Large scale supply chain operations in the food industry

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Webinar organized by TransportLab THE UNIVERSITY OF SYDNEY

September 1st, 2023

Outline

- Motivation
- Problem statement
- Modelling approach
- Solution strategy: Optimization models and packing heuristic
- Instances and results
- Interface
- Final remarks

Motivation

- Designing and operating a supply chain efficiently improves profit margin.
- In addition, increasing customer requirements of variability, speed and affordability are better meet (Chopra, 2003).
- In the food industry, where transport cost are significant (15% to 30% of operational costs), this fact is crucial.
- Information systems help ensure necessary high-quality standards, including sustainability concerns and reduce waste from spoilage (Denof et al., 2018)

Motivation

- Some studies suggest that 40% of food waste is associated with inefficient supply chain operations (Parfitt et al., 2010).

- We develop a model and algorithm to optimize the daily transportation of products nationwide for a relevant food producer in Chile (Agrosuper).
- In their problem, trips can visit multiple plants or demand points with specific constraints related to the transport of different products.

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Motivation

- We consider stock at production plants of fresh and frozen products (chicken, pork, turkey, salmon, frozen vegetables) to meet a nationwide demand at large consumers and company’s distribution centers.
- The main objective is to meet demand for products at minimum transport cost.
- A second objective is to minimize empty transport capacity of the fleet used to meet demand (truck filling problem).

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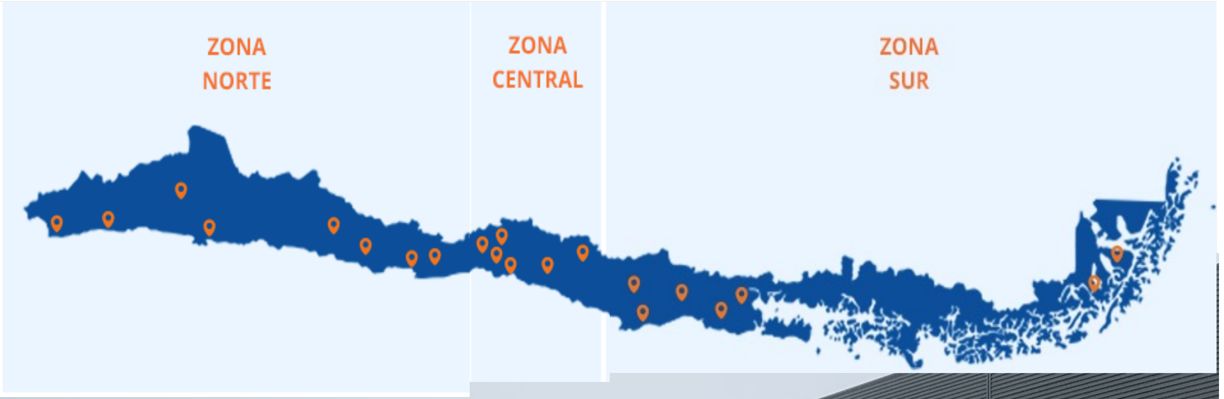
Problem statement

- The company supplies over 50% of the Chilean market (chicken 56%, pork 53%, turkey 62%,) and produces 1.2 million tons of product a year.
- A typical daily operation involves transporting about 2200 tons of more than 1000 different types of products from 7 production plants to about 30 distribution centers and 40 additional large clients using more than 120 different container trucks (25 tons).
- The resulting problem could be conceived as a multi-commodity two-echelon distribution problem, commonly found in applications to the supply chain of the fresh food industry (Flores and Villalobos 2018)



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Literature review

- This problem was recently formulated as a MIP by Archetti et al. (2021), with the goal of minimizing the total transport cost from suppliers to customers. The problem is decomposed in collection and delivery, and solve it through an Adaptive Large Neighborhood Search algorithm.

- Dellaert et al. (2021) studied the one-to-one pickup and delivery problem in a two-echelon distri- bution system. Several metaheuristics have been proposed lately to deal with two-echelon VRP schemes; in this sense, the best methods explored nowadays belong to the large neighborhood search type (Breunig et al., 2019).

- Exact algorithms for two-echelon VRPs are much less frequent in the literature (Baldacci et al., 2013).

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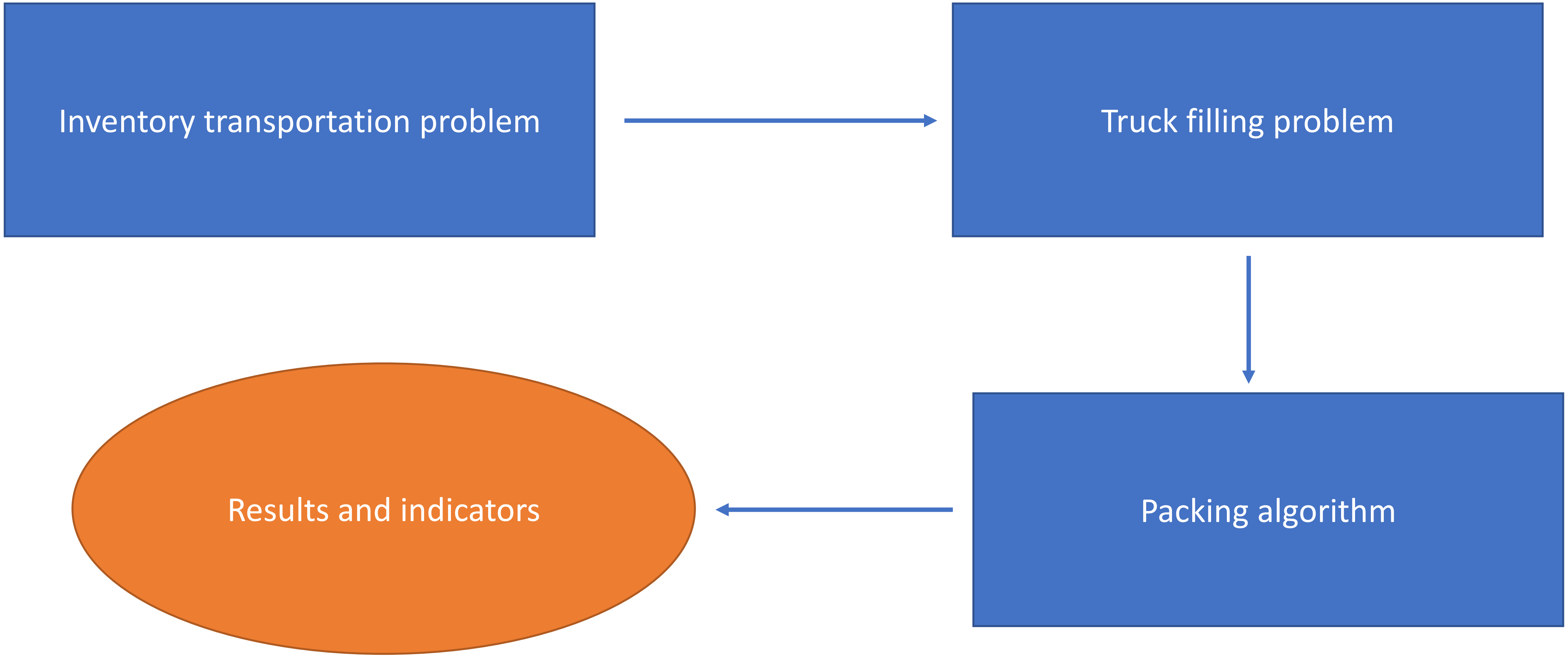
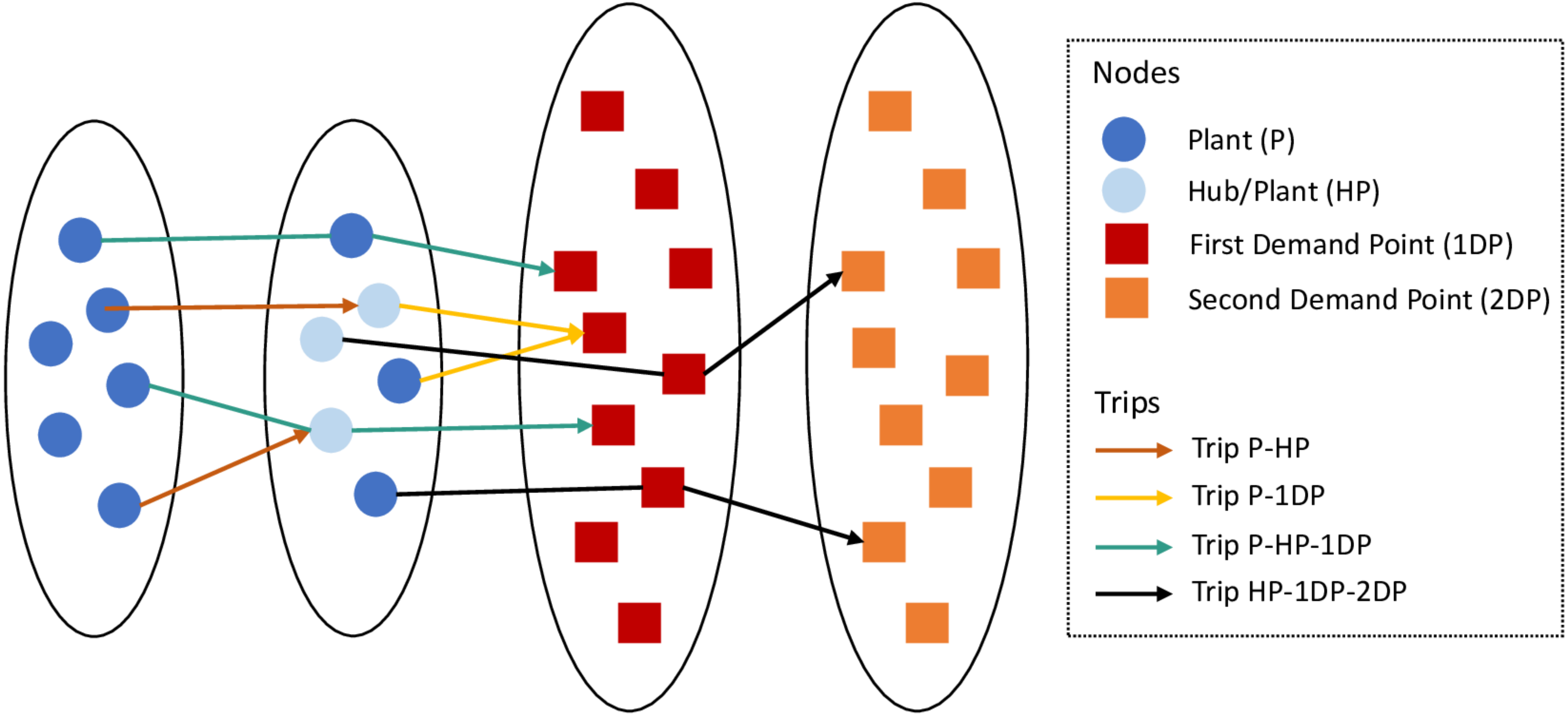
Modelling approach



Modeling approach



Inventory Transportation Problem

Decision variables

Variables that account for product flow, weight and pallets on direct trips between a plant and distribution center, for each arc $(i, j) \in I' \times J$

- x_{hgij}: Number of boxes of product h, of group g, sent from i to j
- p_{ijf} : kg of products of family f sent from i to j
- z_{ijf} : Number of pallets with products from family f sent from i to j (integer)
- zc_{ij} : Number of pairs of frozen pallets sent from i to j (integer)

Variables that account for product flow, weight and pallets on consolidation trips for each triplet $(l, i, j) \in I \times \overline{I} \times J$

- x^r_{hglij}: Number of boxes of product h, of group g, sent on a consolidation trip from $l \in I$ to $i \in \overline{I}$ and then to $j \in J$.
- p^r_{lijf} : kg of products of family f sent from l to i and then to j
- z^r_{lijf} : Number of pallets with products from family f sent from l to i and then to j (integer)
- zc^r_{lij} : Number of pairs of frozen pallets sent from l to i and then to j (integer)

Inventory Transportation Problem

Decision variables (cont.)

