Construction Supply Chain Modeling: Issues and Perspectives (Part 2)

Scott J. Mason, Ph.D.
Fluor Endowed Chair in Supply Chain Optimization and Logistics
Professor of Industrial Engineering
Four Types of Construction Products

• Engineered to Order (ETO)
  – Specially made for customer following detailed specifications
  – Long lead times and complex engineering processes for product specifications

• Make to Order (MTO)
  – Products manufactured once customer orders have been placed
  – Typically no inventory with long or short lead times depending on the manufacturing complexity
Four Types of Construction Products (2)

• Assembled to Order (ATO)
  – Assembled (manufactured) after customer orders
  – Typically standard/made of standard components
  – Short lead times with stock held to manage uncertain mix

• Make to Stock (MTS)
  – Commodities with short lead times
  – Inventory present, but can be complex to manage
• Job sites constitute the demand that needs to be fulfilled by all SCs
  – Typically expressed as when needed, rather than how much
  – Often unstable due to unreliable site production systems

• In case of changes, information should flow quickly to suppliers so they can respond
  – Access to demand information is somewhat limited to a few suppliers and subcontractors
    • Consequence: Coordination of material flows is inefficient and much waste is spread through SCs
Additional Complexities

• Subcontractors with multiple, simultaneous projects
• Risk residing in suppliers that
  – Provide long lead time products
  – Have limited capacity to handle market demand
• Owners delaying approval processes and requiring design changes
• Designers delaying procurement processes
• Designers making independent decisions without considering SC capabilities
  – Supply firm to large EPC firm: “Design what we stock!”
Common Causes of Problems

• Fabrication and/or delivery delay
• Damaged or wrong products arriving at job site
• Subcontracts with low productivity
• Order quantity/frequency/batch size decisions
• Inventory level determination
Project-Phased Decision Making

FIGURE 2.5 Construction project phases and associated SC decisions.
Summary of Construction SC Modeling Efforts to Date

• Tactical, specific decisions
• Descriptive, not prescriptive analysis
  – Deterministic
  – Static (a current snapshot)
• Focus on case descriptions
• Value Stream Mapping
  – Can you say IE? I knew you could 😊
  – Process, material, and information flow modeling
  – Book is wrong... this was developed by Toyota!
  – Identifies waste and inefficiencies, then seeks to remove them
Construction SC Simulation

• Useful for tactical and operational decisions and can help to
  – Predict lead times
  – Predict throughput performance
  – Examine the impact/effect of buffer and batch sizes
  – Characterize variability in process durations
  – Characterize variability in product standardization

• Does “not easily scale to earlier strategic decisions for a given project where details about specific process and material flows have not been firmly identified”
Issues with Construction SC Simulation

• Models have not supported wide-scale analysis of operational decisions
  – Due to lack of data
  – Due to challenges in modeling and calibrating such detailed models

• Mason’s take: Simulation is difficult, especially if you are not a trained IE or “simulationist”
  – Easier to teach a simulationist construction processes than it is to teach a construction expert how to build valid simulation models
Issues with Construction SC Simulation

• Only recently have construction simulation efforts focused on cost

• Models do not allow construction professionals to draw inferences about construction SC strategic decisions
  – Mason’s take: What are the probabilistic inputs that are required for a strategic simulation?
    • Monte Carlo, anyone?

• Need broader view of independent SCs converging to “multiple” construction projects
  – Perhaps executed by the same GC?
SC Model Purposes

- Evaluate the supply chain configuration
  - Evaluate the best SC configuration to fulfill the demand (improve response time)
- Assess SC complexity (# of members, information and material flows, coordination effort)
- Assess location of facilities
  - Show which company is responsible for each process (ownership decisions)
- Reduce product lead time (eliminating or combining activities)
  - Identify the number of processes performed to deliver the product
  - Identify the time spent in each process (conversion and flow)
  - Classify each process performed (value-added or non-value-added)
  - Simplify the SC (eliminating non-value added activities, relocating inventories, consolidating points for distribution)
- Evaluate buffering decisions
  - Locate inventory buffers in the SC (decoupling points)
  - Identify the type and size of buffers
  - Influence of buffer location and size on the product lead time
SC Model Purposes (2)

Evaluate production decisions
Assess batch decisions and their influence in the final product throughput
Influence of set-up time on companies’ delivery performance
Evaluate the effect of capacity decisions on the SC (inventory behavior, lead time, throughput)

Evaluate transportation decisions
Assess how transportation (type and frequency) affects SC (lead time, delivery performance, costs)

Assess SC costs
Inventory costs, process costs, transportation costs, ordering costs, cost of resources
Understand the risk of materials delay (on the construction schedule)

Illustrate the SC information coordination (IT application)
Identify the frequency, content, and type of information exchanged (and how it is transferred)
Evaluate the risk of communication errors and delays on material flows and inventory buffers (Bullwhip Effect)

Assess the impact of product complexity (standardization, # of parts) on the SC response time
## Selected SC Metrics

<table>
<thead>
<tr>
<th>SC Model Purposes</th>
<th>Metrics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identify material supply risks</td>
<td>SC average throughput; SC lead time variability; percent on-time deliveries; lateness of deliveries</td>
</tr>
<tr>
<td>Decrease transportation costs</td>
<td>Delivery frequency; minimum batch size; distance; cost per unit; handling cost</td>
</tr>
<tr>
<td>Decrease manufacturing costs</td>
<td>Labor and machine costs; labor and machine utilization; process cycle time; capacity utilization; total inventory costs</td>
</tr>
<tr>
<td>Increase SC throughput</td>
<td>SC throughput; buffer sizes; batch sizes; number of processes; process cycle time; manufacturing lead time; delivery lead time</td>
</tr>
<tr>
<td>Measure SC reliability</td>
<td>SC lead time variability; percent on-time deliveries; lateness of deliveries; supply quality (shipping errors, customer complaints); stockout probability</td>
</tr>
<tr>
<td>Evaluate supply flexibility</td>
<td>Production volume (capacity); production mix (variety of products); or delivery dates (change planned delivery dates)</td>
</tr>
<tr>
<td>Evaluate SC complexity</td>
<td>Number of processes; number of different companies; geographical locations; flows of materials (number of stages); flow of information (centralized vs. decentralized)</td>
</tr>
</tbody>
</table>
Your Takeaway

• Similarities and differences between production and construction SCs
• Opportunities for strategic, tactical, and operational decision making by a variety of IE-based tools
• Potentially suggestions/hints for Capstone Design project