Operational and Financial Hedging

John R. Birge
The University of Chicago Booth School of Business

www.ChicagoBooth.edu/fac/john.birge
Motivation

Operations (e.g., flexible production, foreign production) can mitigate risk across an enterprise from multiple effects (e.g., demand, supply, price, currency exchange volatility, technology)

Financial instruments also can reduce risks (but should have zero NPV’s if financial markets are efficient)

Questions considered:

What is the value of operational methods for reducing risk (hedging)?

How do they interact with financial methods?
Outline

Preliminary discussion: “hedging” and types of risk
Examples including foreign exchange
Value calculations
Operational policies
Conclusions
Preliminary Discussion: Hedging

Definition here: *reducing risk (volatility)*

Alternative interpretations:

- Only reducing risk without affecting (risk-neutral) mean values
- Using “hedging” instruments (e.g., derivatives): *financial hedging*

Some results (e.g., Chowdhry and Howe 1999):

- Operational hedging can create value (i.e., positive NPV) while financial hedging cannot
- Value from 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, a perfect hedge leads to no risk (i.e., riskfree return)

Aspects of hedges

Allow pricing of financial derivatives
Lead to markets in derivatives
Possibly through operations (operational hedges)
Quantity - flexible production/procurement
Timing
Location (currency)
Examples of Hedges

*Financial hedge*: a forward contract:

An agreement at time $t$ to exchange an asset at a fixed price $f_{tT}$ at a specific future time $T$

<table>
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<th>Execute contract</th>
<th>Exchange/settle</th>
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<td>$t$</td>
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*Example*: Sell €100 for $f_{tT}=$1.25 each in $T-t=1$ month

*Result*: Eliminates the risk of exchanging € for $ in 1 month (assuming the counterparty delivers)
Operational Hedge Example

Production location: US or Europe

Europe: production cost of 100 widgets next month is €100.

US operational hedge: can also produce 100 widgets next month in the US for $125.

Result: The $ risk of next month’s production in Europe is eliminated by US production option.

Note: Unlike the financial contract, the operational hedge does not require settlement – it is an option that has value (the option to keep production in Europe if the exchange rate is favorable).
Production Hedge as Call Option

Financial: forward contract - eliminates risk but does not add value

Operational: option to shift production – eliminates risk of high Euro value in $; equivalent to *call option* (right to buy Euros at $1.25/€)
Hedge Comparisons

• Financial hedges:
  • Can be settled purely financially (i.e., requires no physical activity)
  • Can reduce (or eliminate) risk without fee or premium (e.g., a forward contract)
  • Include options that require a premium for specific form of risk reduction (e.g., a call option)

• Operational hedges
  • Involve some physical activity (e.g., shifting of production)
  • Often include embedded options that can add value
Implications for Valuing Hedges

• Complete and perfect markets:
  • The only risk that matters is that which is not diversifiable (i.e., market or systematic risk)
  • Actions should not depend on idiosyncratic risk
  • Unique valuation with risk adjustment

• With market imperfections (e.g., financial distress):
  • Idiosyncratic risk can matter
  • Can still value in the same framework by valuing operational capabilities as their corresponding options
Imperfections and Operational Valuation

- Suppose the value of a firm depends on demand (with early price commitment) **with no capacity constraint**
- With no market imperfections, this value depends only on the correlation of demand with the market (CAPM)
- The idiosyncratic part of the demand risk makes no difference in value

However, **with limited capacity**, the payoff is concave and value increases with lower volatility.
Evaluation without Capacity Limit

No limit:
For log-normal distribution:
Equivalent to a shift in mean of log-demand depending on correlation with the market
Value equivalent to expectation of shifted demand with risk-free rate
No effect from idiosyncratic variation in demand
Evaluation with Capacity Limit

With capacity:

Value with capacity is full-demand value minus a call option at the capacity level.

Can still be evaluated using risk-neutral approach but, because payoff is concave, lower idiosyncratic variation can increase value with the same capacity.

=> Reducing idiosyncratic variation in demand with fixed capacity can increase value but this is not related to risk preference.
Other Operational Effects

Example: Farmer

Suppose either high-yield or low-yield years for crops
Prices down in high years and up in the low years

Price

Quantity

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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 in 3 months (after harvest)

3 months from start, we receive $150K and must deliver 100 k-bushels
Advantages

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

Potential problems

Risk on amount produced
May have to go into market to meet obligation

Analysis: Hedge the 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: no value to futures (alone); in fact, vol. increases
Farmer’s Operational Hedge

What else does the farmer have?

