Sustainable Food Packaging System Design through Optimized Reuse Networks

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Agenda

- Problem statement
- Optimisation to aid reuse network design and planning
- Industrial case study: CPR System
  - Capacitated Location Problem
  - Managing washing operations
  - Trade-off cost vs transport emissions
- Conclusions & Future developments
Problem statement

• **Packaging** plays a significant role in **FSC**, and its **management** affect overall **environmental sustainability**...

• Packaging accounts for 15% of the municipal solid waste with an increasing trend.

• For certain items, **packaging** contribute to almost **45% of food footprint** depending on product variety and package material.

• **Reuse** is promising strategy for preventing virgin materials extraction...

• …But is limited by **organizational** and **economic** issues.
Problem statement

- **Reuse** is promising strategy for preventing virgin materials extraction...
- ...But is limited by **organizational** and **economic** issues:

**Managerial Issues:**

- Location of the **pooler’s facilities** and intensity of transportation;
- **Geography** of **food vendors** and **distribution channels**;
- Material handling & **washing** operations;
- **Uncertain return** of containers;
- Containers inventory balancing;
- **Costs** raising;
- Transportation emissions;

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Optimisation for reuse network design

- Given the broad set of **actors, entities, flows** involved, optimisation could aid cost and impacts minimization supporting network design:

  - **FOOD PROCESSORS, GROWERS, SUPPLIERS**
  - **RETAILERS, DISTRIBUTORS, SHOPS**
  - **RAW MATERIAL SUPPLIERS**
  - **PACKAGING MAKER**
  - **PACKAGING AND CONTAINERS POOLERS**
  - **COLLECTORS, CLEANING & DISPOSAL**
  - **LOGISTICS PROVIDERS**
  - **CONSUMERS**

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Optimisation for reuse network design

- Given the broad set of actors, entities, flows involved, optimisation could aid cost and impacts minimization supporting network design:
Industrial case study: Location problem

- Capacitated facility location problem and network design to respond to retailers and food packers demand and requirements from the perspective of the pooler:

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Industrial case study: Location problem

- **Capacitated facility location problem** and network design to respond to retailers and food packers demand and requirements from the perspective of the pooler:
Industrial case study: Washing operations

- From the pooler’s perspective, **Service Level** is the percentage of containers washed at each return cycle.
- Increasing service % affect the operational costs of the network, as containers must be shipped to the washing facilities.
Industrial case study: Washing operations

- From the pooler's perspective, **Service Level** is the percentage of containers washed at each return cycle.
- Increasing service % affect the operational costs of the network, as containers must be shipped to the washing facilities.
Industrial case study: Costs vs Transport Emissions

• While optimizing the network (strategically and tactically), the trade-off between poolers costs and transport emissions associated with containers supplies to the food vendors is assessed.
Managing uncertain inventories, washing, and transportation of reusable containers in food retailer supply chains

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Abstract

The food supply chain is exposed to numerous environmental risks and changing consumer preferences. This paper presents a novel approach to inventory management for reusable containers in food retailer supply chains. The proposed methodology integrates uncertainty management, which helps to reduce inventory costs and environmental impacts. A case study of a large retail chain in Europe demonstrates the effectiveness of the proposed approach. The results show significant reductions in inventory costs and environmental footprints. This study highlights the potential of implementing such strategies in the food retail sector to address both economic and environmental challenges.

1. Introduction

Food supply chains (FSCs) are complex and exposed to numerous uncertainties, such as demand variability, supply disruptions, and environmental risks. The use of reusable containers in FSCs can help mitigate these uncertainties by reducing inventory costs and environmental impacts. The proposed methodology integrates uncertainty management, which helps to reduce inventory costs and environmental impacts. A case study of a large retail chain in Europe demonstrates the effectiveness of the proposed approach. The results show significant reductions in inventory costs and environmental footprints. This study highlights the potential of implementing such strategies in the food retail sector to address both economic and environmental challenges.

Keywords: Reusable containers, inventory management, uncertainty, food supply chain, environmental impact.
Conclusions

• **Reuse packaging system** are promising but the management of **circular logistics** is challenging.

• **Optimisation** comes to hand to provide support-decision and planning methods.

• **Addressable Issues** include the optimal location of the poolers facilities, the optimization of dirty and clean containers inventory, and the minimization of the overall environmental impacts associated with transportation.

• **Future developments** involve the design of circular networks for reusable primary packaging solution integrated with secondary and tertiary packaging ([https://www.r3pack.eu/](https://www.r3pack.eu/)).

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Thanks for your Attention

Questions?

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