Supply Chain Complexity

• There is a general consensus that . . .
  • supply chains are complex,
  • they are only getting more complex, and
  • complexity adds costs to a supply chain,

Therefore, we should look to mitigate or minimize complexity.

However, some believe that some complexity is good and should be embraced.
What is complexity?

“I know it when I see it”
Justice Potter Stewart, in Jacobellis v. Ohio regarding possible obscenity in a movie.

Questions to Be Answered

1. What is complexity?
2. What are the drivers of complexity?
3. How is complexity introduced into a Supply Chain?
4. How can you determine which aspects of complexity to eliminate and which to embrace?
   - How can you eliminate complexity?
   - How can you embrace complexity?
Supply Chain as a System

- Take an Engineering Systems Perspective
  - What is a variable and what is a constraint?
  - Continuous expansion of decision variables
  - Increases potential for improvement but increases both complexity and coordination requirements

Objective: Deliver at lowest transport cost
Variable:
  - Select carrier to tender each load to
Constraints:
  - Ship everything each day
  - Must deliver within specified windows
Supply Chain as a System

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<table>
<thead>
<tr>
<th>Supplier</th>
<th>Product Design</th>
<th>Manufacturing</th>
<th>Warehousing</th>
<th>Inventory Mgmt</th>
<th>Material Handling</th>
<th>Transportation</th>
<th>Order Processing</th>
<th>Customer SVC</th>
<th>Retailer</th>
</tr>
</thead>
</table>

Objective:
- Maximize on-shelf availability

Variables:
- Select carrier to tender each load to
- Select time windows to deliver
- Select when to ship what from where
- Determine where to stock which form of product
- Select contract relationships
- Select who should control replenishment
- Which channel member should perform which function

Constraints:
- Total delivered cost to shelf

What is complexity? . . . from the literature

- Distinction between complicated and complex.

- Two types of complexity (Singe 1990)
  - Detail Complexity – distinct number of processes or parts within the system
  - Dynamic Complexity – unpredictability of response of the system due to interactions

- A system is complex if it “is made up of a large number of parts that interact in a non-simple way.” (Simon 1962)

What are the drivers of SC Complexity?

1. Numerousness
2. Variety/Diversity
3. Interconnections/Interactions
4. Opacity of Interactions
5. Dynamic Effects


Why do we care?

- Complexity is not introduced for complexity’s sake
- Drivers of complexity = Drivers of profitability
- Drivers of profitability
  - Increase revenue per unit
  - Increase the number of customers
  - Increase number of units sold
  - Decrease cost per unit
- Implicit to every strategy or action intended to improve profitability is a hidden cost of complexity
Profitability Drivers = Complexity Drivers

Revenue/Unit

# Customers

# Units

Cost/Unit

Numerousness

Variety/Diversity

Interactions

Example: Introduce new packaging format

Revenue/Unit

# Customers

# Units

Cost/Unit

Numerousness

Variety/Diversity

Interactions
### Example: Launch new product line

| Revenue/Unit | Numerousness |
| # Customers  | Variety/Diversity |
| # Units      | Interactions     |
| Cost/Unit    |                |

### Example: Open a joint DC for online and traditional retail replenishment

| Revenue/Unit | Numerousness |
| # Customers  | Variety/Diversity |
| # Units      | Interactions     |
| Cost/Unit    |                |
Where does complexity enter the supply chain?

Complexity enters at the ends!

Desire for unique solutions

Desire for a wide and diverse product portfolio.

Identifying where complexity lies

Complexity “fingerprint”

Packaging - 17 of 33 configurations account for 80% of EBIT (52%)
Customers - 214 of 2142 (just 10%) customers account for 80% of EBIT

How to determine good vs. bad?

- **Value Destroying**
  - Does the cost of complexity outweigh the value?
  - Does it introduce greater confusion to the customer?

- **Value Creating**
  - Is the cost of the complexity less than the increase in value to the customer?
  - Does the added complexity provide potentials for flexibility?
  - Does the added complexity create a competitive advantage?

Complexity Example: Novartis

- Complexity Reduction Initiative (2010)
  - 14,000 SKUs sold across 140 countries
  - Multiple dosage forms (film-coated tablets, pre-filled syringes, sugar coated pills, etc.)
  - Multiple pack sizes and formats
  - Regulatory requirements – same product produced at two plants creates two SKUs
  - Difficulty in retiring products – some required by regulation others due to mergers

Complexity Example: Novartis

Which SKUs to focus on?