**SILO (Granary)**

*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 (assuming no market impact)
Farmer’s Silo Hedge

Expected returns

- High-yield years (prob. $\frac{1}{2}$) $150$ k
- Low-yield years (prob. $\frac{1}{2}$) $300$ k

Expectation: $\frac{1}{2}(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 is useful 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? (Withhold 50 k-lbs from high to low years?)

High years: earn $300k (prob. ½)
Low years: earn $150k (prob. ½)

Expectation: $225k (lower value – don’t save for lower demand years)
Copper Futures?

Suppose we sell 200 k-lbs at $1.50 in future (purely financial, no physical)

Result now:

High demand: $400 - 100 = $300k
(with probability ½)

Low demand: $100 + 100 = $200k
(with probability ½)

Expectation: $250k

Risk reduced ($300 or $200 v. $400 or $100)

Can even reduce the variation to 0.
Best Financial Hedge for Copper Mine

Sell $x$ k-lbs with a future at $1.50$/pound;

Result (in 1000s):

- **Futures return:** $1.5x$ (all the time)
- **High demand:** $+2(200-x)$ (with probability $\frac{1}{2}$)
- **Low demand:** $-1(x-100)$ (with probability $\frac{1}{2}$)
- **Expectation:** $250k$

Risk (volatility) = 0 if $2(200-x) = 1(x-100)$ or $x = 500/3$

$\Rightarrow$ Sell futures of 166,667 pounds at $1.50$/pound.
Overall Observations

Farmer:

Financial and operational can align: reduce risk and high value

Miner:

Reducing volatility in sales not productive but financial hedges can reduce variance in revenues

Next: dynamic model with currency
Operational Flexibility and Foreign Exchange Risk

• Mis-matched operations leads to foreign exchange 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
Advantage of foreign operations:

Cost: \( c_f, c_d \); In domestic currency: \( c_f r_{d/f} \)

If \( r_{d/f} \) is low, then production in \( F \) is favorable;
If \( r_{d/f} \) is high, then production in \( D \) is favorable.

Excess capacity in \( D \) and \( F \) provide an option to shift production to the favorable location.
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.
Value of Flexible Capacity

Can evaluate the capacity as a perpetual option using only correlation to the market for the elimination of risk (Aytekin/Birge 2004).

Value of the capacity is increasing in the volatility of the exchange rate but eventually reaches a limit:

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Flexible Capacity Results

- Operational flexibility can result in gains from foreign exchange exposures
- Additional flexibility can be valued on the basis of rate volatility and changeover costs using principles from financial option pricing
- Operational “hedging” is not just volatility reduction but the exercising of a set of options
- These options can be valued from a market perspective (i.e., not by individual risk preference)
General Cases

- Where can risk reduction actually increase value?

- Cases here: one-sided or concave payoff:
  - Capacity: concave payoff
  - Farmer: one-sided: use inventory when price is high (yields are low)
  - Exchange rate: use alternate site when rate is favorable
  - Option value of operational capability increases with volatility of underlying demand/price
Earnings and Operations

If operations can reduce earnings risk, then lower risk may also create value.

- Suppose market views earnings as signals;
- Low signals lead to downgrades and distress;
- Deadweight losses if below some level.
Use of Risk Criterion

• Reducing risk again leads to increased value because of the deadweight losses

• Evaluation mechanism can be the same
  • Transformation to account for systematic risk
  • Evaluation expectations with some risk-neutral equivalent
  • Include effects of financial distress in evaluation
Key Considerations

• Systematic and idiosyncratic risk are different
  • Systematic risk cannot be avoided (without cost) and requires adjustment (as the market does)
  • Idiosyncratic risk may have consequences but can be included without introducing a risk attitude by including distress costs
  • Method requires correlations to the market (but not that various quantities are actually traded)
Hedging Takeaways

• Financial hedging: Involves purely financial transactions that can reduce overall cash flow volatility but with zero NPV except in reducing financial distress

• Operational hedging: Involves physical operational activity that corresponds to (and can be evaluated as) the exercise of various options on prices, demand, and supply and can have positive NPV (as a payoff from capacity)

• Financial and operational hedges can be combined for maximum effectiveness
Conclusions

• Hedges aim to reduce risk or volatility but can also increase value by eliminating one-sided risk
• Operational hedges in particular can reduce risk and improve contributions and value
• The nature of price, demand, and various exchange risks may change the value of operational risk management
• Valuations are possible for many types of exposures using the tools of option pricing
References


References


Thank you!