event

Variable	Units	N	Mean	Std Dev	Minimum	Maximum
l90	$/lb.	34	5.3794346	0.0393964	5.3055412	5.4432831
l50	$/lb.	34	4.0847355	0.2434951	3.7656090	4.6115498
div9050	$/lb.	34	1.3211110	0.0723319	1.1687714	1.4172392
lcut	$/lb.	34	5.0810336	0.0491692	5.0023544	5.1539850
divC50	$/lb.	34	1.2477883	0.0680511	1.1054796	1.3391843

Table 3 – Pre-LFTB Event Single Mean ADF Test Results

Pre-LFTB Event Single mean ADF Tests	Tau-statistic	P-Value	Conclusion
l90	-0.52	0.8824	Unit Root
l50	-2.00	0.2874	Unit Root
div9050	-2.90	0.0482	No Unit Root → Cointegration
lcut	-0.41	0.9035	Unit Root
divC50	-2.80	0.0608	No Unit Root → Cointegration

Figure 4 - F-test values for div9050

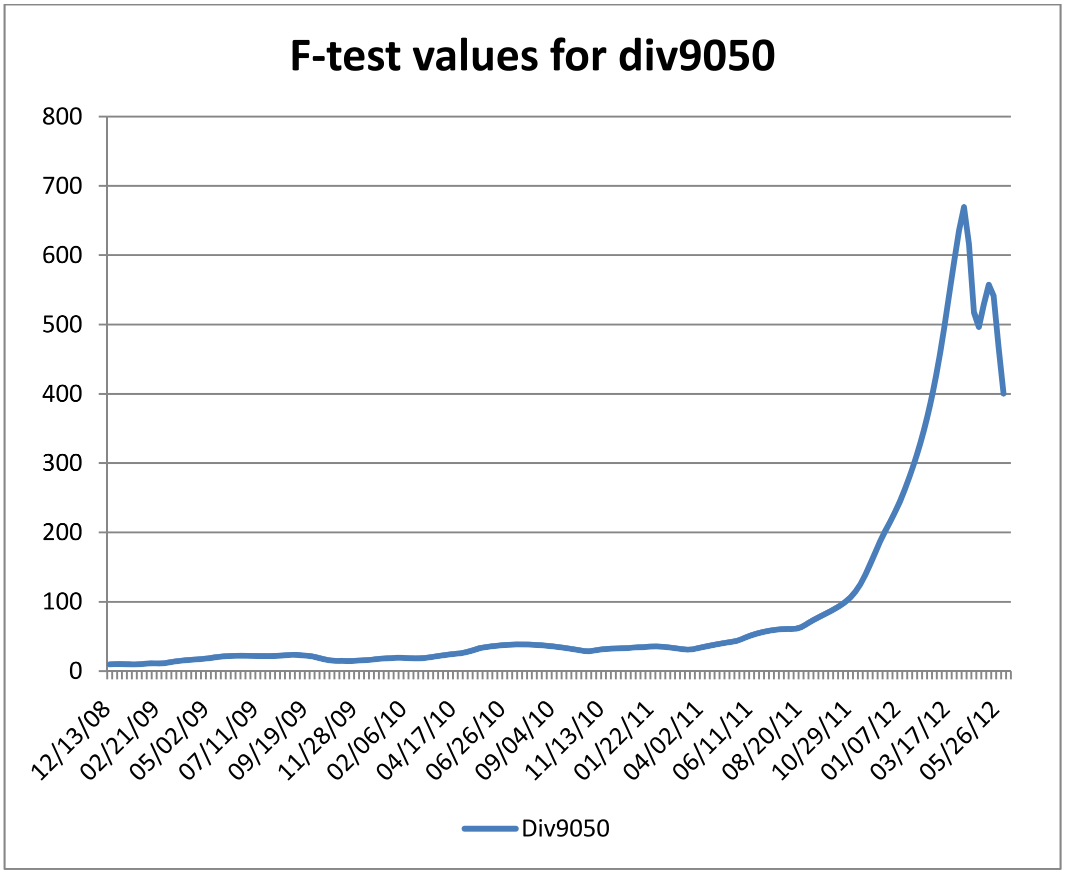

Figure 5 - F-test values for divC50

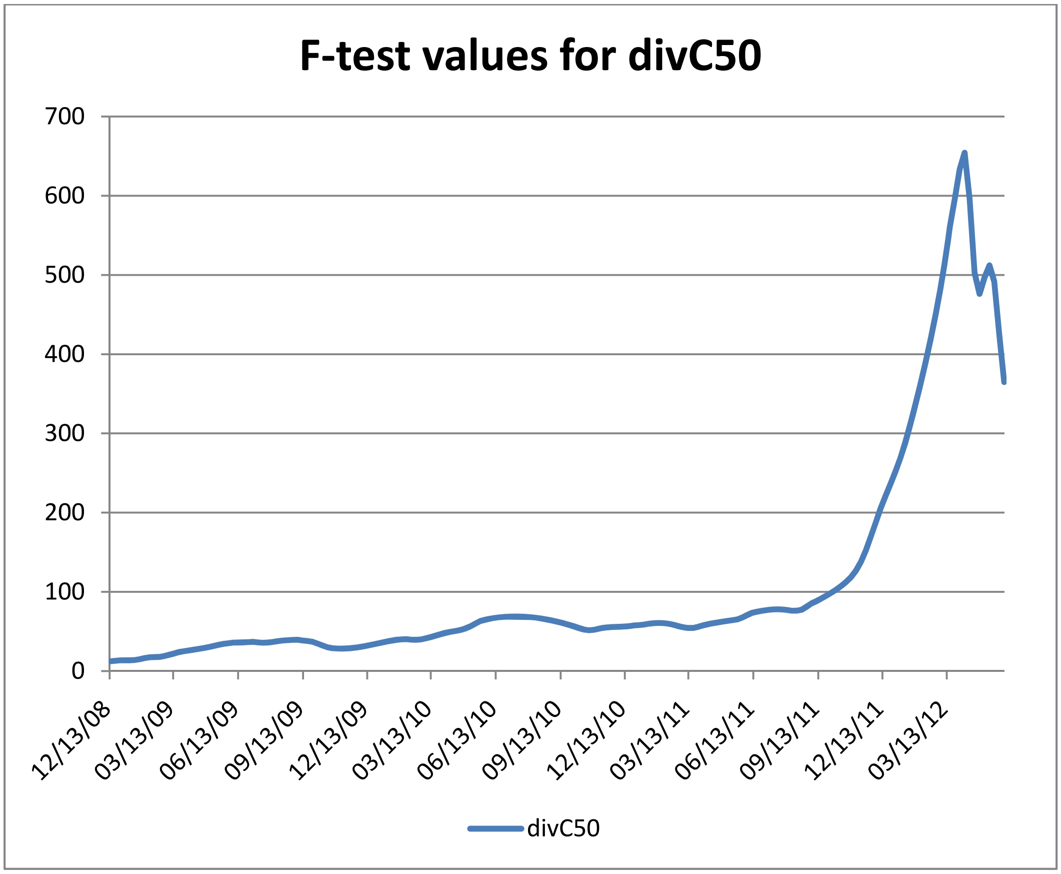

Table 4 - Pre-LFTB ECM Parameters for Model 1

ECM Parameter	50% Lean Beef Trim	90% / 50% Lean Beef Trim	90% Lean Beef Trim
