Designing cascades for systemic circularity in material/product circular supply chains (CASCADES)

Workshop at the 28th International Symposium on Logistics (ISL2024)

Thammasat University, Bangkok, Thailand

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Workshop leaders:

- Rudrajeet Pal, Professor, Department of Business Administration & Textile Management, University of Borås, Sweden
- Erik Sandberg, Professor, Department of Management and Engineering, Linköping University, Sweden

ISL INTERNATIONAL SYMPOSIUM ON LOGISTICS

Background

- In recent years, circular economy (CE) has gained traction in many industrial supply chains due to its increasing potential to tackle sustainability concerns, and create job and economic growth (European Commission, 2020). Essential to CE is the functioning of circular supply chain (CSC) that that enable looping of materials and products upon which CE practices are conducted, thus orchestrating the inter-relationships and collaboration of diverse stakeholders (Parida et al., 2019). In this context, an emerging view of CE for enabling circular flow of material/product, either in same or different form, is ***cascading***, i.e. connecting several CSCs across different resource loops (Campbell-Johnston et al. 2020).

- Closed-loops (depicted by "cascaded use" in the figure) can be typically envisaged to connect inner and outer resource loops of same material/product via product-service systems, sharing, reselling, remanufacturing and recycling, while open-loop flows (depicted by "cascaded flow" in the figure) support cascading of material/product in different forms, to organizations outside the original supply chain (Batista et al., 2018).

- ***Cascading*** thus broadly encompasses systemic arrangement of several CSCs with the aim to increase the efficiency of resource utilization, and the most common practices are typically: by optimizing the flow of material from highest to lowest value form, by optimizing co-production (of product and by-products), and through sequential use of resources (Odegard et al., 2012), as noticed in different industrial supply chains. For example, in the manufacturing sector, for bio-based materials, such as wood, agriculture and food (Rehberger & Hiete, 2020, Jarre et al., 2020), cascading of wastes and by-products are primarily applied in biorefineries, which involve both conventional waste-to-energy strategies and new pathways for material use, such as bioplastics. On the other hand, in technical nutrient value chains, material/product lifetime is optimized by integrating several strategies, such as repair, reuse, remanufacture, refurbish by maintaining the material/product integrity in the highest value forms. Overall, ***cascading*** aims at retaining and recharging end-of-use or end-of-life products with new value and is analogous to "a river flowing over a sequence of plateaus" (Sirkin & ten Houten, 1994) essential for gaining resource effectiveness and optimizing product value retention over extended lifetime (De Angelis et al., 2018), thus vital for improving climate gains.

- From a logistics and supply chain management perspective, this calls for critical systems thinking for designing and configuring novel value chains, both intra- and inter- organizationally and industrially, identifying ecosystem collaboration and orchestration capabilities, and exploring the governance mechanisms, along with the antecedents and barriers to it. However, such systemic perspective of supply chains in CE context has been largely ignored, and in practice hindered by the complexities of operationalizing CSCs in system for delivering transformational value proposition, i.e. long-lasting products, and rethinking of business stakeholder's role for building new collaborative relationships (Batista et al., 2018, Pal et al., 2019).

Idea of the workshop

To discuss how circular material/product flows are operationalized, and stakeholders are engaged, across circular supply chains in designing and implementing cascading in a resource-effective way.

1. Identify current external (environmental- and industry- level) enablers and barriers to appropriate cascading
2. Identify current internal (supply chain level) strategies and operations enablers and barriers to implement cascading material/product flows
3. Elaborate some future needs and directions in supply chain management to implement cascading

Agenda

15:00 - 15:30 Tea/coffee & Networking

15:30 - 15:50 Welcome and brief introduction to the workshop topic by Rudrajeet Pal and Erik Sandberg

15:50 - 16:05 Industry perspectives by:

- Prof. Paul Childerhouse – It’s only natural to circulate biological nutrients
- Dr. Kanchana Dissanayake – Cascading in textile industry
- Prof. Matthias Kalverkamp – Cascading supply chains in the white goods industry

16:05 - 16:15 Workshop process and key questions by Rudrajeet Pal and Erik Sandberg

