The relationship of U.S. and Canadian Cull Cow Prices to lean beef prices: A DAG Analysis

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Introduction

What is the price relationship between a cull cow in San Angelo, Texas, Sioux Falls, South Dakota and other major U.S. cull cow markets and those in Ontario or Alberta Canada? How are these prices impacted by the price for lean beef trimmings or the price of imported lean beef from Australia or New Zealand? What impact did the discovery of bovine spongiform encephalopathy (BSE) in North America in 2003 have on these price relationships? Answers to these and other questions are the purpose of this paper.

Numerous market and price analysis studies exist on the fed cattle and feeder cattle markets in the U.S. However, there have been only a few recent studies on the U.S. cull cow market. Yager, Greer and Burt, 1980, and Tronstad and Gum, 1994, looked at optimal culling and marketing decisions, but neither of these two studies compared markets over time. While only limited research has been done on this market, it is an important part of the total U.S. beef market. Ground beef represents about 44% of all retail beef purchased and 59% of all fresh beef consumed in U.S. households. The cull cow market is a major supplier of lean beef and trimmings for the grinding industry. Beef from cull cows is also used for the low-end steak houses, for many of the thinly sliced deli beef products and for some of the other pre-cooked and further processed beef products for sale in retail grocer stores.

The sale of cull cows is a significant source of income to most cow-calf ranches as well. Feuz has estimated that 15-30 of gross income from the cow-calf enterprise comes from the sale of cull cows. The range is influenced by the stage of the cattle cycle and by individual management decisions on herd culling and re-stocking. Feeding cull cows prior to marketing also can add value to the cull cow and increase the share of ranch income resulting from the sale of cull cows. However, this strategy needs to be examined closely because in recent years, 2004-2005, leaner, thinner cows have been selling at a premium on a price per pound basis compared to fatter cows that have been fed for a period of time prior to selling them. This is particularly true if the sale of the cull cows is directly to a cow slaughter plant. This is a result of there being a relative shortage of lean beef trimmings in the market place. However, many times the auction barns reward the heavier, fleshier type cull cows with a higher per pound market price.

This seemingly contradiction in market price signals between direct prices reported by cow slaughter plants and auction market price quotes raises a number of questions as to the degree of market integration in the cull cow market. What are the market drivers in this market? Are these market drivers consistent across a wide geographic area? How stable have these market drivers been over time?

A major shock occurred to the U.S. cull cow market in May 2003. At that time a cow in Canada was discovered to have BSE. The U.S. closed the border to all Canadian beef and cattle imports. A few months later the border was opened to trade of beef from cattle of less than 30 months of age, and then in July 2005 the border was opened to live cattle trade for cattle of less than 30 months of age that would be slaughtered in the U.S. before reaching 30 months of age. However, as of June 1, 2006 the border between Canada and the U.S. remains closed to cattle over 30 months of age, cull cows. Prior to May 2003, approximately 45% of cull cows in Canada were shipped to the U.S. for slaughter. In 2002, 429,742 cull slaughter animals out of 990,860 head total were exported to the U.S. Cull cow markets and prices have been impacted on both sides of the Canadian-U.S. border. Because of the relationship of the cull cow market to the lean beef market, imports of lean beef from other countries may also have been impacted.

The objective of this paper is to analyze cull cow prices at several U.S. markets and two Canadian markets to determine the price relationships between these markets before and after the discovery of BSE in North America. Furthermore, the price relationship between cull cow prices and the cutter cow cut-out value, the price for fresh boneless beef 90% lean trimmings, and the price for Australian-New Zealand 90% lean beef on the east cost dock will also be analyzed.

Data

Weekly price data from January 2001 through December 2005 collected by the USDA-Agricultural Marketing Service for nine geographically dispersed markets was used for the analysis. The nine markets are Georgia combined auctions; St. Paul, Minnesota; Billings, Montana; Clovis, New Mexico; Oklahoma City, Oklahoma; Lancaster, Pennsylvania; Sioux Falls, South Dakota; San Angelo, Texas and Torrington, Wyoming. There are a number of different market classes reported by the USDA-AMS. This analysis uses the Lean 85-90% market class or when actual USDA Grades are reported, the Cutter grade is used. Two Canadian markets were reported as well, Alberta and Ontario. These prices were obtained from CanFax and are for the D1-2 cow grades and are reported in Canadian dollars. Three other beef price series were also used in the analysis: the Cutter Cut-out value; the boneless beef, fresh, 90% lean trimmings; and the Australia and New Zealand, East coast dock, 90% Lean market report. These prices were all obtained from the Livestock Market Information Center.

