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# Trade-Related Policy and Canadian-U.S. Fed Cattle Transactions Basis

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Price differences among fed cattle prices in Canada and the United States (referred to here as fed cattle basis) are important for Canadian cattle feeders, but changing government regulations in Canada and the United States have made basis more variable. This article uses transaction data from Canadian feedlots to quantify fed cattle price differentials in light of new policy initiatives. Using transaction prices, we find that differing slaughter regulations, labeling laws, and policies affecting access to U.S. markets for Canadian cattle affect fed cattle basis.

*Key words*: basis, Canada, cattle prices, government policy, international trade, market access, transaction prices

## Introduction

The United States has been an important market for Canadian fed cattle and beef for many years, but Canadian exports of fed cattle and beef to the United States were halted in May 2003 when the first case of bovine spongiform encephalopathy (BSE) was found in Canada. Prior to the BSE discovery, U.S. and Canadian cattle feeding industries were highly integrated. Canada produced more fed cattle than it had capacity to slaughter. American packers were therefore an integral part of the geographic market for Canadian fed cattle (Church and Gordon, 2007). The May 2003 discovery of BSE resulted in immediate closure of international markets to Canadian cattle and beef products. With limited market access, the supply of Canadian fed cattle in the domestic market exceeded slaughter capacity. Grier (2005) noted that the border closure created an excess of 60,000 fed cattle and 20,000 cows per month in Canada during the summer of 2003. This gave Alberta packers negotiating leverage resulting in a substantial decrease in Canadian fed cattle prices. Canada's post-BSE cattle slaughter industry underwent rapid growth with opening of several new processing facilities and expansion of existing plants. The added slaughter capacity was utilized to process cattle domestically that, prior to the border closure, would have been exported (Rude, Carlberg, and Pellow, 2007). Numerous other important policy changes ensued following the May 2003 border closure that impacted cattle and beef trade and Canadian prices relative to U.S. prices.

Marketing and pricing practices for fed cattle in the United States and Canada are similar (Ward, Carlberg, and Brocklebank, 2007). A key factor affecting trade in fed cattle is the cash market basis, or difference, between cash fed cattle prices in Canada and the United States (Schroeder and Ward, 2006). Compared to the United States, Canada is a small fed cattle market. Beef production in Canada averaged only 10% of U.S. production over 2005-2009 (Livestock Marketing Information

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Center, 2010). Furthermore, Canada is a net exporter of fed cattle to the United States. When the border is open to cattle trade, Canadian cattle feeders and Canadian and U.S. packers closely monitor prices in both Canada and the United States to determine relative market opportunities. When fed cattle prices in Canada are high relative to the United States (net of transportation and shrink costs), Canadian cattle feeders sell cattle to Canadian packers. Conversely, when the price of fed cattle in Canada is low relative to the United States, Canadian cattle feeders consider selling to U.S. packers. As such, the difference between the Canadian and U.S. fed cattle price (adjusted for transportation and shrink) influences where cattle are slaughtered under free trade.

Fed cattle basis as used here is defined as the difference between Canadian and U.S. fed cattle prices, adjusted for exchange rates. Basis reflects transportation costs (including shrink) and differences in local supply and demand between Canadian and U.S. markets. Generally speaking, a narrow basis (meaning there is little difference between Canadian and U.S. fed cattle cash prices) that is relatively stable over time, with fluctuations simply reflecting transportation and local market fundamentals, indicates integrated markets. Because the Canadian to U.S. fed cattle basis is generally negative, a narrowing basis means that the basis is becoming less negative.

The primary objective of this article is to determine how changing government regulations in Canada and the United States have affected transaction prices for fed cattle in Alberta relative to the United States. Notably, we examine policies affecting Canadian cattle and beef trade flows with the United States, domestic regulations affecting beef processing in Canada, and mandatory country of origin labeling in the United States. Emphasis is placed on quantifying effects of changes in costs and market access for Alberta fed cattle to U.S. packing plants.

Prior to the 2003 border closure, the United States was an important market for Canadian fed cattle. Canada had an excess supply of cattle because the country's cattle feeding industry expanded beyond its slaughter capacity (Fairbairn and Gustafson, 2005). As a result, nearly one million head of cattle annually were exported from Canada to the United States for slaughter prior to the 2003 border closing (Livestock Marketing Information Center, 2010). Trade flow numbers indicate highly integrated Canadian and U.S. livestock and beef markets until May 2003 (Miljkovic, 2006).

In May 2003, Canadian fed cattle and beef exports to the United States were halted, then gradually reopened several months later. The ban on cattle exports created an excess supply of fed cattle in Canada. The result was a 65% reduction in Canadian fed cattle prices from April to July 2003 (Canfax Research Services, 2009), illustrating the importance of U.S. market access for Canadian fed cattle prices. Ward, Brocklebank, and Carlberg (2006) concluded that changes in market policies and economic conditions in either country affect the Canadian fed cattle market because of Canadian cattle market dependence on trade with the United States.