Variables that account for product flow, weight and pallets on plant-plant-distribution center, for each triplet $(l, i, j) \in A^2 \subseteq I \times I' \times J$

- x^2_{hglij}: Number of boxes of product h, of group g, sent on a plant-plant-DC trip from $l \in I$ to $i \in I'$ and then to $j \in J$.
- p^2_{lijf} : kg of products of family f sent on a plant-plant-DC trip from $l \in I$ to $i \in I'$ and then to $j \in J$.
- z^2_{lijf} : Number of pallets with products from family f sent on a plant-plant-DC trip from $l \in I$ to $i \in I'$ and then to $j \in J$ (integer)
- zc^2_{lij} : Number of pairs of frozen pallets sent on a plant-plant-DC trip from $l \in I$ to $i \in I'$ and then to $j \in J$. (integer)

Variables that account for product flow, weight and pallets on shared trips (plant-distribution center-distribution center), for each triplet $(i, j, l) \in A^3 \subseteq I \times J \times J$

- $x^s_{hg\hat{\jmath}ijl}$: Number of boxes of product h, of group g, sent on a shared trip from $i \in I$ to $j \in J$ and then to $l \in J$ that are delivered to $\hat{\jmath} \in \{j, l\}$.
- p^s_{ijlf} : kg of products of family f sent on a shared trip from $i \in I$ to $j \in J$ and then to $l \in J$.
- $z^s_{\hat{\jmath}ijlf}$: Number of pallets with products from family f sent on a shared trip from $i \in I$ to $j \in J$ and then to $l \in J$ and deliverd to $\hat{\jmath} \in \{j, l\}$ (integer)
- zc^s_{ijl} : Number of pairs of frozen pallets sent on a shared trip from $i \in I$ to $j \in J$ and then to $l \in J$. (integer)

Inventory Transportation Problem

Decision variables (cont.)

Demand and offer variables

- o^1_{hgi}: Number of boxes of product h, group g, that leave from $i \in I$ (in a plant-plant-distribution center or consolidation trip)
- o^2_{hgi}: Number of boxes of product h, group g, that leave from $i \in I'$
- u_{hgj}: Number of boxes of product j, group g of unmet demand at distribution center j.

Truck trip variables

- y_{ijk}: Number of type k trucks that travel on the arc $(i,j) \in A \subseteq I \times \overline{I} \ \cup \ I' \times J$ (integer)
- y^2_{lijk}: Number of type k trucks that traverse arcs $(l,i',j) \in A^2 \subseteq I \times I' \times J$ (integer)
- y^s_{ijlk}: Number of type k trucks that traverse arcs $(i,j,l) \in A^3 \subseteq I \times J \times J$ (integer)

Inventory Transportation Problem

Some distribution centers $j \in J$ manage inventory for two types of clients in that region that have different freshness requirements. These two types of clients are grouped into 1) the traditional market and food service clients and 2) the supermarkets. To differentiate these two types of clients we denote by x_{hgij_S}, $x^r_{hglij_S}$, $x^2_{hglij_S}$ and $x^s_{hg\hat{j}_S ijl}$ the variables that represent the boxes of products sent to j to satisfy the demand of the supermarket type clients. The set J_S groups these distribution centers of supermarket demand, where $j_S \in J_S$ is the supermarket distribution center located in the distribution center $j \in S$. With these variables we define the following optimization problem.

Inventory Transportation Problem

Mixed integer optimization formulation

$$\min \sum_{k\in K}\left(\sum_{(i,j)\in A} c_{ijk}y_{ijk} + \sum_{(l,i,j)\in A^2}(c_{lik}+c_{ijk})y^2_{lijk}\right)$$

s.t.

Offer constraints

$$o^1_{hgi} + o^2_{hgi} \leq Of_{hgi} \qquad \forall\ h\in H,\ g\in G,\ i\in I$$

$$\sum_{l\in\overline{I}}\sum_{j\in J\cup J_S} x^r_{hgilj} + \sum_{l\in I'}\sum_{j\in J\cup J_S} x^2_{hgilj} \leq o^1_{hgi} \qquad \forall\ h\in H,\ g\in G,\ i\in I$$

$$\sum_{j\in J\cup J_S} x_{hgij} \leq o^2_{hgi} \qquad \forall\ h\in H,\ g\in G,\ i\in I'$$

Inventory Transportation Problem

Demand constraints

$$\sum_{g'\in G: g'\geq g}\left(\sum_{i\in I'} x_{hg'ij} + \sum_{l\in I}\sum_{i\in \overline{I}} x^r_{hg'lij} + \sum_{l\in I}\sum_{i\in I'} x^2_{hg'lij}\right) + $$

$$+ \sum_{g'\in G: g'\geq g}\ \sum_{(i,l,e)\in A^3\ :j\in\{l,e\}} x^s_{hg'jile} + u_{hgj} \geq Da_{hgj} \quad \forall\ h\in H,\ g\in G,\ j\in J\cup J_S$$

$$\sum_{g\in G}\sum_{j\in J\cup J_S} u_{hgj} \leq \overline{U}_h \quad \forall\ h\in H$$

Total weight per arc and family

$$\sum_{h\in H_f}\sum_{g\in G}(x_{hgij} + x_{hgij_S})KG_h \leq p_{ijf} \quad \forall\ (i,j)\in A,\ f\in F$$

$$\sum_{h\in H_f}\sum_{g\in G}(x^2_{hglij} + x^2_{hglij_S})KG_h \leq p^2_{lijf} \quad \forall\ (l,i,j)\in A^2,\ f\in F$$

$$\sum_{h\in H_f}\sum_{g\in G}(x^r_{hglij} + x^r_{hglij_S})KG_h \leq p^r_{lijf} \quad \forall\ (l,i,j)\in A^2,\ \text{con } i\in\overline{I},\ f\in F$$

$$\sum_{h\in H_f}\sum_{g\in G}\sum_{\hat{\jmath}\in\{j,l\}}(x^s_{hg\hat{\jmath}ijl} + x^s_{hg\hat{\jmath}_S ijl})KG_h \leq p^s_{ijlf} \quad \forall\ (i,j,l)\in A^3,\ f\in F$$

Inventory Transportation Problem

Arc capacity by weight

$$\sum_{f\in F}\left(p_{ijf}+\sum_{(i,j)\in(l,h,e)}p^2_{lhef}+\sum_{(i,j)\in(l,h,e)}p^r_{lhef}\right)\leq$$

$$\leq\sum_{k\in K}\overline{KG}_k\left(y_{ijk}+\sum_{(i,j)\in(l,h,e)}y^2_{lhek}\right)\qquad\forall\ (i,j)\in(I'\times J)\cap A$$

$$\sum_{f\in F}p^2_{lijf}\leq\sum_{k\in K}\overline{KG}_k y^2_{lijk}\qquad\forall\ l\in I',\ i\in I'',\ j\in J$$

$$\sum_{j\in J}\sum_{f\in F}p^r_{lijf}\leq\sum_{k\in K}\overline{KG}_k y_{lik}\qquad\forall\ l\in I,\ i\in\overline{I}$$

$$\sum_{f\in F}p^s_{ijlf}\leq\sum_{k\in K}\overline{KG}_k y^s_{ijlk}\qquad\forall(i,j,l)\in A^3$$

Inventory Transportation Problem

Total pallet per arc and family

$$\sum_{h\in H_f}\sum_{g\in G}(x_{hgij}+x_{hgij_S})/PL_h \leq z_{ijf} \qquad \forall\ (i,j)\in A,\ f\in F$$

$$\sum_{h\in H_f}\sum_{g\in G}(x^2_{hglij}+x^2_{hglij_S})/PL_h \leq z^2_{lijf} \qquad \forall\ (l,i,j)\in A^2,\ f\in F$$

$$\sum_{h\in H_f}\sum_{g\in G}(x^r_{hglij}+x^r_{hglij_S})/PL_h \leq z^r_{lijf} \qquad \forall\ (l,i,j)\in A^2,\ \text{con } i\in \overline{I},\ f\in F$$

$$\sum_{h\in H_f}\sum_{g\in G}(x^s_{hg\hat{\jmath}ijl}+x^s_{hg\hat{\jmath}_S ijl})/PL_h \leq z^s_{\hat{\jmath}ijlf} \qquad \forall\ (i,j,l)\in A^3, \hat{\jmath}\in\{j,l\},\ f\in F$$

$$\sum_{f\in F_c} z_{ijf} \leq 2zc_{ij} \qquad \forall\ (i,j)\in A$$

$$\sum_{f\in F_c} z^2_{lijf} \leq 2zc^2_{lij} \qquad \forall\ (l,i,j)\in A^2$$

$$\sum_{f\in F_c} z^r_{lijf} \leq 2zc^r_{lij} \qquad \forall\ (l,i,j)\in A^2,\ \text{con } i\in \overline{I}$$

$$\sum_{f\in F_c}\sum_{\hat{\jmath}\in\{j,l\}} z^s_{\hat{\jmath}ijlf} \leq 2zc^s_{ijl} \qquad \forall\ (i,j,l)\in A^3$$

Inventory Transportation Problem

Arc capacity by pallet

$$\sum_{f\in F_f} z_{ijf} + 2zc_{ij} + \sum_{(i,j)\in(l,h,e)} \left(\sum_{f\in F_f} z^2_{lhef} + 2zc^2_{lhe} \right) +$$

$$+ \sum_{(i,j)\in(l,h,e)} \left(\sum_{f\in F_f} z^r_{lhef} + 2zc^r_{lhe} \right) \le \sum_{k\in K} \overline{CP}_k \left(y_{ijk} + \sum_{(i,j)\in(l,h,e)} y^2_{lhek} \right) \qquad \forall\ (i,j) \in (I' \times J) \cap A$$

$$\sum_{f\in F_f} z^2_{lijf} + 2zc^2_{lij} \le \sum_{k\in K} \overline{CP}_k y^2_{lijk} \qquad \forall\ (l,i,j) \in A^2$$

$$\sum_{j\in J} \sum_{f\in F_f} z^r_{lijf} + 2zc^r_{lij} \le \sum_{k\in K} \overline{CP}_k y_{lik} \qquad \forall\ l \in I,\ i \in \overline{I}$$

$$\sum_{f\in F_f} \sum_{\hat{\jmath}\in\{j,l\}} z^s_{\hat{\jmath}ijlf} + 2zc^s_{ijl} \le \sum_{k\in K} \overline{CP}_k y^s_{ijlk} \qquad \forall\ (i,j,l) \in A^3$$

$$2zc_{ij} \le \sum_{k\in K} \overline{CP}_k y_{ijk} \qquad \forall\ (i,j) \in (I' \times J) \cap A$$

Inventory Transportation Problem

Cuts

$$\sum_{k\in K}\overline{CP}_k\left(\sum_{i'\in I'} y_{i'jk} + \sum_{(l,h,e)\in A^2\ :\ e=j} y^2_{lhek} + \sum_{(i,l,e)\in A^3\ :\ j\in\{l,e\}} y^s_{ilek}\right) \geq \sum_{h\in H}\sum_{g\in G} Da_{hgj}/PL_h \qquad \forall\ j\in J$$

$$\sum_{i\in I'}\sum_{f\in F} z_{ijf} + \sum_{(l,h,e)\in A^2:e=j}\ \sum_{f\in F} z^2_{lhef} + \sum_{(l,h,e)\in A^2:h\in\overline{I},e=j}\ \sum_{f\in F} z^r_{lhef} + \sum_{(i,e,l)\in A^3:i\in I,j\in\{e,l\}}\ \sum_{f\in F} z^s_{jielf} \geq \sum_{h\in H}\sum_{g\in G} Da_{hgj}/PL_h \quad \forall\ j\in J$$

