Lecture IX

ACE 428
Commodity Futures and Options

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Hedging with Futures

Hedging strategies: More structure

- Steps in decision-making
  - First step: develop objectives that are specific and quantifiable, such as:
    - survival
    - business grow
    - good family living
    - shareholder value
  - Second step: identify all alternative courses of action
    - profit potential
    - risk

- Steps in decision-making
  - Third step: develop strategy that comply with objectives
    - futures, options, production diversification etc
  - Last step: feedback and learning
    - evaluate result relative to objectives
    - probabilistic nature of outcomes
    - improving the odds for success
- Managing risk
  - The question is not whether to take risks, but how to manage them
  - Trade-off between risk and return
    - minimum risk strategy usually leads to small profit potential, while maximum profit strategy usually leads to high risk

- When or whether you decide to hedge can make a big difference on your final revenue
- Producer needs to
  - define income objectives
  - define speculation strategies
  - know fixed and variable costs
  - know market structures on input and output sides
- When to price?
  - separation of pricing and product delivery
- Therefore, producer needs to be always:
  - gathering information and checking forecast ability

Hedging strategies: More complicated cases

- Rolling a hedge
  - to continue a hedge for additional months by offsetting original contract while simultaneously initiating a new position in a more distant month
- It is appropriate when producer
  - has the necessary storage facilities and flexible cash-flow requirements
  - sees an opportunity to obtain additional returns after storage

Rolling a hedge: An example

  - Producer is planning to sell corn in December (break-even price = \$3.40/bu)
- On March 1 she places a hedge using the December'18 futures contract
  - Dec'18 futures = \$3.67/bu
  - expected basis for Dec'18 = -\$0.2/bu
  - brokerage fees = \$0.01/bu
- Producer goes short in Dec'18 contract
  - target price for Dec'18 = 3.67 - 0.2 = \$3.47/bu
  - expected profit = 3.47 - 0.01 - 3.40 = \$0.06/bu

Rolling a hedge: An example (2)

- On August 1
  - Dec'18 futures = \$3.27/bu
  - March'19 futures = \$3.41/bu
  - storage costs = \$0.03/month
  - expected basis for Mar'19 = -\$0.15/bu
- The spread Dec-Mar says that the market is offering \$0.14/bu for storing grain from December through March

Rolling a hedge: An example (3)

- Producer rolls hedge to Mar'19 contract for \$3.41/bu and offsets Dec'18 contract at \$3.27/bu
  - go short Mar'19 and go long Dec'18
  - target price for Mar'19 = 3.41 - 0.15 = \$3.26/bu
  - gain/loss of Dec'18 contract = 3.67 - 3.27 = \$0.40/bu
  - cost of carry from Dec to Mar = \$0.09/bu
  - expected profit = 3.26 + 0.40 - 0.02 - 0.09 - 3.40 = \$0.15/bu

Rolling a hedge: An example (4)

- Expected profit increases by \$0.09/bu (from \$0.06/bu to \$0.15/bu)
- Where does this difference come from?
  - futures spread = +\$0.14/bu
  - basis changes by +\$0.05
    - expected basis for March is greater than for December
  - storage cost for 3 months = \$0.09/bu
  - brokerage fees = \$0.01/bu (Mar'19 contract)
  - 0.14 + 0.05 - 0.09 - 0.01 = \$0.09/bu

Rolling a hedge: An example (5)

- On March 14, 2019
  - March'19 futures = \$3.97/bu
  - realized basis for Mar'19 = -\$0.13/bu
- Producer sells corn in local cash market for \$3.84/bu and offsets futures contract at \$3.97/bu
  - gain/loss of Mar'19 contract = 3.41 - 3.97 = -\$0.56/bu
  - realized profit = 3.84 + 0.40 - 0.56 - 0.02 - 0.09 - 3.40 = \$0.17/bu
  - realized profit is \$0.02/bu higher than expected profit because realized basis is \$0.02/bu higher than expected basis

Additional thoughts...

