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Optimizing food ordering in a multi-stage catering supply chain network using reusable containers

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Abstract: Reusable plastic containers (RPCs) prevent packaging waste in the food supply chains. Food Catering Supply Chain (FCSC) made of multi-stage logistic networks represents a challenging scenario for adopting RPCs to optimize, particularly when the container's flow meets the food supplies. This paper fosters the application of RPCs in such FCSC by proposing a food-ordering MILP model to aid the cross-docking player in selecting the suppliers and releasing packaged food orders efficiently. This model optimizes logistic costs and operations as well as the influence of the container pooler's facilities network in the FCSC. A numerical example extracted by a larger case study provides validation of the model and offers insights for future research investigations.

Keywords: Reusable Containers; Food Catering Supply Chain; Circular network; MILP; Food ordering.

1. INTRODUCTION

Reusable containers prevent packaging waste in the food industry and fostering their adoption in both retailer and food catering supply chains (FCSC) represent a promising pathway toward the environmental sustainability of the overall sector (Coelho et al., 2020). Literature shows that reusable packaging contributes to reducing the environmental impacts(Accorsi et al., 2014; Gallego-Schmid et al., 2018). In the FCSC, the fractionated demand released by hundreds of consumption sites (e.g., school canteens, hospitals, offices' cafeterias) requires disassembling and handling the consolidated inbound supplies into small orders throughout an intermediate stage of logistics operators (e.g., cross-docker or picking system) (van Belle et al., 2012). Such a multi-stage logistic network represents a challenging scenario to optimize, particularly when the container's flow meets the food supplies. The introduction of reusable containers, effectively studied and tested in other environments (Abejón et al., 2020; Accorsi et al., 2020; Camps-Posino et al., 2021; Tua et al., 2019), must be supported in the FCSC with tailored support-decision tools. This paper explores the application of reusable containers in a food catering supply chain. The logistic network is composed of four actors and two stages: (1) food product suppliers/packagers, (2) warehouses, cross-dockers, or picking systems, and (3) centralized kitchens, end-users, or catering production systems (which serve the consumption sites). Additionally, to manage the reusable containers, (4) pooler facilities became necessary. Such actors enhance the complexity of the integrated product-packaging FCSC, resulting in additional phases and processes, as shown in Figure 1.

The impacts of transportation flows and logistic operations in the observed network need to be investigated and trade-off solutions (Mahalik & Nambiar, 2010) involving package choice (Parashar et al., 2020), order type and quantity (Wu et al., 2018), and package hierarchy identified. Due to its pivotal role, the cross-docker is crucial for this supply chain. It carries out receiving, temporary storage, and order picking activities to serve catering customers (e.g., small schools, hospitals, offices, restaurants, and canteens). In cross-docking facilities, the inbound flows are typically consolidated (i.e., full-unit-loads), whilst the outbound flow is highly heterogeneous and fractionated (i.e., less-than-unit load).

In fresh fruit and vegetable CSC, the role of the packaging (i.e., containers) can be studied through its hierarchy. It involves decisions like the proper configuration of the secondary-tertiary package to adopt and the management of handling and storage operations where a disposable and reusable system might perform differently. Indeed, different volumes, payloads, and configurations of the generic unit load affect the space efficiency of the storage areas and transportation activities (Yu & Egbelu, 2008).

Optimization models aid in identifying the trade-off among the overmentioned dimensions in such a multi-stage distribution system. We formulate a model to fulfill fruits and vegetables catering orders under logistics capacity constraints. Despite the general formulation, the model is applied to case-driven instance illustrated and discussed in Sections 3 and 4.

Literature overviews this topic under different considerations and focuses. Agustina et al. (2014) focus on integrating vehicle scheduling and routing with time windows in food cross-docking supply chains. Albeit their model allows order consolidation, they do not incorporate handling operations into the model. Dondo & Cerdá (2014) introduces a mixed-integer linear programming model for truck-door allocation in a cross-docking warehouse. Sel et al. (2017) explore the catering supply chain for a university cafeteria in Turkey, involving food-production lot sizing and delivery scheduling decisions. The role of packaging is not considered. Liu et al. (2020) study

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a reusable system focusing on the role of the poolers. They present an optimization model to minimize total transportation costs without considering the role of the supply chain. The importance of outsourcing and network area are explored by Marampoutis et al. (2022). An optimization model aimed at optimizing the collection of empty reusable containers is presented. They focus on the vehicle type, supply chain topology, and total cost, neglecting the warehouse capacity constraint. Bortolini et al. (2018) find the optimal mix between disposable and reusable containers in the food catering supply chain.