Since full reopening of the border in fall 2005, fed cattle exports from Canada to the United States have been affected by market conditions and a myriad of government regulations enacted in Canada, the United States, and globally. On a broader scale the World Organization for Animal Health (OIE) officially designated Canada as a "BSE Controlled Risk Country" in May 2007 (Canadian Food Inspection Agency, 2007a). This designation enhanced Canada's export capabilities, because it confirms that Canadian regulatory controls are effective and that fresh beef and beef products from cattle of all ages can be safely traded.

Since 2003, many factors have influenced the Canadian to U.S. fed cattle basis. Notable changes include transportation and labor costs, packer ownership and structure, cow slaughter in Canadian plants, regulations governing live cattle and beef trade with the United States, regulations affecting processing costs, and introduction of mandatory country of origin labeling in the United States. All of these factors could impact Canadian fed cattle prices relative to the United States. Knowing how these factors affect live cattle basis over time is essential to Canadian cattle producers who use basis when negotiating and discovering fed cattle sale prices and in making decisions about whether to sell cattle to U.S. packers.

*Characterizing Basis Variability*

Past research provides a foundation for modeling fed cattle transactions and basis determinants. Fed cattle sale prices vary across transactions and over time. Several previous studies have examined fed cattle transaction price determinants. These studies have generally found sale lot characteristics (e.g., lot size, animal weight, distance between feedlot and packer) and market conditions (e.g., transportation costs, plant capacities, seasonality) explain much of the variability in transaction prices within a particular market (Ward, 1992; Jones et al., 1992; Schroeder et al., 1993; Schroeder, 1997; Ward, Koontz, and Schroeder, 1998; Muth et al., 2008). Most empirical work has examined factors in markets with relatively stable trade-related policies and regulations. Recently there has been an increase in the number of trade policy and industry regulation changes in both Canada and the United States involving live cattle and beef. Despite claims about the importance of these policies on fed cattle trade between Canada and the United States, the price impacts of industry regulations and trade policies have not been well established. This is the first study to incorporate trade-related market access policies and export regulations into a model of fed cattle transaction price determinants.

CanFax collects and summarizes negotiated fed cattle prices reported to them on a voluntary basis. However, important structural changes have occurred in the Canadian fed cattle market, resulting in a smaller proportion of cattle trade being represented in CanFax cash price quotes. These changes include more cattle being sold on a grid instead of negotiated cash trade and variation over time in packer feeding of cattle. These changes raised concerns about selective reporting and representativeness of reported prices (Schroeder and Ward, 2006). Similar concerns prompted the regulation of mandatory fed cattle price reporting in the United States in 2001. Use of transaction data alleviates concerns associated with representativeness of voluntarily reported negotiated fed cattle prices in Canada. Sampling bias could still be present in the transaction data used in this study, since only data from participating feedlots are used. Modeling individual transaction prices enables us to estimate factors affecting individual sales transactions that could not be accounted for using aggregate CanFax data. For example, we are better able to adjust for pen characteristics that were changing over time as policies were changing (e.g., animal weights, distance from feedlot to the buyer's packing plant, domestic versus export plant sales).

In most prior studies of fed cattle transactions, price received for each lot of cattle is modeled as the dependent variable. In this study we use basis as the dependent variable. Basis is defined here as an individual transaction price for cattle sold from an Alberta feedlot minus that day's weighted average 5-market (Texas-Oklahoma, Kansas, Colorado, Nebraska, Iowa-Minnesota) fed cattle summary price (converted to Canadian dollars). Five-market prices are weighted-average prices for direct trade, Choice live-weight steers, reported by the United States Department of Agriculture (USDA). We model basis as the dependent variable instead of actual transaction price received because the price differential between Canada and the United States, not the actual price level, is of most interest as we explore the impacts of policy and regulatory changes on Canadian cattle prices. By using basis, we can focus our modeling efforts on factors causing variation in the difference in prices across the two countries. Movements in basis are in response to deviations in Canadian transaction prices relative to U.S. aggregate price. Ultimately, recent basis is what Canadian cattle feeders and packers monitor as they negotiate transaction prices.

We use a hedonic model to estimate the impact of various transaction characteristics and market factors on Alberta-U.S. fed cattle basis. The underlying assumption is that fed cattle transactions can be distinguished by cattle characteristics. Therefore, demand for desired characteristics can be derived from a packer's willingness-to-pay. The basis equation specification is:

$$b_i = \alpha_0 + \sum_{j=1}^{J} \beta_j TC_{ij} + \sum_{k=1}^{K} \gamma_k MC_{ik} + \varepsilon_i, \tag{1}$$

where $b_i$ is the basis for the $i^{th}$ transaction (time subscripts ($t$) on each variable are omitted for convenience), the intercept is represented as $\alpha_0$ with $\varepsilon_i$ as white noise error term, $TC$ is the $j^{th}$ characteristic of animals in the $i^{th}$ transaction, $MC$ is the $k^{th}$ market condition of the $i^{th}$ transaction, and $\beta_j$ and $\gamma_k$ are parameters to be estimated (Bailey, Brorsen, and Fawson, 1993; Feuz et al., 2008).