16:15 – 18:00 Workshop, discussion and concluding summary

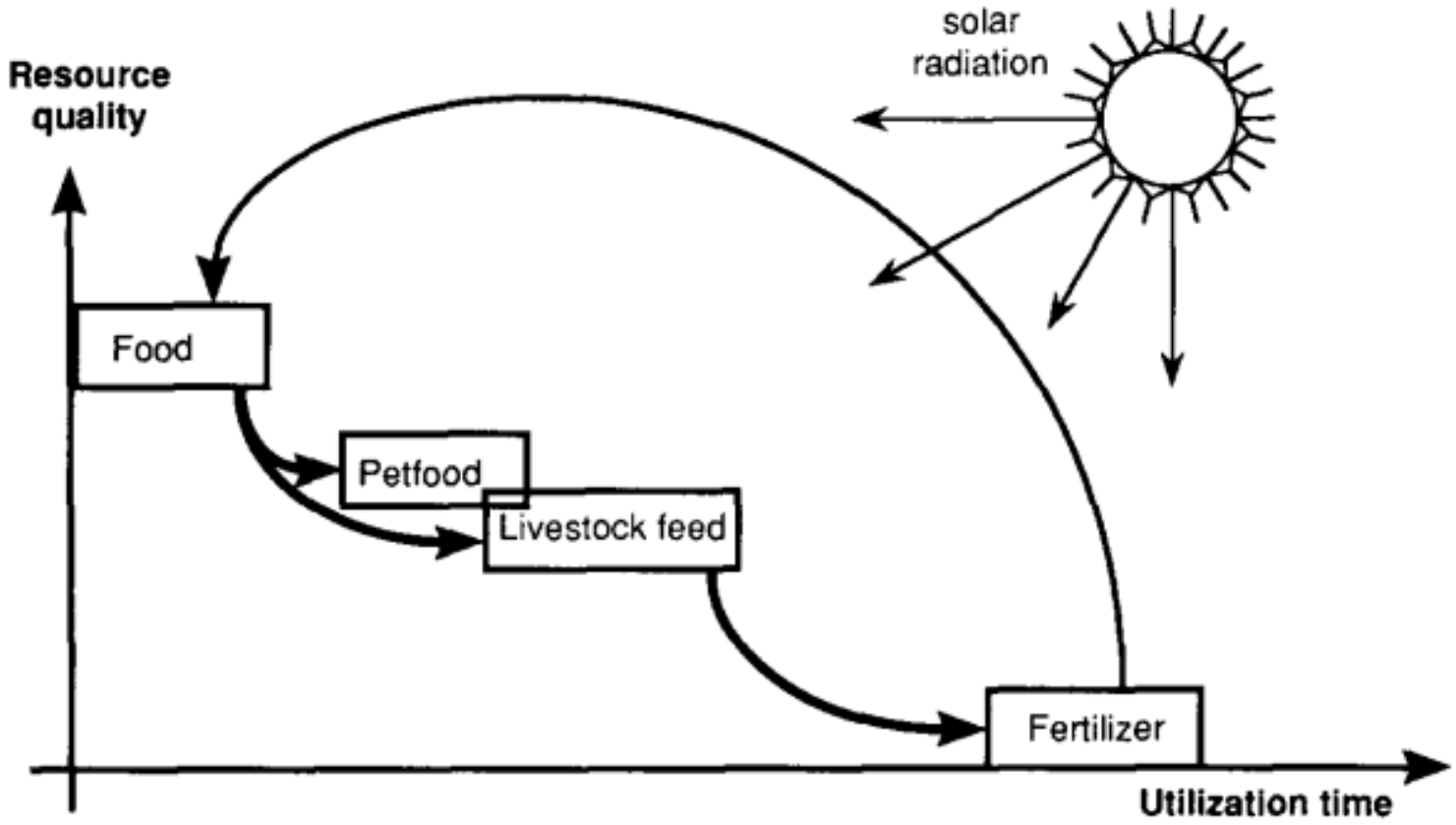
CASCADING: What is it?

*Write short phrases/words that comes to your mind when mentioning **CASCADING** in context to any industrial supply chain that your research pertains.

Loops and flows	Waste and value	Business models	Stakeholders and actors
1.Open and Closed loop supply chains	**1.Towards zero waste, minimum value waste, and higher quality issues**	**1.Beyond end-of-life**	**1.Great variety of stakeholder and actor involvement**
2.Flowing up or down a supply chain	2.Minimize losses while cascading	2.Re- manufacturing	**2.Networks and chain effect**
3.Different levels, steps and sections of granularity	3.Value retention	3.Recycle	3.Waterfall learning
4.Vertical flow			4.Passing from one to another for deployment

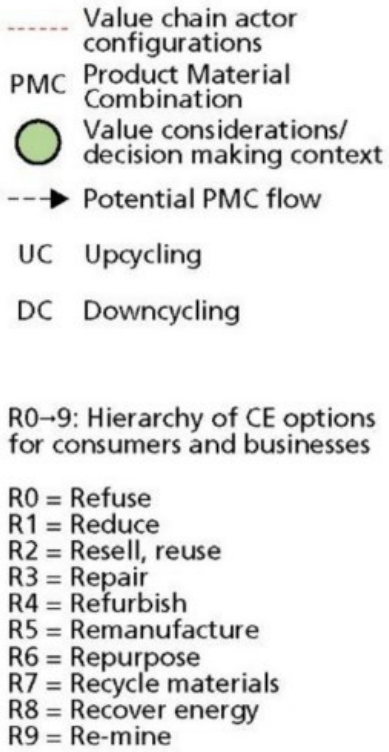
NOTE: **Bold** = Recurring

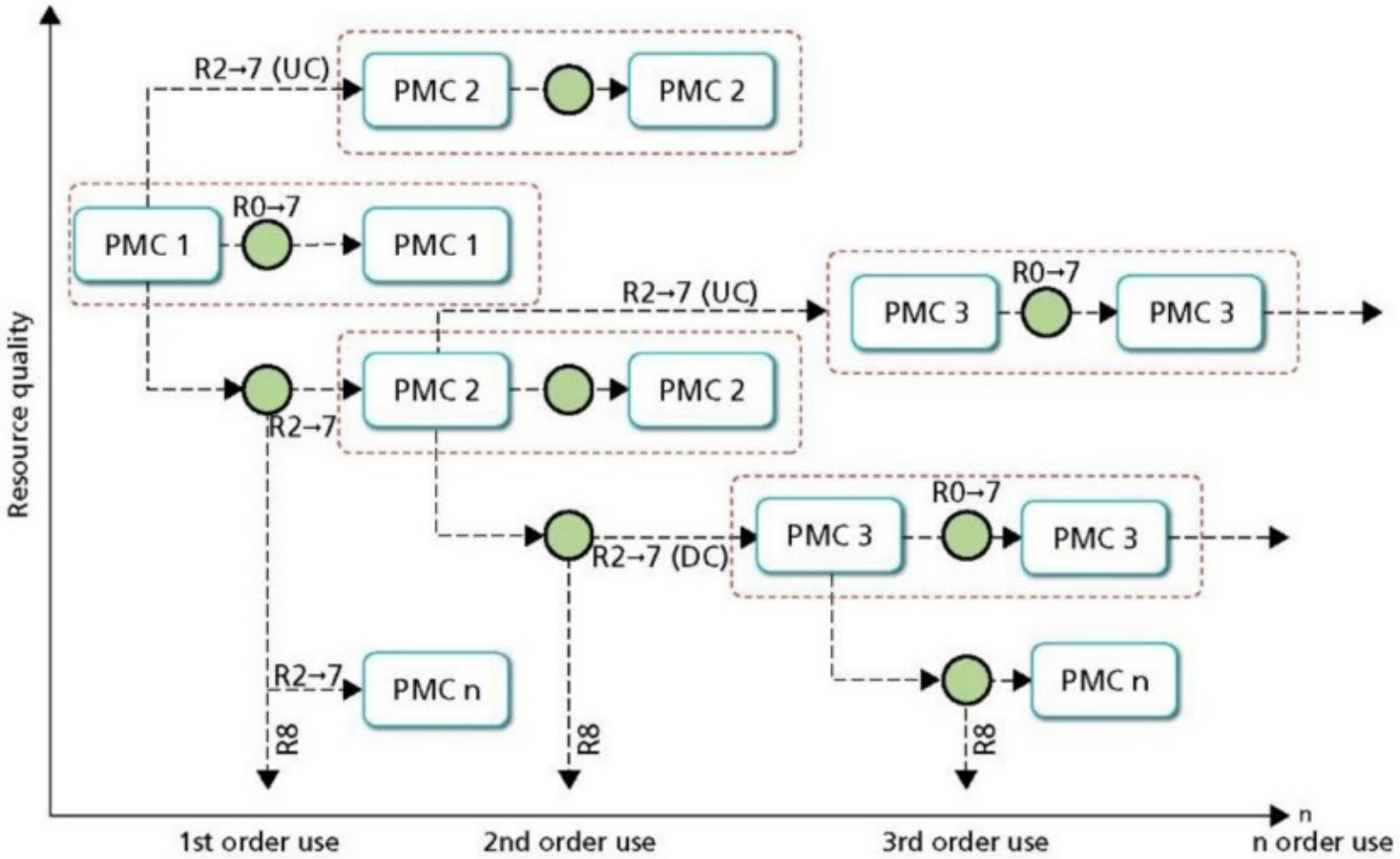
A simple example of resource cascading of nutritional quality



