

Managing Risk with Operational and Financial Instruments

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Motivation

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

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?

Outline

Preliminary discussion: “hedging” and types of risk

Specific case in foreign exchange

Value calculations

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

Location (currency)



Implications

- 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., costs of financial distress) :
 - Idiosyncratic risk can matter
 - Can still value in the same framework but additional adjustment

Imperfections and Operational Valuation

- Suppose value of firm depends on demand (with early price commitment)
- With no market imperfections, an option – just adjust for the correlation of demand with the market
- The idiosyncratic part of the demand risk makes no difference in value

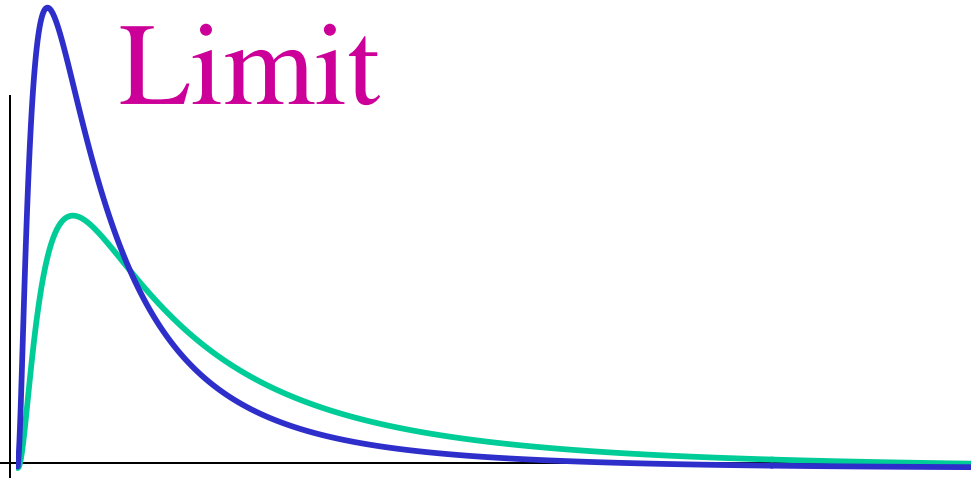
However, with capacity, the payoff is concave and value increases with lower volatility.

Evaluation without Capacity

Limit

No limit:

For log-normal
distribution:



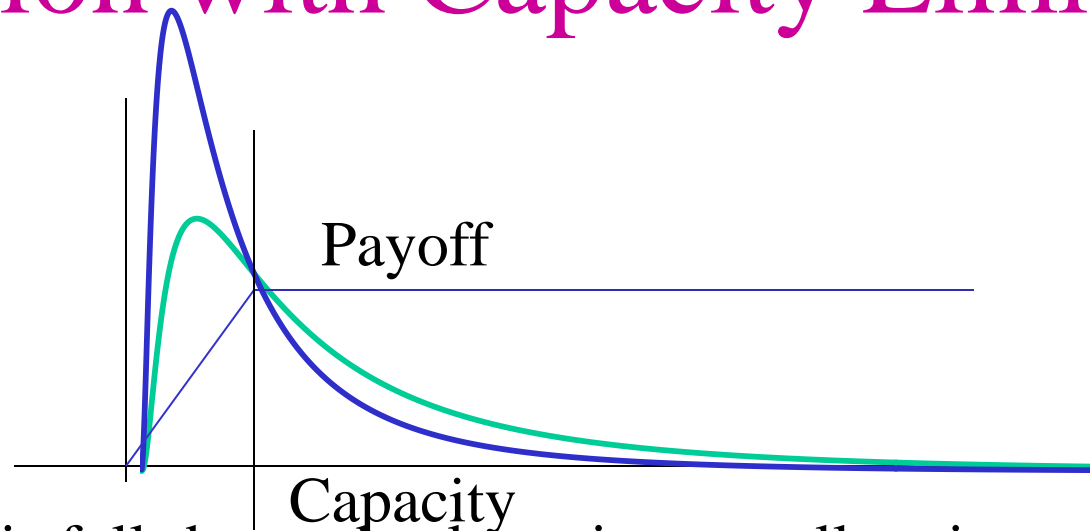
Equivalent to a shift in mean of log-demand
depending on correlation with the market