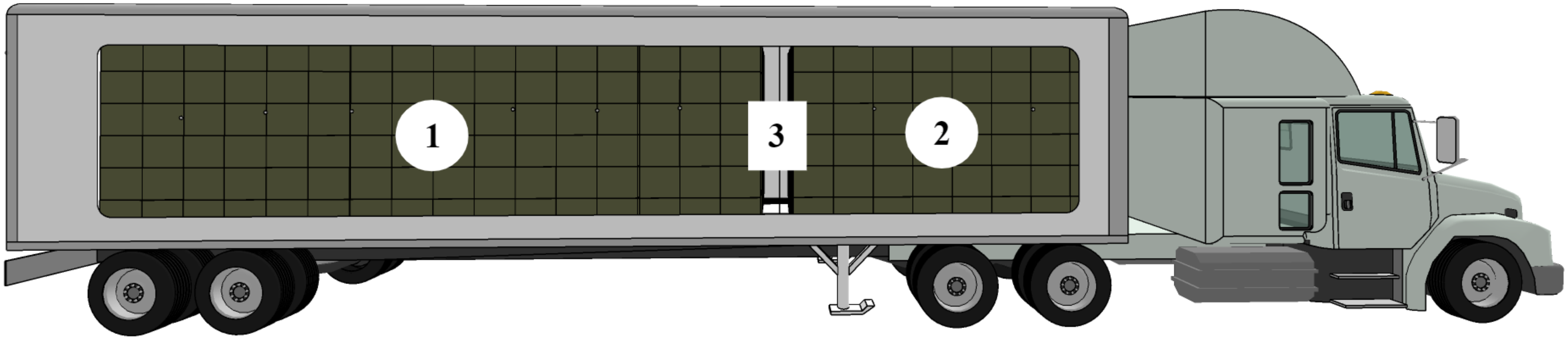
Variable domain

$x_{hgij}\geq 0,\ x^2_{hglij}\geq 0,\ x^r_{hglij}\geq 0$	$\forall\ h\in H,\ (i,j)\in A$
$p_{ijf}\geq 0,\ p^2_{lijf}\geq 0,\ p^r_{lijf}\geq 0$	$\forall\ (i,j)\in A,\ f\in F$
$z_{ijf},\ z^2_{lijf},\ z^r_{lijf}\in\mathbb{Z}_+$	$\forall\ (i,j)\in A,\ f\in F$
$zc_{ij},\ zc^2_{lij},\ zc^r_{lij}\in\mathbb{Z}_+$	$\forall\ (i,j)\in A,\ f\in F$
$y_{ijk}, y^2_{lijk}\in\mathbb{Z}_+$	$\forall\ (i,j)\in A,\ k\in K$

Inventory Transportation Problem

Constraints on number of frozen pallets in trucks with mixed cargo

We describe now a specific constraint on the number of frozen pallets that a truck of 26 pallets can carry if it also carries fresh pallets. If a truck of 26 pallets carries a mixed load (frozen and fresh pallets), then the space for frozen pallets must be at least 4 and no more than 18 pallets. This is due to the physics of adding a separator between the frozen and the fresh pallets and the power of the refrigerating unit. Therefore the space for frozen pallets on a truck of size 26 pallets can be 0, 4 through 18, and 26 pallets.



Inventory Transportation Problem

if zc_{ij} represents the number of pairs of frozen pallets that are on the trip between i and j, we separate this quantity into

- zMc_{ij}: pairs of frozen pallets on trucks of size 26 pallets
- zNc_{ij}: pairs of frozen pallets on trucks different than type 26 pallets.

We also need to introduce two binary variables

- zIc_{ij}: binary variable indicating whether there are frozen pallets on a truck of 26 pallets
- zFc_{ij}: binary variable that indicates that the truck of 26 pallets is full of frozen pallets.

With these variables we can write the following constraints

Upper and lower bound constraints for mixed fresh/frozen cargo trucks

$$zc_{ij} \leq zMc_{ij} + zNc_{ij} \qquad \forall (i,j) \in A$$

$$zMc_{ij} \leq \mathbf{M} zIc_{ij} \qquad \forall (i,j) \in A$$

$$2zMc_{ij} \geq 4zIc_{ij} \qquad \forall (i,j) \in A$$

$$2zMc_{ij} \geq 26(y_{ijk} - \mathbf{M}(1 - zFc_{ij})) \qquad \forall (i,j) \in A,\ k =' 26P'$$

$$2zMc_{ij} \leq 26y_{ijk} - 8(1 - zFc_{ij}) \qquad \forall (i,j) \in A,\ k =' 26P'$$

$$2zNc_{ij} \leq \sum_{k \in K \,:\, k \neq' 26P'} \overline{CP}_k y_{ijk} \qquad \forall (i,j) \in A$$

Inventory Transportation Problem

Where **M** is a large enough big-M constant. These constraints are such, that when $zIc_{ij} = 1$ and $zFc_{ij} = 0$ we have

$$4 \leq 2zMc_{ij} \leq 26y_{ijk} - 8 \qquad \text{for } k =' 26P' \ ,$$

if $zIc_{ij} = 1$ and $zFc_{ij} = 1$ we have that

$$2zMc_{ij} = 26y_{ijk} \qquad \text{for } k =' 26P' \ ,$$

if $zIc_{ij} = 0$, then $zMc_{ij} = 0$. Here zFc_{ij} can be 0 or 1 depending on whether $y_{ijk} > 0$ or $y_{ijk} = 0$. Note that in this situation, it is possible to have frozen pallets on arc (i, j) since zNc_{ij} could be positive, but these pallets travel on trucks different from 26 pallet trucks.

Inventory Transportation Problem

Similar variable and constraints are introduced to separate the frozen pallets into trucks of 26 pallets and other types of trucks for variables zc^2_{lhe}, zc^r_{lij}, and zc^s_{ijl}. Finally we point out that we need to modify the constraints "Arc capacity by pallet" changing zc_{ij} by $zMc_{ij} + zNc_{ij}$, leaving:

Arc capacity by pallet

$$\sum_{f\in F_f} z_{ijf} + 2(zMc_{ij} + zNc_{ij}) + \sum_{(i,j)\in(l,h,e)} \left(\sum_{f\in F_f} z^2_{lhef} + 2(zMc^2_{lhe} + zNc^2_{lhe}) \right) +$$

$$+ \sum_{(i,j)\in(l,h,e)} \left(\sum_{f\in F_f} z^r_{lhef} + 2(zMc^r_{lhe} + zNc^r_{lhe}) \right) \leq \sum_{k\in K} \overline{CP}_k \left(y_{ijk} + \sum_{(i,j)\in(l,h,e)} y^2_{lhek} \right) \qquad \forall\ (i,j) \in (I' \times J) \cap A$$

$$\sum_{f\in F_f} z^2_{lijf} + 2(zMc^2_{lij} + zNc^2_{lij}) \leq \sum_{k\in K} \overline{CP}_k y^2_{lijk} \qquad \forall\ (l,i,j) \in A^2$$

$$\sum_{j\in J} \sum_{f\in F_f} z^r_{lijf} + 2(zMc^r_{lij} + zNc^r_{lij}) \leq \sum_{k\in K} \overline{CP}_k y_{lik} \qquad \forall\ l \in I,\ i \in \overline{I}$$

$$\sum_{f\in F_f} \sum_{\hat{\jmath}\in\{j,l\}} z^s_{\hat{\jmath}ijlf} + 2(zMc^s_{ijl} + zNc^s_{ijl}) \leq \sum_{k\in K} \overline{CP}_k y^s_{ijlk} \qquad \forall\ (i,j,l) \in A^3$$

$$2(zMc_{ij} + zNc_{ij}) \leq \sum_{k\in K} \overline{CP}_k y_{ijk} \qquad \forall\ (i,j) \in (I' \times J) \cap A$$

Truck filling problem

- Given the trips associated with the fleet decided in the previous problem to satisfy the demand, the secondary objective is how to use the available space to maximize the profit.
- The decision is what products to carry on the available space of trucks with the objective of maximizing profit.
- We can fill up pallets with products and volumes identified by the distribution centers as potential products for filling trucks.

Example: total pallets per arc and family

$$Xz_{ijf} + \sum_{h \in H_f} \sum_{g \in G} (x_{hgij} + x_{hgijS})/PL_h \leq z_{ijf}$$

$$Xz^2_{lijf} + \sum_{h \in H_f} \sum_{g \in G} (x^2_{hglij} + x^2_{hglijS})/PL_h \leq z^2_{lijf}$$

$$Xz^r_{lijf} + \sum_{h \in H_f} \sum_{g \in G} (x^r_{hglij} + x^r_{hglijS})/PL_h \leq z^r_{lijf}$$

$$\sum_{f \in F_c} z_{ijf} \leq 2zc_{ij}$$

$$\sum_{f \in F_c} z^2_{lijf} \leq 2zc^2_{lij}$$

$$\sum_{f \in F_c} z^r_{lijf} \leq 2zc^r_{lij}$$

Packing algorithm

- Inputs
  - Tarifs.xls
  - Boxes-pallets.xls
  - Family of products.xls
  - Production cost.xls
  - Selling price.xls
  - Demand.xls
  - Stock.xls
  - Materials features.xls
  - Nodes.xls
  - Output models (aggregate loads)

- Outputs packing (Excel files)
  - Indicators
  - Truck filling file
  - Routes
  - Details
  - SAP files

Packing algorithm

z, z^r, z^2, z^s → **Create Pallets()** → matrix with rows P_1, P_2, ⋮ and columns f_1 f_2 … — LoadP[· , ·]

We create empty pallets
per family of products (matrix)

Problem features

x, x^r, x^2, x^s

→ **Load Pallets()**
xG -> $Prod_k$ -> Family($Prod_k$)=f

LoadP[· , f] →

Prod Pallets(Bunch(xG),f)

- Load boxes of xG product in pallets associated with family f recursively
- Bunch of boxes are loaded in descendent order wrt capacity (boxes/pallets) & in ascendent order wrt pallet occupation.
- Capacity constraints in both weight and volume are respected.

↓ Unloaded boxes (Uboxes)

↓ LoadP[· , f] (filled up)

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Packing algorithm

- Since the boxes are integer values, we sometimes leave boxes unloaded in the previous process, as they cannot fit in the pallets because of volume constraints (in almost all cases).
- To deal with that, we developed a GRASP (Greedy randomized adaptive search procedure) to gain diversity and be able to load most of the boxes to the available pallets obtained from the models (Resende and Ribeiro, 2003).

