Coordination of product design and production planning in supply networks

The case in customized mass production

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Mass customization

- A paradox
  - Meeting individual customers’ requirements
  - With mass production’s efficiency
    - Without significant increase in production and logistic costs
- Customization
  - Not a matter of choice: a competitive necessity
- Accommodating the complexity of the market
  - Large variability of product lines
  - Extremely hard delivery requirements of customers
- Production
  - With highly flexible technology
  - In networks of autonomous enterprises
  - Most of which participating in several networks
Case 1: Mass production of consumer goods

- Coordinating a national supply network
  - Project: VITAL - Real-Time Cooperative Enterprises

- Products
  - Customized mass products
    - electric bulbs, lighting appliances
  - Large product diversity: ~6,000 kinds
  - Packaging material diversity: ~20,000 kinds

- Market
  - “You want to see something risky, try selling a lightbulb to a big box retailer.” Jeff Immelt, GE CEO
  - High forecast fluctuation: ±30-100%
  - Ship-or-cancel customers

- Production
  - Order lead times << production lead times
  - Make-to-stock is necessary
  - High setup costs
  - Large inventory costs, including obsolete inventories

Case 2: Automotive industry

- AC/DC FP6 project within the “Five-days car” initiative
  - With leading German OEMs and suppliers

- Goals
  - new design, production and logistics environment that cuts down
    - the inventory and the time to produce a specific
    - customized car configuration

- Approach
  - Customize-to-order (CtO)
    - Combining individual built-to order and series production by „late customization“
  - Customer-anonymous chassis and body production
  - (Mostly) software-based customization before finishing
General problem statement

- **Common goal of each network partner**
  - High service level towards its customer
  - At the lowest possible production and logistic costs

- **Issues**
  - Conflicting goals
    - High service level can be guaranteed by inventories only
    - Component, packaging material, end-product
  - Low cost can be achieved only with mass production's efficiency
  - Increasing logistic costs (including obsolete inventories)
  - Product line complexity
  - Spiraling costs (inventory)
  - Paralysis of the production network
  - Sharing costs and benefits between autonomous network partners

- **Our specific interest**
  - Cooperative planning
  - ... and sooner or later, also product design

Cooperative planning: requirements

- Autonomy of network partners respected
- Service level guaranteed
- Channels coordinated
  - Minimal total cost: setup + inventory holding + obsolete inventory
  - As a result of local decisions
- Coordination supported at several levels of aggregation
  - Tactical
  - Operational
- Regular actualization of plans
  - Feedback from execution
- Profits and losses shared
  - Partners should “laugh and cry together”.
- Cooperation as self-interest
Cooperative planning: VITAL

- Detaching the two main criteria
  - **Service level**: exchanging production and delivery schedules
  - **Minimum total cost**: exchanging component demand forecasts and production plans of suppliers
- Coupling the two levels: inventory management

**Logistics Platform**

**LOCAL DECISIONS**

- Supplier
- Manufacturer

**LOGISTICS FRAMEWORK**

- Product information
- Component forecast
- Production schedule
- Inventory status
- Call-off

**LOCAL DECISIONS**

- Raw material demand
- Raw materials
- FILL
- Delivery schedule
- Prod. plan (acknowledgment)

**Logistics Platform**

**Single PO Channel Scheduling Level**

<table>
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<tr>
<th>Channel</th>
<th>Inventory policy</th>
<th>Forecast</th>
<th>MRP/forecast coverage</th>
<th>On-hand inventory</th>
<th>On-hand supplier</th>
<th>Consignment Supplier</th>
<th>On-hand material</th>
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Cooperated planning: example
Cooperative planning: AC/DC

Objectives
- 100% reliability in service
- Decreasing inventories

Phases
1. Customer-anonymous production at suppliers
2. Just-in-sequence delivery of components to OEMs
3. Final customization during transport or at car-traders place

Continuous dynamic planning loops
- Collaborative demand prediction
  - Exchange of stochastic demand patterns
- Collaborative planning
  - common communication platform to keep information up-to-date for everybody concerned
- Real-time, fail-safe event handling
  - With feedback to demand prediction

Network-wide maximal total benefit, profit sharing

Forecasts
Make/Assemble-to-Stock production remains essential
Transition of forecasts

Forecast accuracy
- On aggregate level, actual usage corresponds well prior forecasts
- Large variability per individual components
  - Both large positive and negative deviations

Planning alone cannot resolve this issue
Component modularization (VITAL)

- In manufacturer-supplier cooperation
- Decreasing the variability of components
  - Reflex response: standardization
  - Standardizing shapes and sizes of boxes and packaging → cutout
  - Limiting the color spectrum
  - Using standard materials
  - Clustering
    - Modular product families and operations
    - Based on usage frequency, risk, resource requirements
- Merits
  - Fewer/cheaper setups at the suppliers
  - More reliable component forecasts
  - Less excess inventories of special materials
- Adverse effects
  - Conflict with customers
  - Against innovative products
  - Easier to copy and replicate
From standardization to differentiation (AC/DC)

- **Configurable product**
  - As alternative to mass customized product
- **Delayed product differentiation**
  - Flexible chassis design and configuration
- **Modularization**
  - Should enable last minute configuration and differentiation
  - Consistent interfaces between
    - Mechanics, electronics and software
  - Massive reduction of the number of components
    - E.g. chassis: 47 → 7
  - Tailoring of mechatronical modules by software
- **Focus set first on a mechatronic module: rear axle**
  - Lessons transferable to other components

Conclusions

- **Mass customization**
  - Primary objectives in sharp conflict
  - Unrealistic (almost irrational) delivery requirements
  - Overcoming the challenge of customer introduced variability
- **Cooperation against uncertainty**
  - Supply planning
    - Information exchange about future intentions, at several levels
    - Telling the truth should be in the interest of the partners
  - Product design
    - Jointly developed modular components
    - Re-configurable, differentiable components
- **However, cooperation can be against**
  - Competition
  - Innovation
- **Instead of accepting, rather shaping market complexity**
Thanks for your attention!