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

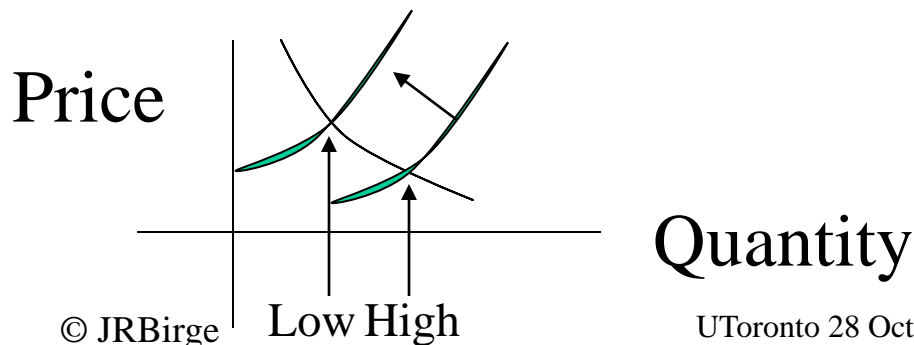
=> Reducing idiosyncratic variation in demand with fixed capacity can increase value but this is not related to risk preference.

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





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?

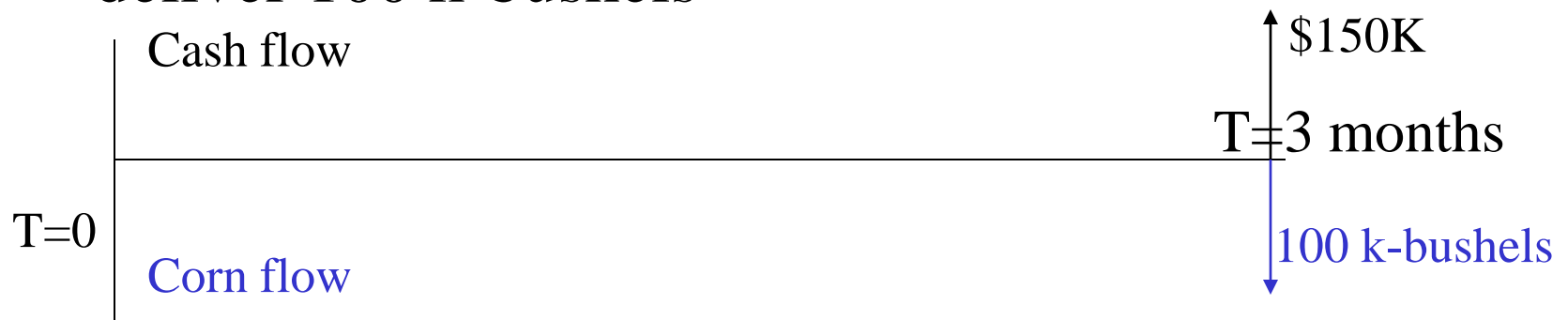
If so, how much?

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



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 produced

May have to go into market

Analysis: Hedge the expected yield (150 k-bushels)

Guaranteed (all the time) \$225K

High yield – can sell 50 more + \$50K (probability 1/2)

Low yield – must buy 50 -\$100K (probability 1/2)

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

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

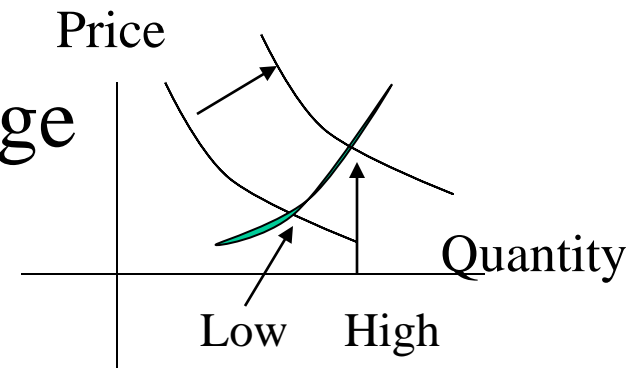
Moral: Financial instrument only has value if farmer uses operational hedge

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. $\frac{1}{2}$) or \$100k (prob. $\frac{1}{2}$)

Expected value of \$250k

Operational hedge? (save 50 k-lbs from high to low years?)