Algorithm 1 LoadPalletsProds()

```
CreatePallets()
xP.SortCuad()
for i = 0; i < xP.size(); i++ do
  LoadPallets(xP[i], UBoxesAux)
end for
if (UBoxesAux) == 0 ∨xP.size() <PGRASP then
  LoadP ← LoadAux; UBoxes ← UBoxesAux
else
  LoadPBEST ← LoadPAux; UBoxesBEST ← UBoxesAux
  for g = 0; g < IterGRASP; g++ do
    CreatePallets(LoadPAux)
    bool NotAssigned ← TRUE
    set<int> counter
    while NotAssigned do
      vector<int> GRASPcandidates
      for i = 0; i < xP.size(); i++ do
        GRASPcandidates.pushBack(i)
        if GRASPcandidates.size() ==PGRASP then
          Break
        end if
      end for
      if GRASPcandidates.size() == 0 then
        NotAssigned ← FALSE
      else
        int RNumber ← rand() % GRASPcandidates.size()
        LoadPallets(xP[GRASPcandidates[RNumber]], LoadPAux)
        counter.insert(GRASPcandidates[RNumber])
      end if
    end while
    if UBoxesAux < UBoxesBEST then
      UBoxesBEST ← UBoxesAux; LoadPBEST ← LoadPAux
    end if
    UBoxesAux.clear(); LoadPAux.clear()
  end for
  UBoxes ← UBoxesBEST; LoadP ← LoadPBEST
end if
UpdateIndicators()
```

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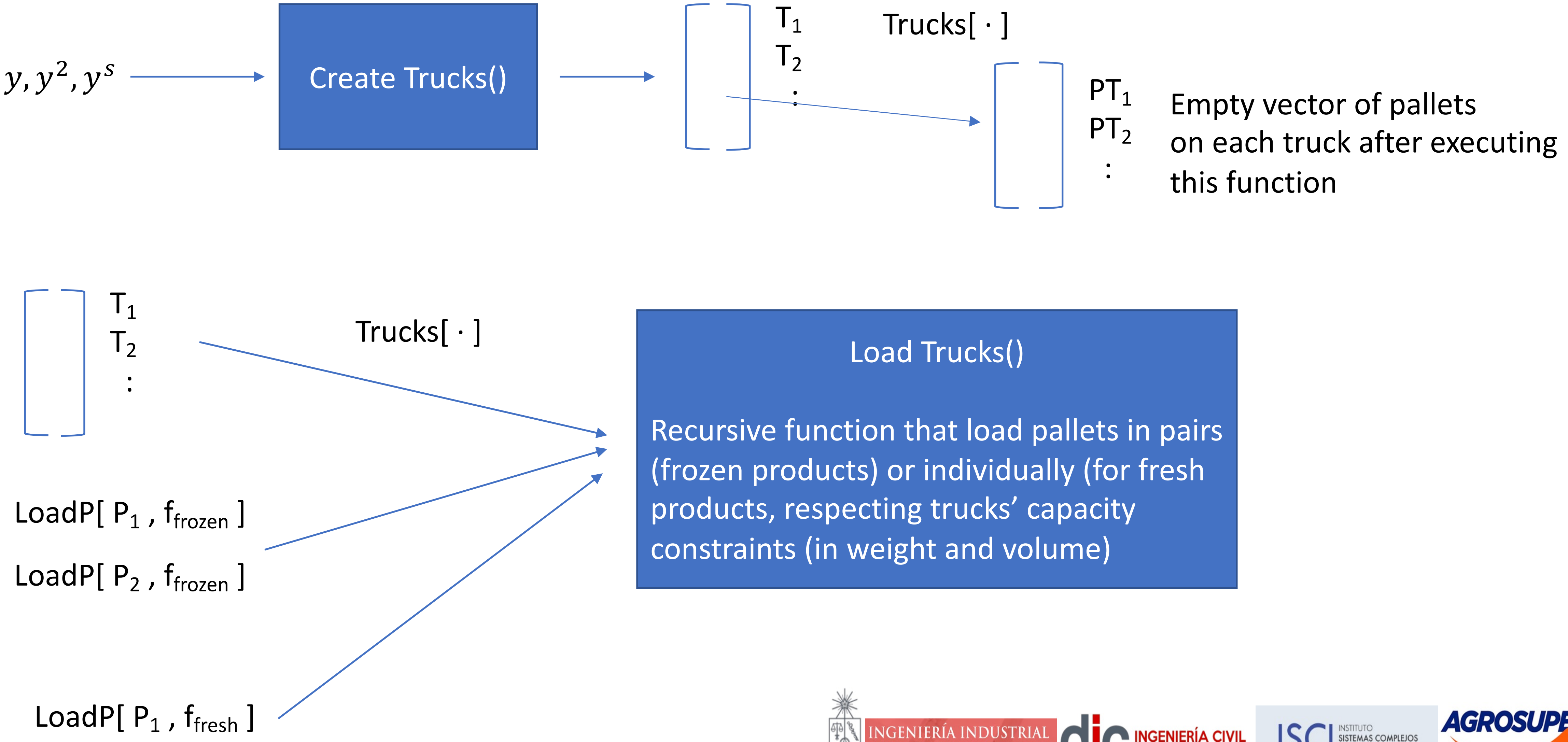
Packing algorithm

Comparison of GRASP vs GREEDY in a real instance of a total of more than 82,827 boxes on a specific day

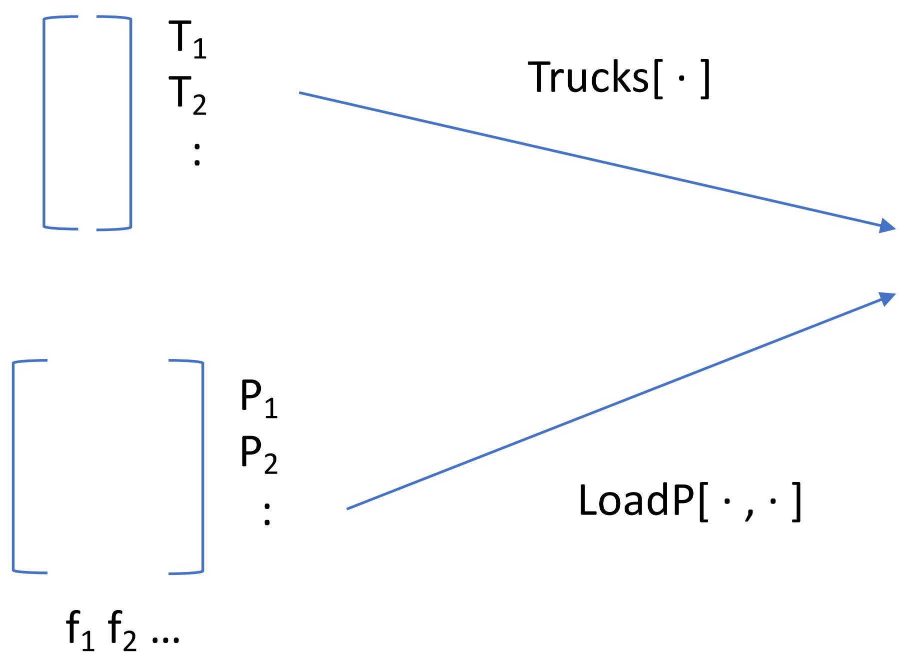
GRASP (PGRASP = 3, ITER_GRASP = 1000)					GREEDY				
Type Var.	code	Nboxes	Weight	Boxes per Pallet	Type Var.	code	Nboxes	Weight	Boxes per Pallet
qx	1010220	1	21	50	qx	1010077	2	11.5	64
qx	1010267	1	22	50	qx	1010105	1	22	50
qx	1010390	2	21.651	50	x	1010110	4	9.168	80
qx	1020001	1	17.37	40	qx	1010220	1	21	50
qx	1020085	1	18.9	40	qx	1010267	7	22	50
qx	1020417	2	22	40	qx	1010306	1	21.749	50
qxr	1030010	1	14.4	60	qx	1010335	3	22	50
x	1100419	1	3.08	224	qx2	1010390	1	21.651	50
x	1100449	1	5.6	104	qx	1010390	4	21.651	50
x	1100640	1	4	182	qx	1010503	1	22	50
qx	1110003	1	10	60	qx	1010733	1	22	50
					qx	1011142	1	16	50
					qx	1011146	1	18	50
					qx	1011678	1	18	50
					⋮	⋮	⋮	⋮	⋮
					qx	1110003	1	10	60
					qxr	1120234	2	3.5	90

Total Variab-prod.	Total Boxes	Total Weight	Total Pallets	Total Variab-prod.	Total Boxes	Total Weight	Total Pallets
11	13	204	0.23	48	81	1211	1.39

Packing algorithm



Packing algorithm



Load Trucks Edge()

- First, frozen pallets are loaded; next, fresh pallets are loaded using the available capacity on trucks left by frozen load process.
- In case of frozen products, we have to respect the frozen pallets constraints (minimum and maximum number of pallets frozen if the truck is shared and need separator). This constraint is active at this stage, even tough later on we could have some trucks with no separator.
- Then, we load the fresh products once frozen products are all on the trucks. For fresh products, trucks are sorted based on two criteria. We start with trucks with largest capacity. If two trucks are the same capacity, we sorted them in ascendent order wrt occupancy in weight.
- Trucks are filling up one at a time using Load Trucks() recursively.

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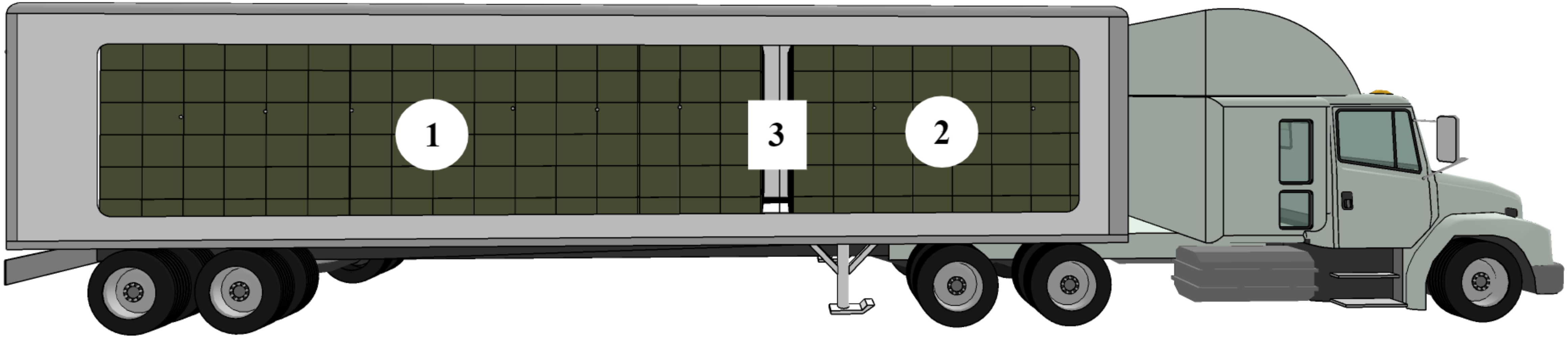
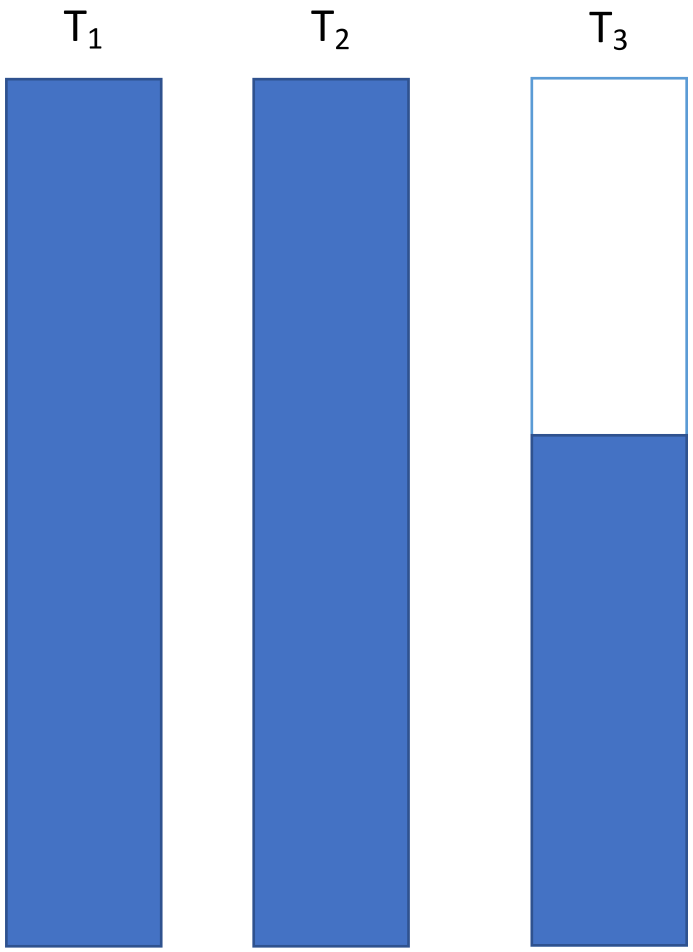
Packing algorithm

- In case of frozen products, the separator forces us to load the pallets respecting a minimum and maximum threshold

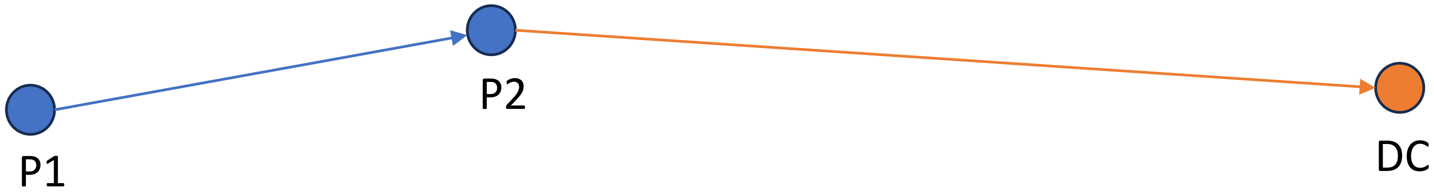


Packing algorithm

- The loading procedure for frozen products uses recursive function Load Trucks () filling trucks once at the time.
- The trucks are filled at top (when capacity in volume is reached respecting constraints on maximum truck weight).
- If the last truck does not fulfill min and max threshold conditions, the load is adjusted to finally fulfill such conditions properly



Packing algorithm



- In the case of routes containing more than one arc (*P1-P2-DC*), we need to be consistent with the pallets loaded in the second arc (*P2-DC*) wrt the first one (*P1-P2*).