Thus, the specific peculiarities of FCSCs are not explored enough in the literature (Yadav et al., 2022). This paper aims to support the adoption of reusable containers in FCSCs by optimizing packaging hierarchy levers under typical logistic operations constraints (i.e., storage and transportation).

The following section introduces and discusses the model and the generalized network. Section 3 presents the case study, whilst in Section 4 we interpret the results.

2. MATERIALS AND METHODS

This section formulates an optimization MILP model to design the logistic provider's network by integrating the FCSC with a reusable plastic containers (RPC) system managed through a network of pooler's facilities. The model aims (1) to suggest the type of secondary package for each supplier, (2) to manage flows of empty RPC or packaged food between the SC's actors, and (3) to plan the transferring and picking operations whilst minimizing the overall logistic provider's costs. The objective function minimizes the transportation cost to deliver the customer's orders to the catering customers, the packaging disposal costs, and the handling and storage costs. The model notation and formulation are presented in the following sub-sessions.

2.1 Network modeling

The analyzed supply chain comprises four main actors: the package pooler's facility nodes, suppliers, order-picking warehouses (later called warehouses), and customers. Supplier nodes receive and consolidate food products from the packagers/growers. These actors are committed to the post-harvest processes. Food products are washed, selected, packaged, and sent to the intermediate warehouse. Warehouses receive packaged food from the suppliers and prepare the orders for customers. Customers are private or public entities that cannot supply from retailers' distribution points, e.g., schools, hospitals, and catering services. The customers' orders impose the proper choice of secondary and tertiary packaging types and sizes. Package poolers manage the RPCs supply chain, enabling the inventory of cleaned containers when and where needed.

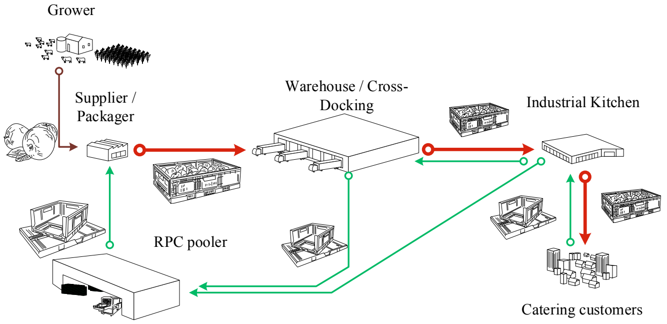

Fig. 1. Integrated FCSC and RPCs network.

Whereas the suppliers do not employ RPCs or use other container's sizes, a transferring task is needed at the warehouse and packaging waste is generated. The warehouse's operators transfer the product from the supplier's package to the customer's package to satisfy the customers' requests. The initial package must be disposed of whenever a product is transferred to another container.

The introduction of RPCs in the catering supply chain compels new partnerships and agreements among the network's actors and adds the pooler to such a system. In such a context, suppliers and distribution centers can evaluate RPCs instead of disposable containers, resulting in the generation of new flows of RPCs, as shown in Fig 1. The pooler facilities ship the empty containers to the suppliers. Suppliers fill the RPC with perishable products, consolidate orders, and send full containers or full-pallet orders to the order-picking warehouses.

2.1 Problem formulation

In such a network, a warehouse also behaves as a pooler facility, which holds containers inventory, replenishes the supplier's inventory, and collects the empty containers from the customers. We seek to assess whether the RPC system is more efficient in logistic costs and waste reduction than a disposable packaging system. We considered a set V of supplier facilities, a set C of customers, a set R of RPCs pooler facilities (including warehouses), and a subset W ⊆ R of warehouses implementing the new management system.

