The Rise of Computer-Enabled Supply Chain Design

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What is Supply Chain Design?
Where did it come from?
Why does it matter?
What are the key recent advancements?
What’s next?
What is supply chain design?
What infrastructure is required for manufacturing and distribution?

When should we buy or make product for the best use of capacity?

How should we transport product through the supply chain?

How much and where should inventory be positioned in the supply chain?

What is the best flowpath?

At what service level can we profitably satisfy demand?
What is supply chain design?

**Key Data**

- Raw material costs
- Supplier capacity and service
- Inbound material lead time
- Inbound lane costs

- Labor, energy, land, facility cost
- Production speed and capacity
- Shift schedules
- Lots, batching, yield, loss

- Contract carrier rates
- Private fleet sizing
- Equipment and driver expense
- Fuel surcharges
- Load consolidation

- Greenfield DC locations
- Transfer lane costs
- Outbound lane costs

- Service level, fill rates
- Forecast error and variability

- Customer demand
- Product profitability
- Price
Why is supply chain design important?

The majority of a supply chain’s lifecycle costs are locked-in at the start.

- Overall strategy first, then specific sites and incentives
- Just like investment decisions – pick asset allocation first, then specific stocks, mutual funds, etc.

Decisions

<table>
<thead>
<tr>
<th>Strategic</th>
<th>Supply Chain Design and Optimization</th>
<th>80%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tactical</td>
<td>Advanced Planning and Scheduling</td>
<td></td>
</tr>
<tr>
<td>Operational</td>
<td>MRP/ERP</td>
<td>20%</td>
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<tr>
<td></td>
<td>Execution</td>
<td></td>
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</tbody>
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Source: Gartner / AMR Research
What do supply chain design engineers do?

- Sift through a vast quantity of data and options to arrive at the best design – one that meets the needs of the business and its customers with minimum **cost**, **risk**, and **environmental impact**
- Increasingly use large-scale mathematical programming models to evaluate trade-offs between cost and performance
- Supply chain design has become a respected area of Industrial Engineering, with dedicated academics, practitioners, software vendors, and consultants
The rise of optimization and supply chain design are inter-related.

- **1939**: Linear Programming
  - Soviet economist, Leonid Kantorovich is credited with development

- **1947**: Simplex Method
  - George Dantzig’s published method led to broader applications of LP

- **1980s**: Network Optimization
  - LP models replacing heuristics to answer network flow questions

- **Today**: Mixed Integer Programming
  - MIP embraces advances in technology, making it better suited for Supply Chain Design
Why are MIP and computing power so critical?

Consider a warehouse rationalization model with “on-off” decisions for each site:

- Each facility has 2 states: “On” or “Off”
- For a simple network with 3 candidate warehouse location or size alternatives, the number of combinations is $2^3$ or 8
- A modest network with 15 candidate warehouse location or size alternatives has $2^{15}$ or 32,768 combinations
- A network with 300 candidate warehouse location/size alternatives yields $2^{300}$ or $2 \times 10^{90}$ combinations

By the way, the number of atoms in the universe is about $10^{80}$.
Computer hardware availability and cost (Moore’s Law)

- 64-bit Windows removed prior limits on RAM
- Multi-Core & Multi-processor systems
- Cloud-based solving capability
The increasing availability of computing power, as described by Moore’s Law, has significantly enhanced the complexity, accuracy, and adoption of computer-enabled supply chain design.
Computer hardware availability and cost (Moore’s Law)

**Big data systems** make it possible to access and manipulate the large datasets which underlie supply chain design models

- Access to historical data like shipment history and POS data
- Predictive, **unbiased** “design data” for new options to test
“Big Data” Drives Freight Cost Prediction

Annual TL Freight Market
$300B

Transport Topics Top 10 Carriers
$13B (4%)

$18B
(6%)

“Large” $200MM Shipper

Chainalytics TL Consortium

$18B in Freight Spend
15MM+ Truckloads
108 Member Companies
Refreshed multiple times per year

Sources: CSCMP, Transport Topics, Chainalytics FMIC
Predicting Freight Costs
Where do trucks want to go (and not want to go)?

Trucks want to end up where they can get another load nearby (blue areas).

Source: Chainalytics FMIC
Recent Advances in Supply Chain Design

Computer hardware availability and cost (Moore’s Law)

Big data systems make it possible to access and manipulate the large datasets which underlie supply chain design models

Modeling tools have become sophisticated and easier to use

- Multi-objective functions
- Coupling of optimization and simulation
- Automated sensitivity analysis
- Math formulation and solver improvements
- Usability to engage business leaders
Modern Supply Chain Design Technology

Source: LLamasoft
External factors will keep pushing companies to improve and adapt
  - Complexity and change will keep accelerating (fuel, disasters, customer req’ts…)
  - Supply chain design will grow increasingly critical

Firms will depend more on collaboration and consortium-driven insights

The scope that we can address in a single model will continue to grow

The frequency of analysis will keep increasing (weekly, real-time “anomaly detection”?)

In the move from Intelligent to Cognitive, we will have to decide how much cognitive autonomy we permit…
  - M&A targets?
  - Opening and closing facilities?
  - Staffing decisions???
Questions?

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