Asymmetric Price Transmission and Volatility Spillovers in Alberta Cattle, Feed Barley and U.S. Corn Markets

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Background and Objectives

- The Canadian cattle industry has faced a number of shocks over the last decade – BSE, feed price surges and overall consolidation in herd size.
- This study aims to assess:
  - Price volatilities in the Alberta cattle, feed barley and the U.S. corn markets.
  - Market interdependencies among the aforementioned markets.
  - We included the U.S. corn market as Alberta feedlot owners are starting to import U.S. corn as a substitute for barley (Crawford et al 2012), this would potentially create a direct link between the Alberta cattle and the U.S. corn markets.

Methodology (Price Volatility)

- We used the diagonal Asymmetric Generalized Dynamic Condition Correlation GARCH (AG-DCC GARCH) model (Cappiello et al 2006).
- Two stage estimation is utilized.
- The first stage is to build the mean and variance models.
  - For mean equations, we estimated a penta-variate VAR model and included error correction terms where appropriate.
  - For variance equations, we selected proper conditional variance structures among the Exponential and GJR GARCH models (Nelson 1991; Glosten et al 1993).
- In the second stage, the dynamic conditional correlation model is build upon the standardized residuals from the first stage.
- To illustrate, assuming a bivariate Vector Error Correction model:

$$Z_t = \omega + \sum_{i=1}^{p} \Pi_i Z_{t-i} + \Phi ECT_{t-1} + E_t;$$

$$Z_t = \begin{bmatrix}\Delta p_{1,t} \\ \Delta p_{2,t}\end{bmatrix}, E_t|\Omega_{t-1} \sim (O, H_t), H_t = \begin{bmatrix} h_{11,t} & h_{12,t} \\ h_{21,t} & h_{22,t}\end{bmatrix};$$

$$E_t = \begin{bmatrix} e_{1,t} \\ e_{2,t}\end{bmatrix}, ECT_{t-1} = \begin{bmatrix} ect_{t-1} \\ ect_{t-1}\end{bmatrix}, \Pi_i = \begin{bmatrix} \gamma_{11}^{(i)} & \gamma_{12}^{(i)} \\ \gamma_{21}^{(i)} & \gamma_{22}^{(i)}\end{bmatrix}, \Phi = \begin{bmatrix}\theta_1 \\ \theta_2\end{bmatrix};$$

$$\ln(h_{11,t}) = c_{10} + \alpha_{11}\left|\frac{e_{1,t-1}}{\sqrt{h_{11,t-1}}}\right| + \beta_{11}\ln(h_{11,t-1}) + d_1\frac{e_{1,t-1}}{\sqrt{h_{11,t-1}}};$$

$$h_{22,t} = c_{20} + (\alpha_{21} + \gamma D)e_{2,t-1}^2 + \beta_{21}h_{22,t-1} \quad where \begin{cases} D = 1\ if\ e_t < 0 \\ D = 0\ if\ e_t \geq 0 \end{cases}$$

Methodology (Conditional Correlation)

- To build the time-varying correlation model, we will need to decompose the Correlation matrix R_t from the first stage as follows:

$$R_t = D_t^{-1} H_t D_t^{-1}$$

  - Where $D_t = diag(\sqrt{h_{11,t}}, \sqrt{h_{22,t}})$, $\sqrt{h_{ii,t}} \forall\ i = 1,2)$ are the conditional standard deviations (or conditional volatilities) estimated from univariate GARCH models from the first stage, and H_t is the variance-covariance matrix.
- H_t can be estimated as the following specification:

$$H_t = \bar{R} \circ (ii' - aa' - bb') - \bar{N} \circ gg' + aa' \circ \varepsilon_{t-1}\varepsilon_{t-1}' + gg' \circ n_{t-1}n_{t-1}' + bb' \circ H_{t-1};$$
$$\bar{R} = E[\varepsilon_t \varepsilon_t'], \bar{N} = E[n_t n_t'].$$