Sets:

$v \in V$:	Set of suppliers
$i \in M$:	Set of perishable products
$c \in C$:	Set of customers
$r \in R$:	Set of CPR nodes
$w \in W$:	Set of warehouses
$p, p^{in}, p^{out} \in Pkg^{II}$:	Set of secondary packages
$t \in Pkg^{III}$:	Set of tertiary packages

Cost assessment involves the cost of the logistic activities to satisfy the customer's requests and manage the distribution network of reusable containers. Costs can be clustered into four groups: (1) packages purchase cost, (2) unit loads transportation cost from warehouses to customers and from suppliers to warehouses, (3) handling cost, and (4) disposal cost.

To quantify purchasing, we considered the number of secondary packages (i.e., $nPkgvw_{vwip}$ and $nPkgtrav_{wip^{in}p^{out}}$) times the unit cost of RPC (i.e., Ec_p). To compute the transportation cost, we use the number of unit loads sent from suppliers to warehouses (i.e., pl_{vwip}) times the transportation unit cost of the unit load (i.e., Ep_{vw}). For the transportation cost related to the warehouse-customers shipments, we use the number and type of tertiary packages (i.e., $nPkg_{ct}^{III}$) multiplied the transportation fee applied by a third logistic partner (i.e., Ecl_{wct}). Internal handling is estimated in terms of the labor hourly cost (i.e., lc) at the warehouse. The tallied person-hour is the time necessary to record the incoming goods and manage their handling between inbound and outbound (i.e., ht). The time required to move the products within the warehouse includes the handling made by the operators through the receiving dock, the storage cells (i.e., reserve area), and the picking area. We measure the disposal cost considering the cost per package (i.e., Ec_p) multiplied the weight and the unit disposal costs (i.e., wc). The cost of RPCs' waste includes a correction coefficient that counts the number of package rotations per year.

New flows of food and packaging must be defined in the modeled network. Suppliers receive empty RPCs from pooler facilities. Since warehouses are considered as RPC poolers, they also send empty containers to suppliers. Such flow is modeled via nF_{rvp} and accounts for the cost parameter $tcPkg_t$ paid for one pallet of empty RPCs. Whereas RPCs are not available at the supplier, the food is transferred into reusable containers at the warehouse, generating an extra handling cost. Food must be delivered in the proper package d_{cipt} according to a packaging hierarchy (i.e., nUL_{wcpt}). Two types of flows for the empty containers are generated. The first determines the disposal of non-returnable containers, whilst the second is for the consigned RCPs that must be returned from the catering customers. The model quantifies the flows of disposal and delivery of empty containers and minimizes the overall cost, including those for packaging collection.

Parameters:

lc	Labor cost at warehouse *w*[€/h]
wc	Waste cost for warehouse *w* [€/kg]
vp	Hand pallet truck average speed [m/s]
ht	Registration time for products *i* [h/kg]
$cPkg_{rp}^{II}$	Max number of package *p* storable in node *r* [# package]
Ep_{vw}	Transportation cost for one pallet from suppliers *v* to warehouse *w* [€/pallet]
ps_v	Number of secondary package type at supplier *v*
di_{wi}	Distance from in bays and storage area for product *i* [m]
kp_p	Number of containers of type *p* for one pallet [container/pallet]
Ec_p	Cost for type *p* package [€/container]
wg_p	Weight of empty secondary package *p* [kg/container]
$tcPkg_t$	Transportation cost for one pallet of empty CPR container [€/km]
o_{vi}	Capacity of product *i* for supplier *v*
kgc_{ip}	Max weight of product *i* in secondary package *p* [kg/container]
cp_{vp}	Setup cost to use package *p* for the supplier *v* [€]
Ecl_{wct}	Transportation cost for tertiary package *t* to costumer *c* [€/Pkg^{III}]
$distrv_{rv}$	Distance between *r* node and supplier *v* [km]
$distrc_{rc}$	Distance between *r* node and customer *c* [km]
$nPkg_{rp}$	Capacity of package *p* in node *r*
$nPkg_{pt}$	Capacity of tertiary package *t* to contain secondary package *p*
$ncPkg_{pt}$	Number of close reusable container *p* contained in tertiary package *t*
$ht_{ip^{in}p^{out}}$	Time to transfer product *i* from package p^{in} to p^{out}[h/kg]
d_{cipt}	Demand of product *i* by customer *c* in package *p* on tertiary package *t*

Variables:

We distinguish two types of decision variables. The first ones are binary values that provide information on which packages are chosen, while the second ones represent good flows.