- Moreover, this implies that the procedure must be able of refill trucks with pallets added in the intermediate plant.

- The former argument implies that first we load the arcs of type *P1-P2*, filling the pallets on such arcs, and then, loading the trucks, for both trip: between plants (consolidations) and for two-stage *P1-P2-DC* trips.

Packing algorithm

- Then, we load the *P2-DC* arcs, filling up the corresponding pallets, and then, they are assigned to direct trucks (primary trips) or on trucks coming from a previous plant (primary two-stage trips) with some remaining space in both volume and weight.

- Trips of type *P-DC1-DC2* are treated separately, using the same described procedure.

- The procedure always respects capacity constraints in both dimensions (volume and weight).

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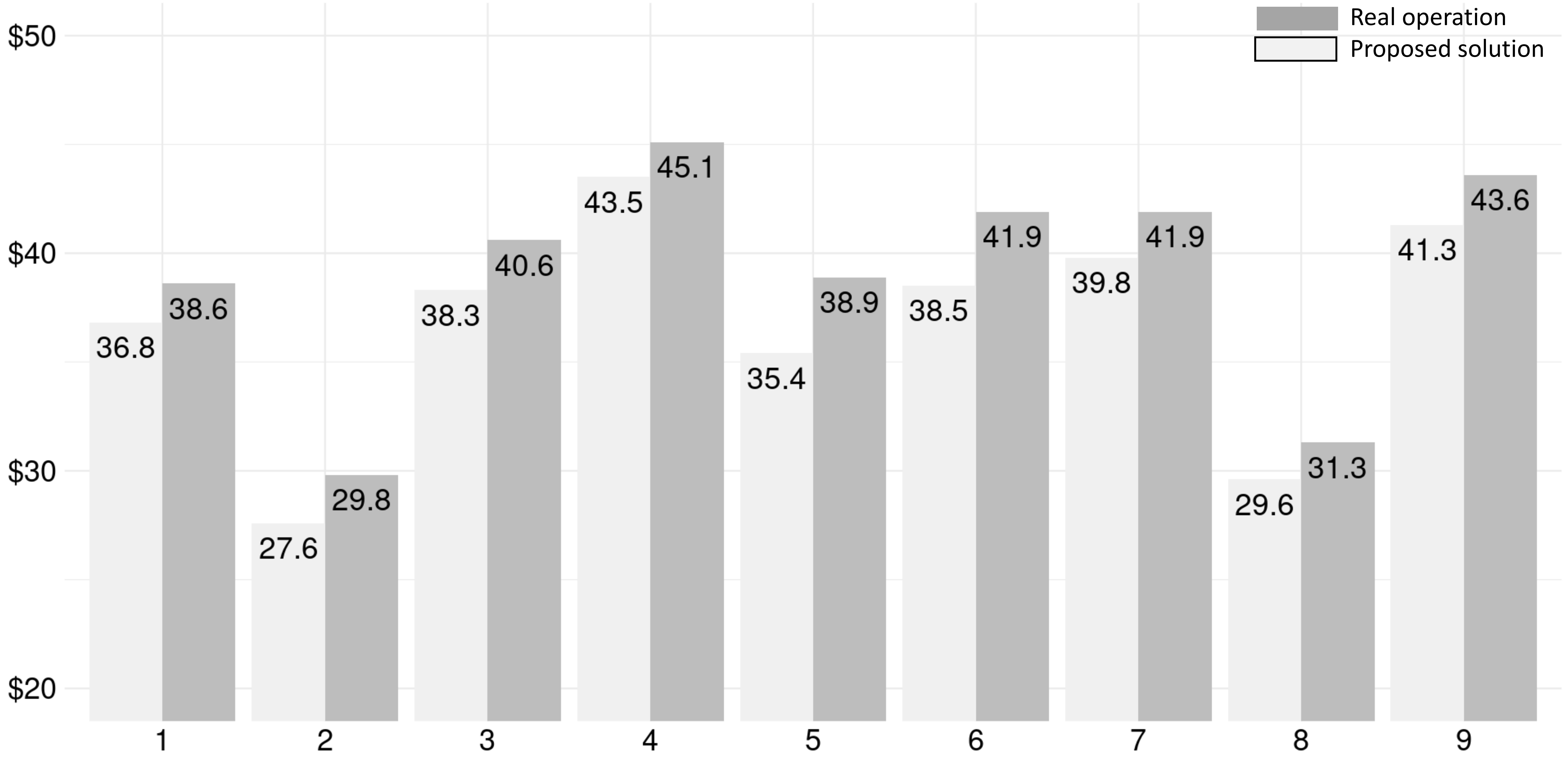
Characterization of Instances

Instance	Plants	Distribution Centers	Large Customer	Total Demand (ton)	MTT GAP (%)	MPP GAP (%)
1	7	27	17	1869	1.31%	0.00%
2	7	24	19	1866	5.26%	0.00%
3	7	28	18	2006	1.06%	0.00%
4	7	27	18	1805	2.85%	0.00%
5	7	26	20	1888	3.53%	0.00%
6	7	25	17	1953	1.46%	0.00%
7	7	24	7	1706	4.78%	0.00%
8	7	27	17	1307	3.40%	0.00%
9	7	27	18	1880	2.89%	0.00%

Some results: transport costs to DC ($MM CLP)



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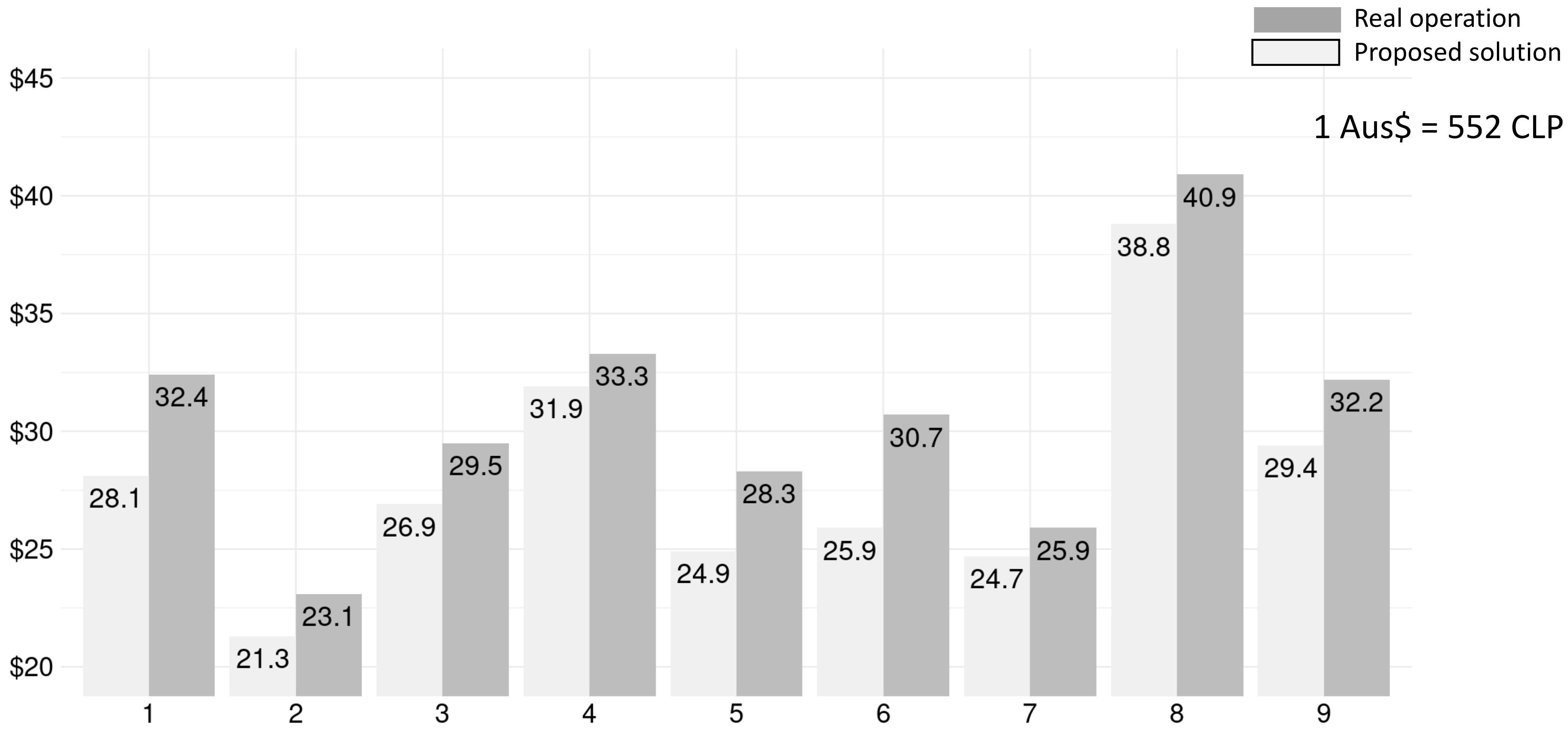
Transport costs savings to DC