Means and standard deviations for each of the prices series are reported in Table 1. Depending upon what day of the week Christmas is there is frequently no market report for the auctions the week of Christmas and New Year. If there were no reports for those two weeks, then those two weeks were eliminated from the analysis. The data are also split into pre BSE and post BSE time periods with the week ending May 17, 2003 being the last week in the pre BSE time period. The week of September 6, 2003 was used as the first week in the post BSE time period. The weeks between May 17 and September 6 were not included in either time period as the markets, particularly the Canadian markets were adjusting to the border closure.

Methods

A directed acyclical graphing (DAG) methodology was used to determine the relationships among the 14 different weekly time series. The DAG as developed by Pearl and associates, Spirtes, Glmour and Scheines, and is similar in application as used by Bessler and Davis, who determined heavy heifer classes (600-700 and 700-800 pound categories) were the causal force in the Texas feeder cattle markets, and Stockton and Feuz (2006) who determined the causal relationships between market classes of cull cows in the Sioux Falls, South Dakota market. This paper is also comparable in methodology to the Bessler and Kergna (2002), where the causal effects of spatial difference was determined for a group of localized markets for millet in the city of Bamako, Mali.

The difference between these past studies and the current study is that the two DAGs will be used in a comparison between two time periods divided by an event which presumably has created a structural change in the market. The event is the ban on the import of Canadian cows for slaughter into the United States. Enough time has passed since the ban to obtain a reasonable amount of information to construct such a model. By dividing the data into two parts an analysis of the effects the ban has had on the flow of market information and causal differences is made known.

An overview and brief description of the development and characteristics of the DAG process and corresponding assumptions is found in Casillai-Olvera and Bessler (2006).

However, as a help in understanding the application of a DAG, a simplified explanation is given here. A DAG is a simple graphiod that uses lines and arrows between variables (vectors) to indicate relationship and causal flow, where the flow is non-circular. This methodology was used as a tool in developing artificial intelligence algorithms, but more recently has been applied in other disciplines. One of the primary uses of DAG in economics has been in price analysis and in price discovery. The DAG is based on three axioms, combined with a statistical testing regime used to associate and direct relationships between variables.

The three axioms are: 1) that the variables found to have a relationship do indeed have a relationship, 2) that any variable associated with another variable has an edge directly to that variable, and 3) that no significant variable have been left out of the model.

In the case of a statistical or an econometric model, once the model is decided on and formalized it implicitly relates the right hand side, causes, to the left hand side, effect. Typically a model is expressed in term of the left hand variable as a function of the right hand variable(s) Gujarati states in his introductory econometrics book “the dependant variable, is expressed as a linear function of one or more of the explanatory variables. In such models it is assumed implicitly that causal relationships, if any, between the dependent and explanatory variables flow in one direction only, namely from the explanatory variables to the dependent variable.” This concept not only applies to linear models but to econometric models in general. It is therefore expedient to carefully distinguish between the causes and effects. It would be ideal to be able to properly identify all of the variables used in the model.

Economic data generally is secondary in nature, and does not provide for the direct identification of cause and effect. Thus we have the development and use of theory. The DAG methodology is an attempt to go beyond intuition and provide an empirical method of discerning the causal relationships omitted by the absence of actual observation of direct experimentation, or in the void of theoretical specification.

To create the DAG it was necessary to first test each of the fourteen data series using an augmented Dickey-Fuller (ADF) test to determine the integration level for stationarity. Because of the close relationship between the data series they were treated as if they were cointegrated. This assumption was verified using a modified Dickey-Fuller (MDF) test on the 14 innovation errors, from the vector auto regression (VAR). The VAR was used to account for the time order or non-contemporaneous relationships with the innovations containing the contemporaneous relationships and white noise. The proper use of a VAR verses an error correction model (ECM) was also verified using MDF on the innovations (Griffith et al. 1996). The unrestricted level of the VAR was based on the use of an Akaike loss function. The innovations from the VAR were then used in creating a correlation matrix which became the input for the DAG analysis. The construction of the DAG was completed using a Bayesian search algorithm, particularly the greedy equivalent search (GES) algorithm found in the TETRAD IV program, (see http://www.phil.cmu.edu/projects/tetrad/ and Scheines et al., 1996).

Casillas-Olevra and Bessler describe the GES as a “two phase search algorithm that looks over equivalence classes of DAGs starting from a DAG representation with no edges.” It is important to note that a DAG without edges implies that all variables are independent of each other. The GES algorithm proceeds in a stepwise fashion searching over more and more complex DAG representations.