y_{vp}	1 if supplier *v* uses package *p;* 0 otherwise.
yc_{rc}	1 if the empty containers flow from customer *c* to node *r* is possible; 0 otherwise.
x_{vwip}	Flow of product *i* in package *p* supplied by *v to* warehouse *w*
$z_{wip^{in}p}$	Flow of product *i* received in warehouse *w* in package p^{in} and transferred in p^{out}
$nPkgv$	Flow of product *i* in package *p* moved by supplier *v* to warehouse *w*
$nPkgt$	Number of containers of product *i* transferred from package p^{in} to p^{out} at warehouse *w*
pl_{vwiv}	Pallet of product *i* in package *p* delivered by supplier *v* to warehouse *w*
nUL_{wc}	Flow of secondary package *p* in tertiary package *t* form warehouse *w* to customer *c*
nF_{rvp}	Number of package *p* delivered from node *r* to supplier *v*
$nPkg_{ct}^{II}$	Number of tertiary packages t delivered from warehouse *w* to customer *c*

Objective Function

The model is built on a single objective function (1), defined as follows:

$$
\begin{aligned}
&\min \sum_{p\in Pkg^{II}} \sum_{v\in V} y_{vp} \cdot cp_{vp} + \\
&\sum_{v\in V} \sum_{r\in R} \sum_{p\in Pkg^{II}} \sum_{t\in Pkg^{III}} nF_{rvp} \cdot \frac{1}{ncPkg_{pt}} \cdot ctPkg_t \cdot distrv_{rv} + \\
&\sum_{r\in R} \sum_{t\in Pkg^{III}} \sum_{p\in Pkg^{II}} \sum_{c\in C} \sum_{i\in M} \frac{d_{cipt}}{kgc_{ip}} \cdot \frac{1}{ncPkg_{pt}} \cdot ctPkg_t \cdot distrc_{rc} \\
&\quad \cdot yc_{rc} + \\
&\sum_{i\in M} \sum_{v\in V} \sum_{p\in Pkg^{II}} \sum_{w\in W} pl_{vwip} \cdot Ep_{vw} + \\
&\sum_{p\in Pgk^{II}} \sum_{i\in M} \sum_{w\in W} \left(\sum_{v\in V} nPkgvw_{vwip} + \sum_{p^{in}\in Pkg^{II}} nPkgtr_{wip^{in}p} \right) \\
&\quad \cdot Ec_p + \\
&\sum_{i\in M} \sum_{p^{in},p^{out}\in Pkg^{II}} \sum_{w\in W} z_{wip^{in}p^{out}} \cdot ht_{ip^{in}p^{out}} \cdot lc +
\end{aligned}
\tag{1}
$$

$$\sum_{i\in M}\sum_{v\in V}\sum_{p\in Pkg^{II}}\sum_{w\in W} pl_{vwip}\cdot\left(\frac{di_{wi}}{vp}+ht\right)\cdot lc +$$
$$\sum_{c\in C}\sum_{w\in W}\sum_{t\in Pkg^{III}_{ct}} nPkg^{III}_{ct}\cdot Ecl_{wct} +$$
$$\sum_{p\in Pkg^{II}}\sum_{i\in M}\sum_{w\in W}\left(\sum_{p^{in}\in Pkg^{II}} nPkgtr_{wip^{in}p}\cdot\sum_{v\in V} nPkgvw_{vwip}\right)\cdot wg_p$$
$$\cdot\, wc$$

Each term in equation (1) evaluates a specific cost item.
The term

$$\sum_{p\in Pkg^{II}}\sum_{v\in V} y_{vp}\cdot cp_{vp}$$

considers the integration cost of the new reusable secondary package *p* for the supplier *v*. The second and third addenda of the objective function account for the transportation cost. The former assesses the cost of empty RPCs transportation from *r* to *v*, whilst the latter evaluates loaded RPCs transportation cost from *r* to *c*.
For measuring transportation cost from a generic supplier *v* to warehouse *w*, we used a mean-cost for unit load of product i in secondary package p gathered from the company information system. This cost estimation is represented with the term

$$\sum_{i\in M}\sum_{v\in V}\sum_{p\in Pkg^{II}}\sum_{w\in W} pl_{vwip}\cdot Ep_{vw}$$