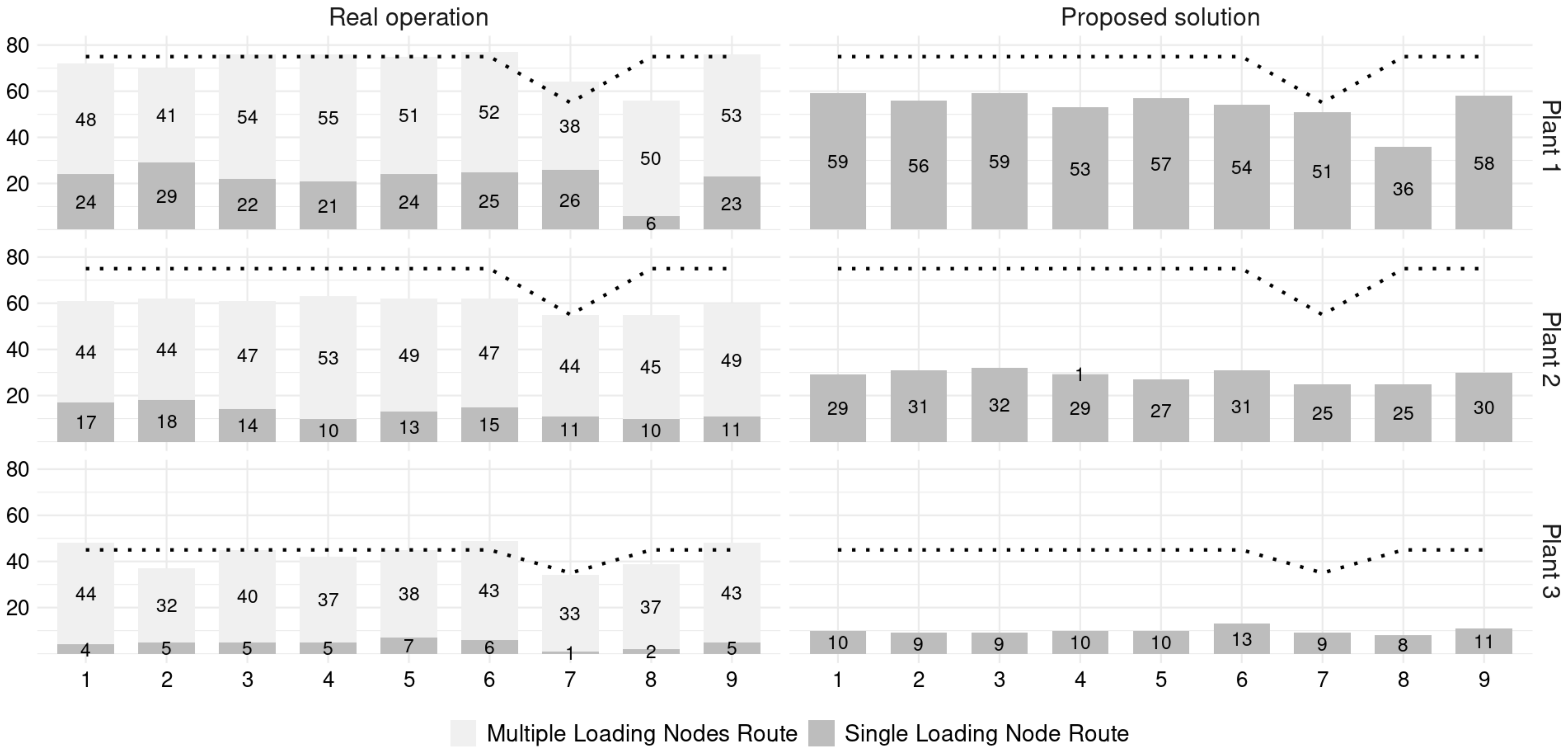
Instance	Optimized	Real	MMCh$	MAus$
1	36.8	38.6	1.8	3261
2	27.6	29.8	2.2	3985
3	38.3	40.6	2.3	4166
4	43.5	45.1	1.6	2898
5	35.4	38.9	3.5	6340
6	38.5	41.9	3.4	6159
7	39.8	41.9	2.1	3804
8	29.6	31.3	1.7	3079
9	41.3	43.6	2.3	4166

Some results: cost/kg per trip in CLP

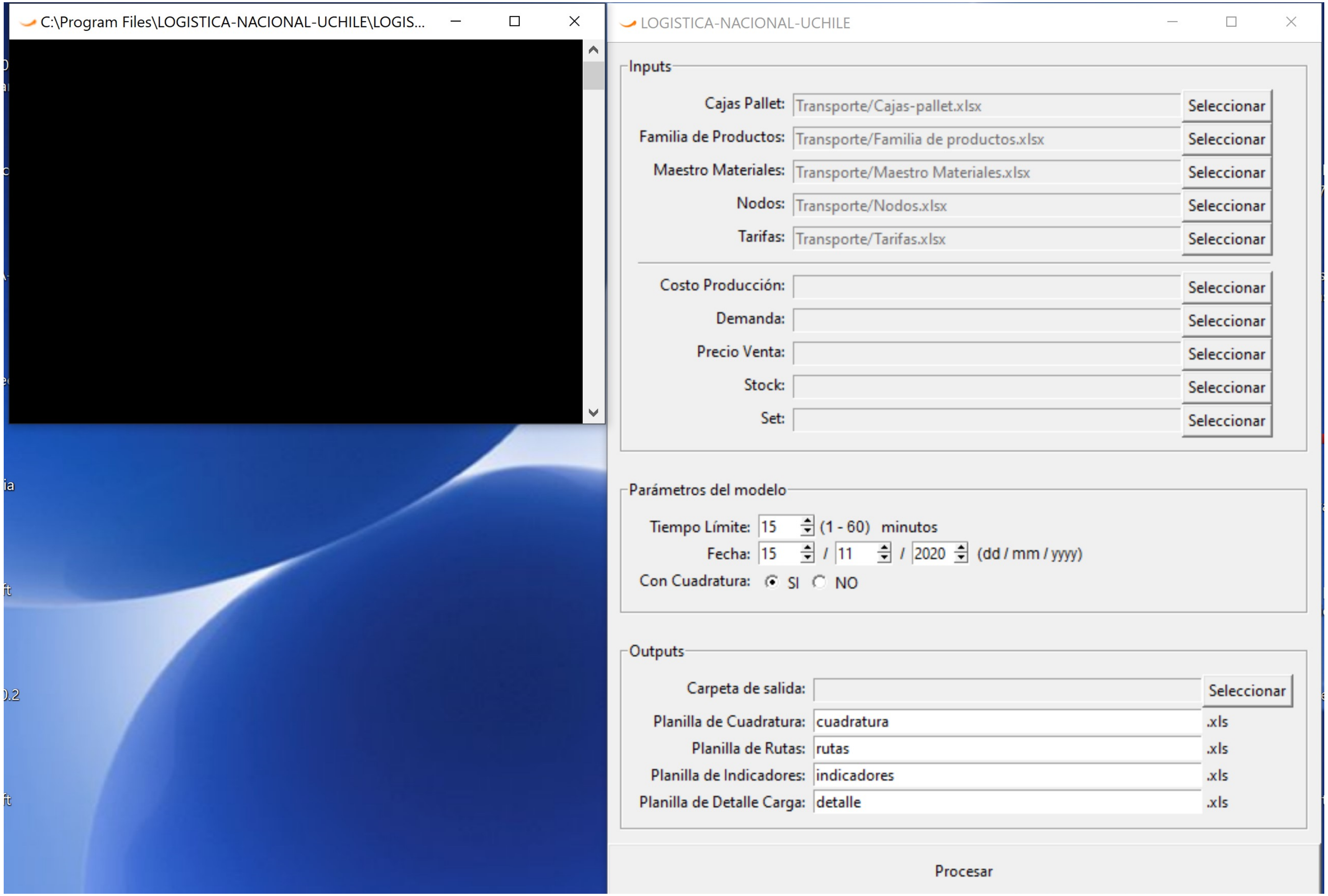


1 Aus$ = 552 CLP

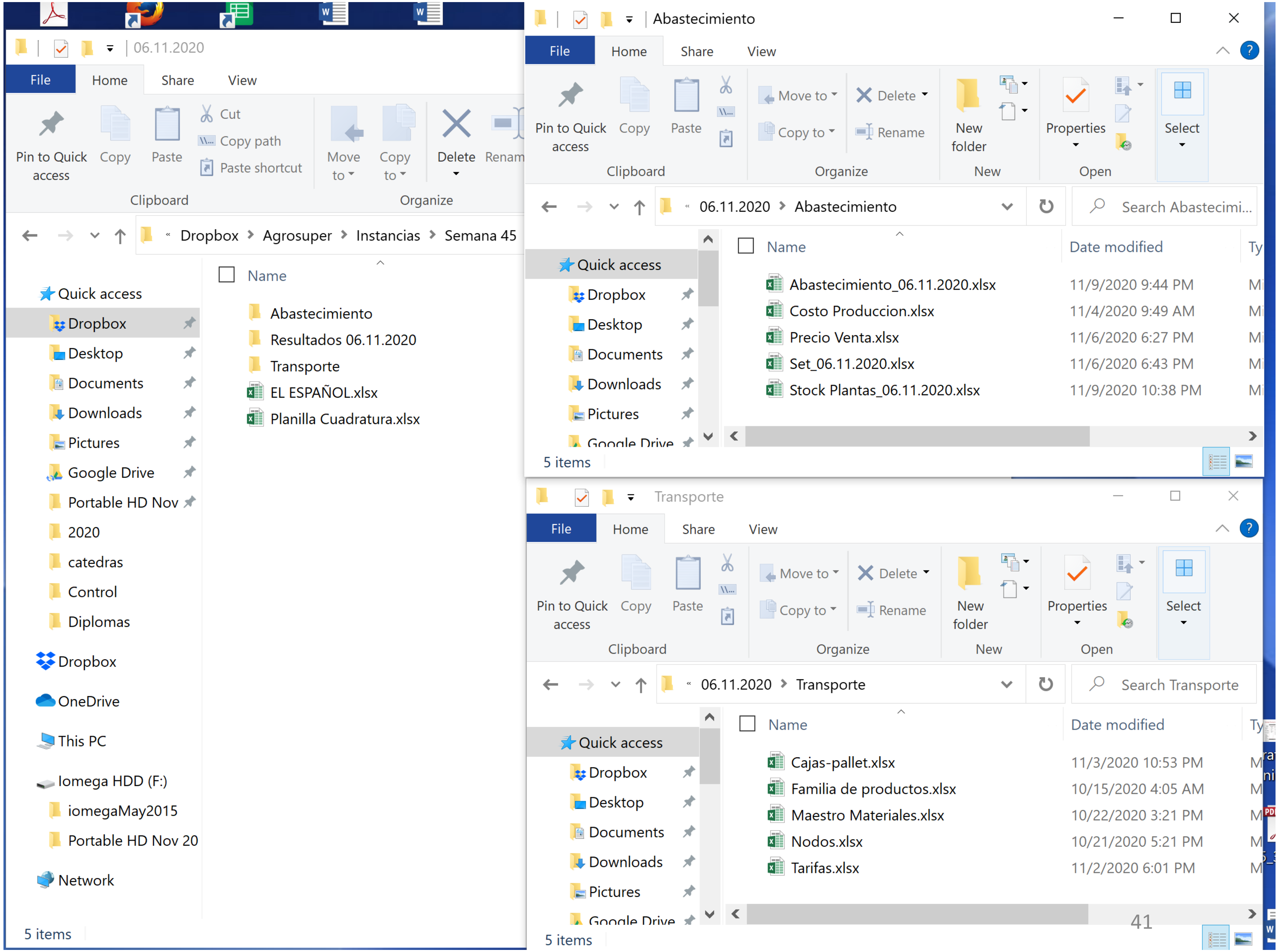
Some results: effect on loading dock capacity vs dispatched trucks (3 largest plants)



