Closed-Loop Supply Chains: Practice and Potential

V. Daniel R. Guide, Jr.       Luk N. Van Wassenhove
Pennsylvania State University INSEAD
Presentation outline

- Definition and examples
- Business process approach
- Economic attractiveness
- Time value
- Roadmap for reverse supply chain redesign
Definition

Closed-loop supply chains:
are designed and managed to explicitly consider the reverse and forward supply chain activities over the entire life cycle of the product.
A closed-loop supply chain

- Raw Matls
- Manufacturing
- Distribution
- Reseller or Customer
- Sales

- Overstocks
- Return Stream
- Returns Evaluation
- Scrap

- Spares Recovery

- Refurbished product (Secondary Market)
- Spare Components
Types of returns

- **Commercial returns**
  - 30 to 90 day free returns policy in US
  - HP: total costs: 2% of gross $ sales annually
- **Repair / warranty returns**
- **Leasing**
- **End-of-use returns**
  - Cell phones: 80% replaced after first year of use
- **End-of-life returns**
  - Mandatory take-back in EU (WEEE)
Closed-loop supply chains for containers

**Cartridge reuse**
- Supplier
- Manufacturer
- Retailers
- Customers
  - Pre-paid mailers

**Single-use cameras**
- Supplier
- Manufacturer
- Retailers
- Customers
  - Cash for return

**Characteristics:** commodity goods, simple products, high volumes, low variance, non-distinguishable products, OEM controlled, short lead times
A closed-loop supply chain for photocopiers

Characteristics: high variances, stable production technology, limited volumes, modular design, imbalances in supply and demand, cannibalization
A closed-loop supply chain for commercial tire retreading

Characteristics: low variance in returns timing, low variance in quality, easy to sell, intermediate logistics costs
Key activities

- Product returns management
  - Product acquisition
  - Reverse logistics
  - Test, sort, grade, and disposition
- Remanufacturing/reconditioning operational issues
  - Repair
  - Remanufacture
  - Recycle
- Remarketing
  - Distribution
  - Sales
  - Reuse
### How hard are these key activities?

<table>
<thead>
<tr>
<th>Activity</th>
<th>Product Acquisition</th>
<th>Reverse Logistics</th>
<th>Test Sort Grade</th>
<th>Remanufacture/ refurbish</th>
<th>Remarketing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product Life Extension</td>
<td>Easy</td>
<td>Easy</td>
<td>Hard</td>
<td>Hard</td>
<td>Easy</td>
</tr>
<tr>
<td>⇒ Jet engines</td>
<td></td>
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<tr>
<td>Refillable Containers</td>
<td>Easy</td>
<td>Easy</td>
<td>Easy</td>
<td>Easy</td>
<td>Easy</td>
</tr>
<tr>
<td>⇒ Toner cartridges</td>
<td></td>
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</tr>
<tr>
<td>Tire Retreading</td>
<td>Easy</td>
<td>Intermediate</td>
<td>Intermediate</td>
<td>Intermediate</td>
<td>Easy</td>
</tr>
<tr>
<td>⇒ Commercial</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consumer Electronics Reuse</td>
<td>Hard</td>
<td>Easy</td>
<td>Easy</td>
<td>Easy</td>
<td>Intermediate</td>
</tr>
<tr>
<td>⇒ Cellular Phones</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Industrial Remanufacturing</td>
<td>Intermediate</td>
<td>Intermediate</td>
<td>Hard</td>
<td>Hard</td>
<td>Hard</td>
</tr>
<tr>
<td>⇒ Copiers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tire Retreading</td>
<td>Easy</td>
<td>Hard</td>
<td>Intermediate</td>
<td>Intermediate</td>
<td>Hard</td>
</tr>
<tr>
<td>⇒ Passenger</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
OR research on closed loop supply chains

- focus on single cells of the matrix, optimising only part of the process
- a cost minimisation perspective
- intricate models for a given sector
  - e.g.: minimum cost disassembly scheduling algorithms for car engines
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A *business process* approach

- Need to remove bottlenecks (acquisition, remanufacturing, remarketing)
- Need to optimise as a global process with a view on maximising value recovery (as opposed to cost minimisation)
- Need to consider time value of the product over its lifecycle
A business process approach

- Product acquisition is a major driver of success
- Creating effective remarketing channels is another major driver
- Research emphasis has largely been on reverse logistics, disassembly and remanufacturing operations
A business process approach
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Product returns represent a value stream, not just a waste stream
A simple view on the impact of acquisition price

A given acquisition price

Quality distribution

Expected quantity to be acquired

Total acquisition cost

Disposal cost

Average inventory

Replacement materials

Labor costs

Machines & buildings

OPERATING COSTS

OPERATING COSTS

CURRENT ASSETS

OPERATING COSTS

FIXED ASSETS
EVA calculation

Revenue
- Fixed SP· Volume

OperCosts
- Materials, Labor, Acquisition Price, Disposal

PBIT
- Revenue - Costs

Cash taxes
- Fixed

NOPAT
- PBIT - Cash taxes

Capital Charge
- Average assets · WACC

EVA

Current assets
- Inventory, Prepaid Rent and Insurance

Fixed assets
- Machines & Bldg

Working capital requirement

Current liabilities
- Trade Payables, Accrued Expenses (e.g. unpaid salaries)