High years: earn \$300k (prob. $\frac{1}{2}$)

Low years: earn \$150k (prob. $\frac{1}{2}$)

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:

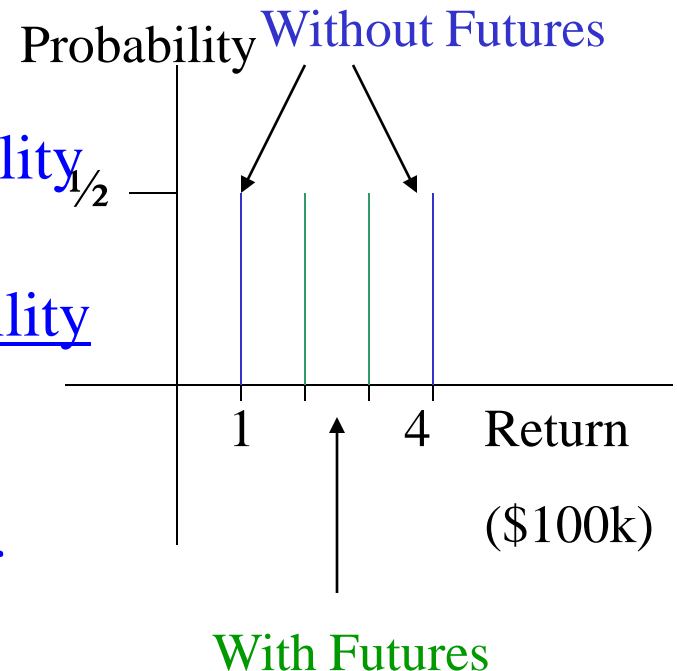
Futures return: \$300k (all the time)

High demand: + \$ 0k (with probability $\frac{1}{2}$)

Low demand: - \$ 100k (with probability $\frac{1}{2}$)

Expectation: \$250k

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



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

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

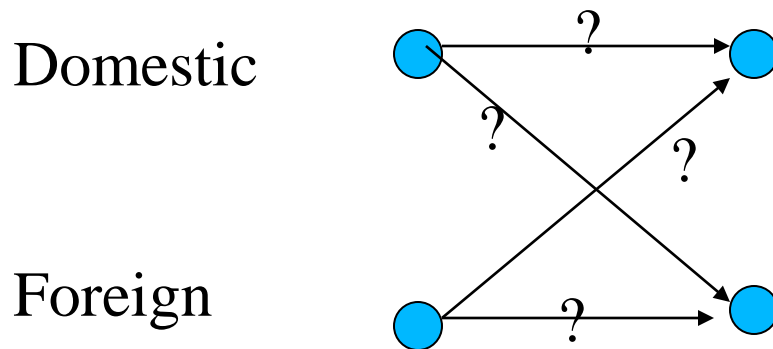
Next: dynamic model with currency

Operational Flexibility and 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

Production Distribution



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.

