Real Options in Process Industry
Supply Chain Management

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Outline

• Real options in process industries
  • Location
  • Contract
  • Capacity

• Real-option structure

• Conclusions
Real Option in the Process Industries

• Characteristics of process industries
  – Expensive capacity
  – High volatility prices
  – High volatility demand
  – Geographical revenue/cost variation
  – Global market

• Supply chain areas
  – Capacity
  – Contract
  – Location

• Key theme: Consider option value in choice
Location Decisions

• Where should processing occur?
• How much capacity to place in different areas?
• What is the (real option) value of capacity in a new location?

• Example:
  – Suppose customers in US and Europe
  – Existing plant in Europe
  – What would a US plant be worth?
US/Europe Decision

• Data:
  – Demand of 100 in each market
  – Production cost: $1 in US, € 1 in Europe
  – Selling price: $2 in US, € 2 in Europe
  – Capacity of 200 in Europe
  – Current exchange rate: $1/€
  – Future exchange rate:
    • $1.50/€ or $0.50/€ equally likely
Europe-Only Value

• Expected Value of Europe-only

<table>
<thead>
<tr>
<th>Ex. Rate</th>
<th>US profit</th>
<th>Eur profit</th>
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<tbody>
<tr>
<td>$0.50/€</td>
<td>$150</td>
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<tr>
<td>$1.50/€</td>
<td>$50</td>
<td>$150</td>
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<tr>
<td>Expected:</td>
<td>$100</td>
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• Long-run Value: $200/0.10 = $2000
US and Europe Production

• Expectation with US producing when price is favorable ($1.50/€)

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<td>$200</td>
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<tr>
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• Long-term value: $250/0.10=$2500

• Option value of geographic flexibility:
Contract Decisions

• When to fix a long-term contract price?
• How to structure arrangements with different vendors/customers?
• How to price volume flexibility?
• How to manage risks on contract terms?
Example: Metallgesellschaft

• Problem:
  – Control long-run price uncertainty in oil contracts

• Resolution:
  – Sold long-term contracts to fixed prices
  – Hedged positions by buying futures
MG Issues

• Reasoning for futures
  – If prices rose, then would gain on futures to offset losses on the fixed price contracts
  – If prices fell, would gain on fixed contracts and lose on futures

• Problem:
  – Prices fell, creating margin calls on futures
  – $1Billion in cash required
Resolving Contract Issues

• Needs
  – Consider all positions in assessing contracts
  – Weigh option value on flexible (floating) prices versus fixed prices
  – Measure impact on other operations

• Research areas
  – Coordination of contracting and operations
  – Overall value of contract terms in context of entire enterprise
Real Options

- Idea: Assets that are not fully used may still have option value (includes contracts, licenses)
- Value may be lost when the option is exercised (e.g., developing a new product, invoking option for second vendor)
- Traditional NPV analyses are flawed by missing the option value

How to capture in model?
Example 3: Capacity Decision

- How much to produce?
- How much is capacity worth?

**EXAMPLE:** Products 1,2, 3 ; Plants A,B

How much is capacity for 2 worth at B?
Measuring Investor Value

• OBSERVATIONS:
  – Investors prefer lower risk
  – Investors can diversify away unique risk
  – Only important risk is market - contribution to portfolio

• CONSEQUENCE: Capital asset pricing model (CAPM)
  – With CAPM, can find a discount rate
Discount Rate Determination

• Traditional approach
  – Discount rate is the same for all decisions in program evaluation

• Problems
  – Program evaluation includes decisions on capacity, distribution channel, vendor contracts
  – These decisions affect correlation to market – hence, change the discount rate

• Need: discount rate to change with decisions as they are determined; How?
Discount Rate Determination

- USE CAP-M? FIND CORRELATION TO THE MARKET?
  - Can measure for known markets (beta values)
  - If capacitated, depends on decisions
    - Constrained resources - capacity
    - Correlations among demands

- ALTERNATIVES?
  - Option Theory
    - Allows for non-symmetric risk
    - Explicitly considers constraints -
      - As if selling excess to competitors at a given price

High revenue variation (risk) - high discount
No revenue variation - low discount

Revenue
Capacity
Demand
Using Option Valuation for Capacity

- **Goal**: Production value with capacity $K$
  - **Compute uncapacitated value based on CAPM**:
    - $S_t = e^{-r(T-t)} \int c_T S_T dF(S_T)$
    - where $c_T =$ margin, $F$ is distribution (with risk aversion),
    - $r$ is rate from CAPM (with risk aversion)
  - **Assume $S_t$ now grows at riskfree rate, $r_f$; evaluate as if risk neutral**:
    - Production value $= S_t - C_t = e^{-r_f(T-t)} \int c_T \min(S_T, K) dF_f(S_T)$
    - where $F_f$ is distribution (with risk neutrality)
Generalizations for Other Long-term Decisions

- Model: period t decisions: \(x_t\)
- START: Eliminate constraints on production
  - Demand uncertainty remains
  - Can value unconstrained revenue with market rate, \(r\):
    \[
    \frac{1}{(1+r)^t} c_t x_t
    \]

**IMPLICATIONS OF RISK NEUTRAL HEDGE:**
Can model as if investors are risk neutral
=> value grows at riskfree rate, \(r_f\)

**Future value:** \[
\frac{1}{(1+r)^t} c_t (1+r_f)^t x_t
\]

**BUT:** This new quantity is constrained
Operational and Financial Hedging uses of Real Options

• Objective: Determine capacity levels in different markets, production in each market, distribution across markets, and use of financial hedging instruments to maximize total global value

• Challenges:
  • Demand and exchange rates may change
  • Correlations among demand and exchange
  • What is enough capacity?
  • What performance metrics to use?
Conclusions

• Process industry supply chains have volatility issues that create option value
• Assessing option on location, contract, and capacity decisions requires a comprehensive view of enterprise
• Research opportunities in modeling decisions within context of financial, operational, and marketing decisions