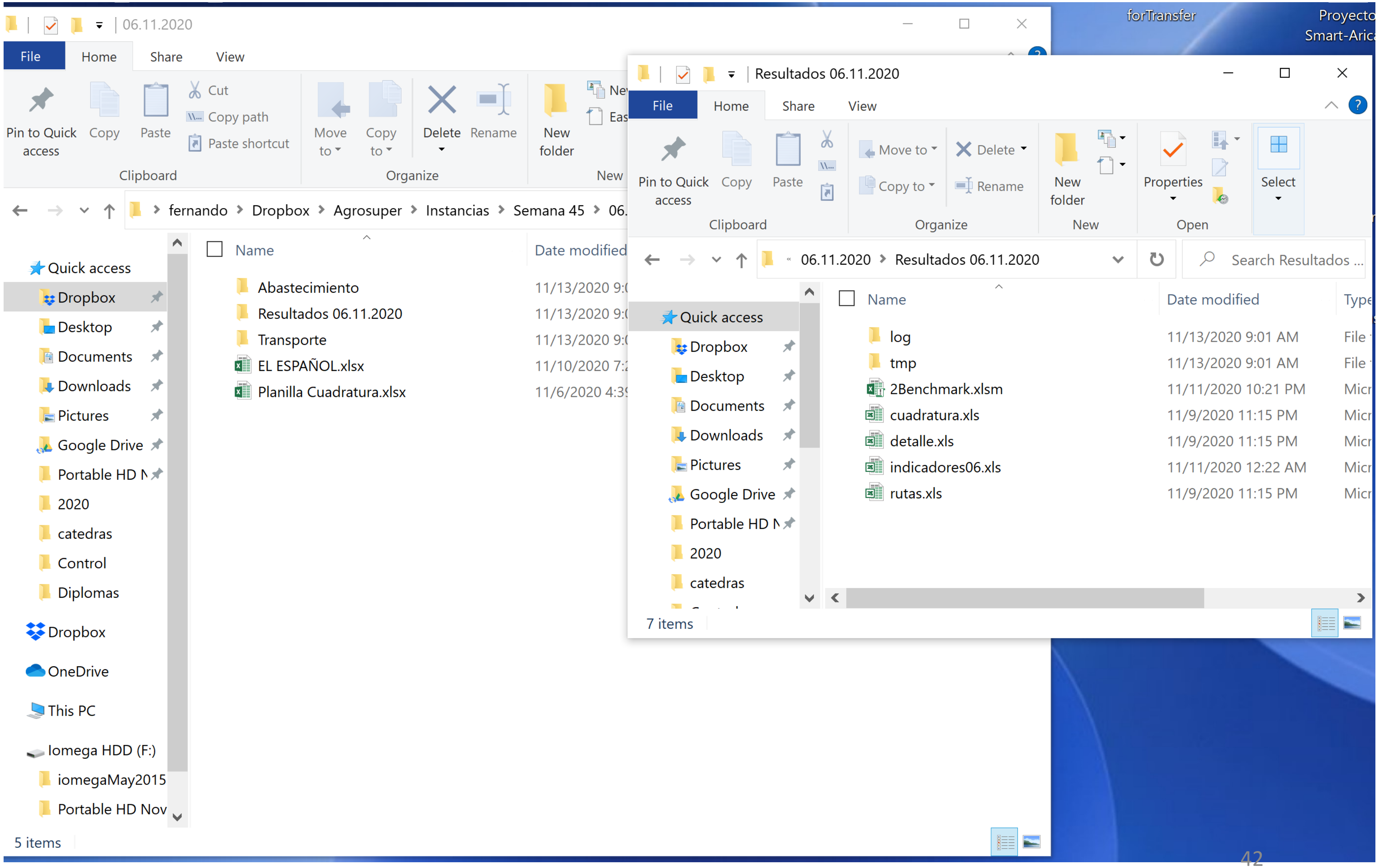
Interface


C:\Program Files\LOGISTICA-NACIONAL-UCHILE\LOGIS...
LOGISTICA-NACIONAL-UCHILE
Inputs
Cajas Pallet: Transporte/Cajas-pallet.xlsx Seleccionar
Familia de Productos: Transporte/Familia de productos.xlsx Seleccionar
Maestro Materiales: Transporte/Maestro Materiales.xlsx Seleccionar
Nodos: Transporte/Nodos.xlsx Seleccionar
Tarifas: Transporte/Tarifas.xlsx Seleccionar
Costo Producción: Seleccionar
Demanda: Seleccionar
Precio Venta: Seleccionar
Stock: Seleccionar
Set: Seleccionar
Parámetros del modelo
Tiempo Límite: 15 (1 - 60) minutos
Fecha: 15 / 11 / 2020 (dd / mm / yyyy)
Con Cuadratura: SI NO
Outputs
Carpeta de salida: Seleccionar
Planilla de Cuadratura: cuadratura .xls
Planilla de Rutas: rutas .xls
Planilla de Indicadores: indicadores .xls
Planilla de Detalle Carga: detalle .xls
Procesar

Input


06.11.2020
File
Home
Share
View
Pin to Quick access
Copy
Paste
Cut
Copy path
Paste shortcut
Move to
Copy to
Delete
Rename
Clipboard
Organize
Dropbox › Agrosuper › Instancias › Semana 45
Quick access
Dropbox
Desktop
Documents
Downloads
Pictures
Google Drive
Portable HD Nov
2020
catedras
Control
Diplomas
Dropbox
OneDrive
This PC
Iomega HDD (F:)
iomegaMay2015
Portable HD Nov 20
Network
5 items
Name
Abastecimiento
Resultados 06.11.2020
Transporte
EL ESPAÑOL.xlsx
Planilla Cuadratura.xlsx
Abastecimiento
New folder
Properties
Select
New
Open
06.11.2020 › Abastecimiento
Search Abastecimi...
Name
Date modified
Abastecimiento_06.11.2020.xlsx 11/9/2020 9:44 PM
Costo Produccion.xlsx 11/4/2020 9:49 AM
Precio Venta.xlsx 11/6/2020 6:27 PM
Set_06.11.2020.xlsx 11/6/2020 6:43 PM
Stock Plantas_06.11.2020.xlsx 11/9/2020 10:38 PM
5 items
Transporte
06.11.2020 › Transporte
Search Transporte
Name
Date modified
Cajas-pallet.xlsx 11/3/2020 10:53 PM
Familia de productos.xlsx 10/15/2020 4:05 AM
Maestro Materiales.xlsx 10/22/2020 3:21 PM
Nodos.xlsx 10/21/2020 5:21 PM
Tarifas.xlsx 11/2/2020 6:01 PM
5 items

Output


06.11.2020
File
Home
Share
View
Pin to Quick access
Copy
Paste
Cut
Copy path
Paste shortcut
Move to
Copy to
Delete
Rename
New folder
Clipboard
Organize
New
fernando > Dropbox > Agrosuper > Instancias > Semana 45 > 06.
Quick access
Dropbox
Desktop
Documents
Downloads
Pictures
Google Drive
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Diplomas
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This PC
Iomega HDD (F:)
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Date modified
Abastecimiento
Resultados 06.11.2020
Transporte
EL ESPAÑOL.xlsx
Planilla Cuadratura.xlsx
5 items
Resultados 06.11.2020
Properties
Select
Open
06.11.2020 > Resultados 06.11.2020
Search Resultados ...
Type
log 11/13/2020 9:01 AM
tmp 11/13/2020 9:01 AM
2Benchmark.xlsm 11/11/2020 10:21 PM
cuadratura.xls 11/9/2020 11:15 PM
detalle.xls 11/9/2020 11:15 PM
indicadores06.xls 11/11/2020 12:22 AM
rutas.xls 11/9/2020 11:15 PM
7 items
forTransfer

Summary of indicators of solution

Global indicators			
Total distribution costs	48569631		(CLP)
Distribution costs between plants	1397472		(CLP)
Dsitribution costs (primary)	47172159		(CLP)
Percentage of utilization in kilogrames total	0.718		(%)
Percentage of utilization in kilogrames (plant-plant)	0.689		(%)
Percentage of utilization in kilogrames (primary)	0.722		(%)
Percentage of utilization in pallets total	0.887		(%)
Percentage of utilization in pallets (plant-plant)	0.921		(%)
Percentage of utilization in pallets (primary)	0.883		(%)
Demand fulfillment	1.185		(%)
Ratio cost/kg	21.81		(CLP/kg)
VisitNodesPLant	1		(stops/route)
LoadNodesPLant (OUT-IN)	2226940	242692	(kgs)
TrucksNodesPLant(OUT-IN)	124	15	(trucks)

Final remarks

- A system that incorporates the solution approach (in two stages) is being implemented and tested in the field by the company.
- A truck scheduling model (heuristic + MIP) is also being coded as a complement to the two-stage procedure presented.
- This model was presented in Odysseus 2021 (held in 2022), and now a scientific dissemination paper is under preparation.
- Considerable savings are found in transport cost due to a better use and organization of resources (through consolidation) for the nationwide movement of products of the company.

Large scale supply chain operations in the food industry

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[b]Agrosuper

[c]Instituto Sistemas Complejos de Ingeniería

Webinar organized by TransportLab, The University of Sydney

September 1st, 2023

Example detail

Fecha	Nro. Camión	Tipo Viaje	Id Pallet	Sector	Estado	Material	Descripción	Nodo Origen	Nombre Orig	Nodo Destino	Nombre Dest	Cajas
19/03/2020	41	primario	1001	Pollo	Congelado	1011330	PO File IQF@ Bo Cj SP	P001	Planta Lo Mir	T049	Castro	10
19/03/2020	41	primario	1001	Pollo	Congelado	1011331	PO PchDeh Lam IQF@ Bo Cj SP	P001	Planta Lo Mir	T049	Castro	15
19/03/2020	41	primario	1001	Cerdo	Congelado	1021477	GO Chu Vet Porc IQF@ Cj 7.5k SC	P001	Planta Lo Mir	T049	Castro	50
19/03/2020	41	primario	1001	Pollo	Congelado	1012347	PO Bistec Pech 150g@ Cj 3kg SP	P001	Planta Lo Mir	T049	Castro	10
19/03/2020	41	primario	27	Elaborado	Congelado	1100007	Nugg Pollo@ Bo 0.4k x12 Cj SP	P001	Planta Lo Mir	T049	Castro	21
19/03/2020	41	primario	27	Elaborado	Congelado	1100039	Nugg Pollo@ Zip 1k x5 Cj SP	P001	Planta Lo Mir	T049	Castro	5
19/03/2020	41	primario	27	Elaborado	Congelado	1100267	Hamb Mastod 185g@ Fp x40 Cj LC	P001	Planta Lo Mir	T049	Castro	6
19/03/2020	41	primario	27	Elaborado	Congelado	1100372	Hamb Vacuno 185g@ Fp x40 Cj KI	P001	Planta Lo Mir	T049	Castro	5
19/03/2020	41	primario	27	Elaborado	Congelado	1100520	Nugg Prm Pollo@ FS Bo 2.5k x2 Cj KI	P001	Planta Lo Mir	T049	Castro	4
19/03/2020	41	primario	27	Elaborado	Congelado	1100339	Croc Pollo 100g@ Fp x60 Cj SP	P001	Planta Lo Mir	T049	Castro	6
19/03/2020	41	primario	27	Elaborado	Congelado	1100440	Hamb Pavo 100g@ Fp x56 Cj LC	P001	Planta Lo Mir	T049	Castro	5
19/03/2020	41	primario	27	Elaborado	Congelado	1100444	Hamb Pollo 100g@ Fp x56 Cj LC	P001	Planta Lo Mir	T049	Castro	6
19/03/2020	41	primario	27	Elaborado	Congelado	1100449	Hamb Prm100g@ Fp x56 Cj LC	P001	Planta Lo Mir	T049	Castro	5
19/03/2020	41	primario	27	Elaborado	Congelado	1100193	Croc Pollo 100g@ Fp x30 Cj SP	P001	Planta Lo Mir	T049	Castro	34
19/03/2020	41	primario	27	Elaborado	Congelado	1100332	Hamb Pollo 55g@ Fp x52 Cj SP	P001	Planta Lo Mir	T049	Castro	16
19/03/2020	41	primario	28	Elaborado	Congelado	1100332	Hamb Pollo 55g@ Fp x52 Cj SP	P001	Planta Lo Mir	T049	Castro	4
19/03/2020	41	primario	28	Elaborado	Congelado	1100343	Hamb Pollo 50g@ Fp x56 Cj KI	P001	Planta Lo Mir	T049	Castro	24
19/03/2020	41	primario	28	Elaborado	Congelado	1100365	Cne Mol 250g@ Tripa Cj KI	P001	Planta Lo Mir	T049	Castro	6
19/03/2020	41	primario	28	Elaborado	Congelado	1100539	Churr Vacuno 90g@ Fp x 39 Cj KI	P001	Planta Lo Mir	T049	Castro	9
19/03/2020	41	primario	28	Elaborado	Congelado	1100545	Lomito Fiesta@ Fp x39 Cj SC	P001	Planta Lo Mir	T049	Castro	5
19/03/2020	41	primario	28	Elaborado	Congelado	1100586	Hamb vac 120g@ Fp x 24 Cj LC	P001	Planta Lo Mir	T049	Castro	2
19/03/2020	41	primario	28	Elaborado	Congelado	1100350	Hamb Tradicional 50g@ Fp x56 Cj KI	P001	Planta Lo Mir	T049	Castro	120
19/03/2020	41	primario	28	Elaborado	Congelado	1100332	Hamb Pollo 55g@ Fp x52 Cj SP	P001	Planta Lo Mir	T049	Castro	2
19/03/2020	41	primario	28	Elaborado	Congelado	1100545	Lomito Fiesta@ Fp x39 Cj SC	P001	Planta Lo Mir	T049	Castro	5
19/03/2020	41	primario	1000	Cerdo	Congelado	1021620	GO BB Ribs estuche 1kg@ Cj 10kg SC	P001	Planta Lo Mir	T049	Castro	10
19/03/2020	41	primario	1000	Pollo	Congelado	1011627	PO Tru Cort Selec pf@ Bo 16x800g Cj SP	P001	Planta Lo Mir	T049	Castro	5
19/03/2020	41	primario	1000	Pollo	Congelado	1011632	PO Tru Selec pf@ Bo 6x2k Cj SP	P001	Planta Lo Mir	T049	Castro	2
19/03/2020	41	primario	1000	Cerdo	Congelado	1022746	GO Chu Ctro Porc IQF 180-200@Cj 7.2 SC	P001	Planta Lo Mir	T049	Castro	35
19/03/2020	41	primario	1000	Pollo	Congelado	1011330	PO File IQF@ Bo Cj SP	P001	Planta Lo Mir	T049	Castro	5
19/03/2020	41	primario	1000	Cerdo	Congelado	1021477	GO Chu Vet Porc IQF@ Cj 7.5k SC	P001	Planta Lo Mir	T049	Castro	1
19/03/2020	41	primario	1002	Pollo	Congelado	1011627	PO Tru Cort Selec pf@ Bo 16x800g Cj SP	P001	Planta Lo Mir	T049	Castro	5
19/03/2020	41	primario	1002	Pollo	Congelado	1011632	PO Tru Selec pf@ Bo 6x2k Cj SP	P001	Planta Lo Mir	T049	Castro	5
19/03/2020	41	primario	1002	Pollo	Congelado	1011330	PO File IQF@ Bo Cj SP	P001	Planta Lo Mir	T049	Castro	1
19/03/2020	41	primario	1002	Cerdo	Congelado	1021477	GO Chu Vet Porc IQF@ Cj 7.5k SC	P001	Planta Lo Mir	T049	Castro	49
19/03/2020	41	primario	993	Pollo	Refrigerado	1010048	PO Pch Selec# Cj 14 SP	P001	Planta Lo Mir	T049	Castro	50
19/03/2020	41	primario	994	Pollo	Refrigerado	1010048	PO Pch Selec# Cj 14 SP	P001	Planta Lo Mir	T049	Castro	36
19/03/2020	41	primario	994	Pollo	Refrigerado	1010124	PO Caz# Mall Cj 14 SP	P001	Planta Lo Mir	T049	Castro	8

