Real-Options Valuation and Supply-Chain Management

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Outline

• Supply chain planning questions
• Problems with traditional analyses
• Real-option structure
• Assumptions
• Resolving inconsistencies
• Conclusions
Supply Chain Situation: Automotive Company

• Goal:
  • Decide on coordinated production, distribution capacity and vendor contracts for multiple models in multiple markets (e.g., NA, Eur, LA, Asia)

• Traditional approach
  • Forecast demand for each model/market
  • Forecast costs
  • Obtain piece rates and proposals
  • Construct cash flows and discount

• ☀ Optimize supply chain for a single-point forecast
Traditional Methods Results

• **Focus on:**
  • Cost orientation (not revenue management)
  • Single program (model, product)
  • NPV
  • Piece rates

• **Result:** support of traditional, fixed designs, little flexibility, little ability to change, immediate investment or no investment
Trends Limiting Traditional Analysis

- **Market changes**
  - **Former competition:**
    - Cost
    - Quality
  - **New competition:**
    - Customization
    - Responsiveness
Limitations of Traditional Methods for New Trends

- Myopic - ignoring long-term effects
- Often missing time value of cash flow
- Excluding potential synergies
- Ignoring uncertainty effects
- Not capturing option value of delay, scalability, and agility (changing product mix)
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
- Missing parts:
  - Value to delay and learn
  - Option to scale and reuse
  - Option to change with demand variation (uncertainty)
  - Not changing discount rates for varying utilizations
Value to Delay Example

- Suppose a project may earn:
  - $100M if economy booms
  - $-50M if economy busts
- Each (boom or bust) is equally likely
- NPV = $25M (expected) - Start project
- Missing: Can we wait to observe economy?

Here, we don’t need to invest in “Bust” - Now we expect $50M

It’s worth $25M to wait.
Scale Option Example

- Scalability

- Suppose a five year program
  - Cost of fixed capacity is $100M
  - Cost of scalable capacity is $150M for same capacity
  - Predicted cash flow stream:

<table>
<thead>
<tr>
<th>Year</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net</td>
<td>25</td>
<td>50</td>
<td>75</td>
<td>50</td>
<td>25</td>
</tr>
</tbody>
</table>
Scalability Example - cont.

• Assume 15% opportunity cost of capital:
  • NPV(Traditional) = $50M
  • NPV(Scalable) = 0

• Problem: Scalable can be configured over time:

<table>
<thead>
<tr>
<th>Year 0</th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spend $50M for capacity to $25M</td>
<td>Spend $50M for cap. to $50M</td>
<td>Spend $50M for cap. to $75M</td>
</tr>
</tbody>
</table>
Scalability Result

Cash flow for Scalable:

<table>
<thead>
<tr>
<th>Year</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net</td>
<td>-50</td>
<td>-25</td>
<td>0</td>
<td>75</td>
<td>50</td>
<td>25</td>
</tr>
</tbody>
</table>

Now, \( \text{NPV(Scalable)} = 75M > \text{NPV(Fixed)} \)

Traditional approach misses scalability advantage.
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
Using Option Valuation for Capacity

- **Goal:** Production value with capacity $K$
  - Compute uncapacitated value based on CAPM:
    - $S_t = e^{-r(T-t)}c_T S_T dF(S_T)$
    - 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 $= S_t - C_t = e^{-r_f(T-t)}c_T \min(S_T, K) dF_f(S_T)$
    - where $F_f$ is distribution (with risk neutrality)
Assumptions

• Process of prices or sales forecasts
• No transaction fees
• Complete market
  • How to construct a hedge?
  • If NPV > 0, inconsistency
  • Process: Trade option and asset to create riskfree security
Creating Best Hedge

- Underlying asset: Max potential sales in market
- Option: Plant or contract with given capacity
- Other marketable securities:
  - Competitors’ shares
  - Overall all securities min residual volatility
  - Due to incompleteness, some volatility remains (otherwise, NPV=0)
- Result:
  - Remaining volatility provides a range of choices which cannot be arbitrated
  - Can use utility max or other factors to choose within range
Summary

- Options apply to supply chain problems
- Can evaluate supply chain planning with proper option evaluation techniques
- Relaxed market assumptions lead to models that determine a range of policies
- Firm or investor utility can choose within range