Sirkin and ten Houten, 1994

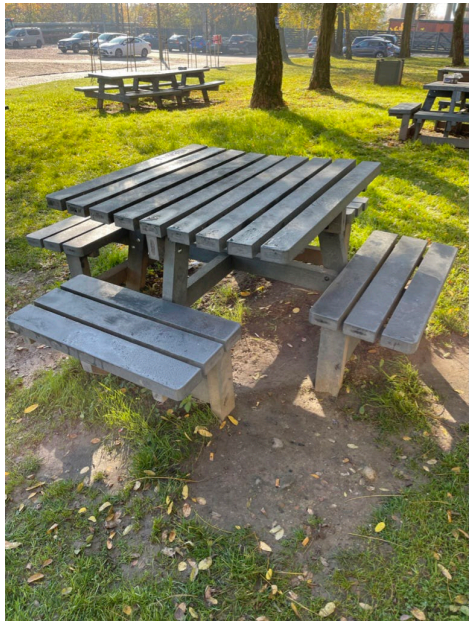
Cascading in a circular economy complex



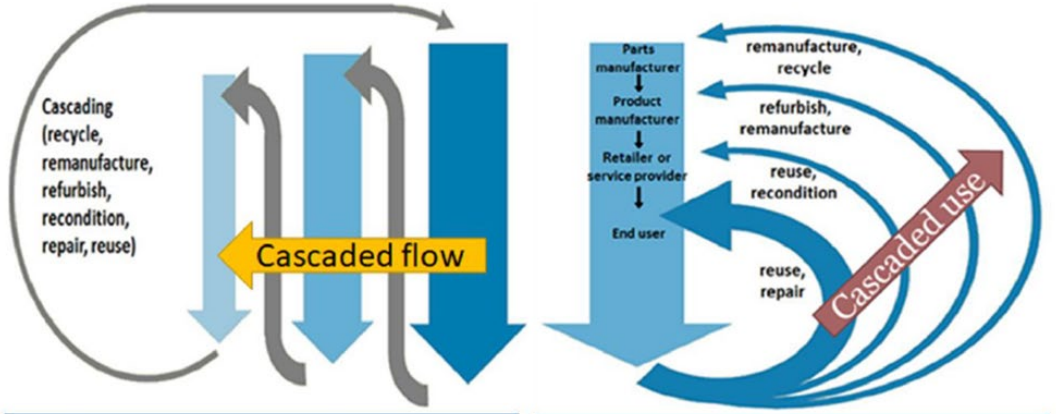


[Campbell-Johnston et al. 2020]

CASCADING



CASCADING from different perspectives in industrial circular supply chains



- Open-loop cascades (across supply chains)
- Different M/PCs (material/product combinations)

- Closed-loop cascaded flows (within a supply chain)
- Same M/PCs (material/product combinations)

(Adapted from EMF, 2014)

In terms of approaches	In terms of material/production combination	In terms of supply chain and ownership
• Cascading in value • Cascading in function • Cascading in time	• Open loop cascade • Closed loop cascade	• Cascaded use • Cascaded flow

Odegard et al. (2012); Jarre et al. (2020)

Cascading examples from industrial value chains

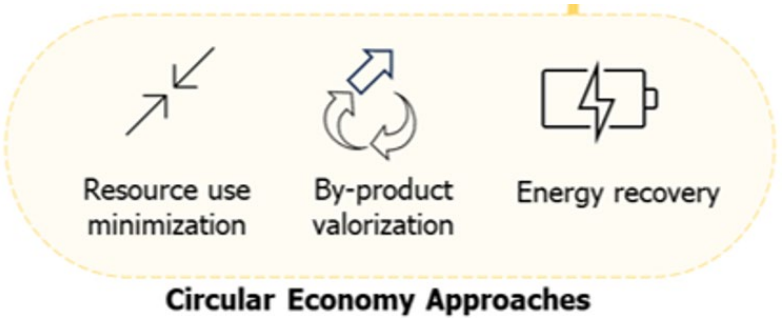
-Prof. Paul Childerhouse – It’s only natural to circulate biological nutrients
- Dr. Kanchana Dissanayake – Cascading in textile industry
- Prof. Matthias Kalverkamp – Cascading supply chains in the white goods industry

Prof. Paul Childerhouse – RMIT Australia
It’s only natural to circulate biological nutrients