## Data

We collected data on fed cattle sales from seven feedlots located in the Alberta market region over the January 2006 through April 2009 time period.[1] Transactions from the seven feedlots included 4,091 useable sales records. The sales records represent prices per cwt for pens of cattle sold. Data recorded for each transaction included shipment date, net proceeds - $CAD (included are check-off, brand inspection, grading, transportation costs, and export costs in the case of export sales), type of sale (live or dressed sales), pricing method (cash or grid), lot size, animal sex, average live weight, feedlot location, buyer (packing plant), and distance from feedlot to the buyer's packing plant.

A bid date for each transaction, as opposed to shipment date, was needed to identify the appropriate daily weighted average 5-market U.S. price to be used in calculation of basis. Approximately 20% of the bid dates were missing from the data. Therefore, we used eight days prior to the date of cattle shipment to the packer (average of the available bid dates) as a rule to establish missing bid dates.

To obtain a consistent price series, all transaction prices were converted to live-weight equivalent prices ($CAD/cwt) at the packing plant. Average live weight (not adjusted for shrink) was calculated as the total sale gross live weight at the feedlot divided by the total number of animals sold in the transaction. Some cattle were sold based on live weight, while others were sold based on dressed weight. All prices were adjusted to live weight. For live sales, net proceeds were divided by total sale live weight and then adjusted for pencil shrink to arrive at a $CAD/cwt price. There were 1,404 live sale transactions; average pencil shrink was 4.82% with a range of 2.50% to 5.02%. For dressed sales, net proceeds (with shipping charges to the plant deducted) were divided by total sale live weight to arrive at a $CAD/cwt price.

Basis levels for all transactions are illustrated in figure 1. Each point in figure 1 represents an Alberta feedlot transaction price minus the 5-market U.S. price (note that multiple transactions occur on some days and none on others). The average basis was -$10.02/cwt; however, considerable variation is present over time and across transactions. Because basis is negative, a narrower basis means that the basis has become less negative (that is, the Canadian transaction price is approaching the U.S. fed cattle price from below).

Specific feedlot and packing plant names cannot be identified for confidentiality reasons. Therefore, we identify the feedlots as *Feedlot 1* through *Feedlot 7* and the packing plants as *Plant 1* through *Plant 8*. Additional data in our model includes: west coast diesel fuel prices available from the Energy Information Center (converted to Canadian dollars); regional federally-inspected steer and heifer slaughter in the United States, reported by USDA and available from the Livestock Marketing Information Center (LMIC); regional steer and heifer slaughter in Canada from CanFax; and weekly federally-inspected (e.g., all cattle) slaughter capacity utilization in Canada from CanFax. All relevant price series were adjusted for exchange rate. Canadian-U.S. dollar exchange rates were available from CanFax.

In addition to details of individual transactions, three dates and types of government policy and regulatory events were hypothesized to affect Alberta fed cattle transaction prices relative to U.S. prices:

[1] A sale of at least ten head of cattle at a particular feedlot on a particular day to a packer was considered a single transaction.

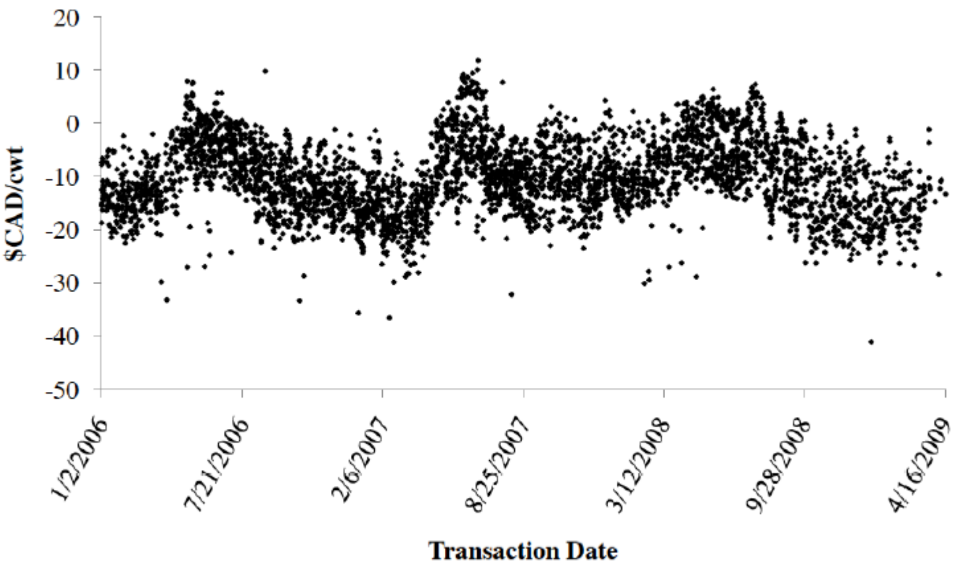


**Figure 1. Alberta Fed Cattle Transactions Basis, January 2006 through April 2009**

1. July 12, 2007 - Canadian Food Inspection Agency (CFIA) announced that cattle tissue capable of transmitting BSE, known as specified risk material (SRM), was banned from all animal feed (Canadian Food Inspection Agency, 2007a).[2]

2. November 20, 2007 - Approval of Rule 2 in the United States which allowed for exporting of beef (of all ages) and live cattle born after March 1, 1999, to the United States for slaughter and breeding purposes.[3]

3. September 30, 2008 - Implementation of mandatory country of origin labeling in the United States, with a six-month grace period before retailers were to be charged for non-compliance.[4]

## Empirical Modeling

Table 1 provides definitions and table 2 provides summary statistics of variables used in this study. Variables included in the model were drawn from previous research (see Ward, 1981, 1992; Jones

[2] "Under the enhanced feed ban, producers can no longer feed any animal products containing SRM to livestock and abattoirs must properly identify SRM to ensure that it is removed from the feed system. In addition, a permit from the CFIA is required to handle, transport or dispose of cattle carcasses and certain cattle tissues" (Canadian Food Inspection Agency, 2007a).