The first phase of the GES adds or reverses arrow direction by using the representation that maximizes the Bayesian loss criterion function for a single iteration. The GES continues to iterate in this first phases until no additional gain can be made in the loss function. Upon completion of the first phase the second phase commences with the specification of the last iteration of the first phase, proceeding thorough each iteration this time by removing edges or reversing arrow directions, again only selecting the DAG specification for each iteration that increases the Bayesian loss function, and given alternative increases in that loss function choosing the one with the greatest increase, thus the title greedy search algorithm. Further explanation of this algorithm is described in detail in Chickering (2002), and briefly in Casillas-Olvera and Bessler (2006).

Results

A graph (Figure 1) of all 14 data series shows that the market classes of cull cows appear to move in a cointegrated fashion. The Canadian cull cow price series for both Ontario and Alberta drop considerably relative to the U.S. cull cow prices near the end of May coinciding with the BSE caused trade ban. This stylized fact supports the hypothesis that causal relationships in the cull cow market may have change. The ADF was used for three different sets of data series. The complete data set as a whole consisting of 253 weeks and all series. A second data set for the weeks preceding May 24, 2003, referred to here as the pre BSE ban period, made up of 123 weeks of observations. The third data set being the post BSE ban period running for the 116 weeks starting in September 6, 2003, allowing the market to settle after the announcement of the BSE ban. Each of the fourteen series was tested for each of the three data sets. The complete data indicated that all fourteen price series were stationary at I(1), first difference, at any confidence level (See Table 2). The pre BSE ban data was found to have three market series to be stationary at I(0) at the 95% confidence level, Clovis, Georgia and Lean Trimmings (See Table 3). The Post BSE ban data also had three market series at the 95% level which were I(0), Clovis, Oklahoma City and San Angelo (See Table 4). While the two shorter data sets contained series which varied in integration level, the overall data showed all series to be of the same integration level. Since the complete data series were all I(1) a VAR was used rather then an Error Correction Model or procedure. The use of the VAR rather than an ECM was further supported by a modified Dickey-Fuller (MDF) on the innovations or error terms which showed them to all be stationary at the I(0) level for both the pre and post BSE models (See Tables 5 and 6). The best fitted VAR model reflected by the lowest Akaike and Schwarz loss criterion was a VAR(1), a single lag, for both the pre BSE ban and the post BSE ban models (See Table 7).

Showing that the innovations are stationary not only confirms that the VAR was the appropriate model of choice but also that data series are cointegrated and that the estimates in the VAR were super consistent.(Griffith et al. 1996) The residuals, innovations, were than used to construct the two covariance matrices (Table 8 and 9). The covariance matrix were then in turn used as the data source for the GES algorithm found in Tetrad IV which created both DAG's (Figure 2 and 3).

The DAG for the Pre BSE Ban has twenty-four edges, two undirected between Alberta and Ontario, and Ontario and Oklahoma City. Oklahoma City has the most associated edges, six are out going and one undirected edge. If all edges for Oklahoma City were out going it would be considered a source, causal to other markets but not caused by any other market. With so many edges pointing away from Oklahoma City it is evident that it is market with the most influence on all other markets. The two Canadian markets also have no incoming arrows. Looking closely Oklahoma City is either the parent or grandparent of all the US markets. In the case of Canada it is undetermined since the edge between Ontario and Oklahoma City and Ontario and Alberta are undirected. Four of the fourteen markets are sinks, having only in coming arrows, Imports, San Angelo, Georgia, and St. Paul (See Figure 2).

The post BSE Ban DAG (Figure 3) has twenty-five edges, sixteen unchanged, four with a direction reversal, two newly directed, and three new edges from the pre BSE ban DAG. The lost edges were between Alberta/Torrington and Billings/Sioux Falls. The three new edges were between Imports→Ontario, Clovis →Billings, and Georgia→Sioux Falls. The undirected edges between Oklahoma City-- Ontario and Ontario--Alberta are now directed as Oklahoma City→ Ontario and Ontario→Alberta. Oklahoma City is now a definite source, the only source, with all seven edges being direct away from it. Oklahoma City is now the parent or grand parent of every market both Canadian and U.S. The Canadian markets are now more isolated only having a causal effect on the Billings market, which has become a sink, and the Cutter Cut out value. The Clovis market no longer is a sink, while the St. Paul and the San Angelo markets remain sinks. Causal flow is reversed for Torrington/Sioux Falls, Cutter Cut out/Sioux Falls, Clovis/Cutter Cut out, and Imports/Clovis.

Implications

The post BSE ban DAG clearly indicates that casual relationships did change with the advent of the BSE trade ban. The graph of the raw data shows the Canadian market prices declined sharply relative to the US prices following the trade ban. The exclusion of the Canadian cull cows from the U.S. shifted the relationship between several US markets, both with Canadian markets and with other U.S. markets. The Canadian markets are more isolated with the removal of two edges either directly associated with them, or with in one generation. Only four of the fourteen markets were unchanged from the pre to post BSE ban. Two of the four unaffected markets were sinks, San Angelo, and St. Paul, the remaining two were there parents, Lean Trimmings and Lancaster.