It’s only natural to circulate biological nutrients

- CE is particularly relevant for the agri-food sector
- The sector has been heavily reliant on large-scale systems (GHG emissions, loss of bio-diversity, soil degradation, reduced social cohesion, and excessive wastes)
- Globally one-third of all food produced is wasted (Soma, 2021)

- A circular approach to food systems can reduce chemical fertilizers usage by 80% (Ellen MacArthur Foundation, 2016)



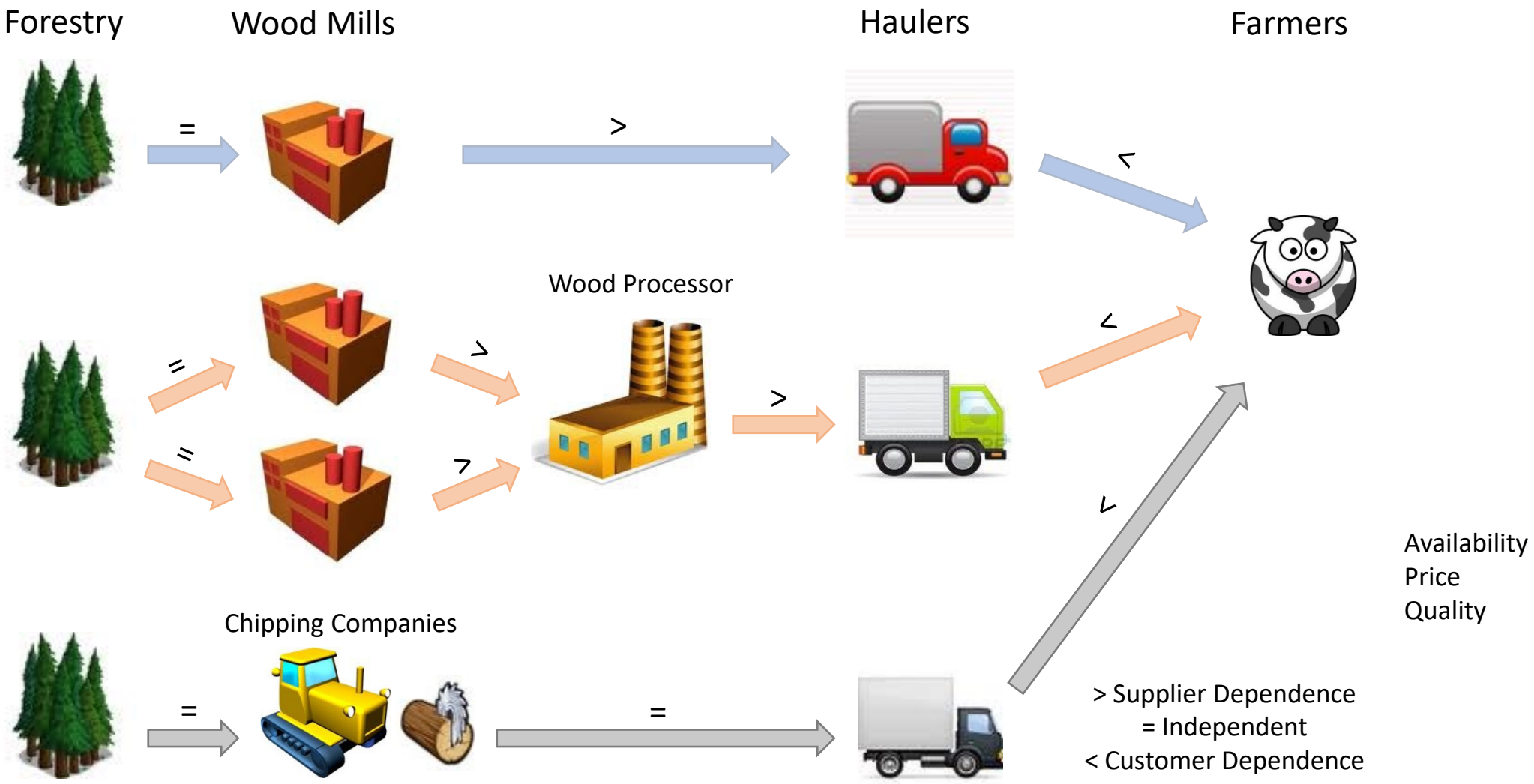
Open-loop Supply Chains

By-product synergy (by-product valorisation)

Industrial symbiosis; eco-industrial parks

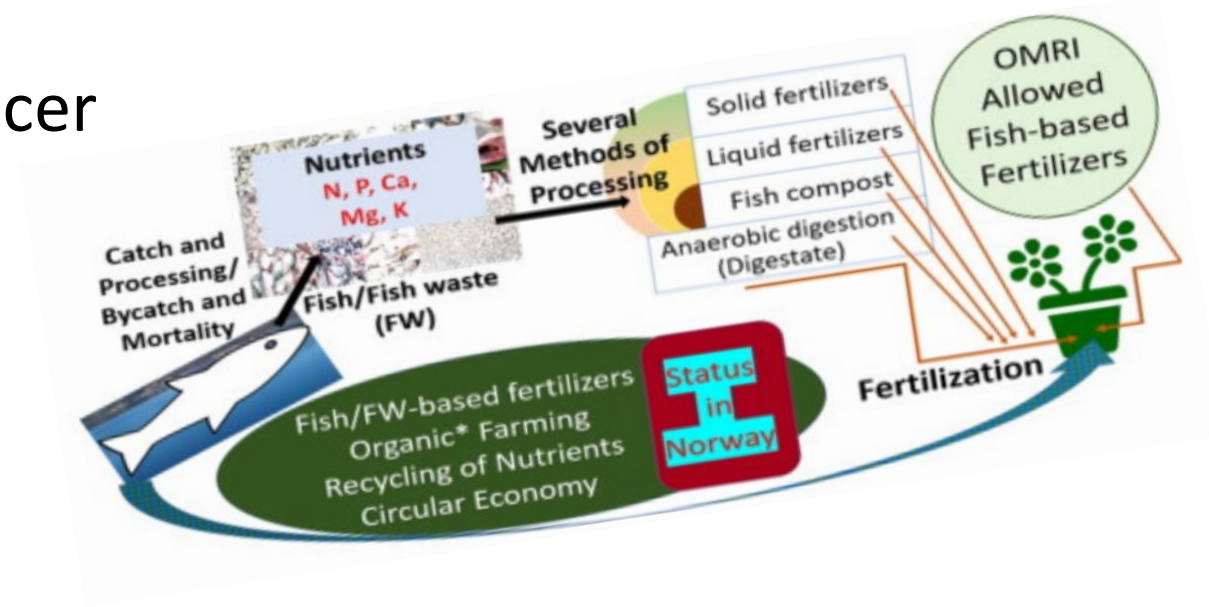
- Mostly conceptual and qualitative discussions, proposing open-loop supply chain as a direction of circularity
- Current modelling work, if any, are mostly about reverse logistics or closed-loop supply chain
- Modelling by-product processes is mainly on production (manufacturing) planning perspective