[3] Age can be confirmed in one of three ways: (i) birth records (farm records or Canadian Cattle Identification Agency (CCIA) birth certificate); (ii) by visual assessment (if under 3 years of age); (iii) dentition. Cattle for breeding, feeding, or shows need to be designated as Canadian cattle by a CAN hot iron or freeze brand or a CAN tattoo in the left ear, while animals for immediate slaughter do not require a brand or tattoo. Cattle must have CCIA tags, and the CCIA tag numbers must be recorded on the export certificate, as well as sex, age, breed, and description. All export loads must be accompanied by an official CFIA Health Certificate, which is valid for 30 days after inspection (Canadian Food Inspection Agency, 2007b).

[4] "The Farm Security and Rural Investment Act of 2002 (2002 Farm Bill), the 2002 Supplemental Appropriations Act (2002 Appropriations), and the Food, Conservation and Energy Act of 2008 (2008 Farm Bill) amended the Agricultural Marketing Act of 1946 (Act) to require retailers to notify their customers of the country of origin of covered commodities" (United States Department of Agriculture. Agricultural Marketing Service (USDA-AMS), 2009, p. 2658).

et al., 1992; Schroeder et al., 1993; Schroeder, 1997; Ward, Koontz, and Schroeder, 1998; Ward, 2005; Muth et al., 2008). The cash market basis for each lot of cattle was modeled as:

$$
\begin{aligned}
BASIS_{it} = \quad & CTRP_{it} - 5MRKTCP_t = \\
& f(DDOW_{dt}, DMON_{mt}, NOHD_{it}, WGHT_{it}, \\
& WGHT_{it}^2, DSX_i, DMETHOD_i, DISTP_i, WCDP_t, CAP_t, \\
& SHWCNUS_t, DFLT_i, DPPT_i, FSRM_{it}, RULE2_{it}, MCOOL_{it}),
\end{aligned} \tag{2}
$$

where $i$ refers to an individual transaction at time $t$. Buyer activity has been shown to exhibit a within-week pattern (Ward, 1990), suggesting a corresponding within-week price pattern. Dummy variables for each day of the week (*DDOW*) were included to allow for day-of-week patterns in buying activity. Seasonality (*DMON*) is expected to have varied effects on basis depending on seasonal supply and demand conditions.

Our independent variable is the basis calculated for individual transactions. As such, characteristics unique to each pen of cattle in the transaction, such as number of head and weight, might affect the transaction price, *ceteris paribus*, and thus the basis for that transaction. Therefore, to account for specific attributes of cattle in a transaction, we include individual pen characteristics as explanatory variables in the model. A lot size variable was included (*NOHD*) because per unit procurement costs for meatpackers decline as sale lot size increases (Ward, 1992). The average weight of marketed cattle (*WGHT*) is included because packers prefer cattle within a specific weight range. Both linear and quadratic terms for weight were included because this variable was expected to be nonlinearly related to basis. A dummy variable for cattle sex (*DSX*) accounts for quality differences among cattle associated with gender. Across feedlots, different types of pricing methods were used. Grid pricing and individually negotiated prices (*DMETHOD*) were each used on about one-half the transactions in the data set. Grid prices may be higher or lower than cash prices and, thus, are expected to have varied effects on basis depending on feedlot/packer relationships. Distance from a feedlot to a packing plant (*DISTP*) is expected to have a negative effect on basis. Additional basis determinants used in our model include diesel fuel prices (*WCDP*) to account for changing transportation costs over time, measures of packing plant capacity utilization (*CAP*), and steer and heifer slaughter differences (*SHWCNUS*) to account for variation in local competition or changing feedlot versus packer market leverage over time.

We include market and trade policy variables in the specification to estimate their impacts on fed cattle basis. We include a binary variable for the ban of SRM in Canada (*FSRM*), which accounts for additional costs incurred by Canadian packers for handling, transporting, or disposing of SRM, thus decreasing the return from slaughtering cattle in Canada. Resumption of trade for cattle older than thirty months (*RULE2*), between Canada and the United States was included as a binary variable to determine whether this regulation had an impact on basis. Increasing access of older cattle to U.S. markets would be expected to strengthen basis if it reduces excess supply of cattle in Canada.

