Optimal Hedging

Julieta Frank
University of Manitoba

Workshop on Agricultural Risk Management
November 6, 2017 - Winnipeg, MB
Motivation

- Agricultural markets have become more volatile in recent years. In particular, in livestock markets we observed structural and policy changes.
- Also, because of the linkages between U.S and Canadian markets, the high price variability in the U.S. market was compounded in Canada because of the variation in the foreign exchange rate.
- No established mechanism to reduce price risk in cattle industry. Marketing strategies may help reduce risk associated with price fluctuations. However, previous results on the benefits of using U.S. futures markets to hedge Canadian cattle are mixed.
Carter & Loyns (1985) find that not hedging yields larger average returns and lower price risk for Canadian cattle than hedging using CME futures and forward exchange rates (1972-1981). Results attributed to the high variability of the basis.


Novak & Unterschultz also show that exchange rate contributes less than 1% to price risk whereas futures prices and commodity basis remove about 60% and 40% respectively of total price risk.
Background

- Thompson and Bond (1987) suggest that incorporating interaction effects between changes in the U.S. dollars and commodity prices in deriving optimal hedge ratios for offshore traders may yield more realistic estimates and help improve hedging strategies.
Objectives

- Investigate the short-run price risk faced by a Canadian livestock producer hedging using U.S. futures markets
  - Examine the basis and develop forecasting models.
  - Decompose price risk and identify relative contributions of futures prices, exchange rate, and basis risk.
- Assess the hedging usefulness of the CME Group futures contract in total price risk reduction for Canadian cattle market participants.
- Examine the implications of exchange rate variability on optimal commodity hedging.
Short-run price risk

- Squared deviation of the realized net price from the forecast net price (Novak & Unterschultz, 1996):

\[
MSE = \frac{\sum_{t=-j+1}^{T-j} (NP_{t+j} - \bar{NP}_{t+j})^2}{T - 1}
\]

\(\bar{NP}_{t+j}\) is the forecasted net price for period \(t+j\)

\(T\) is the total number of periods

\(j\) is the forecast horizon
Realized NP for three strategies:

- No hedging
  \[ NP_{t+j} = p_{t+j} \]

- Commodity hedging only
  \[ NP_{t+j} = p_{t+j} + (f_t - f_{t+j}) \cdot e_{t+j} \]

- Combined commodity-currency hedging
  \[ NP_{t+j} = p_{t+j} + (f_t - f_{t+j}) \cdot e_{t+j} + f_t (x_t - x_{t+j}) \]

\( t \) is the trading day when the hedge is placed,
\( t+j \) is the trading day when the hedge is lifted,
\( p \) is the cash price, \( f \) is the futures price,
\( e \) is the currency spot rate, and \( x \) is the futures exchange rate
Expanding the MSE for the three strategies yields:

- **No hedging**
  \[
  MSE = \frac{\sum_{t=-j+1}^{T-j} [f_{t+j}e_{t+j} - f_te_t] + (B_{t+j} - \tilde{B}_{t+j})]^2}{T - 1}
  \]

- **Commodity hedging only**
  \[
  MSE = \frac{\sum_{t=-j+1}^{T-j} f_t(e_{t+j} - e_t) + (B_{t+j} - \tilde{B}_{t+j})]^2}{T - 1}
  \]

- **Combined commodity-currency hedging**
  \[
  MSE = \frac{\sum_{t=-j+1}^{T-j} (B_{t+j} - \tilde{B}_{t+j})^2}{T - 1}
  \]
Basis forecast

\[ \Delta B_t = \beta_0 + \beta_1 B_t + \beta_2 BSE + \beta_3 D_S + \varepsilon_t \]

\[ \Delta B_t = B_{t+j} - B_t \] is the change in the basis,

\( B_t \) is the basis at the beginning of hedging period,

\( B_{t+j} \) is the basis when the hedge is lifted,

\( BSE = 1 \) after BSE (May 2003) and 0 otherwise,

(perform test for variances before and after BSE)