These preliminary findings do point to a structural change in the cull cow markets and point to a need for further analysis of this market. One critical need is to analyze what the potential impacts may be, when the border is opened to cattle trade for cattle over 30 months of age.

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Table 1. Descriptive Statistics for weekly price data for seven U.S. cull cow markets, two Canadian cull cow markets, the Cutter cut-out value, the fresh beef 90% lean trimmings market, and the Australian-New Zealand 90% lean Import Market.[a]

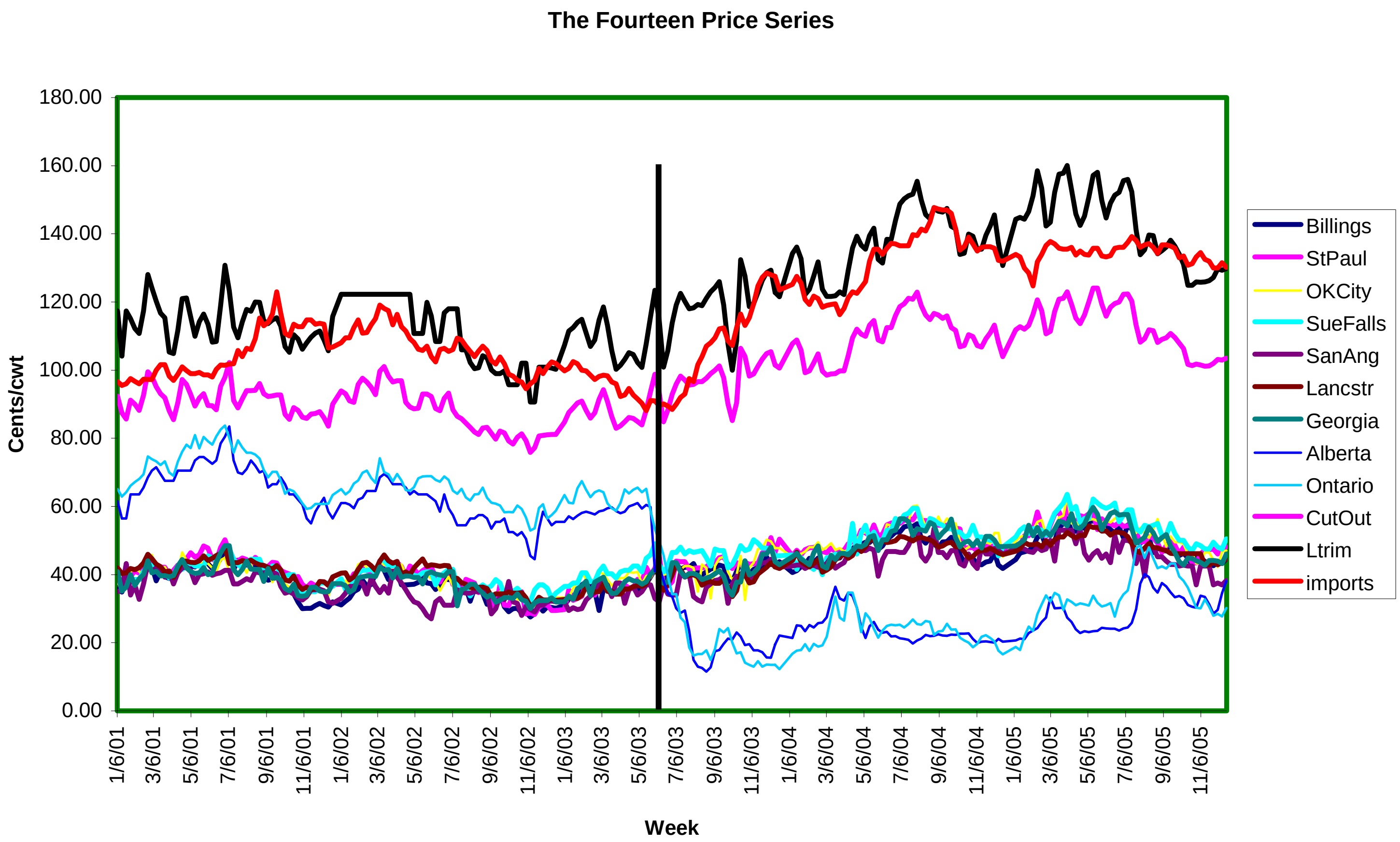
	Georgia	St. Paul	Bill ings	Clovis	Ok City	Lan caster	Sioux Falls	San Angelo	Torr ington	Alberta	Ontario	Cutter Cut Out	90% LTrim	AU NZ Imports
Mean	43.13	44.40	41.83	41.48	44.22	42.71	45.47	39.79	42.07	43.49	46.42	98.84	123.67	115.97
Std Dev	7.080	7.210	6.893	6.544	7.319	5.505	7.227	6.037	6.819	19.629	21.321	12.017	16.123	16.154
Weeks[b]	253	253	253	253	253	253	253	253	253	253	253	253	253	253
Pre BSE														
Mean	37.84	38.98	36.59	36.05	38.54	39.34	39.58	35.53	36.56	62.47	66.84	89.08	111.54	104.07
Std Dev	3.653	4.760	4.571	3.738	3.678	4.169	3.361	3.851	3.738	6.992	6.525	5.546	8.401	7.219
Weeks[c]	122	122	122	122	122	122	122	122	122	122	122	122	122	122
Post BSE														
Mean	49.07	50.47	47.47	47.54	50.66	46.69	51.65	44.82	47.95	25.47	26.90	109.62	137.30	131.15
Std Dev	5.424	4.493	4.594	4.243	4.982	4.277	5.201	4.045	4.498	5.727	8.431	7.958	11.988	8.684
Weeks[d]	116	116	116	116	116	116	116	116	116	116	116	116	116	116