The implementation of mandatory country of origin labeling in the United States warrants an *ex post* evaluation of this policy's economic impacts on beef and cattle trade. Mandatory country of origin labeling requires labeling the provenance of fresh beef and numerous other products). Proponents of mandatory country of origin labeling have argued that the impact of animal diseases (e.g., BSE) on the U.S. beef and cattle industries would have been lessened if a country of origin or regional labeling system had been in place when the first U.S. BSE incidence occurred. We include a binary variable for the introduction of mandatory country of origin labeling (*MCOOL*) to determine whether this regulation had an impact on basis.

**Table 1. Definitions of Variables**

| Variable | Definition |
|---|---|
| *BASIS* | Feedlot specific Canadian fed cattle transaction live price minus daily weighted average 5-market fed cattle live steer cash price, adjusted for Canadian exchange rate ($/cwt live weight) |
| *CTRP* | Feedlot specific Canadian fed cattle transaction live price ($/cwt live weight) |
| *5MRKTCP* | Daily weighted average 5-market fed cattle live cash market price, adjusted for Canadian exchange rate ($/cwt live weight) |
| *DDOW* | Zero-one dummy variable for the day of the week cash market cattle were purchased (Sunday, Monday,..., Saturday) |
| *DMON* | Zero-one dummy variable for month of the year cash market cattle were purchased (January, February,..., December) |
| *NOHD* | Number of head in the sale lot |
| *WGHT* | Average live weight in the sale lot (pounds/head) |
| *DSX* | Zero-one dummy variable for the type of cattle purchased (steers, heifers, mixed/unidentified sex) |
| *DMETHOD* | Zero-one dummy variable for pricing method (grid or cash) |
| *DISTP* | Distance to packer (kilometers) |
| *WCDP* | West coast diesel fuel price, adjusted for Canadian exchange rate (cents/gallon) |
| *CAP* | Canadian packing plant utilization rate during the data period (%) |
| *SHWCNUS* | Ratio of western Canada steer & heifer slaughter volume (number of head) to western U.S. steer & heifer slaughter volume (%) |
| *DFLT* | Zero-one dummy variable for the feedlot that sold cash market cattle (feedlot 1, feedlot 2,..., feedlot 7) |
| *DPPT* | Zero-one dummy variable for the packing plant that purchased cash market cattle (plant 1, plant 2,..., plant 8) |
| *FSRM* | Zero-one dummy variable for the enactment of the enhanced feedban and specified risk materials regulation (July 12, 2007) |
| *RULE2* | Zero-one dummy variable or the approval of Rule 2 which allowed for exporting of beef (of all ages) and live cattle born after March 1, 1999 for slaughter and breeding purposes (November 20, 2007) |
| *MCOOL* | Zero-one dummy variable for the enactment of Mandatory COOL in the U.S. (September 30, 2008) |
| *AWAGE* | Monthly reported Alberta meat product manufacturing wage unadjusted for seasonality and excluding overtime ($/hour) |

*Notes:* All prices are in Canadian dollars unless otherwise noted.

**Table 2. Selected Summary Statistics, 4,092 Alberta Fed Cattle Transactions**

| Variable | Unit | Mean | Std. Dev. | Min. | Max. |
|---|---|---|---|---|---|
| *BASIS* | $/cwt | −10.02 | 6.76 | −41.07 | 11.82 |
| *CTRP* | $/cwt | 88.00 | 7.29 | 60.29 | 112.01 |
| *5MRKTCP* | $/cwt | 98.03 | 6.88 | 82.53 | 117.00 |
| *NOHD* | head | 194.65 | 175.29 | 10.00 | 1548.00 |
| *WGHT* | lbs | 1358.96 | 78.70 | 1002.12 | 1656.38 |
| *DISTP* | kilometers | 353.40 | 404.94 | 14.00 | 2,100.00 |
| *WCDP* | cents/gallon | 337.55 | 59.44 | 255.92 | 482.48 |
| *CAP* | % | 71.84 | 4.71 | 62.33 | 82.72 |
| *SHWCNUS* | % | 18.22 | 2.26 | 13.93 | 28.28 |
| *AWAGE* | $/hour | 17.99 | 1.07 | 14.91 | 20.48 |

*Notes:* All prices are in Canadian dollars unless otherwise noted.

## Econometric Procedure

The transactions data represent a panel consisting of many sales across time. The panel of transactions is unbalanced in that there are different numbers of sale lots for each feedlot across time. Panel data have traditionally been analyzed using unobserved effects models. The use of a fixed effects estimator allows us to control for the time invariant unobservable factors that may impact the Alberta-U.S. fed cattle cash basis.[5] Consider the model:

$$y_{it} = (\alpha + c_i) + \boldsymbol{x}_{it}\beta + u_{it} \quad i\text{=feedlot } 1, 2, ..., 7 \quad \text{and} \quad t\text{=}1, 2, ..., T, \tag{3}$$

where $\alpha$ is the overall model intercept; $c_i$ is the time invariant feedlot effect considered part of the intercept; $\boldsymbol{x}_{it}$ is a 1x$K$ row vector of observable variables that change across $t$ but not $i$, variables that change across $i$ but not $t$, and variables that change across $i$ and $t$; $\beta$ is a $K$x1 parameter vector of marginal effects of these variables; and $u_{it}$ are the idiosyncratic errors which change across $t$ as well as across $i$ (Wooldridge, 2002). Because of the small number of feedlots, we generate a dummy variable for each and include them as part of the $c_i$ component. The regression is a least squares dummy variable (LSDV), a fixed effects model with constant slopes but intercepts that differ according to the cross-sectional (group) unit, in this case, feedlots.