- Rolling a hedge can be seen as speculating on the basis and futures spreads
- Hedge can be rolled forward (move to further maturities) and also backward (move to closer maturities)
- A hedger speculating on the basis must monitor price relationships
- Basis risk is still present (**basis risk is always present**)

- Basis = Cash price – Futures price
- Cash price represents local supply and demand conditions at a destination location such at the Gulf ports
- Futures price represents demand and supply conditions on the average through the country
- It is possible for local demand and supply conditions to become tighter than they became nationally
- While both prices would rise, local cash price may rise by more than national price (called strengthening basis or narrowing basis, meaning the basis is increasing or more positive or less negative)
- Generally, a farmer benefits from a strengthening basis and a buyer loses from a strengthening basis

Hedge ratio

- Hedge ratio is the ratio between the size of the futures position and the size of the cash position
$$h = \frac{Q_F}{Q_S} \tag{1}$$
where h = the hedge ratio, Q_F = the quantity traded in futures market, Q_S = the quantity traded in cash market

- Naive hedge ratio: $h = 1$
  - hedge in the futures market exactly the same quantity that you have in the cash market
$$h = \frac{Q_F}{Q_S} = 1 \Rightarrow Q_F = Q_S \tag{2}$$

Hedge ratio (cont.)

- Hedge ratio example
  - today is 9/15/18 and producer knows he will have 500,000 bu of soybeans by November
  - on 9/15/18: cash price = \$6.06/bu and Nov'18 futures price = \$6.19/bu
  - break-even price = \$6.00/bu
  - producer hedges future sale using futures market

    $$100 \text{ contracts} = 500{,}000 \text{ bu, hedge ratio} = 1$$

  - current basis = –\$0.13/bu
  - expects basis to stay the same in November

Hedge ratio (cont.)

- Expectation that basis will not change
  - change in futures price will be the same as change in spot price
  - relative prices will not change
- Locks in a target (selling) price of \$6.06/bu
  - \$6.19/bu (futures) – \$0.13/bu (exp. basis)
- Break-even price = \$6.00/bu
- Expected profit = \$0.06/bu
  - total profit = \$0.06/bu x 500,000 bu = \$30,000
  - assume no transaction costs

Hedge ratio (cont.)

- On 11/10/18
  - producer delivers 500,000 bu of soybeans and offsets futures position
  - cash price = \$7.75/bu and Nov'18 futures price = \$7.97/bu
- Realized price of \$5.97/bu
- Break-even price = \$6.00/bu
- Realized loss = -\$0.03/bu
  - total loss = -\$0.03/bu x 500,000 bu = -\$15,000

Hedge ratio (cont.)

	cash	futures	basis
09/15/18	6.06	6.19	-0.13
11/10/18	7.75	7.97	-0.22
change	1.69	1.78	-0.09

- Expected profit: +\$30,000
- Realized profit: –\$15,000
- difference: –\$45,000
- Change in basis: –\$0.09/bu (–\$0.09/bu x 500,000 bu = –\$45,000)
- Change in basis = change in profit

Hedge ratio (cont.)

- You wanted basis to stay the same

$$\Delta B = 0 \Rightarrow \Delta S = \Delta F \tag{3}$$

- However, basis in November decreased by \$0.09/bu
  - decreasing basis (which means the basis is becoming more negative or less positive; this is also called weakening basis or widening basis)
  - price change in futures market was greater than price change in cash market
  - relative prices changed: futures price increased relative to cash price
- What could you have done to avoid this loss due to basis change?
  - change hedge ratio

Hedge ratio (cont.)

- Consider a producer (short hedger) who holds
  - long in the cash market
  - short in the futures market
- Define V as the value of total hedged position
- Change in V can be written as

$$\Delta V_H = \Delta S \cdot Q_S - \Delta F \cdot Q_F \tag{4}$$

- ΔV_H consists of two components
  - change in cash price x quantity traded in spot market
  - change in futures price x quantity traded in futures market

Hedge ratio (cont.)

- Dividing all terms in Equation (4) by Q_S:

$$\Delta v_H = \Delta S - \Delta F \cdot \frac{Q_F}{Q_S} = \Delta S - h\Delta F \tag{5}$$

- You want to hedge your grains such that the change in value of total hedged position is as small as possible
  - realized profit as close to expected profit as possible
  - change in basis as small as possible
- So you want to minimize the variance of Δv_H with respect to the hedge ratio h
  - minimize the variance of the basis

Hedge ratio (cont.)