[a] All values are in dollars per hundred pounds, except the two Canadian markets are in Canadian dollars per hundred pounds.

[b] January 2001 through December 2005 with the weeks of Christmas and New Years excluded if no data were available.

[c] January 2001 through May 17, 2003 with the weeks of Christmas and New Years excluded if no data were available.

[d] September 6, 2003 through December 2005 with the weeks of Christmas and New Years excluded if no data were available.



The Fourteen Price Series
Cents/cwt
180.00
160.00
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
1/6/01
3/6/01
5/6/01
7/6/01
9/6/01
11/6/01
1/6/02
3/6/02
5/6/02
7/6/02
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7/6/04
9/6/04
11/6/04
1/6/05
3/6/05
5/6/05
7/6/05
9/6/05
11/6/05
Week
Billings
StPaul
OKCity
SueFalls
SanAng
Lancstr
Georgia
Alberta
Ontario
CutOut
Ltrim
imports

Table 2. Results of the Augmented Dickey-Fuller Test on All Fourteen Price Series For the Complete Time Period

	Intergration Level			
	I(0)		I(1)	
Market	**Test Statistic**	**p-value**	**Test Statistic**	**p-value**
Alberta	1.30	0.630	-13.43	0.000
Billings	-1.57	0.497	-14.78	0.000
Clovis	-1.50	0.532	-12.91	0.000
Cut Out	-1.42	0.574	-13.20	0.000
Georgia	-1.41	0.576	-13.93	0.000
Imports (Australia)	-1.52	0.524	-6.47	0.000
Lancaster	-1.61	0.477	-14.38	0.000
Lean Trimmings	-1.88	0.344	-13.74	0.000
Oklahoma City	-1.49	0.538	-13.21	0.000
Ontario	-1.02	0.746	-14.24	0.000
San Angelo	-1.98	0.298	-13.17	0.000
St Paul	-1.35	0.608	-12.98	0.000
Sioux Falls	-2.13	0.232	-14.37	0.000
Torrington	-1.68	0.439	-20.67	0.000

Table 3. Results of the Augmented Dickey-Fuller Test on the Fourteen Price Series Pre BSE Ban

	Integration level			
	I(0)		I(1)	
Market	**Test Statistic**	**p-value**	**Test Statistic**	**p-value**
Alberta	-1.27	0.641	-9.11	0.000
Billings	-2.24	0.194	-10.16	0.000
Clovis	-2.89	0.049	-10.51	0.000
Cut Out	-1.97	0.298	-9.16	0.000
Georgia	-3.43	0.012	-13.81	0.000
Imports (Australia)	-1.38	0.589	-10.48	0.000
Lancaster	-1.91	0.328	-11.17	0.000
Lean Trimmings	-2.73	0.071	-9.67	0.000
Oklahoma City	-1.91	0.329	-5.83	0.000
Ontario	-1.78	0.388	-9.12	0.000
San Angelo	3.85	0.003	-14.81	0.000
St Paul	-1.19	0.678	-9.80	0.000
Sioux Falls	-2.62	0.092	-10.04	0.000
Torrington	-1.78	0.388	-14.50	0.000

Table 4. Results of the Augmented Dickey-Fuller Test on the Fourteen Price Series Post BSE Ban

