Design of Supply Chains and Recent SCM development

KPP341 – Supply Chain Management

Magnus Wiktorsson
Fundamentals of Supply chain design

Short on the design process of complex systems

Classic models and methods for SC design

Variables and criteria

Key concepts in recent SCM development (Ch 16)

(Some cases)
Defining the supply chain

Fig. 1. The supply chain process.

Key SCM Concepts

Each interface in the Supply Chain represents:
- movement of goods
- information flows
- transfer of title
- purchase and sale

Strategic SCM consists of developing smarter ways to
- choose,
- buy from, and
- sell to your business partners.

Source: MIT Open course ware
Levels of supply chain design

**Overall Operations design**
- Vertical integration. Location. Capacity

**Tactical decisions for supply chain design**
- Delivery pattern
- Sourcing policies
- Customer order decoupling point

**Specific supply chain design aspects**
- Materials management and planning
- Lot sizing and safety stock
- Transport and route planning
- Procurement contracts
3 strategic design decisions in operations design

*Vertical Integration:* How much of the network should the operation own? Where, from a value-add perspective, is the interface to suppliers and customers?

*Operations Location:* Where should each part of the network owned by the company be located? Should it be close to the suppliers or close to its customers, or somewhere in between?

*Long-term Capacity Management:* What physical capacity should each part of the network owned by the company have at any point in time?

Slack et al. (1998)
Discussion

What development applies for different business sectors?
Concerning:
- Vertical or lateral integration
- Operations location
- Capacity management

**Vertical Integration:** How much of the network should the operation own? Where, from a value-add perspective, is the interface to suppliers and customers?

**Operations Location:** Where should each part of the network owned by the company be located? Should it be close to the suppliers or close to its customers, or somewhere in between?

**Long-term Capacity Management:** What physical capacity should each part of the network owned by the company have at any point in time?

1. Consumer goods?
2. Automotive industry?
3. Electronics components and products?
4. IT services?

Slack et al. (1998)
Levels of supply chain design

Overall Operations design
- Vertical integration. Location. Capacity

Tactical decisions for supply chain design
- Delivery pattern
- Sourcing policies
- Customer order decoupling point

Specific supply chain design aspects
- Materials management and planning
- Lot sizing and safety stock
- Transport and route planning
- Procurement contracts
Discussion

Identify a real case (type of product/producer) for each of the following delivery patterns:

(1) Batch delivery to stock.
(2) Direct delivery to production.
(3) Delivery through logistics centre.
(4) Vendor-managed inventory.
(5) In-plant store.
(6) Direct delivery to customer’s customer.
Kraljic Model
Purchasing Portfolio Management

- **Leverage Items**: Exploitation of purchasing power
- **Strategic Items**: Diversify, balance, or exploit
- **Non-critical Items**: Efficient Processing
- **Bottleneck Items**: Volume assurance
Customer Order Decoupling Point

Levels of supply chain design

Overall Operations design
- Vertical integration. Location. Capacity

Tactical decisions for supply chain design
- Delivery pattern
- Sourcing policies
- Customer order decoupling point

Specific supply chain design aspects
- Materials management and planning (Ch 12-13)
- Lot sizing and safety stock (Ch 12)
- Transport and route planning (Ch 14)
- Procurement contracts (Ch 15)
EOQ

Total cost of carrying inventory and ordering process:

\[ TC = i \times c \times \frac{Q}{2} + O \times \frac{D}{Q} \]

Where

- \( c \) = cost per unit
- \( i \times c \) = inventory carrying cost per unit and year
- \( O \) = ordering cost per occasion
- \( D \) = demand per time unit
- \( Q \) = order quantity

Derive with respect to \( Q \) gives:

\[ Q_{opt} = \sqrt{\frac{2 \times D \times O}{i \times c}} \]
Fundamentals of Supply chain design

Short on the design process of complex systems

Classic models and methods for SC design

Variables and criteria

Key concepts in recent SCM development (Ch 16)

(Some cases)
The design paradox

"How can you decide the whole, without knowing the parts? The parts depend in turn on the whole."
Developments of the general model of the design process

(Rosell, 1990)
Problem statement

Visions / Objective

Requirements

Pre-conditions

Propositions

Evaluation

Rosell, 1990
Design as a reduction process

Choice and evaluation screens

Large number of design options

Concept

Time

One design

Final design specification

Uncertainty regarding the final design

Certainty regarding the final design

Slack et al., 1998
The hierarchy of systems

Pahl and Beitz, 1996
One example on design process for production systems

1. Identifying the required manufacturing functions needed.
2. Make vs. buy decisions.
3. Input/output-diagrams (IOD) of a number of Business System Options (BSOs) fulfilling the requirements of the desired, physical system.
4. Convert the physical IOD to including control models.
5. Refine control specific aspects within the different BSOs

(Wu, 1994)
Fundamentals of Supply chain design

Short on the design process of complex systems

Classic models and methods for SC design

Variables and criteria

Key concepts in recent SCM development (Ch 16)

(Some cases)
There are many mathematical models to based on quantitative data determine e.g. localisation.