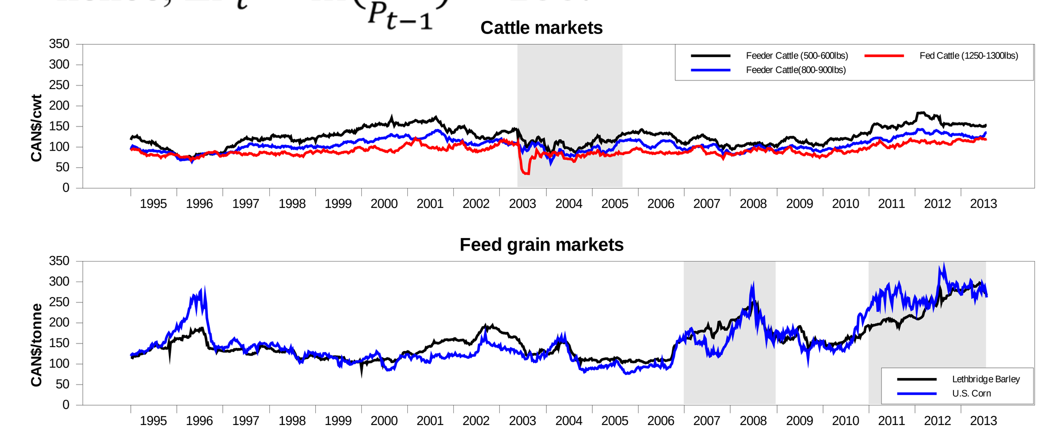
  - Where ε_t is the vector of standardized residuals from the first stage, $n_t = I[\varepsilon_t < 0] \circ \varepsilon_t$, $I[\cdot]$ is a $k \times 1$ indicator function (in our case, $k = 2$), a, b, g are parameter vectors and $\circ$ denotes the Hadamard product.
- Finally, for any covariance ($h_{ij,t} \forall i \neq j$) and correlation ($\rho_{ij,t} \forall i \neq j$), they have the following specifications:

$$h_{ij,t} = (1 - a_i a_j - b_i b_j)E[\varepsilon_{i,t}\varepsilon_{j,t}] - g_i g_j E[n_{i,t} n_{j,t}] + a_i a_j \varepsilon_{i,t-1}\varepsilon_{j,t-1} + g_i g_j n_{i,t-1} n_{j,t-1} + b_i b_j h_{ij,t-1};$$

$$\rho_{ij,t} = \frac{h_{ij,t}}{\sqrt{h_{ii,t}}\sqrt{h_{jj,t}}}.$$

Data

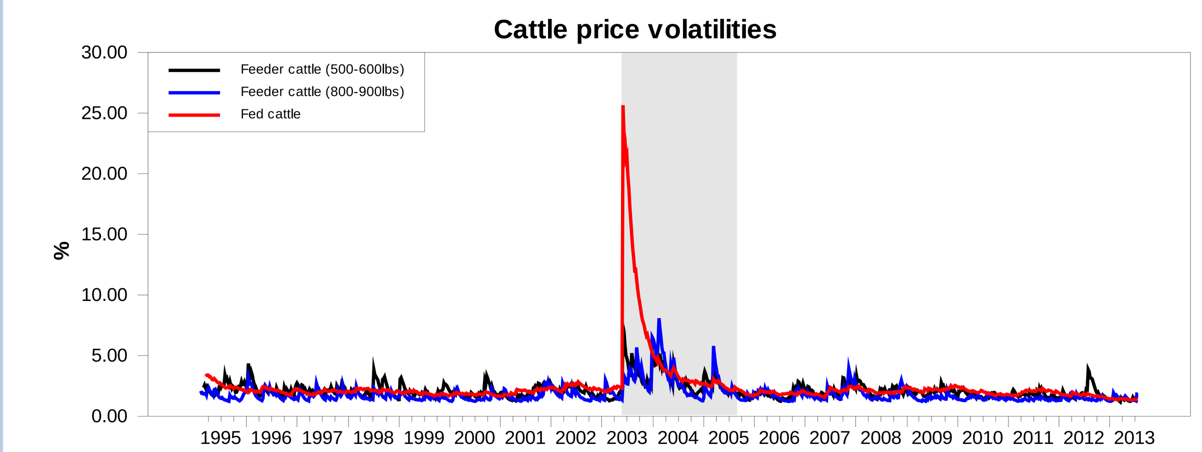
- Weekly nominal prices from January 4, 1995 to July 24, 2013 of Alberta fed steers, feeder steers (500-600lbs), feeder steers (800-900lbs), Lethbridge barley and the U.S. corn, from January 4, 1995 to July 24, 2013 are used in this study
- Data used for model estimation is in price changes, hence, $\Delta P_t = \ln(\frac{P_t}{P_{t-1}}) \times 100$.