	Integration level			
	I(0)		I(1)	
Market	**Test Statistic**	**p-value**	**Test Statistic**	**p-value**
Alberta	-2.24	0.194	-7.40	0.000
Billings	-2.35	0.159	-12.32	0.000
Clovis	-3.19	0.023	-10.96	0.000
Cut Out	-2.08	0.253	-11.16	0.000
Georgia	-2.62	0.092	-9.29	0.000
Imports (Australia)	-2.57	0.103	-8.61	0.000
Lancaster	-2.41	0.141	-10.59	0.000
Lean Trimmings	-2.15	0.227	-11.32	0.000
Oklahoma City	-3.33	0.016	-14.35	0.000
Ontario	-1.86	0.351	-10.46	0.000
San Angelo	-3.04	0.034	-9.83	0.000
St Paul	-2.03	0.273	-14.57	0.000
Sioux Falls	-2.07	0.258	-14.49	0.000
Torrington	-1.51	0.523	-13.28	0.000

Table 5 Modified Dickey-Fuller* Test for the Pre BSE Ban Data Series

	I(0)	
Market	**Test Statistic**	**p-value**
Alberta	-10.55	0.000
Billings	-11.07	0.000
Clovis	-10.48	0.000
Cut Out	-8.22	0.000
Georgia	-9.84	0.000
Imports (Australia)	-8.79	0.000
Lancaster	-11.09	0.000
Lean Trimmings	-9.83	0.000
Oklahoma City	-11.14	0.000
Ontario	-5.20	0.000
San Angelo	-11.49	0.000
St Paul	-10.90	0.000
Sioux Falls	-10.94	0.000
Torrington	-10.87	0.000

*The MDF has a slightly different statistical significance level then the Standard ADF

Table 6 Modified Dickey-Fuller* Test for the Post BSE Ban Data Series

	I(0)	
Market	**Test Statistic**	**p-value**
Alberta	-11.91	0.000
Billings	-7.34	0.000
Clovis	-10.47	0.000
Cut Out	-9.87	0.000
Georgia	-9.86	0.000
Imports (Australia)	-8.50	0.000
Lancaster	-8.82	0.000
Lean Trimmings	-9.81	0.000
Oklahoma City	-10.36	0.000
Ontario	-10.32	0.000
San Angelo	-9.80	0.000
St Paul	-11.18	0.000
Sioux Falls	-11.17	0.000
Torrington	-12.10	0.000

* The MDF has a slightly different statistical significance level then the Standard ADF

Table 7 Lag Length Choice Criterion

Data Series	Number of Lags in the Unrestricted Model			Criterion
	VAR (1)	**VAR (2)**	**VAR (3)**	
Pre BSE Ban	53.72	54.19	54.64	Akaike Loss Criterion
	58.55	63.57	68.63	Schwarz Loss Criterion
Post BSE Ban	54.85	55.00	55.28	Akaike Loss Criterion
	59.87	64.75	69.81	Schwarz Loss Criterion

Table 8. Pre BSE Ban Innovation Correlation Matrix

	Alberta	Billings	Clovis	Cut Out	Georgia	Imports	Lancaster	Lean Trim	Oklahoma City	Ontario	San Angelo	St Paul	Sioux Falls	Torrington
Alberta	1.00													
Billings	0.30	1.00												
Clovis	0.14	0.38	1.00											
Cut Out	0.32	0.45	0.54	1.00										
Georgia	0.29	0.37	0.47	0.59	1.00									
Imports	0.04	0.10	0.31	0.26	0.10	1.00								
Lancaster	0.28	0.44	0.33	0.52	0.36	0.23	1.00							
Lean Trim	0.27	0.37	0.48	0.72	0.45	0.25	0.43	1.00						
Oklahoma City	0.49	0.43	0.21	0.45	0.40	0.13	0.51	0.42	1.00					
Ontario	0.19	0.45	0.47	0.53	0.53	0.05	0.50	0.51	0.52	1.00				
San Angelo	0.06	0.11	0.12	0.24	0.07	0.21	0.16	0.33	0.03	0.19	1.00			
St Paul	0.12	0.30	0.28	0.38	0.28	0.04	0.36	0.38	0.34	0.28	0.12	1.00		
Sioux Falls	0.21	0.46	0.39	0.46	0.41	0.09	0.29	0.35	0.36	0.33	0.02	0.30	1.00	
Torrington	0.27	0.51	0.36	0.44	0.34	0.15	0.41	0.36	0.38	0.50	0.20	0.26	0.54	1.00