Stand-off Pad SC



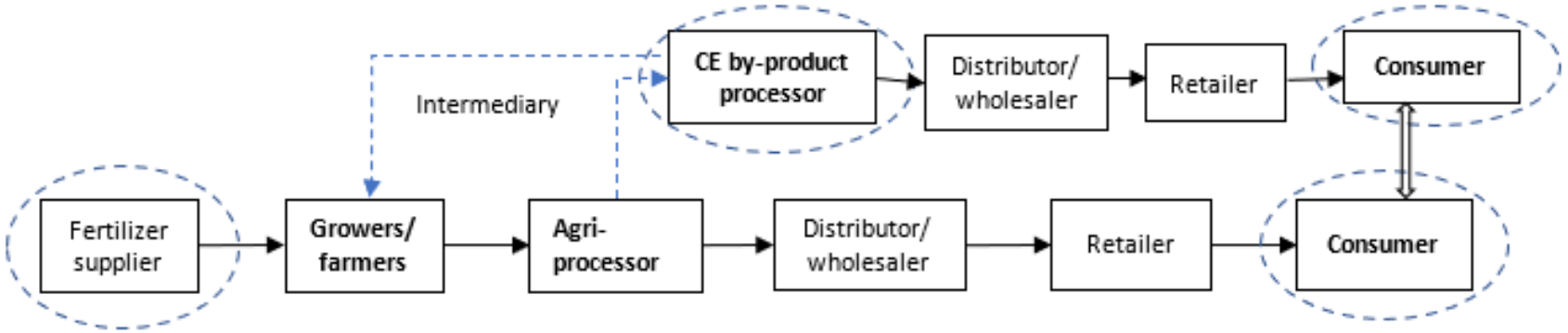
Marine Wastes

- Mussel shells, seaweed, and fish scraps are collected and processed into organic fertilizer
- Mussel farmers get paid for providing these by-products/wastes
- Lost 50% supply to a fishball producer



Circular Supply Chain Dynamics

- Different operational models for open-loop and closed-loop circular chain
- Combination of open-loop and closed-loop archetypes
- The role of intermediaries
- Supply competition



Cascading in the Textile Industry

Dr. Kanchana Dissanayake

Swedish School of Textiles

University of Borås.

Sweden.

Introduction to cascading in the textile industry

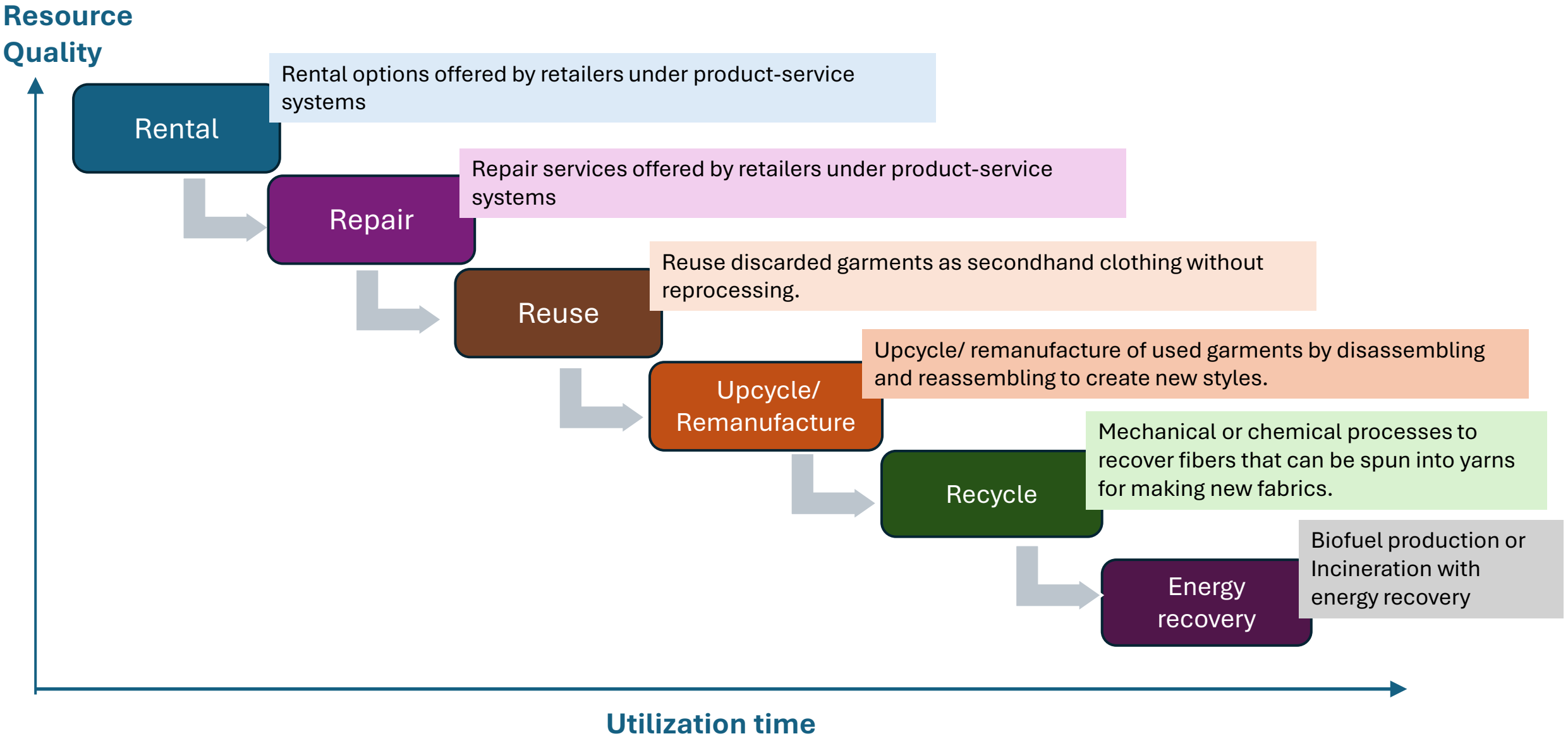
Optimizing resource utilization through a sequential reuse of textile materials.