The packing plant capacity utilization variable (*CAP*) is potentially endogenous, as it may be influenced by basis. The two-stage Hausman procedure is used to test for endogeneity. The first stage involves regressing the packing plant capacity utilization variable on all exogenous variables and the monthly Alberta hourly meat product manufacturing wage (unadjusted for seasonality and excluding overtime). The second stage involves estimating equation (2) with the residuals from the first stage as an additional explanatory variable. The null hypothesis of no endogeneity was rejected at the 1% significance level. Therefore, we use an instrumental variable for *CAP*, obtained by regressing all exogenous variables and instrumental variables on the endogenous variable. This new instrumental variable replaces the endogenous variable in a second stage regression. Consequently, the hedonic model was estimated using two-stage least squares (2SLS).

The data utilized in this study have repeated observations per cross-section and over time for individual feedlots. As a result, the errors are potentially serially correlated (i.e., correlation over $t$ for a given $i$) and/or heteroskedastic. Inclusion of fixed individual-specific effects can reduce serial correlation (Cameron and Trivedi, 2005).[6] To obtain efficient coefficient estimates, first-order serial correlation was accounted for using the Cochrane-Orcutt iterative procedure (Cochrane and Orcutt, 1949). A Pagan-Hall test of heteroskedasticity rejected the null hypothesis that the error variances are equal. White's heteroskedasticity consistent covariance matrix is used to estimate standard errors.[7]

Following Greene (2003), an $F$-test, resembling the structure of the $F$ test for $R^2$ change, is used to test the hypothesis that the feedlot-specific constants are all equal. Thereby testing the significance of the individual feedlot fixed effects. The $F$ ratio used for this test is:

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[5] The Durbin-Wu-Hausman (DWH) test was used to determine if the time invariant unobservable factors should be treated as a fixed effect or random effect (Wu, 1973). The test was performed by obtaining the group means of the time invariant variables and adding them to the estimated random effects model. Then the joint hypothesis that the coefficients on the group means are all zero was tested. The hypothesis that the individual effects are uncorrelated with the other regressors was rejected. This suggests that these effects are correlated with other variables in the model, thus the fixed effects model is appropriate.

[6] In order to test for serial correlation, a time variable must be specified. However, for this data there was not a consistent time variable because we often have zero or more than one observation per time period per cross section. Thus, to detect the presence of first-order serial correlation, the mean of the errors from equation (3) were computed for each unique transaction date. These mean errors were utilized in a Cochrane-Orcutt procedure, which showed a statistically significant (Rho) first-order autocorrelation estimate.

[7] White's robust standard error estimation was used instead of feasible generalized least squares (FGLS) because the loss of efficiency in parameter estimates is rather small given the large sample size. Results using the FGLS estimator were quantitatively similar.

(4) $$F\left(n-1, \sum_{i=1}^{n} T_i - n - K\right) = \frac{(R^2_{LSDV} - R^2_{Pooled})/(n-1)}{(1 - R^2_{LSDV})/(\sum_{i-1}^{n} T_i - n - K)},$$

where *LSDV* and *Pooled* indicate a LSDV model and a pooled model with only a single intercept for *n* feedlots and *T* time periods. Under the null hypothesis that the feedlot-specific constants are the same, this statistic is an $F$ random variable with $n$-1 numerator and $nT - n - K$ denominator degrees of freedom. The value of the $F$ random variable is $F(6, 4039)$ = 1297.25 ($p$-value = 0.000). This shows that the feedlot-specific constants differ and a pooled model with one intercept is not appropriate. Overall, we conclude that the alternative pooled model omits important time-invariant feedlot effects, and hence we use a feedlot fixed effects model.

## Results

Empirical results for the basis model are presented in Table 3. Results show estimated coefficients from the basis model with accompanying heteroskedasticity-robust standard errors. Coefficient estimates refer to a change in basis in $CAD/cwt from a one unit change in the independent variable, *ceteris paribus*. Positive coefficients represent a strengthening/narrowing basis, meaning the Alberta fed cattle transaction price is increasing relative to the U.S. fed cattle price. Negative coefficients indicate a weakening/widening of the basis.

One day-of-the week dummy variable was statistically significant, indicating there was a systematic day-of-week basis pattern. Monday Alberta fed cattle transaction prices were lower than Sunday prices, resulting in a widening of basis. Monthly dummy variables revealed seasonality in basis.

Basis narrowed (i.e., the transaction price increased relative to the U.S. fed cattle price) as transaction lot size increased. In Canada, cattle feeders typically sort cattle for uniformity in preparation for sales to packers. Thus, a single transaction may contain animals that originated from several different pens. In contrast, U.S. cattle feeders usually sell cattle to packers based on unsorted pens. As such, Canadian cattle transactions often consist of more than 500 cattle (whereas U.S. transactions contain 200-400 head). An additional 100 head of cattle results in a $0.20/cwt stronger basis for an individual transaction. Packers prefer larger lot sizes to reduce buying search costs. Our model has a dependent variable of individual transaction prices minus the U.S. fed cattle average market price. As such, unique pen characteristics for a particular transaction, such as lot size, impact the transaction price for that pen relative to the aggregate U.S. price.