routes.xls

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB
6																												
7															Planta Lo Miranda										Planta Sopraval		Elaborado	Planta Ros
8															361.716	74.675	90.961	620.507	46.557	17.298	4.488	25.995	17.214	0.995	124.387	55.347	25.995	337.132
9	Número	Nombre	Rut	Fecha-Hor	Fecha-Hor	Salida Pro	Tipo	Costo	Códigos	Descripció	Tipo	Tipo		Total	PLM	PLM	PLM	PLM	PLM	PLM	PLM	PLM	PLM	PLM	PS	PS	EADL	PR
10	Camión	Cliente	Transp.	Citación R	Citación P	Última Pla	Viaje	Ruta	Ruta	Ruta	Destino	Camión	Separador	Pallets	Cer F	Cer C	Pol C	Pol F	Pav F	Pav C	Sal C	Cec F	Hor C	Ela C	Pav F	Pav C	Cec F	Cer F
11	1						interplanta	47507	P001-P00	Planta Lo	Planta	26 P	si	25.98	2	18	5.98											
12	4						interplanta	231825	P010-P00	Planta Sop	Planta	26 P	si	20.9											15.483	5.417		
13	2						interplanta	231825	P010-P00	Planta Sop	Planta	26 P	si	20.855											15.467	5.388		
14	3						interplanta	231825	P010-P00	Planta Sop	Planta	26 P	si	22.1											15.607	6.493		
15	5						interplanta	238278	P010-P00	Planta Sop	Planta	26 P	si	24.958											15.137	9.821		
16	6						primario	222863	P010-P60	Planta Sop	Sucursal	26 P	si	2.789											2.503	0.286		
17	7						primario	244465	P010-P60	Planta Sop	Venta Dire	26 P		20											20			
18	8						primario	244465	P010-P60	Planta Sop	Venta Dire	26 P		20											20			
19	9						interplanta	104233	P60472-P	Elaborado	Planta	26 P		25.995													25.995	
20	11						interplanta	39288	P005-P00	Planta Ros	Planta	26 P		25.856														25.856
21	10						interplanta	39288	P005-P00	Planta Ros	Planta	26 P		25.73														25.73
22	13						interplanta	39288	P005-P00	Planta Ros	Planta	26 P		25.807														25.807
23	12						interplanta	39288	P005-P00	Planta Ros	Planta	26 P		25.931														25.931
24	14						interplanta	101255	0002-P00	Frutos del	Planta	26 P		17.214														
25	15						interplanta	53572	P002-P00	Planta San	Planta	26 P	si	25.929														
26	17						primario	218218	P001-T00	Planta Lo	Sucursal	26 P	si	25.986		1.914	4.077	19.995										
27	16						primario	218218	P001-T00	Planta Lo	Sucursal	26 P	si	24.995	1	2	2	19.995										
28	18						primario	218218	P001-T00	Planta Lo	Sucursal	26 P	si	25	1		4	20										
29	23						primario	218218	P001-T02	Planta Lo	Sucursal	26 P	si	25.993	3.375	2.984	1.009	17.625	1									
30	21						primario	218218	P001-T02	Planta Lo	Sucursal	26 P	si	25.981	4.191	3	1	16.8	0.99									
31	22						primario	218218	P001-T02	Planta Lo	Sucursal	26 P	si	25.992	4.098	2.014	1.98	16.9	1									
32	20						primario	218218	P001-T02	Planta Lo	Sucursal	26 P	si	24.994	3.925	1.09	0.909	19.07										
33	19						primario	218218	P001-T02	Planta Lo	Sucursal	26 P	si	25.938	4.992	0.223	1.773	18	0.95									
34	24						primario	218218	P002-T00	Planta San	Sucursal	26 P		25.982														
35	27						primario	218218	P002-T02	Planta San	Sucursal	26 P	si	25.995														
36	26						primario	218218	P002-T02	Planta San	Sucursal	26 P	si	25.982														
37	25						primario	218218	P002-T02	Planta San	Sucursal	26 P	si	25.824														
38	28						primario	218218	P005-T00	Planta Ros	Sucursal	26 P	si	16.402														15.762
39	29						primario	146928	P010-T00	Planta Sop	Sucursal	26 P	si	25.035											7.04	17.995		
40	30						primario	320102	P001-T00	Planta Lo	Sucursal	26 P	si	25.441	4.436		2.99	15.545	1.47		1							
41	31						primario	320102	P001-T00	Planta Lo	Sucursal	26 P	si	24.806	3.506	0.556	3.442	14.486	1.983	0.833								
42	32						primario	130958	P001-T00	Planta Lo	Sucursal	26 P	si	25.983	8.974	1.402	1.59	12.024	1	0.993								
43	34						primario	130958	P001-T00	Planta Lo	Sucursal	26 P	si	25.272	6.329		1	12.66	2.283	3								
44	33						primario	130958	P001-T00	Planta Lo	Sucursal	26 P	si	25.979	10.292	0.472	1.523	11.692		2								
45	37						primario	480000	P001-T00	Planta Lo	Sucursal	26 P	si	24.997	2.011	2	3	16.986	1									
46	36						primario	480000	P001-T00	Planta Lo	Sucursal	26 P	si	25.487	3.324	1.657	1.338	17.67	0.95	0.548								

Rutas

READY 83%

FillingTrucks.xls

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	
1																									
2				P	P	P	V	V	V	V	V	V	V	V	V	V	V	P	V	V	V	V	S	S	S
3			Und.	Planta Lo Miranda	Planta San Vicente	Frigorifico El Milagro	Neira Arellanos Neftali Emilio	Cecinas Bavaria Limitada	Refineria Grasas y Aceites Com Via	Central De Distribucion (DyS)	Prod y Com Pecuarios del Sur Ltda	CDR DHL Sucursal	Soc Com e Imp Gasca SPA	Cecinas de Santiago SA	Comercializadora Ji Rou SPA	Frio Carne SPA	Star Meat SPA	Elaboradora Alimentos Donihue Ltd	Jerez Pavez y Cia Ltda	Consorcio Ind de Alimentos S A	Productos Fernandez S A	Consorcio Ind de Alimentos S A	Sucursal Huechuraba	Sucursal Viña del Mar	
4		**Total**	**Pl**	184.578	76.6962	25.98	3.605	1.66667	15	141.615	43.9	12.74	12	5.625	12.25	8.945	5.5	73	39.85	167	130.225	2.8	143.399	102.198	10
5		**Total Fresco Camión**	**Pl**	138.102	66.8747	2	3.605	0	15	101.033	43.9	0	12	5.625	12.25	8.945	5.5	38.875	39.85	167	130.225	2.8	110.774	87.3771	77
6	**Cuadratu**	**Total Congelado Camión**	**Pl**	46.4764	9.82143	23.98	0	1.66667	0	40.5827	0	12.74	0	0	0	0	0	34.125	0	0	0	0	32.6258	14.8207	25
7	**Fresco**	Total Pollo	Pl	13.9641	0	0	0	0	0	61.2678	0	0	0	0	11	0	0	17	0	120	65	0	81.9719	50.006	47
8		Total Cerdo	Pl	51.586	51.7381	2	3.605	0	15	29.4281	43.9	0	12	5.625	1.25	8.945	5.5	18.875	39.85	7	58.225	2.8	21.7618	33.9178	2
9		Total Pavo	Pl	46.5567	15.1367	0	0	0	0	10.3367	0	0	0	0	0	0	0	3	0	40	7	0	7.04	3.45333	3.2
10		Total Cecina	Pl	25.9952	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
11		**Total Fresco por Cliente**	**Pl**	138.102	66.8747	2	3.605	0	15	101.033	43.9	0	12	5.625	12.25	8.945	5.5	38.875	39.85	167	130.225	2.8	110.774	87.3771	77
12	**Congelado**	Total Pollo	Pl	10.9448	0	5.98	0	1	0	25.9	0	12.74	0	0	0	0	0	0	0	0	0	0	10.0768	6.43156	6.1
13		Total Cerdo	Pl	0.025	0	18	0	0	0	2.50658	0	0	0	0	0	0	0	34.125	0	0	0	0	4.55375	0.5558	1
14		Total Pavo	Pl	17.2976	9.82143	0	0	0.66667	0	1.95429	0	0	0	0	0	0	0	0	0	0	0	0	17.9952	0.83333	5.9
15		Total Elaborado	Pl	0.99471	0	0	0	0	0	9.2218	0	0	0	0	0	0	0	0	0	0	0	0	0	6	11
16		Total Hortalizas y Frutas	Pl	17.2143	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
17		Total Salmón	Pl	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
18		**Total Congelado por Cliente**	**Pl**	46.4764	9.82143	23.98	0	1.66667	0	40.5827	0	12.74	0	0	0	0	0	34.125	0	0	0	0	32.6258	14.8207	25
19	**Código**	**Producto**																							
20		**Pollo**																							
21	1010076	PO Tru Ent# 4D Cj SP	E	5																				4	
22	1010077	PO Tru Ent# Cj ch SP	E	103																			50	15	
23	1010078	PO Tru Ent# Cj SP	E	126						499													798	400	
24	1010095	PO Tru Larg# 2D Cj 10k SP	E	16						119														8	
25	1010096	PO Tru Larg# 2D Cj SP	E	1																				3	
26	1010102	PO Tru Cort# 2D Cj 10k SP	E	5						46														6	
27	1010103	PO Tru Cort# 2D Cj SP	E	3																				2	

Cuadratura

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