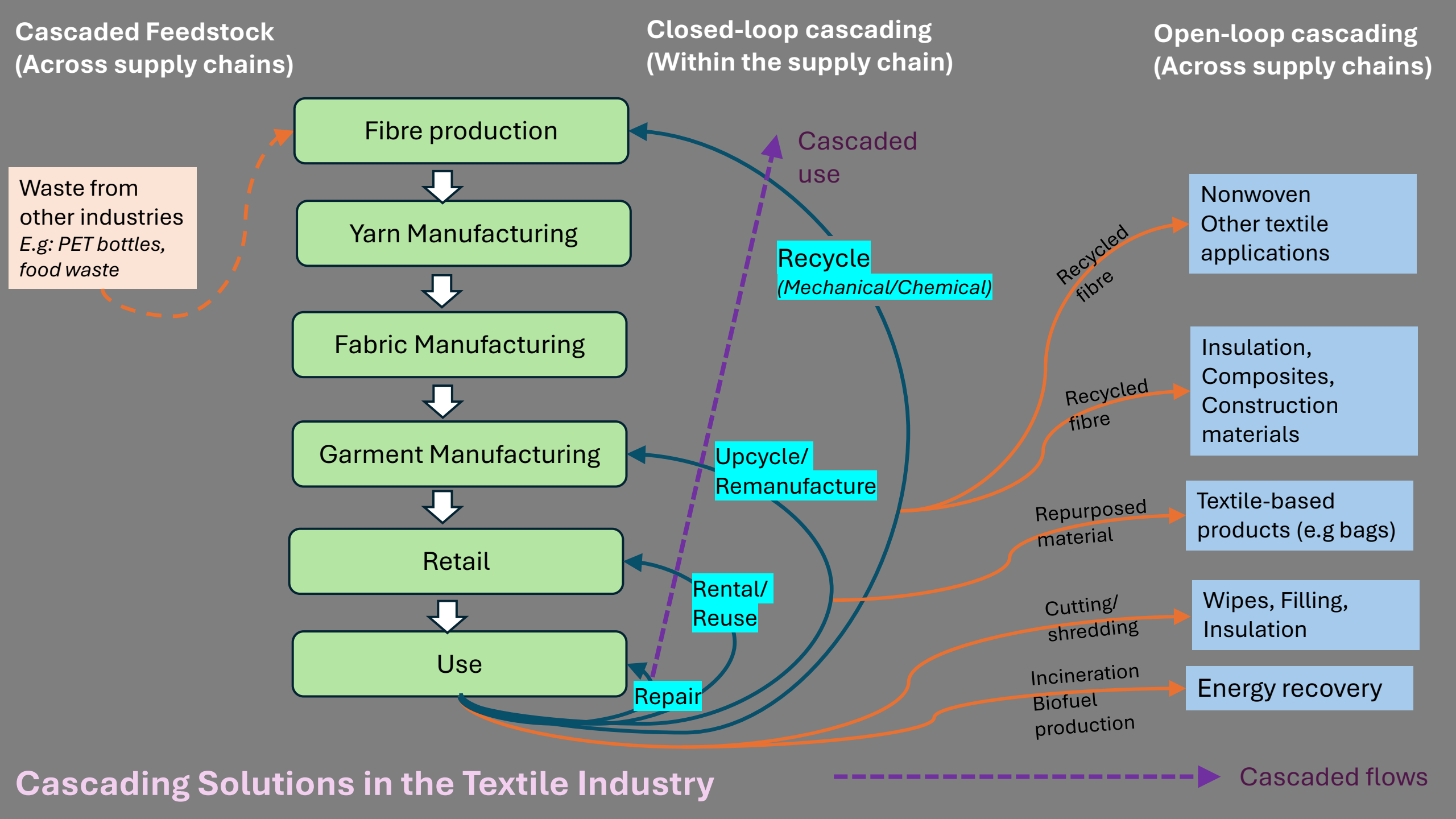
Textile materials are sequentially passed through various stages or applications, often aiming to retain value as long as possible, maximize utility, and minimize waste.

This approach aims to extend the life cycle of the resource and reduce overall consumption and waste.

By implementing resource cascading, the textile industry can improve sustainability and reduce environmental impact.

Hierarchical overview of cascading in the Textile Industry




Cascaded Feedstock
(Across supply chains)
Closed-loop cascading
(Within the supply chain)
Open-loop cascading
(Across supply chains)
Waste from other industries
E.g: PET bottles, food waste
Fibre production
Yarn Manufacturing
Fabric Manufacturing
Garment Manufacturing
Retail
Use
Cascaded use
Recycle
(Mechanical/Chemical)
Upcycle/
Remanufacture
Rental/
Reuse
Repair
Recycled fibre
Recycled fibre
Repurposed material
Cutting/ shredding
Incineration
Biofuel production
Nonwoven
Other textile applications
Insulation, Composites, Construction materials
Textile-based products (e.g bags)
Wipes, Filling, Insulation
Energy recovery
Cascading Solutions in the Textile Industry
Cascaded flows

Examples

HOUDINI
Swedish Circular Sportswear

- **Rental** — Let customers rent instead of buying
- **Repair** — Designs for repair and offers repair services
- **Reuse** — Offers secondhand sale of used Houdini products
- **Recycle** — Collects worn-out polyester clothes and recycle to make new garments

Closed-loop cascading

Wolkat

Post-consumer textile waste

- **Reuse**
- **Repurpose** → Industrial wipes
- **Recycle** → Fabrics (Blankets, bags)
- Nonwovens (mattresses, insulation, shopping bags)

Open-loop cascading

Challenges

01

Material/ product complexity

02

Nature of the Fashion Industry and Business

03

Inclusion of additional cascadable properties in the design process

04

Lack of reverse logistics/supply chains and business models for cascaded use/flows.