**Justification Methodologies**

- **Strategic Approaches**
  - Technical benefits
  - Business Advantage
  - Competitive factors
  - Future Expansion

- **Analytic Approaches**
  - Value Analysis
    - Scorecards
    - Linear additive models
    - AHP Models
  - Mathematical Analysis
    - "Back-of-the-envelope" calculations
    - Spreadsheets
    - Queuing networks
    - Optimisation techniques
  - Experimental Analysis
    - Trace-driven simulations
    - Monte Carlo simulations

- **Economic Approaches**
  - Payback
  - Net Present Value
  - Internal Rate of Return
  - Other Discounted Cash Flow methods
  - Non DCF methods
  - Sensitivity Analysis

*Wiktorsson, 2000*
Models for supply chain design and analysis

Multi-stage models for supply chain design and analysis can be divided in four categories depending on modeling approach:

- Deterministic analytical models (known and specified variables). batch sizes, order quantities, stock levels, lead times, transportation mode, location etc)
- Stochastic analytical models (at least one variable unknown, assumed to followed a distribution)
- Economic models (e.g. game-theoretic models)
- Simulation models (sensitivity, scenario-testing, decision support)

Center of mass – classic mechanics … based on production sources, markets and transportation costs

```
P_1
M_1
P_2
M_3
```

“Transportation – mass center”

Distance $d_{p2}$
Value analysis models

Profile charts, checklists and symbolic scorecards

```
| Criterion A | 4 | 3 | ... | 1 |
| Criterion B | 2 | 7 | ... | 5 |
| Criterion C | 1 | 4 | ... | 7 |
| ...         |   |   | ... |   |
| Criterion X | 2 | 1 | ... | 3 |
```

Weighted scores: 105 ... 77

Linear additive models

Analytical hierarchy process (AHP)

Strategic attributes

Level 1 Categories

Level 2 Attributes

Level 3 Alternatives

Wiktorsson, 2000
AHP method

AHP combine quantitative and qualitative data
AHP is a structured method based on pair wise comparison to get weight factors

Källa: Min (1994) sid 31
Ways of integrating analytic and simulation approaches

Fig. 4. Hybrid methods

Fundamentals of Supply chain design

Short on the design process of complex systems

Classic models and methods for SC design

Variables and criteria

Key concepts in recent SCM development (Ch 16)

(Some cases)
Back to mathematics…

Generic optimization formula…

Maximise \( f(x) \)  
Subject to  
\[ g_i(x) = 0 \quad i \in I \]  
\[ h_j(x) \geq 0 \quad j \in J \]  
\( x \in S \)

… applied on production system design

Maximise \( w(x) \)  
Subject to  
\[ p_i(x) = R_i \quad i \in I \]  
\[ q_j(x) \geq R_j \quad j \in J \]  
\( x \in C \)

Where  
\( x \) represents the production system design  
\( w(x) \) represents the winning abilities  
\( p_i(x) = R_i \) represents the functional requirements: nominal values  
\( q_j(x) \geq R_j \) represents the functional requirements: threshold values  
\( x \in C \) represents the design constraints

Wiktorsson, 2000
Examples on Design variables

- Production / distribution scheduling
- Inventory levels
- Number of stages (echelons)
- Distribution Center – Customer assignment
- Plant – Product assignment
- Buyer – Supplier relationships
- Product differentiation step specification (where is the product differentiated)
- Number of product types held in inventory

Discussion

Discuss three aspects:
A. Objective Function (key performance measure?)
B. Design Variables (what is possible to modify?)
C. Constraints (limitations, boundaries?)

for determining:
1. batch sizes in manufacturing,
2. order quantities of supplier’s standard component,
3. stock levels of finished goods,
4. lead times from customer order to delivery,
5. transportation mode from supplier/DC to manufacturing site
6. location of distribution centres (DC) of finished goods
Classic methods for production location is based on:

- Land
- Work force
- Capital

Then are consideration taken to:

- Suppliers, material sources.
- Market, Need.
- Production influence
- Transportation, infrastructure

Total cost model is a classic model within SCM to evaluate "trade-offs"

My total cost = transportation cost + storage cost + production cost + order handling cost + information cost + handling cost + costs for loss of sales

(Lambert, 1976)
Simplified – find “real” cost curves, and evaluate the effect of changes

Traditional view of cost curves

(Compare Skjøtt-Larsen et al. (2007), s. 144. (2002: s. 119))
The trend towards more centralized structures are stronger that traditional quantitative methods propose.