The affect on basis of an additional pound of live animal weight was quadratic. Basis strengthened as average live weight of an individual transaction increased from 1,000 lbs to 1,280 lbs by about $4.20/cwt; basis weakened as live weight increased beyond 1,280 lbs. Higher prices are typically realized for cattle that meet packers' preferred weight specifications, because light-weight cattle reduce slaughter and processing efficiency and heavy-weight cattle produce excessively large wholesale products relative to customer preferences. As such, the transaction price for a pen of cattle, *ceteris paribus*, changes with the weight of cattle in the transaction.

Basis decreased with the distance from a feedlot to a packer at a rate of about $0.10 per cwt per 100 km. That is, the Canadian fed cattle transaction price relative to the U.S. fed cattle price declined as distance from the feedlot to the purchasing packing plant increased. These findings are similar to previous studies involving fed cattle transaction prices (Jones et al., 1992; Schroeder et al., 1993; Schroeter and Azzam, 2003).

Diesel fuel prices were included in the model as a proxy for changes in transportation costs between Canada and the U.S. Increasing diesel fuel prices adversely affected the Alberta-U.S. basis, as a one cent per gallon increase in diesel fuel price reduced the Alberta-U.S. basis by $0.03/cwt.

**Table 3. Panel Data Regression Estimates of Transactions Basis Model**

| Independent Variable | Coefficient Estimate | Independent Variable | Coefficient Estimate | Independent Variable | Coefficient Estimate | Independent Variable | Coefficient Estimate |
|---|---|---|---|---|---|---|---|
| Intercept | −109.38*** | Day-of-Week | | Animal Sex | | Packer (Default = $DPPT_1$) | |
| | (16.64) | (Default = $DDOW_{Sunday}$) | | (Default = $DSX_{Mixed/Unidentified}$) | | $DPPT_2$ | −0.68** |
| | | $DDOW_{Monday}$ | −0.61** | $DSX_{Steer}$ | −0.15 | | (0.28) |
| Month-of-Year | | | (0.26) | | (0.26) | $DPPT_3$ | 2.16*** |
| (Default = $DMON_{January}$) | | $DDOW_{Tuesday}$ | −0.44 | $DSX_{Heifer}$ | 0.68** | | (0.51) |
| $DMON_{February}$ | 0.49 | | (0.28) | | (0.28) | $DPPT_4$ | −3.09*** |
| | (0.37) | $DDOW_{Wednesday}$ | −0.47 | | | | (0.49) |
| $DMON_{March}$ | 1.45*** | | (0.29) | Pricing Method | | $DPPT_5$ | −2.55*** |
| | (0.41) | $DDOW_{Thursday}$ | 0.12 | (Default = $DMETHOD_{Cash}$) | | | (0.73) |
| $DMON_{April}$ | 5.57*** | | (0.30) | $DMETHOD_{Grid}$ | 0.53 | $DPPT_6$ | 2.29*** |
| | (0.44) | $DDOW_{Friday}$ | 0.39 | | (0.59) | | (0.66) |
| $DMON_{May}$ | 9.39*** | | (0.34) | | | $DPPT_7$ | 3.26*** |
| | (0.56) | $DDOW_{Saturday}$ | 0.41 | Continuous Factors | | | (0.88) |
| $DMON_{June}$ | 8.92*** | | (0.50) | *NOHD* | 0.002*** | $DPPT_8$ | 4.14*** |
| | (0.93) | Feedlot | | | (0.00) | | (0.85) |
| $DMON_{July}$ | 8.37*** | (Default = $DFLT_1$) | | *WGHT* | 0.14*** | | |
| | (0.45) | $DFLT_2$ | 5.45*** | | (0.02) | Policy and Regulatory Changes | |
| $DMON_{August}$ | 4.80*** | | (0.60) | *WGHT2* | −0.0001*** | *FSRM* | 0.16 |
| | (0.43) | $DFLT_3$ | 2.78*** | | (0.00) | | (0.67) |
| $DMON_{September}$ | 2.29*** | | (0.73) | *DISTP* | −0.001** | *RULE2* | 4.98*** |
| | (0.49) | $DFLT_4$ | 7.50*** | | (0.00) | | (0.51) |
| $DMON_{October}$ | 2.75*** | | (0.26) | *WCDP* | −0.03*** | *MCOOL* | −6.04*** |
| | (0.47) | $DFLT_5$ | 4.03*** | | (0.00) | | (0.40) |
| $DMON_{November}$ | 2.02*** | | (0.68) | *CAP - inst. var.* | 0.17 | | |
| | (0.42) | $DFLT_6$ | 0.36 | | (0.14) | Rho | 0.3 |
| $DMON_{December}$ | 0.87** | | (0.69) | *SHWCNUS* | −0.15 | $R^2$ | 0.658 |
| | (0.36) | $DFLT_7$ | 1.11*** | | (0.10) | RMSE | 3.393 |
| | | | (0.42) | | | Observations | 4090 |

*Notes:* Numbers in parenthesis are standard errors. Single, double, and triple asterisks (*, **, ***) indicate significance at the 10%, 5%, and 1% level, respectively.