05

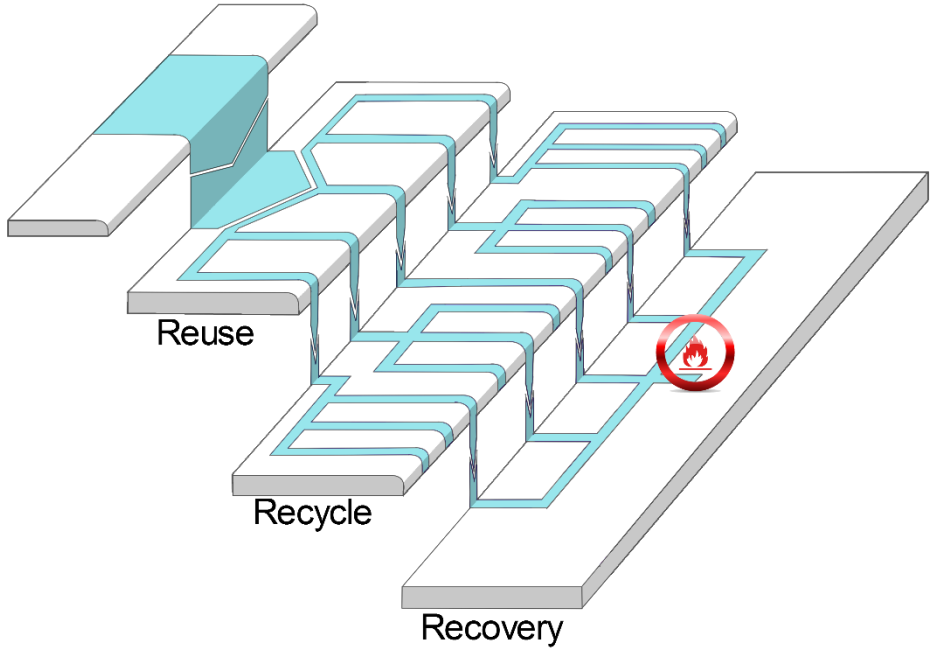
Economic feasibility

Market barriers

- Prof. Matthias Kalverkamp – Cascading supply chains in the white goods industry

SUPPLY CHAINS IN THE CIRCULAR ECONOMY

- Circular Economy (CE) and loops:
  - exploiting residual and
  - intrinsic value.
- Business models for extending resource value require product recovery / returns.
- Theory implicates vertical integration to reduce corresponding risks.
  - Product service systems, leasing, renting, etc.



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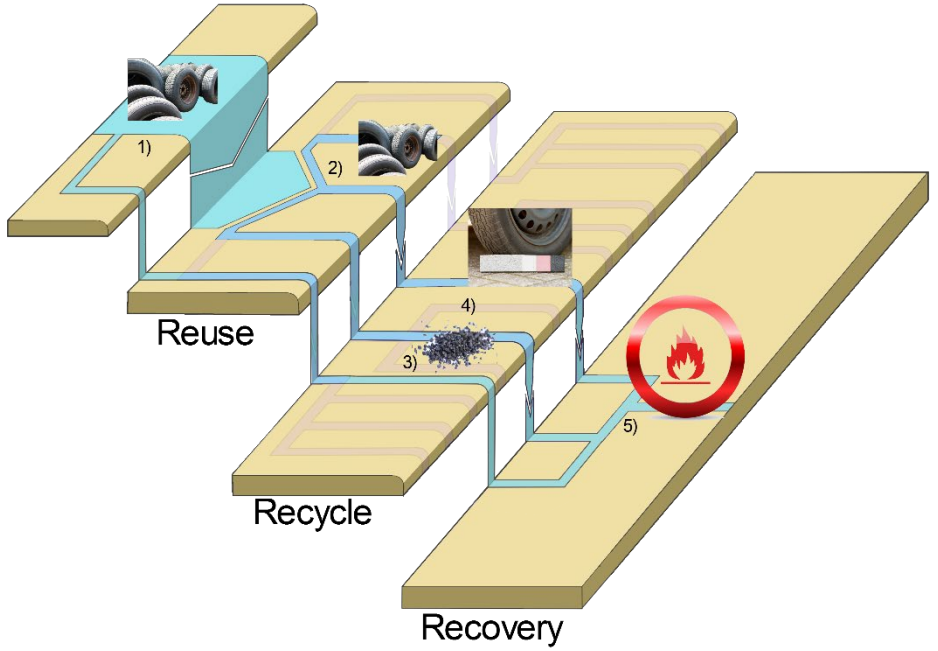


!