- Didn’t reduce entire set of SKUs
- Strategic reasons for limiting set of SKUs
- Consensus between stakeholders for initial analysis and focus


Complexity Example: Novartis

- Simultaneous Two Pronged Approach
  - Redundant Product Rationalization
  - Tail-end Pruning

Step #1: Redundant Product Rationalization

- Bottoms up approach
- Identify redundant profits by product
- Match true customer requirements and align to products
  - Example: one month vs. two month dosage packs

Complexity Example: Novartis

Redundant Product Rationalization Results

- Reduced SKUs by 30% with no sales loss
- Reduced SKUs lead to better forecasting
- Very resource intensive initiative
- Required buy-in by heads of finance & marketing

Complexity Example: Novartis

Step #2: Tail-end Pruning
- Top-down approach
- Identify and remove small less profitable products
- Devil is in the details and the tail always regenerates

![Diagram](image)


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Complexity Example: Novartis

- Tail-end Pruning
  - What level of detail makes sense?
  - Measure by SKU by Brand by Drug . . .
  - Two approaches considered:
    - MILP – when high quality data is available
    - Criteria Threshold – when data is imperfect

![Diagram](image)

Complexity Example: Novartis

- Results of Complexity Reduction Initiative (2010)
  - Approximately 1100 SKUs pruned
  - 43 complete brands were pruned!
  - Inventory savings of $22 M


Complexity Example: Hewlett Packard

- Hewlett-Packard circa 2008
  - More than a billion customers in 170 countries
  - Wide variety of product lines and SKUs
    - > 2,000 Laser Printers
    - >15,000 Server SKUs
    - > 8 million Laptop & Desktop configurations
  - Multiple sales channels with variety of order cycle times
  - Shorter overall product lifecycles
  - New products constantly introduced
    - Marketing decision based on marginal revenue improvement
    - Minimal supply chain input on costs

Complexity Example: Hewlett Packard

- Portfolio Rationalization Project
  - Focus on Personal Systems Group (PSG)
  - Configurable PC products
  - Low per SKU costs - but high underlying costs
  - Orders must ship 100% complete - one component short kills entire order
  - Lead to long and unpredictable Order Cycle Time (OCT)

- Two Simultaneous Initiatives
  1. New Product ROI Screening
     - keeping overly complex products out
  2. Revenue Coverage Optimization
     - for pruning existing products

New Product Introduction Process (Stage-Gate)

Open Innovation Stage-Gate®: External Interfaces (In-Bound & Out-Bound)

at Multiple Points in the Process

- Discovery: Ideas Generation
- Stage 1: Scoping
- Stage 2: Build Business Case
- Stage 3: Development
- Stage 4: Testing & Validation
- Stage 5: Full Launch
- PLR

- Externally generated ideas from multiple sources: Scan, handle & screen ideas from inventors, start-ups, small companies, partners, consumers, many other sources
- Determine capabilities gap
  - Seek & vet partners or outsourced-suppliers
  - Co-operative work in VOC, Technical Feasibility, Building Business Case, Legal & IP strategy
- Seek external sources of IP & technology solutions
  - Coop or outsourced development work
- Out-license or sell IP & technology
- Out-license or sell commercial products & IP or in-license products

- New gate criteria required, especially at early gates
### Complexity Example: Hewlett Packard

#### #1: New Product ROI Screening
- **ABC approach with volume and variety as distinct drivers**
- **Used mix of approaches (ABC, regression) for variety drivers**
  - More SKUs lead to higher returns
  - Lower volumes lead to higher variability

#### Low Volumes of a SKU drive Costs

#### # SKUs drive Costs

#### Complexity ROI

\[
\text{Complexity ROI} = \frac{\text{Incremental margin} - \text{Variable complexity costs}}{\text{Fixed complexity costs}}
\]
Complexity Example: Hewlett Packard

#2: Revenue Coverage Optimization

- Pruning existing products
- Maximizing value of active portfolio
- Measuring revenue generation by item misses interactions and interdependencies
- RCO answers the question: If I could only have 100 products, which should I choose?
- New metrics:
  - Order Coverage – percent of previous order that could be filled with existing portfolio
  - Revenue Coverage – revenue (margin) of covered orders as a percent of the total revenue

![Image](RCO_compared_to_heuristic_ranking_methods.png)

Complexity Example: Hewlett Packard

- Portfolio Rationalization Project Results
  - Over $500 M saved since 2005
  - Product adoption rate improved from 18% to 85%
  - Shift from revenue focused to margin focused management
  - LaserJet SKU count reduced by 40% in 3 years (2006-9)
  - RCO eliminated 3,300 of 11,000 SKUs from HPs Business Critical Systems division
  - Soft benefits
    - Higher customer satisfaction
    - Less confusion for sales and customers
    - Higher forecasting accuracy
    - Better organizational efficiency – forcing Green, Blue & Red to talk!

What about embracing complexity?

- What industry has:
  - Very small batch sizes
  - Long set up times with very short desired lead times
  - Highly customized products (no two are alike)
  - Unpredictable order frequency
  - Many many very small customers

Printing Business Cards

- Traditional Process
  - Relatively high design costs & time
  - High switch over and set up costs between runs
  - Individual card runs – requires high minimum orders
  - Rough costs are about $10-$20 per MSI
    - Business cards are 2” x 3.5” so 500 cards ≈ 3.5 MSI = $35

- Vistaprint
  - Printing business cards and other marketing for micro-businesses
Embracing Complexity Example

Online Design & Ordering

- Integrated Production Processes
  - Software tied directly from ordering & design to production
  - Gang Run Printing - Batching together different print jobs into a single print run on a single sheet.
  - Automated sorting, aggregating, and organizing of jobs
Embracing Complexity Example

- A "minefield of patents"
- Initial patents filed in France in 2000
- 28 issued in US as of 2013
- Example; VistaBridge - Patent 6,992,794

Vistaprint Results

Revenue ($, million)
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