\( D_S \) is a seasonal dummy variable.
Optimal hedge ratios

- **Objective function**

\[
NP_{t+j} = Q_t p_{t+j} + H_t (f_t - f_{t+j}) e_{t+j} + G_t (x_t - x_{t+j})
\]

- Using mean-variance framework (Thompson & Bond 1987) the objective is specified as the maximization of:

\[
\Omega_t = E(NP_{t+j}) - \lambda V(NP_{t+j})
\]

where \(\lambda\) is the decision maker’s risk aversion coefficient and estimates of \(E(NP_{t+j})\) and \(V(NP_{t+j})\) are conditional on the information available to the decision maker at time \(t\).
Optimal hedge ratios (cont’d)

- Taking first derivatives and solving for $Q_t$, $H_t$, and $G_t$ yields (Sarassoro & Leuthold, 1987):

\[
Q_t + a_1 H_t - a_2 G_t = L_1 \\
b_0 Q_t + H_t - b_2 G_t = L_2 \\
- c_0 Q_t - c_1 H_t + G_t = L_3
\]

where $a_i$, $b_i$, and $c_i$ are regression coefficients and $L_i$ are the speculative components of the hedge ratio.

- Solving the system for $H_t/Q_t$ and $G_t/Q_t$ yields the optimal commodity and currency hedge ratios, respectively.
Data

- Spot prices for steers from Winnipeg auction market.
- Futures prices for CME Group live cattle contract from the Commodity Research Bureau (CRB).
- Spot exchange rate at the foreign exchange market from CRB.
- Futures exchange rates contracts trading in the International Monetary Market from CRB.
- MSE, basis models and hedge ratio employ cash and futures prices for the third Tuesday of the expiration month \((t+j)\) at 3-month and 5-month hedging horizons.
Results: Basis forecast

Predictability of the basis for Canadian cash markets and U.S. futures markets

<table>
<thead>
<tr>
<th></th>
<th>3-month</th>
<th>5-month</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Constant</strong></td>
<td>52.55**</td>
<td>40.84***</td>
</tr>
<tr>
<td></td>
<td>(21.98)</td>
<td>(9.03)</td>
</tr>
<tr>
<td><strong>$B_t$</strong></td>
<td>-0.49**</td>
<td>-0.73***</td>
</tr>
<tr>
<td></td>
<td>(0.19)</td>
<td>(0.15)</td>
</tr>
<tr>
<td><strong>$BSE$</strong></td>
<td>-14.32*</td>
<td>-35.98***</td>
</tr>
<tr>
<td></td>
<td>(7.60)</td>
<td>(7.99)</td>
</tr>
<tr>
<td><strong>$D_{10}$</strong></td>
<td>2.36</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(3.94)</td>
<td></td>
</tr>
<tr>
<td><strong>Adj. $R^2$</strong></td>
<td>0.11</td>
<td>0.53</td>
</tr>
</tbody>
</table>

Standard errors are between parenthesis.
Significance: * 10%, ** 5%, *** 1%
## Results: Short-run risk

NP and MSE of NP ($/cwt) for Canadian cattle using U.S. futures markets, 3-month forecast horizon.

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Before BSE</th>
<th></th>
<th>After BSE</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean NP</td>
<td>MSE</td>
<td>Mean NP</td>
<td>MSE</td>
</tr>
<tr>
<td>No hedging</td>
<td>124.74</td>
<td>314.35</td>
<td>97.01</td>
<td>289.28</td>
</tr>
<tr>
<td>Commodity hedging</td>
<td>124.56</td>
<td>259.96 (17.30%)</td>
<td>96.05</td>
<td>189.23 (34.59%)</td>
</tr>
<tr>
<td>Commodity currency hedging</td>
<td>125.20</td>
<td>229.72 (26.92%)</td>
<td>96.66</td>
<td>139.80 (51.67%)</td>
</tr>
</tbody>
</table>
Results: Short-run risk (cont’d)

NP and MSE of NP ($/cwt) for Canadian cattle using U.S. futures markets, 5-month forecast horizon.