Table 9. Post BSE Ban Innovation Correlation Matrix

	Alberta	Billings	Clovis	Cut Out	Georgia	Imports	Lancaster	Lean Trim	Oklahoma City	Ontario	San Angelo	St Paul	Sioux Falls	Torrington
Alberta	1.00													
Billings	0.23	1.00												
Clovis	0.19	0.37	1.00											
Cut Out	0.47	0.36	0.49	1.00										
Georgia	0.32	0.35	0.43	0.60	1.00									
Imports	0.05	0.16	0.28	0.23	0.13	1.00								
Lancaster	0.24	0.41	0.38	0.49	0.37	0.25	1.00							
Lean Trim	0.40	0.36	0.48	0.76	0.51	0.26	0.45	1.00						
Oklahoma City	0.31	0.41	0.51	0.58	0.51	0.04	0.50	0.55	1.00					
Ontario	0.48	0.44	0.25	0.48	0.41	0.21	0.50	0.46	0.51	1.00				
San Angelo	0.04	0.13	0.11	0.17	0.01	0.20	0.11	0.24	0.14	0.03	1.00			
St Paul	0.23	0.30	0.33	0.42	0.31	0.10	0.40	0.45	0.35	0.38	0.06	1.00		
Sioux Falls	0.27	0.41	0.33	0.48	0.44	0.15	0.30	0.40	0.35	0.38	-0.01	0.37	1.00	
Torrington	0.28	0.48	0.33	0.41	0.32	0.19	0.34	0.34	0.48	0.40	0.18	0.28	0.54	1.00