whilst

$$\sum_{c\in C}\sum_{w\in W}\sum_{t\in Pkg^{III}_{ct}} nPkg^{III}_{ct}\cdot Ecl_{wct}$$

represents the transportation cost of unit loads from a warehouse to customers. The term

$$\sum_{p\in Pgk^{II}}\sum_{i\in M}\sum_{w\in W}\left(\sum_{v\in V} nPkgvw_{vwip}+\sum_{p^{in}\in Pkg^{II}} nPkgtr_{wip^{in}p}\right)\cdot Ec_p$$

represents the cost of packages. Handling cost is evaluated through the following terms

$$\sum_{i\in M}\sum_{p^{in},p^{out}\in Pkg^{II}}\sum_{w\in W} z_{wip^{in}p^{out}}\cdot ht_{ip^{in}p^{out}}\cdot lc$$
$$+\sum_{i\in M}\sum_{v\in V}\sum_{p\in Pkg^{II}}\sum_{w\in W} pl_{vwip}\cdot\left(\frac{di_{wi}}{vp}+ht\right)\cdot lc$$

This calculation accounts for product transferring from the original package p^{in} to the customer-imposed one p^{out}, the registration, and internal handling. The last part of the objective function assesses the disposal cost.

Constraints

The set of constraints can be clustered into two different groups. Constraints (2)-(8) refers to flows throughout the supply chain, whilst constraints (9)-(13) link the variables to each other. These clusters of constraints are formulated as follows:

$$\sum_{v\in V} nF_{rvp}\le nPkg_{rp}\ \forall r\in R, p\in Pkg^{II} \tag{2}$$

$$\sum_{ww\in W} x_{vwip}\le o_{iv}\cdot y_{vp}\ \forall i\in M, v\in V, p\in Pkg^{II} \tag{3}$$

$$\sum_{p^{out}\in Pkg^{II}} z_{wipp^{out}}\le\sum_{v\in V} x_{vwip}\ \forall i\in M, w\in W, p\in Pkg^{II} \tag{4}$$

$$\sum_{p\in Pkg^{II}}\sum_{t\in Pkg^{III}}\sum_{c\in C} y_{rc}\cdot\sum_{i\in M}\frac{d_{cipt}}{kgc_{ip}}\le\sum_{p\in Pkg^{II}} cPkg^{II}_{rp}\ \forall r\in R \tag{5}$$

$$\sum_{v\in V} x_{vwip}+\sum_{p^{in}\in Pkg^{II}} z_{wip^{in}p}-\sum_{p^{out}\in Pkg^{II}} z_{wipp^{out}}\ge d_{icpt}\forall i\in M, w\in W, c\in C, p\in Pkg^{II}, t\in Pkg^{III} \tag{6}$$

$$\sum_{p\in Pkg^{II}} y_{vp}\le ps_v\ \forall v\in V \tag{7}$$

$$\sum_{r\in R} yc_{rc}=1\ \forall c\in C \tag{8}$$

$$\sum_{i\in M}\frac{x_{vwip}}{kgc_{ip}}\le\sum_{r\in R} nF_{rvp}\ \forall v\in V, p\in Pkg^{III}, w\in W \tag{9}$$

$$nPkgvw_{vwip}\ge\frac{x_{vwip}}{kgc_{ip}}\ \forall i\in M, v\in V, p\in Pkg^{II}, w\in W \tag{10}$$

$$pl_{vwip}\ge\frac{nPkgvw_{vwip}}{kp_p}\ \forall i\in M, v\in V, p\in Pkg^{III}, w\in W \tag{11}$$

$$nPkgtr_{wip^{in}p}\ge\frac{z_{wip^{in}p}}{kgc_{ip}}\ \forall i\in M, p^{in}\in Pkg^{II}, p\in Pkg^{II}, w\in W \tag{12}$$

$$\sum_{w\in W} nUL_{wcpt}\ge\sum_{i\in M}\frac{d_{cipt}}{kgc_{ip}}\ \forall c\in C, p\in Pkg^{II}, t\in Pkg^{III} \tag{13}$$