$$Var(\Delta v_H) = Var(\Delta S) + h^2 Var(\Delta F) - 2hCov(\Delta S, \Delta F)$$

$$\frac{dVar(\Delta v_H)}{dh} = 2hVar(\Delta F) - 2Cov(\Delta S, \Delta F) = 0$$

$$hVar(\Delta F) - Cov(\Delta S, \Delta F) = 0$$

$$h = \frac{Cov(\Delta S, \Delta F)}{Var(\Delta F)}$$

Since $Cov(\Delta S, \Delta F) = Corr(\Delta S, \Delta F) \cdot SD(\Delta S) \cdot SD(\Delta F)$

$$h = \frac{Cov(\Delta S, \Delta F)}{Var(\Delta F)} = Corr(\Delta S, \Delta F)\frac{SD(\Delta S)}{SD(\Delta F)}$$

This is called minimum-variance (minimum-risk) hedge ratio

Hedge ratio (cont.)

- For example, if
  - std. deviation of cash price change = 0.108
  - std. deviation of futures price change = 0.104
  - correlation between cash and futures price changes = 0.982
- $h = 0.982 \times \frac{0.104}{0.108} \approx 0.95$
- You should have traded in the futures market 95% of the quantity you will trade in the cash market
  - trade 95 contracts instead of 100 contracts
  - 95 contracts = 475,000 bu

Hedge ratio (cont.)

- What happens if you have hedged using 95 contracts
- Cash market
  - sell at \$7.75/bu
  - break-even price = \$6.00/bu
  - profit = \$1.75/bu x 500,000 bu = \$875,000
- Futures market
  - total loss = -\$1.78/bu x 475,000 bu = -\$845,500
- Overall, profit of \$29,500
  - almost equal to expected profit in the beginning (\$30,000)

Hedge ratio (cont.)

- Minimum-variance hedge ratio depends on
  - correlation coefficient between cash and futures prices
    - measures how close cash and futures prices move
  - variability of cash and futures prices
    - measures the magnitude of price changes
- Minimum-variance hedge ratio is usually less than 1 because correlation is less perfect
- Minimum-variance hedge ratio is sensitive to sample selection
  - time-varying hedging ratio based on complex models

Hedging effectiveness

- How to evaluate a hedging strategy?
- Hedging effectiveness (HE)
  - is the percentage reduction in risk from total unhedged position to total hedged position
  - measure how much hedging can reduce your risk
- Risk involved in hedged position: change in value of combined cash and futures position
- Risk involved in unhedged position: change in value of cash position

Hedging effectiveness (cont.)

- Define
$$HE = 1 - \frac{Var(\Delta v_H)}{Var(\Delta S)} \tag{6}$$
- Since $Var(\Delta v_H) = Var(\Delta S) + h^2 \cdot Var(\Delta F) - 2 \cdot h \cdot Cov(\Delta S, \Delta F)$

  $HE = 1 - \frac{Var(\Delta S) + h^2 \cdot Var(\Delta F) - 2 \cdot h \cdot Cov(\Delta S, \Delta F)}{Var(\Delta S)}$
- We know the minimum-variance hedge ratio:

  $h = Corr(\Delta S, \Delta F) \frac{SD(\Delta S)}{SD(\Delta F)}$
- $HE = Corr^2(\Delta S, \Delta F)$
- In our example, $Corr(\Delta S, \Delta F) = 0.981521$, then $HE \approx 96\%$. Hedging allowed a risk reduction of 96%.

Hedging effectiveness (cont.)

- h and HE can be estimated using regression analysis
- Obtain a series of historical price changes in cash and futures markets and estimate the following equation

$$\varDelta S = \alpha + \beta \times \varDelta F + \epsilon \tag{7}$$

  where $\alpha,\ \beta$ = parameters to be estimated and ϵ = error term

- Estimate equation by ordinary least squares
- After you estimate the equation
  - β is the minimum-variance hedge ratio
  - typically, α is statistically equal to zero
  - R^2 (coefficient of determination) is the hedging effectiveness

Hedging effectiveness (cont.)

- Hedge ratio shows how much of the cash position is hedged in the futures market
- Adjustments in the number of futures contracts used in the hedge is sometimes necessary to account for changes in relative prices between spot and futures markets
- Risk-minimizing hedge ratio is only optimal to minimize the risk of the hedged position
  - It doesn't let the hedger take advantage of favorable price changes
- Hedging effectiveness measures the percentage change in risk from an unhedged position to a hedged position