Figure 2. Pre BSE Ban Cull Cow Market DAG

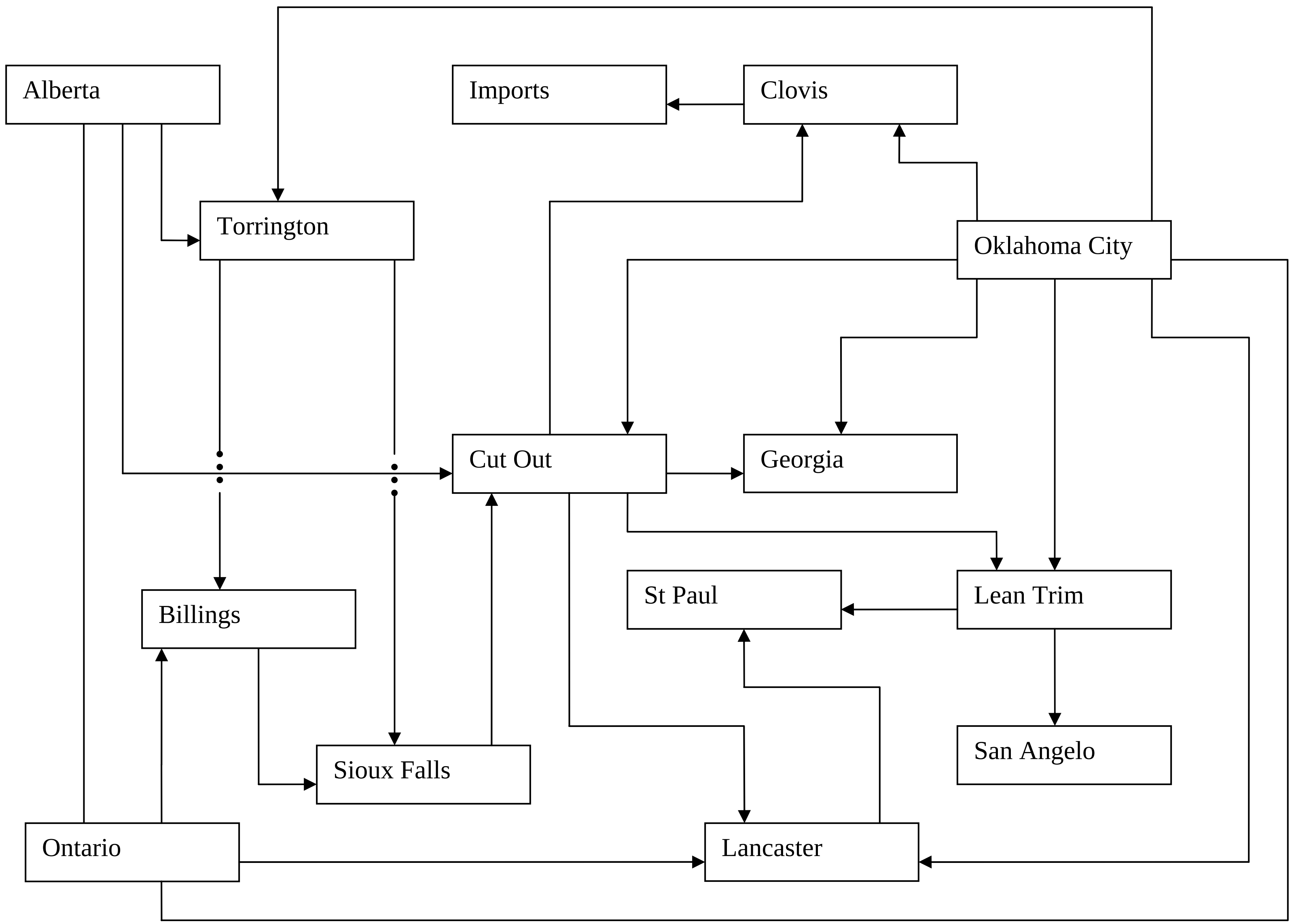
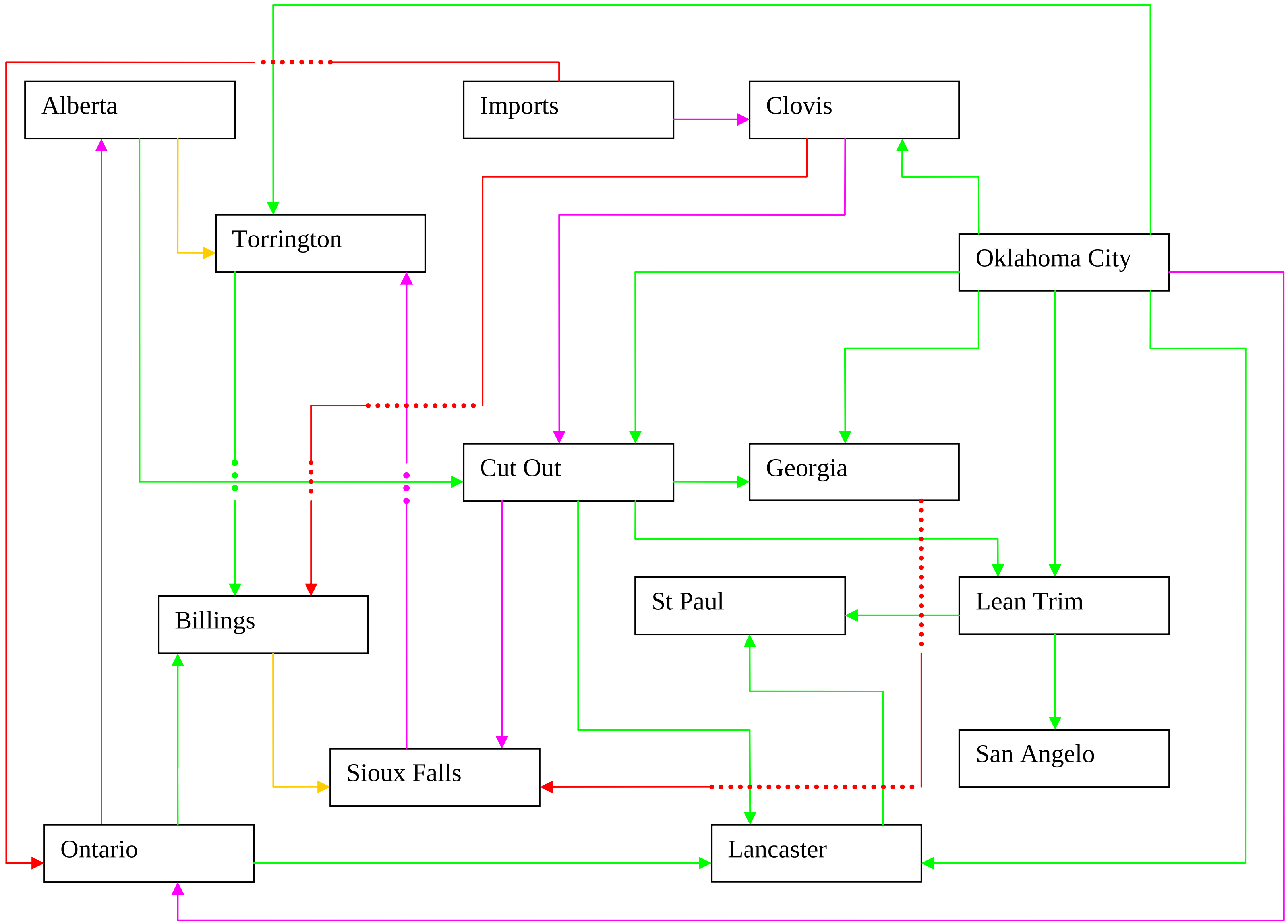


Figure 3. Post BSE Ban Cull Cow Market DAG



Red - new edge, Yellow - eliminated edge, Green - no change in edge, Lavender – change in direction