Supply Chain Planning Decisions under Demand Uncertainty

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Companies need to invest in supply chain based upon forecast in mid or long term.

Flexible supply chain may handle uncertainty and disruption better, but flexibility may come with cost.
Research Question

Can we develop a simple and easy approach:

to understand the impact of demand uncertainty on supply chain planning and

to optimize supply chain designs under demand uncertainty
Research Methodology

Monte Carlo Simulation of Multiple Demand Variables

Value at Risk and Gain Curve Analysis

Real Option Analysis

Spreadsheet Sensitivity Analysis and Optimization
Monte Carlo Simulation Approach

Generating simulated demands
- Unconstrained demand distribution estimate
- Spreadsheet simulations

Inputting demands to various supply chain designs
- Net income NPV distribution
- Cost NPV distribution
- Environmental impact
- Real Option Values

Optimization
- Changing parameters to visualize outputs
- Using Solver to optimize the designs
Investment Decisions

- Ocean Shipping Options
- Trucking Options
Ocean Shipping Plans

- Plan 1. Small Ship
  - 490 containers

- Plan 2. Two Small Ship
  - 490 + 500 containers

- Plan 3. One Large Ship
  - 1000 containers

- Plan 4. One small ship and one pallet ship
  - 490 + 400 containers
Ocean Shipping Model

\[
\text{Cost NPV} = \sum \frac{C_{\text{variable}} \cdot \text{Min}(d_{\text{Capacity}}, D_{\text{Unconstrained}}) + C_{\text{fixed}} - (P_{\text{Backhaul}} \cdot D_{\text{Backhaul}} + P_{\text{Fronthaul}} \cdot d_{\text{Fronthaul}})}{(1+0.10)^i}
\]
Net Income NPV
Net Income NPV

10 Percentile

90 Percentile

MIT Center for Transportation & Logistics

Huang

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Impact of Fuel Cost on Net Income NPV and Option Value
Trucking Plans

- **Common carrier**
  Maximum flexibility
  Less revenue for backhaul

- **Dedicated fleet**
  Fixed cost + variable cost
  Significant revenue for backhaul
  Very little flexibility
# Trucking options

### Trucking Option Comparison

### Net Trucking Cost Comparison

<table>
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<tr>
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<th>Dedicated Fleet</th>
<th>Common Carrier</th>
<th>Mixed</th>
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### Dedicated Fleet Size, Containers

|                | 440             | 0               | 83        |
Common Carrier vs. Dedicated Fleet
Summary

- Supply chain designs under demand uncertainty can be analyzed and optimized using a three step approach

- The analysis and optimization can be performed in excel. Model building and analysis can be straight-forward and in a format that is familiar to decision makers

- This approach was used to analyze Chiquita’s ocean shipping and trucking plans
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