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Before BSE</th>
<th></th>
<th>After BSE</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean NP</td>
<td>MSE</td>
<td>Mean NP</td>
</tr>
<tr>
<td>No hedging</td>
<td></td>
<td>126.33</td>
<td>51.51</td>
<td>98.25</td>
</tr>
<tr>
<td>Commodity hedging</td>
<td></td>
<td>128.35</td>
<td>54.90</td>
<td>95.51</td>
</tr>
<tr>
<td>Commodity currency hedging</td>
<td></td>
<td>129.26</td>
<td>19.86</td>
<td>96.50</td>
</tr>
</tbody>
</table>

NP and MSE of NP ($/cwt) for Canadian cattle using U.S. futures markets, 5-month forecast horizon.
Results: Optimal hedge ratios

Optimal commodity and currency hedge ratios for Canadian cattle using U.S. futures markets.

<table>
<thead>
<tr>
<th>Strategy</th>
<th>$H_t/Q_t$</th>
<th>$G_t/Q_t$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3-month</td>
<td>5-month</td>
</tr>
<tr>
<td>Commodity hedging</td>
<td>0.37</td>
<td>0.20</td>
</tr>
<tr>
<td>Commodity currency hedging</td>
<td>0.29</td>
<td>0.29</td>
</tr>
</tbody>
</table>

|                              | 3-month    | 5-month    |
| Commodity currency hedging   | 0.15       | 0.24       |
Summary of findings and conclusions

- Short-term commodity hedges using U.S. futures markets appear to be effective in the most recent period to reduce price risk. Findings for the first period using a 5-month forecast horizon are consistent with Carter & Loyns (1985)

- Futures hedging after BSE removes approximately 35% (11%) of the risk for a 3(5)-month hedging horizon.

- Combined commodity and currency hedging after BSE removes approximately 50% of the risk for both hedging horizons. The remaining price risk is due to the basis variability.
In general, risk reduction is larger after BSE which may be due to more integrated and volatile markets.

Exposure to exchange rate risk has an effect on decisions to hedge commodity.
Thank you!

Questions?
Taking first derivatives and solving for $Q_t$, $H_t$, and $G_t$ yields the system (Sarassoro & Leuthold, 1987):

$$Q_t + a_1 H_t - a_2 G_t = L_1$$

$$b_0 Q_t + H_t - b_2 G_t = L_2$$

$$-c_0 Q_t - c_1 H_t + G_t = L_3$$

Solving the system yields the following hedge ratios:

$$\frac{H_t}{Q_t} = \frac{-L_1(b_0 - c_0 b_2) + L_2(1 - c_0 a_2) - L_3(-b_2 + b_0 a_2)}{L_1(1 - c_1 b_2) - L_2(a_1 - c_1 a_2) + L_3(-a_1 b_2 + a_2)}$$

$$\frac{G_t}{Q_t} = \frac{L_1(-b_0 c_1 - a_2 c_0) + L_2(-a_1 c_0 + c_1) + L_3(1 - a_1 b_0)}{L_1(1 - c_1 b_2) - L_2(a_1 - c_1 a_2) + L_3(-a_1 b_2 + a_2)}$$
Regression coefficients

\[ a_1: (f_t - f_{t-1})e_{t+j} = F(p_{t+j} e_{t+j}) \]
\[ a_2: e_{t+j} = F(p_{t+j} e_{t+j}) \]
\[ b_0: p_{t+j} e_{t+j} = ((f_t - f_{t-1})e_{t+j}) \]
\[ b_2: e = F((f_t - f_{t-1})e_{t+j}) \]
\[ c_0 = p_{t+j} e_{t+j} = F(e_{t+j}) \]
\[ c_1: (f_t - f_{t-1})e_{t+j} = F(e_{t+j}) \]