Valuing Operational Flexibility and Financial Hedging

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Motivation

• Operations (e.g., flexible production, foreign production) can mitigate the effects of demand, price, and currency exchange risks
• Financial instruments also can reduce risks (but should have zero NPVs)
• Questions: what is the value of operational methods and how do they interact with financial methods?
Outline

• Discussion of “hedging”
• Uses of operation and financial mechanisms
• Differences in correlations
• Conclusions
Preliminary Discussion: Hedging

• Definition here: reducing risk (volatility)
• Alternative interpretations:
  – Only reducing risk without affecting mean values
  – Using “hedging” instruments (e.g., derivatives): financial hedging
• Some results (e.g., Chowdhry and Howe 1999):
  – Operational hedging has value over financial hedging because of flexibility in output and correlation between demand and prices (examples later)
Risk Management and Hedging

• What is a hedge?
  – Action designed to reduce risk of future outcome
  – In finance, perfect hedge leads to no risk (risk-free return)

• Use of hedges
  – Allow pricing of financial derivatives
  – Lead to markets in derivatives
  – Also possible with operations (operational hedges)
    • Quantity - flexible production
    • Timing
Who Should Hedge?

- Farmers?
- Situation:
  - Suppose either high-yield or low-yield years for crops
  - Prices down in high years and up in the low years
Farmer’s Example

• Suppose yield of corn is either 200 k-bushels (high) or 100 k-bushels (low)

• Suppose price with high yield is $1 and price with low yield is $2

• Should the farmer use financial hedge? i.e., sell a future?
  – If so, how much?
Futures Contracts as Hedges

- *Futures contract*: an agreement to buy or sell a fixed quantity at given price at fixed time in future (marked to market every day)
- Example: can agree to sell 100 k-bushels at $1.50/bushel on October 15
- On October 15, we receive $150K and must deliver 100 k-bushels
Futures for the Farmer

• Advantages
  – Can accept the expected price now
  – No risk in the price for the amount we sell

• Potential problems
  – Risk on amount we can produce
  – May have to go into market

• Analysis: Hedge our expected yield (150 k-bushels)

  Guaranteed (all the time) $225K
  High yield – can sell 50 more + $50K (probability ½)
  Low yield – must buy 50 -$100K (probability ½)
  Expectation=225+50/2-100/2= $200k (same as no hedge)
  BUT variance (risk) is up (either $275k or $125 instead of $200k all the time)

• RESULT: should not use futures (alone)
Farmer’s Operational Hedge for Risk Management

• What else does the farmer have?

• **SILO!!**
  - *Operational hedge*
  - *Keep corn from high yield to sell at low yield*

• Now, suppose we keep 50 k-bushels in silo from high to low yield years
Farmer’s Silo “Hedge”

• Expected returns
  – High-yield years (prob. ½) $150 k
  – Low-yield years (prob. ½) $300 k
  – Expectation: ½(150+300)= $225k
  – Worth $225k-200k =$25k to use the silo
  – Value of the operational instrument *(option value of silo storage)*

• Combine with future?
  – Now, sell 150 k-bushels for $1.50 in October
  – Now, have the return guaranteed $225K

• Moral: Financial instrument only has value if farmer uses operational instrument
Copper Miner’s Example

- Should a copper mine hedge its output with futures?
- What is the nature of copper price differences?
- Demand versus supply curve change means high price-high quantity and low price-low quantity
Copper Hedging

• Suppose high demand leads to 200 k-pounds at $2/pound and low demand leads to 100 k-pounds at $1/pound

• Earn $400k (prob. ½) or $100k (prob. ½)

• Expected value of $250k

• Operational hedge? (save 50 k-lbs from high to low years – sell forward to customers)
  – High years: earn $300k (prob. ½)
  – Low years: earn $150k (prob. ½)
  – Expectation: $225k (lower value!)
Copper Futures?

- Suppose we sell all our customers forward contracts for 150 k-lbs at $1.50 in future
- Result now:
  - Guaranteed return: $225k
  - Risk reduced to 0
- Here: financial derivatives reduce risk but return is still down

<table>
<thead>
<tr>
<th>Probability</th>
<th>With Futures</th>
<th>Without Futures</th>
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<tbody>
<tr>
<td>$\frac{1}{2}$</td>
<td>150 ($k$)</td>
<td>300 ($k$)</td>
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($k$)
Model for Single Period

- Suppose:
  - Price: $p(\omega)$
  - Cost: $c$
  - Max production: $l + kp(\omega)$ ($k > 0$ or $< 0$)
  - Decision: $\alpha$ (fraction of customers to sell forward)

- Objective

$$\text{Max } 0 \leq \alpha \leq 1 \alpha (E(p) - c)(E(l + kp)) + (1 - \alpha)E[(p - c)(l + kp)]$$

$$\Leftrightarrow \text{Max } 0 \leq \alpha \leq 1 \alpha k[E(p)^2 - E(p^2)] + E(p)l + kE(p^2) - c(1 + kE(p))$$

$$= k[E(p)^2 - E(p^2)] + E(p)l + kE(p^2) - c(1 + kE(p))n \text{ if } k \leq 0 \text{ and }$$

$$E(p)l + kE(p^2) - c(1 + kE(p))n \text{ if } k \geq 0$$

So, sell all forward if negative correlation and sell none forward if positive correlation (assuming this is possible).
Overall Observations

• Farmer:
  – Sell forward using operational instrument (storage)

• Miner:
  – Sell at spot price

• Financial instruments can reduce risk (but careful on use)