(Compare Skjøtt-Larsen et al. (2007), s. 133-. (2002: s. 122-))
The cost curves must have data from the real case – theory and old assumptions on variables are not always fit.

\(\text{Updated cost curves}\)

\[\text{Costs} \quad \rightarrow \quad \text{Number of stocking points}\]

(Abrahamsson (1992); compare Skjøtt-Larsen et al. (2007), s. 144. (2002: s. 119))
There are also many (other) variables to consider

- Current demand (measured by GDP)
- Closeness to other major markets
- Labour (how likely to employ)
- Taxes and tariffs
- Economic incentives (tax incentives and low-interest economic development loans)
- Location costs (rent etc.)
- Availability and quality of infrastructure (transport and communications)
- Logistical competences (quality and availability of logistics services)
- Border administration (efficiency of customs, import, and export procedures)
- Logistical cost (country based)
- Ability to track and trace consignments/goods
- Frequency of on time shipments

Source: Eskilsson & Hansson (2010) examensarbete
Discussion

Challenges, e.g.
- Lot sizes
- Materials handling
- Order principles

Discuss key performance measures for the specific area
## Supply chain performance measures

<table>
<thead>
<tr>
<th>Qualitative performance measures</th>
<th>Quantitative performance measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Customer satisfaction</td>
<td>• Cost based measures</td>
</tr>
<tr>
<td>• Flexibility</td>
<td>– Aggregated cost</td>
</tr>
<tr>
<td>• Information and material flow integration</td>
<td>– Average inventory levels</td>
</tr>
<tr>
<td>• Effective risk management</td>
<td>– Profit</td>
</tr>
<tr>
<td>• Supplier performance</td>
<td>– Obsolete inventory</td>
</tr>
<tr>
<td></td>
<td>• Customer responsiveness</td>
</tr>
<tr>
<td></td>
<td>– Service levels</td>
</tr>
<tr>
<td></td>
<td>– Stockout</td>
</tr>
<tr>
<td></td>
<td>– Demand amplification</td>
</tr>
<tr>
<td></td>
<td>– Buyer-supplier benefit</td>
</tr>
<tr>
<td></td>
<td>– Available system capacity</td>
</tr>
</tbody>
</table>

Complex problem – framework for Supply Chain decision

COMPETITIVE STRATEGY

INTERNAL CONSTRAINTS
Capital, growth strategy, existing network

PRODUCTION METHODS
Skill needs, response time

PRODUCTION TECHNOLOGIES
Cost, scale/scope impact, support required, flexibility

COMPETITIVE ENVIRONMENT

FACTOR COSTS
Labor, materials, site specific

PHASE I
Supply Chain Strategy

PHASE II
Regional Facility Configuration

PHASE III
Desirable Sites

PHASE IV
Location Choices

GLOBAL COMPETITION

TARIFFS AND TAX INCENTIVES

REGIONAL DEMAND
Size, growth, homogeneity, local specifications

POLITICAL, EXCHANGE RATE, AND DEMAND RISK

AVAILABLE INFRASTRUCTURE

LOGISTICS COSTS
Transport, inventory, coordination

Källa: Chopra & Meindl, 2004, p. 107
Fundamentals of Supply chain design

Short on the design process of complex systems

Classic models and methods for SC design

Variables and criteria

Key concepts in recent SCM development (Ch 16)

(Some cases)
The bullwip effect

One of the main control mechanisms is collaboration
Recent development in supply chain management (ch 16)

- Increased co-operation in Supply Chains
  - Uncertain demand
  - Operative dependency relationships
  - Outsourcing and transaction costs
- Supply chain collaboration concepts
  - Customer managed ordering process
  - Vendor managed inventory
  - Quick response
  - Efficient customer response
  - Collaborative planning, forecasting and replenishment
Collaborative planning forecasting and replenishment

Source: www.vics.org
Discussion

For each concept:

1. Customer managed ordering process
2. Vendor managed inventory
3. Quick response / Efficient customer response / Collaborative planning forecasting and replenishment

For what situation / business / cases is the concept most relevant?

Discuss applicability (Strengths, Weakness, Enabling features, Obstructing features)?
Handling of uncertainties

Traditional Supply Chain

Source: MIT Open Course Ware
Handling of uncertainties

Improved Supply Chain

- 1000 Shoe sample ordered
- Samples air-freighted to 5 US stores
- Sales in test stores?
  - Yes: Increase production
  - No: No change to plan
- Production
- Delivery to stores
- Delivery to 2nd or 3rd channel

Source: MIT Open course ware