μ		1.1558***	
α	0.49594***		0.00170
γ	0.54704***		0.0.1077
δ	0.17264		0.0.69923***

Model 1 Specification

50% Lean Beef Trim: $\Delta l50_t = \alpha_{50} Z_t 9050 + \gamma_{50}(L)\Delta l50_{t-1} + \delta_{50}(L)\Delta l90_{t-1} + \epsilon_{(50)t}$

90% Lean Beef Trim: $\Delta l90_t = \alpha_{90} Z_t 9050 + \gamma_{90}(L)\Delta l50_{t-1} + \delta_{90}(L)\Delta l90_{t-1} + \epsilon_{90_t}$

Table 5 - Pre-LFTB ECM Parameters for Model 2

ECM Parameter	50% Lean Beef Trim	Cutter cows / 50% Lean Beef Trim	Cutter cow prices
μ		1.0768***	
α	0.42552***		-0.03819
γ	0.23358		0.57429***
δ	0.54767***		0.02182

Model 2 Specification

50% Lean Beef Trim: $\Delta l50_t = \alpha_{c50} Z_t cut50 + \gamma_{c50}(L)\Delta l50_{t-1} + \delta_{c50}(L)\Delta l90_{t-1} + \epsilon_{c50t}$

Cutter cow price: $\Delta lcut_t = \alpha_c Z_t cut50 + \gamma_c(L)\Delta l50_{t-1} + \delta_c(L)\Delta l90_{t-1} + \epsilon_{ct}$