$$nPkg^{III}_{ct}\ge\sum_{w\in W}\sum_{p\in Pkg^{II}} nUL_{wcpt}\cdot percocc_{pt}\ \forall c\in C, t\in Pkg^{III}, w\in W \tag{14}$$

$$x_{vip}\ \forall i\in M, v\in V, p\in Pkg^{II} \tag{15}$$

$$z_{ip^{in}p^{out}}\in\mathbb{R}^+\ \forall i\in M, p^{in}, p^{out}\in Pkg^{II} \tag{16}$$

$$nF_{rvp}\in\mathbb{R}^+\ \forall r\in R, v\in V, p\in Pkg^{II} \tag{17}$$

Eqs. (2)-(5) are capacity constraints. The maximum number of delivered containers *p* from node *r* cannot exceed the node capacity for such container (2). Eq. (3) defines the production capacity of product *i* in secondary package *p* for each supplier. The quantity of product *i* in package *p* delivered by all suppliers is an upper bound for the quantity of product *i* received by warehouse *w* in the same package (4). Eq. (5) imposes an upper bound to the overall warehouse's storage capacity. Since the model is order-driven, demand adherence is imposed (6). Orders are composed of product-package combinations ordered by customer *c*. Eq. (7) allows the supplier to use only the package available in its inventory. Eq. (8) ensures that the flow of empty containers between two nodes is unique per each order profile (i.e., instance). Constraints (9)-(14) link the variables to each other. Eq. (9) defines the number of packages *p* available at the supplier *v*. Eqs. (10) and (11) compute the products-package couples *i-p* sent from *v* and the number of unit loads, respectively. Eq. (12) impose the quantity of product *i* to be transferred from package p^{in} to package *p*, whilst (13) assesses the number of unit loads sent to the customer *c*. Eq. (14) evaluates the number of tertiary packages at the warehouse. The last three constraints impose the feasible region of the variables.

3. CASE STUDY

The model optimizes a subset of orders received by a single warehouse of Conor. For validation purposes, we applied this model to optimize a subset of orders received by a single warehouse node (i.e., Conor in the following). Conor is a renowned Italian logistic provider operating in the catering supply chain.
The selected order profile corresponds to on 1% of a typical daily orders profiles handled by Conor. The numerical example comprises orders of 3800 [kg] of fresh fruits, 17 suppliers, 17 orders, 17 pooler facility nodes, 15 customers, 4 secondary package type, 3 tertiary package types, and 4 food

varieties. The catering customers involved are in Italy, Emilia Romagna region, and are served by a warehouse owned by Conor located in Bologna.

We use the model to optimize the supply chain costs through packaged food ordering within the proposed numerical example. Such analysis optimizes the adoption of RPCs and compares the costs of the current business-as-Usual (BUA) scenario to the costs experienced when the pooler's facilities location is involved into decision-making. The proposed food ordering-support model allows considering alternative supply flows by considering the role of the catering chain actors, including the pooler. Even though the generic formulation of the model entails both reusable and disposable containers, we only focus on the assessment of the RPCs, implemented in both scenarios. The first scenario (BUA) fixes the current network and imposes the As-Is suppliers for the selected daily order profile. The second scenario (To-Be) enables optimizing the pool of suppliers serving the fruit products into a given secondary package. Because of RPCs, not only the forward food flow drives such decision, even affected by the location of the pooler's facilities. The model is intended for aiding daily food-ordering without exploring other configuration of the catering supply chain's network.

4. RESULTS AND DISCUSSION

The model highlights the cost reduction arising from optimizing the suppliers of packaged food using RPCs when the packaging supply chain (i.e., poolers' network) is incorporated into a unique problem. Such improvement derives from several factors.

The introduction of RPCs within the catering supply chain increases the number of involved actors (i.e., the pooler) and the overall transportation connections. Although the pooler enhances the network connectivity and eventually increases transportation costs, the supply chain optimization generates cost savings, as shown in Table 1.

Table 1. Results comparison.

Supply Chain Operations	FO term	% BAU vs. Optimized Order
Suppliers-Warehouses	*Transportation costs*	-27%
Warehouses-Customers		-
Customers-Poolers		-
Poolers-Suppliers		-83%
Package Transferring	*Handling costs*	-
Internal handling		-9%
Package purchase	*Package costs*	-
Package disposal		-
Total Cost		-34%

Figure 2 compares the connections triggered by the model (i.e., straight line) with the BUA scenario (i.e., dashed line). We notice that new suppliers are selected to serve the warehouse (i.e., Conor) depending on their distance from the package pooler's facilities.