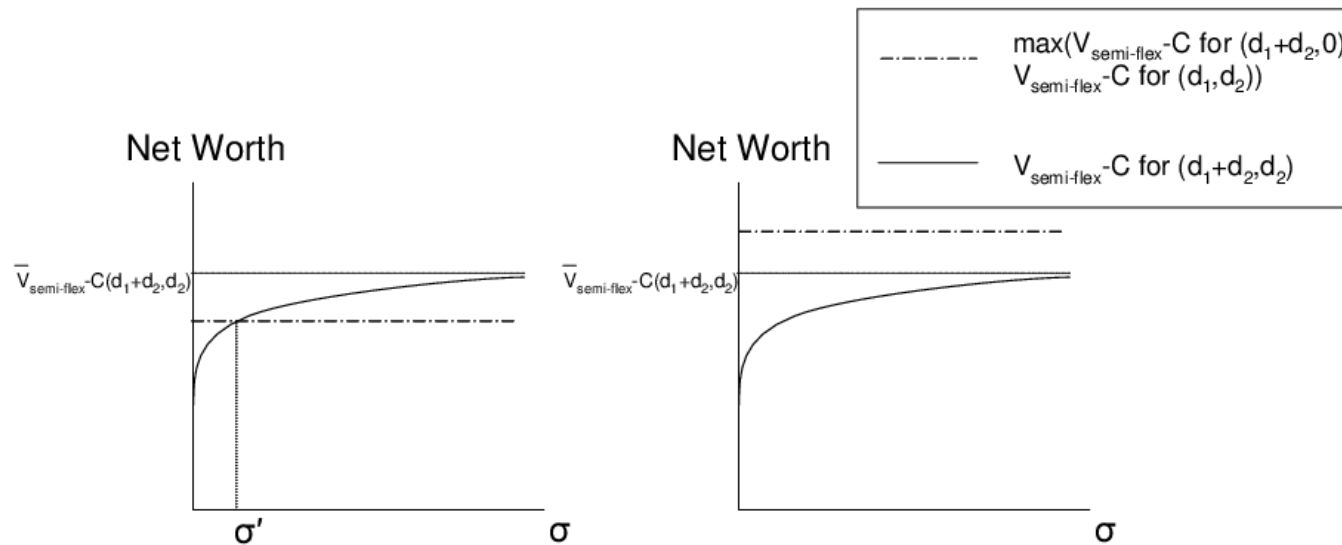
Valuing the Alternatives

- 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

Value also increasing in the volatility of the exchange rate but reaches a limit:



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
- Operational “hedging” is really not volatility reduction but exercising a set of options
- No use of risk preferences

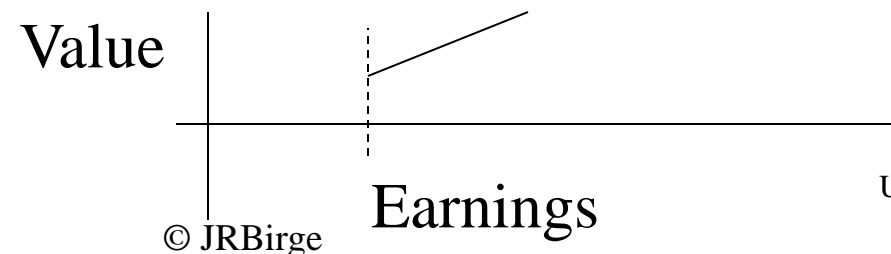
General Cases

- Where can risk reduction actual increase value?
- Cases here:
 - Capacity: concave payoff
 - Farmer: inventory follows relative storage advantage
 - Exchange rate: option value of operations increasing with volatility

Earnings and Operations

If operations can reduce earnings risk, then lower risk may 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 losses
- Evaluation mechanism can be the same
 - Transformation to account for systematic risk
 - Evaluation expectations with some risk-neutral measure
 - 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 they can be measured without introducing a risk attitude
 - Method requires correlations to the market (but not that various quantities are actually traded)

Impact on Evaluating Investments

- Key parameters for the innovations are the correlations of returns with the market
- Idiosyncratic successes and failures can be captured with nominal probabilities
- Evaluation requires care in consideration of the outcomes (and the options to continue or discontinue).

Conclusions

- Risk management should include operational flexibility
- Operations can reduce risk and improve contributions and value (but this is not a statement about risk attitudes)
- 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!

Model for Single Period

Payoff

Suppose:

Price: $p(\omega)$

Max sales/Capacity: $l + kp(\omega)$ ($k > 0$ or < 0)

Decision: x (amount to hedge/hold)

Objective

$$\max E[U((p) (l + kp - x(p)))]$$

$$s.t. \text{ Storage} \geq x(p) \geq -x^{-1}$$

Single Period Results

When does operational hedging add value?

For $k < 0$, can reduce volatility in sales and keep revenue high.

For $k > 0$, want to increase volatility in sales to take advantage of prices.

When prices are supply-driven, hedging (with-holding product) can be beneficial in securing higher prices when demand is high.

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