Notes: the shaded areas indicating the time periods of three major market incidents

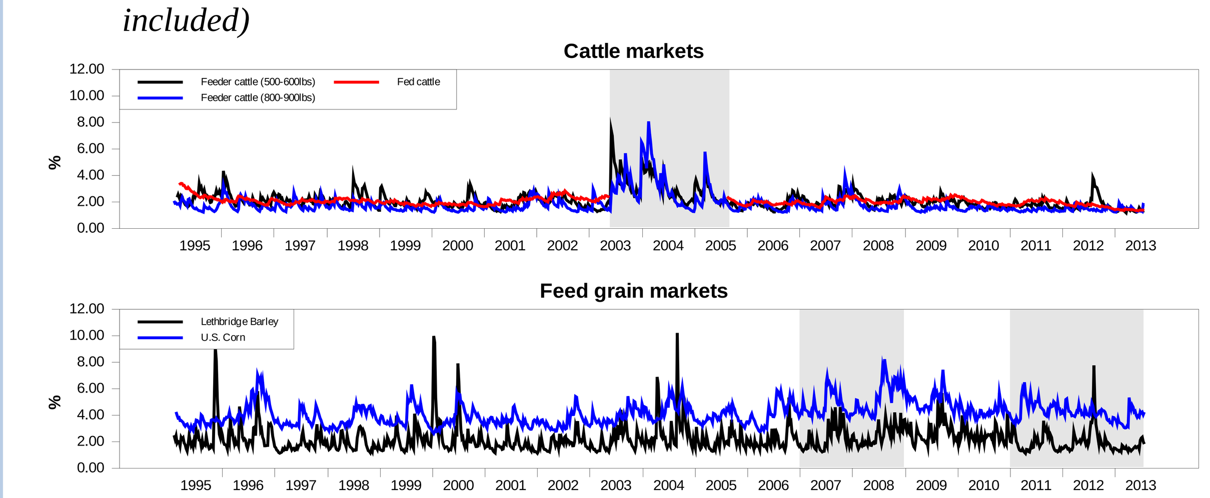
Figure 1. Price Movements (1995-2013)

Results (Price Volatility)



Notes:the shaded area indicating the time period of the Canadian BSE crisis

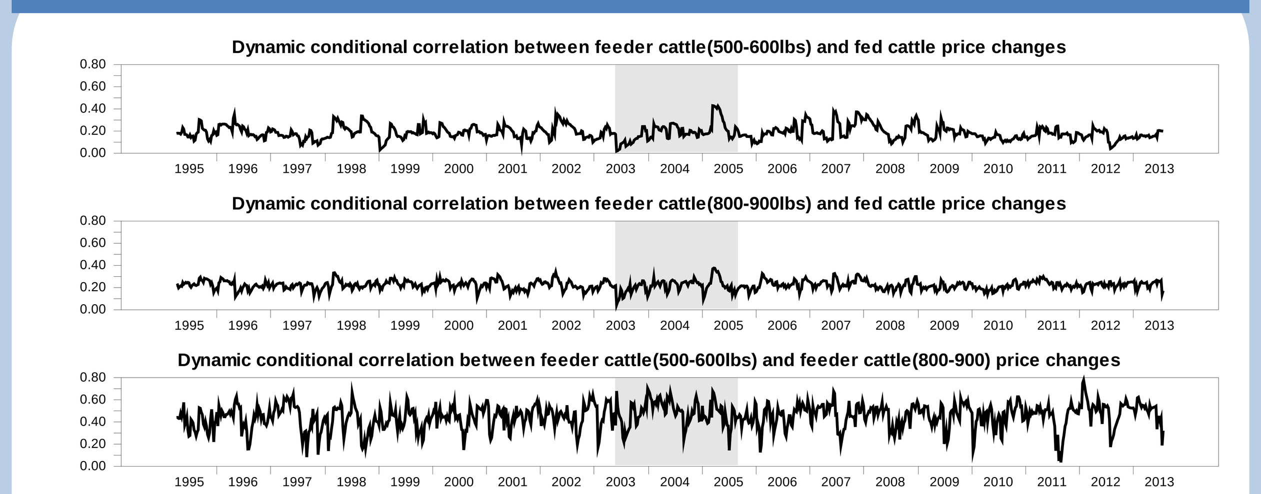
Figure 2. Conditional Volatility Estimated for Cattle Markets (BSE period included)