Table 6 - Forecast Error Summary Statistics

	90% and 50% Beef Trimmings Model			Cull cow and 50% Beef Trimmings Model		
Forecast Error Summary Statistics	50% beef trim	90% beef trim	RelError |90+50|	Cull cows	50% beef trim	RelError |cull+50|
Mean	-0.09938	-0.00225	-0.12151	0.00945	-0.08936	-0.10925
Median	-0.11052	-0.00416	-0.12757	0.01062	-0.09507	-0.10727
Minimum	-0.19975	-0.05120	-0.23611	-0.00036	-0.20242	-0.20449
Maximum	0.03671	0.04400	-0.00719	0.01492	0.05239	-0.01713

Figure 6 - Forecast Errors for 50% and 90% Beef Trim

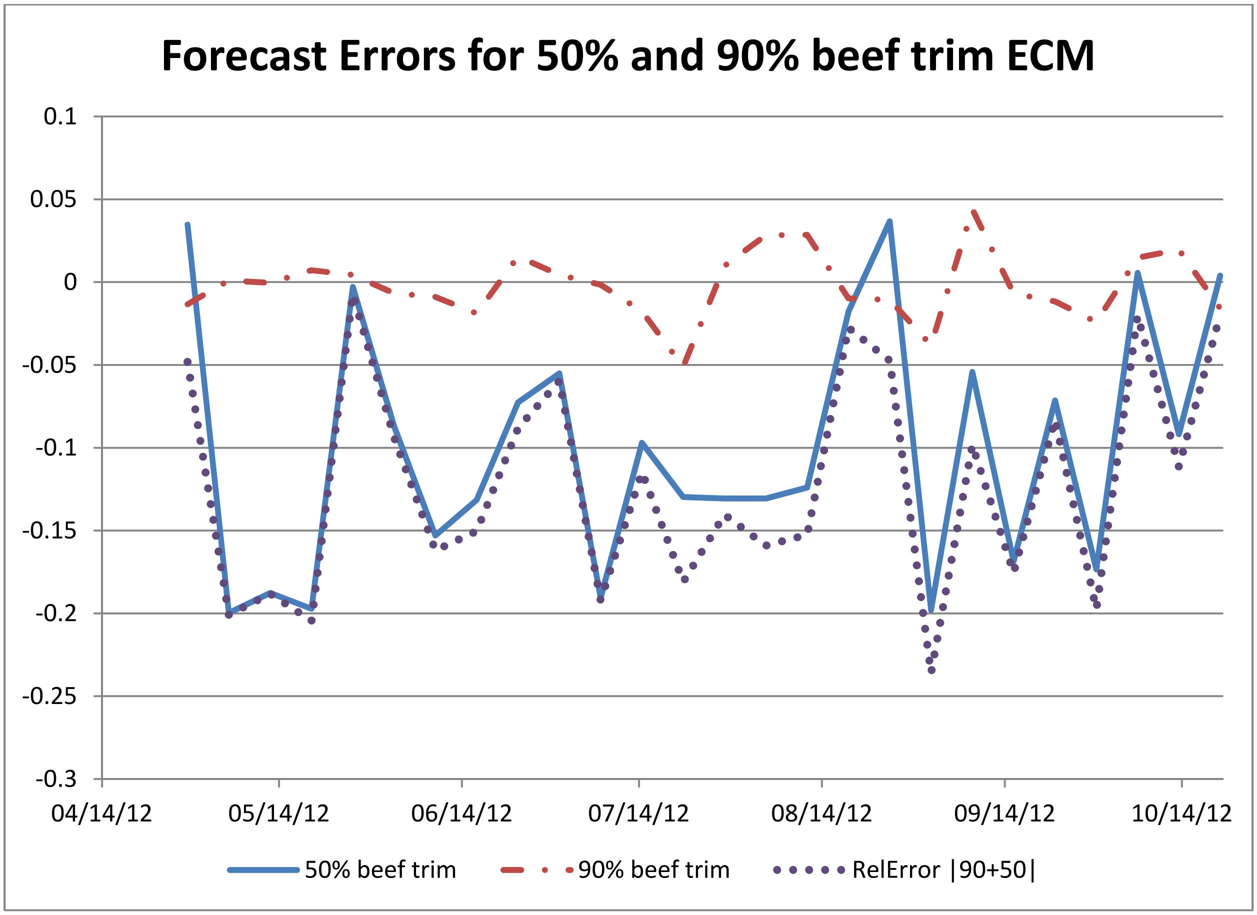

Figure 7 - Forecast Errors for Cull Cow and 50% Beef Trim ECM