 NOPAT = Net operating profit after taxes
 WACC = Weighted average cost of capital

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Example of a simple acquisition model

- Determine quantities to be acquired of different quality classes of used phones
- Within a given quality class prices increase with quantity
- Lower quality phones require higher refurbishment costs
- The quantity of refurbished phones sold decreases with the sales price
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Time-sensitive product return streams

- Short life-cycles; high obsolescence risk
- Returned products losing value rapidly
- “Value of time” a key parameter
- Examples:
  - PCs
  - Printers and Computer Peripherals
  - Mobile Phones
  - Telecommunications Equipment
How to maximize value recovery?

- The *longer* it takes to put a returned product back on the market, the *lower* the likelihood that there are economically viable reuse options.

- Cost minimisation typically leads to slow and centralized returns handling and high product value erosion.
Two types of optimisation model opportunities

- *Optimise across the key activities* for a given type of returns
- *Optimise across types of returns* over the lifecycle of the product

The latter is more important for short life cycle products
Example: operational management for rapid response

- Notebooks returns management at HP Europe
- Returned notebooks refurbished by ODM
- Fragmented process designed to minimise refurbishment costs
- Management did not take into account time value
Example: price erosion notebooks

Average price erosion laptops
all channels

Average price

Age (months)

Price erosion: quality 1: $25 per month
quality 2: $40 per month

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Cumulative shipments to and from the ODM over a 10 month period

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Flow diagram for notebook computers
High-touch refurbishment by the ODM, assuming the ODM lead time is two months
The effect of better disposition

**POLICY TEST**

**INPUT (used products)**

**TEST**

\[1 - \alpha\]

**ODM refurbishment**

**Low touch refurbishment**

**SALES**

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**Price erosion 1 (same price)**

- ODM LT = 3 m
- ODM LT = 2 m
- ODM LT = 1 m

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Example: design for rapid response

- When should one design product return processes for minimum cost as opposed to minimum time value decay?
- What are the major drivers?
- Queuing model to maximise profit over the lifecycle of the product
Centralized, “Efficient” Returns Process Design

Product Returns

Centralized Evaluation & Test Facility

- Re-stock
- Remanufacture
- Parts Recovery
- Scrap

Retailers & Resellers
Differences in Marginal Value of Time for Returns

% Loss in Value

Time

Time-sensitive Product (High MVT)

Time-insensitive Product (Low MVT)

e.g. Power Tools

e.g. Printers & mobile phones
The value of lead time reduction

- **HP printers (US):**
  - One day reduction between evaluation and remanufacturing \( \approx $72k \)
  - One day reduction between remanufacturing and the secondary market \( \approx $79k \)

- **Bosch Power Tools:**
  - One day reduction between evaluation and remanufacturing \( \approx $11k \)
  - One day reduction between remanufacturing and the secondary market \( \approx $12k \)
Value ($\) of One–Day Reduction Between Evaluating Facility and Remanufacturing Completion as a Function of Value Decay Parameter, Return Rate (left), and Product Value (right)
Decentralized reverse supply chain with pre-ponement for fast clock speed industries

Evaluation of product at retailer or reseller
Process Flow: Decentralized Network with "Preponement"

As $p$ increases

- Increased value of "preponement"
- Decreased congestion, lower delay cost

**Process Flow Diagram**

1. **Factory** ($\mu_f$)
   - $\lambda + (1-p)\lambda_r$

2. **Distributor** ($\mu_d$)
   - $\lambda + (1-p)\lambda_r$

3. **Retailer** ($\mu_r$)
   - $\lambda + \lambda_r$

4. **Customer** ($\mu_c$)
   - $\lambda$

**Remanufacturing** ($\mu_m$)
- $(1-p-s)\lambda_r$

**Sales**
- $\lambda + \lambda r$

**Returns**
- $s\lambda_r$

**Scrap**
- $s\lambda_r$

**Sales: secondary market**
- $(1-p-s)\lambda_r$

**Preponement Eval.**
- $p\lambda_r$

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Roadmap for reverse supply chain redesign

1. Treat returns as a value stream, as opposed to a waste stream.
2. Consider the reverse supply chain from end-to-end.
   - Any sub-process can become a system bottleneck.
3. Identify and develop the right performance metrics and track them systematically.
Roadmap for reverse supply chain redesign

4. Start by constructing simple models based on the right information.
   - Pay particular attention to the economic impact of time.

5. Use the insights obtained from the models to fully understand the economic impact of alternative designs and operational policies.

6. Align the organizational structure and the incentives/reward systems.
Where do we go from here?

- Additional empirical research
  - Case studies
  - Laboratory and field experiments
- Commercial product returns projects
- Models that take into account the time-value of product returns (e.g.: demo reuse)
- Product acquisition models
- Marketing models (e.g.: cannibalisation)
- Installed base management
For further reading