SOCIETY OF ACTUARIES

# ERM Symposium
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# 6F: The Value of Operational Hedges in Enterprise Risk Management

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- Degrees from Stanford and Princeton



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# The Value of Operational Hedges in Enterprise Risk Management

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# Motivation

- Operations (e.g., flexible production, foreign production) can mitigate risk across an enterprise from the effects of demand, price, and currency exchange volatility
- Financial instruments also can reduce risks (but should have zero NPV's)
- Questions: what is the value of operational methods and how do they interact with financial methods?



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# Outline

- Preliminary discussion of "hedging"
- Specific case in foreign exchange
- Value calculations
- Investment problem solutions
- Operational policies
- 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

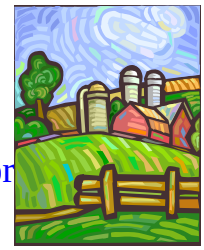
What is a hedge?

- Action designed to reduce risk of future outcome
- In finance, perfect hedge leads to no risk (riskfree return)

Use of hedges

- Allow pricing of financial derivatives
- Lead to markets in derivatives
- Also possible with operations (operational hedges)
  - Quantity - flexible production
  - Timing

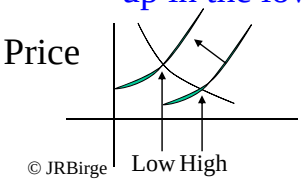
# Who Should Hedge?



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?

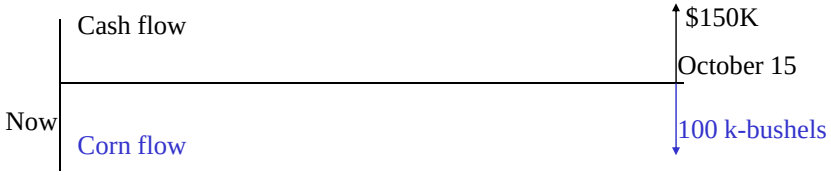
- If so, how much?

# 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

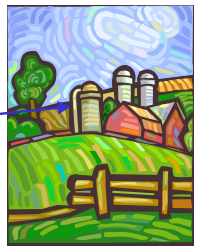
- Risk on amount we can produce
- May have to go into market

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 hedge (***option value of silo***)

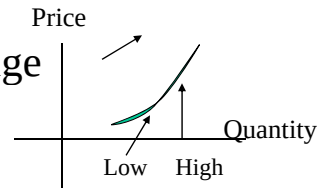
Combine with future?

- 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 hedge

# 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

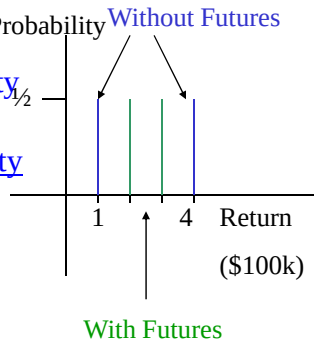
- Suppose high demand leads to 200 k-pounds at $2/pound and low demand leads to 100 k-pounds at $1/pound
- Earn $400k (prob. ½) or $100k (prob. ½)
- Expected value of $250k
- Operational hedge? (save 50 k-lbs from high to low years?)
  - High years: earn $300k (prob. ½)
  - Low years: earn $150k (prob. ½)
  - Expectation: $225k ***(lower value!)***

# Copper Futures?

Suppose we sell 200 k-lbs at $1.50 in future

Result now:

- Futures return: $300k (all the time)
- High demand: + $ 0k (with probability ½)
- Low demand: - $ 100k (with probability ½)
- Expectation: $250k
- Risk reduced ($300 or $200 v. $400 or $100)




Here: financial derivatives give value (how much? present value?)



# Model for Single Period

Suppose:

- Price: $p(\omega)$
- Cost: $c$
- Max sales: $l+kp(\omega)$ ($k>0$ or $<0$)
- Decision: $x$ (amount to hedge, i.e., sell forward)

Objective

max $(E(p)-c)x + E[(p-c)^+(l+kp-x)^+ + (c-p)(l+kp-x)^-]$

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# Single Period Results

When does hedging add value?

- For $k < k^*$, hedge.
- For $k >= k^*$, do not hedge.

When prices are supply-driven, hedging can be beneficial in securing higher prices when demand is high.

When prices are demand-driven, hedging can negate the value of potential cost advantage over the market.



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# Overall Observations

Farmer:

- Financial and operational together

Miner:

- Financial alone (but only for risk reduction)

One-period model

- Hedging when correlation of price and quantity is below a threshold

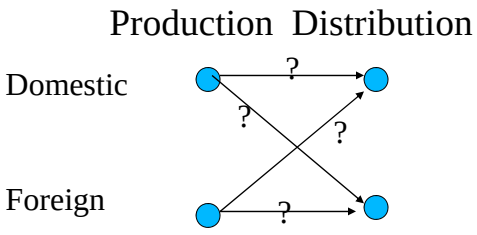
Next: dynamic model with currency

## Operational Flexibility and ForEx Risk

- Mis-matched operations leads to FOREX risk
- Flexible operations can be valuable in shifting costs to balance risk exposures
- Optimal policies involving operations in different regions and can be valued effectively



## Alternative Operations



## Valuing the Alternatives

- If sufficient flexible capacity, produce in the market with favorable exchange rate
- Set thresholds for production shifts to overcome setup and changeover costs
- Shift production when limits are exceeded
- Gain: natural balance
- Cost: additional capacity and transaction



## Flexible Capacity Results

- Operational flexible can result in gains from FOREX exposures
- Additional flexibility can be valued on the basis of rate volatility and changeover costs
- Risk can be reduced without relying on financial instruments (although they can be added)

## Conclusions

- Risk management should include operational flexibility
- Operations can reduce risk and improve contributions
- The nature of price, demand, and exchange risks may change the value of operational risk management
- Valuations possible with respect to many types of exposures



# Thank you!