Centrally managed closed-loop supply chains ‘for everything’ are a myth

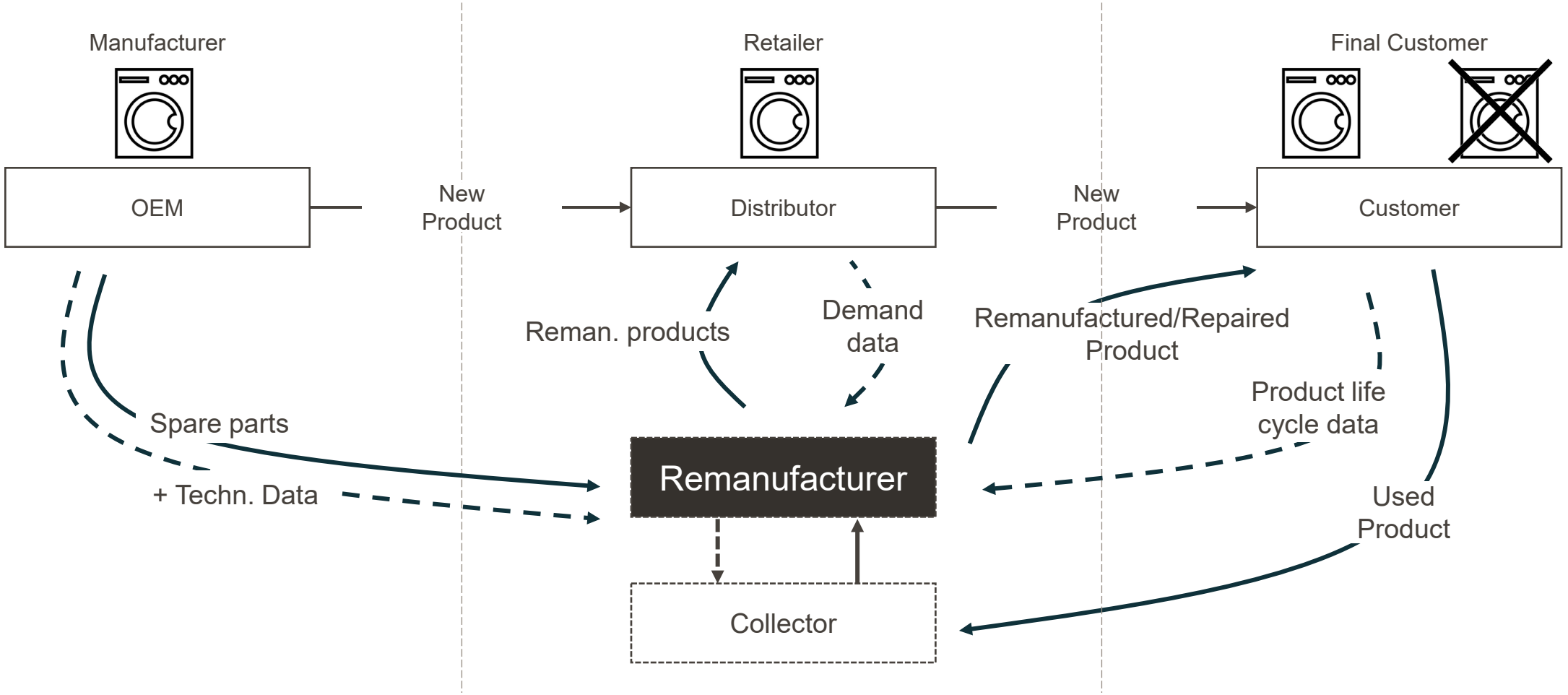
CHALLENGES IN SUPPLY OF USED PRODUCTS

- Circular business models require the integration of new (independent) market actors.

- Challenges:
  - identification and procurement of end-of-life products and components.
  - New suppliers & new relationships
  - … and more …

INSIGHTS FROM THE WHITE GOODS INDUSTRY

Remanufacturing and the White Good Industry



Source: Franzé et al 2023

Workshop approach

Group of x

4-6 people per group

1. Discuss in own group each question raised
2. Prioritize top 3 aspects in your group
3. Choose a group spokesperson
4. Spokesperson inputs group response in Wooclap poll
5. Moderated discussion

Question 1

1. CASCADING: External enablers and barriers
Identify the current **key "external" factors** that can (i) enable (ii) hinder CASCADING.

Question 2

2. CASCADING: Internal strategies and operations
Identify the most crucial **L/SCM-related strategic and operational factors*** that can (i) enable (ii) hinder CASCADING.

Question 3

3. CASCADING: Future needs and directions
Identify the future SCM needs and what L/SCM research should include to address this topic

CASCADING: External enablers & barriers

Enablers

- **Regulation/policy**
- Incentives
- Circular financing
- Technology
- Awareness /Education

Barriers

- **Policy / regulations**
- Maturity
- Product complexity (e.g. composites)
- Neglecting externalities in terms of "true" cost
- Lack of circular financing
- Geography
- Lack of knowledge

NOTE: **Bold** = Recurring

CASCADING: Internal L/SCM enablers & barriers

Enablers

1. Product-as-a-Service
2. New business model
3. Production village / uncertainties
4. Scale
5. Value Proposition
6. Convenience
7. Marketing
8. Capability
9. Technology and innovation
10. 3 PL
11. Collaboration
12. Information sharing
13. Aligning incentive systems
14. Data-driven/Transparency
15. Organization and governance

Barriers

1. Incremental superficial certifications
2. Lack of connectivity
3. Lack of availability of Resources
4. Time
5. Capitalism
6. High degrees of transportation
7. Lack of data availability
8. Priority on Profit as the bottom line
9. Capacity/quality
10. Cost

CASCADING: Future L/SCM research needs & directions

1. **Inter-disciplinarity**
2. Mix of gender, culture & ethnicity
3. Design for optimal usage
4. Design for circularity
5. Addressing Scope 3
6. Inform policy makers and regulatory bodies about the lifetime of reused products (green steel) - best practices can impact policy makers
7. Role of influencers for circularity (e.g. Taylor Shift Paradigm)
8. New business configuration

NOTE: **Bold** = Recurring

Circular supply chains need systems thinking!

- **Value retention:** As long as possible without violating “waste = resource” hierarchy and slowing resource thru’put and metabolism
- **Optimization:** Effective reverse operations needed for favourable outcome of the economic cost drivers. Design less resource- and energy- intensive ‘provisioning systems’
- **Rebound effects and unforeseen consequences:** Cause and effects are better understood to mitigate environmental risk and reduce paradoxes arising across different circular supply chain alternatives, e.g. between reuse and recycling
- **Truly operationalize decoupling:** Between resource use, economic development, human wellbeing, and environmental impacts. Between products and their business models