Heifers had a $0.68/cwt stronger basis and steers had no difference in basis relative to lots of mixed or unidentified gender. Cattle sold using grid pricing did not have statistically different basis than cash sales.

Statistically and economically significant feedlot and packer effects were present. Basis varies across feedlots by as much as $7.50/cwt relative to the base feedlot. Differences exist due to relationships with certain packers and/or market access in the domestic or export market. Also, which packer bought the cattle in a transaction resulted in significantly different basis levels ranging from -$3.09/cwt to $4.15/cwt relative to the base packer.

The announcement and implementation of the Canadian feed ban (*FSRM*) was expected to adversely affect the Canadian-U.S. basis. Specifically, regulations requiring removal of SRM from carcasses during processing were expected to increase Canadian slaughter costs, relative to the United States, resulting in lower fed cattle bids from Canadian packers relative to U.S. packers. The coefficient estimate associated with SRM removal regulations was not statistically different from zero. One possible reason for the lack of an effect may be that a somewhat less restrictive feed ban on specified risk material had been implemented years earlier. The CFIA instituted a national surveillance program for BSE in 1992, and in 1997, a preemptive feed ban was instituted that prohibited feeding of most protein materials from mammals to ruminant animals.

Full resumption of cattle and beef movement across the Canadian-U.S. border (*RULE2*) positively and statistically significantly affected the Alberta basis. Because basis is negative, this positive impact results in a narrowing of the basis by $4.98/cwt. That is, Rule 2 caused Alberta fed cattle transaction prices to move closer to the U.S. prices as the U.S. market became a more accessible market for Canadian cattle. Competition from U.S. packers for fed cattle from Alberta feedlots, under full resumption of cattle and beef trade, caused Alberta and U.S. cattle prices to converge.

*MCOOL* was statistically significant and associated with a $6.04/cwt decline in basis for Alberta fed cattle transactions, indicating the Alberta fed cattle transaction price decreased relative to the U.S. price. Mandatory country of origin labeling has limited the harvest of Canadian fed cattle to just a few U.S. plants (and in some cases plants slaughter Canadian cattle only during certain days), adversely affecting Canadian exports of fed cattle. Mandatory country of origin labeling requires, among other things, that beef sold in the U.S. be labeled with the country where the animal was born. Mandatory country of origin labeling results in U.S. packers incurring extra costs associated with separating meat from Canadian-born cattle versus U.S.-born cattle. Thus, U.S. companies that continue to purchase Canadian cattle have reduced their bid prices to offset additional costs of managing inventories.

## Conclusions and Implications

Alberta to U.S. fed cattle cash basis determinants are important for Canadian cattle feeders because Alberta prices rely heavily upon access to the U.S. market. Basis is defined here as the Alberta feedlot transaction price minus the daily weighted average 5-market (Texas-Oklahoma, Kansas, Colorado, Nebraska, Iowa-Minnesota) fed cattle summary price (converted to Canadian dollars). Strengthening basis means the Alberta fed cattle transaction price is increasing relative to the U.S. fed cattle price. Alternatively, a weakening basis indicates that Alberta cattle prices are decreasing relative to U.S. prices. When cattle feeders in Alberta sell cattle, they regularly monitor cash basis to gauge the competitiveness of bids from packers. Weak basis encourages Alberta feedlots to consider exporting live cattle, whereas strong basis encourages them to sell to local packers. Of considerable interest to Canadian cattle feeders is how trade related policy changes have affected cash basis for their cattle in recent years. For example, Canada (and Mexico) has recently filed a complaint with the World Trade Organization regarding U.S. mandatory country of origin labeling regulations. The complaint alleges economic damages to the Canadian cattle industry from the U.S. policy, resulting in reduced fed cattle prices in Canada. Our study estimates the magnitude of this and other important trade policy impacts on Canadian fed cattle prices.

The Canadian government's regulation against feeding products containing specific risk material to livestock may have increased access to the U.S. market because the regulation was intended to decrease risk of disease transmission. However, the policy also likely increased Canadian slaughter costs. This regulation did not statistically alter Alberta fed cattle prices relative to the United States. The new feeding regulation apparently increased slaughter costs for the Canadian processing industry relative to the U.S. by roughly the same amount that it expanded market access for Canadian cattle. Regulation that increased market access, Rule 2, strengthened basis by $4.98/cwt. This demonstrates the importance to Canadian cattle feeders of unrestricted access to the U.S. market. Mandatory country of origin labeling in the U.S. adversely affected Alberta fed cattle basis. Canfax Research Services's (2009, p. 4) claim that "while mandatory country of origin labeling is not a direct barrier to market access it has resulted in decreased demand for Canadian cattle by U.S. packers and therefore has influenced Canadian fed cattle prices" is supported by our research. Mandatory country of origin labeling enactment widened Alberta fed cattle transaction basis by $6.04/cwt. The disruptions to Canadian producers involved in mixed country of origin supply chains have been considerable.

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