Notes:the shaded areas indicating the time periods of three major market incidents

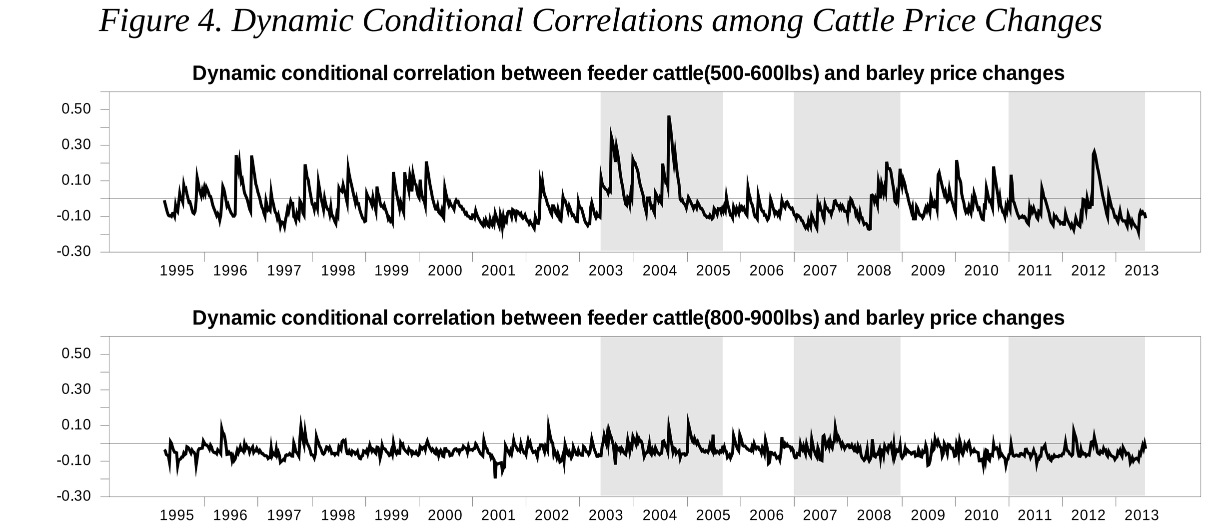
Figure 3. Conditional Volatility Estimated for Cattle and Feed Grain Markets (BSE period excluded)

Results (Conditional Correlation)



Notes:the shaded area indicating the time period of the Canadian BSE crisis

Figure 4. Dynamic Conditional Correlations among Cattle Price Changes



Notes:the shaded areas indicating the time periods of three major market incidents

Figure 5. Dynamic Conditional Correlations Between Feeder Cattle and Barley Price Changes

Conclusions

- Pairwise Johansen cointegration tests (Johansen 1988) indicated the existence of a long-run relationship in price changes between two feeder cattle markets. Likewise in we found the same results in price changes between two feed grain markets.
- Results from univariate GARCH models imply:
  - The barley price volatility is the most susceptible to market shocks, while the feeder cattle (800-900lbs) price volatility is found to be the least among all five markets.
  - General shocks have larger impacts on feed grain price volatilities than cattle price volatilities.
  - Cattle price volatilities are more persistent than feed grain price volatilities.
  - Asymmetric effects are only found in cattle price volatilities.
- Results from AG - DCC GARCH models suggest:
  - **Cattle supply chain:** Time-varying conditional correlations between feeder cattle and fed cattle price changes dropped substantially at the beginning of the 2003 Canadian BSE crisis.
  - **Between cattle and barley markets:** in general, the feeder cattle (500 – 600 lbs) and the feed barley price changes, and the feeder cattle (800 – 900 lbs) and the feed barley price changes have negative and near zero dynamic conditional correlations over the study period.

Acknowledgement

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