While allocating the food orders to the suppliers, the model considers the cost of delivering empty reusable containers from the pooler. Compared to the BUA scenario we gained an 83% saving of the RPCs transportation cost. Because catering customers and demand parameter are equivalent in both scenarios, no improvement associated to the downstream routes are experienced. Optimized supply connections among the pooler, the warehouse, and the suppliers is the main achievement of the proposed model.

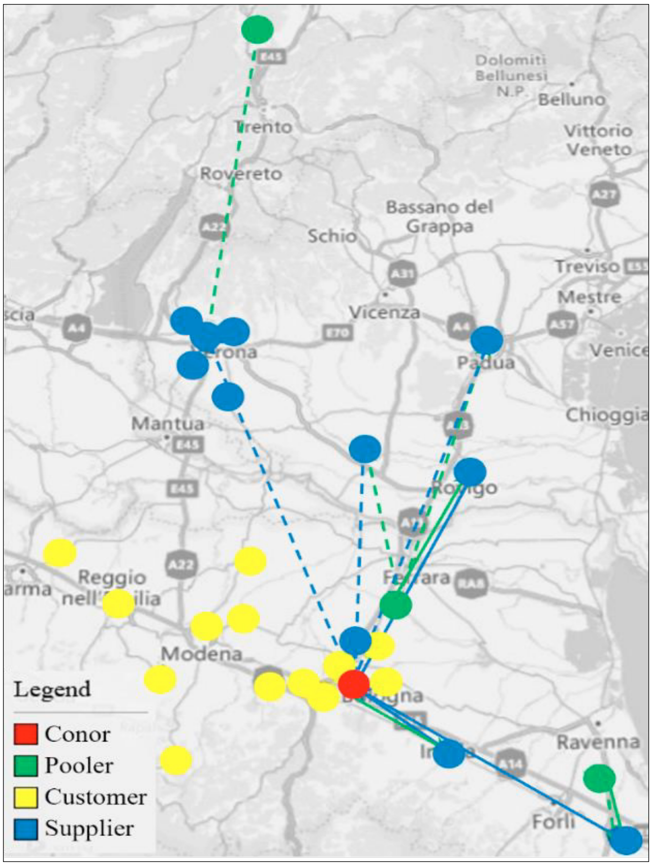

Fig. 2. As-Is vs. To-Be FCSC network

Other savings are obtained at the warehouse (i.e., Conor) considering handling task and activities (-9%). Specifically, the labor cost for truck unloading, storage and picking area replenishment are considered as a function of the product-packaging hierarchy and configuration.

Within the FCSC, intermediate warehouses balance the consolidated inbound flow from suppliers and the fractionated demand to customers. We propose a MILP model to manage such imbalance, aiding food ordering and deciding on the packaging type to adopt. Such as formulated, this problem provides several dimensions for future investigation. Different configuration of packaging hierarchy can be tested, to assess feasibility and convenience of other package size and configuration. The role played by the pooler's network also deserves attention when planning catering or food supply chain using reusable containers. Modifying configuration and pairing of packages and food items would lead to sensitivity analysis able to identify the main factors of the logistic efficiency.

5. CONCLUSION

Throughout the FCSC, the role of the packaging can be studied considering its hierarchy. The study of how the packing hierarchy influences the logistic costs allowed a multifactorial optimization. The packaging hierarchy affects both outbound and inbound logistics operations. Implementing optimization models that represent the entire food catering supply chain is needed to ensure a multivariate study. The presented model enables optimizing the supply chain operations by selecting suppliers and related travelling routes. The choice of RPCs poolers' facilities guarantees the reduction of the total cost of the supply chain while increasing its complexity. The chosen routes and nodes provided with the solution sets a new configuration of the FCSC. According to the triple bottom line paradigm (Birkel & Müller, 2021; Pedroso et al., 2021), the model might implement a multi-objectivity aimed to minimize costs, social (intended for labor) and environmental impacts due to transport, and end-of-life the product-packaging life cycle throughout the supply chain.

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