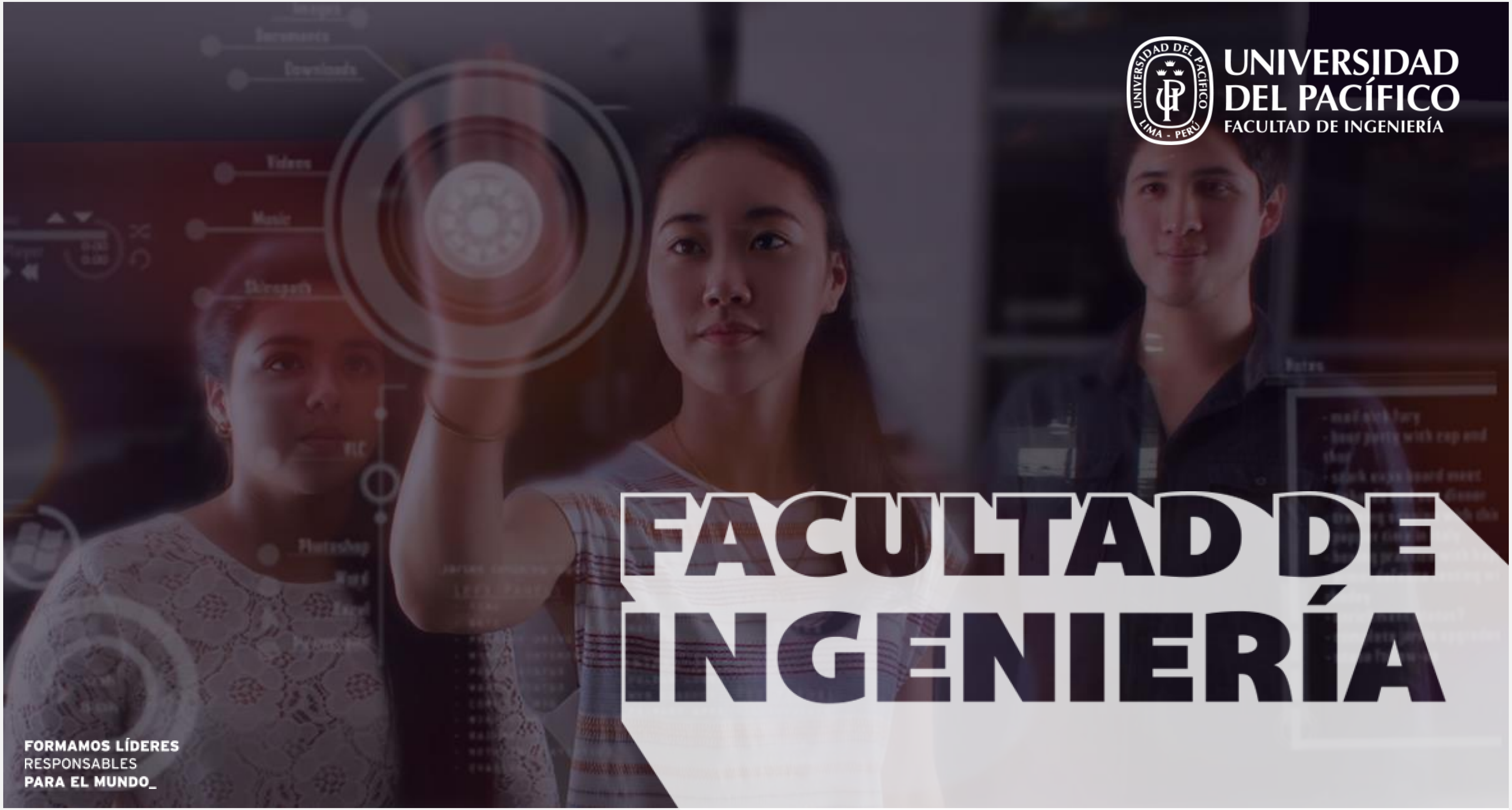
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FORMAMOS LÍDERES
RESPONSABLES
PARA EL MUNDO_

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Distribution of non-alcoholic beverages in the city of Lima

AGENDA

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- Introduction
- Methodology
- Results
- Conclusions
- References

Introduction

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The purpose

The purpose of this paper is to analyze the transportation configuration characteristics of non-alcoholic beverages in a Latin-American city

The city

Which are the more congested cities in the world?

The city

Ranking of the most congested cities Globally (Overall daily congestion level – extra travel time – population over 800,000):

1	Mumbai, India	65%	6	Istanbul, Turkey	53%
2	Bogota, Colombia	63%	7	Jakarta, Indonesia	53%
3	Lima, Peru	58%	8	Bangkok, Thailand	53%
4	New Delhi, India	58%	9	Mexico City, Mexico	52%
5	Moscow, Russia	56%	10	Recife, Brazil	49%

Source: TomTom. (2018). Tom Tom Traffic Index: Mumbai takes Crown of 'Most Traffic Congested City' in World

The city

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The model

The model proposes routes that improve customer satisfaction due to on-time deliveries through the administration of inventories and the paths of the trucks filling pending orders

The constraints

- Limited number of trucks that also have a limited capacity
- Loading requirements that are established in the contracts
- Inventory limitations
- Product stacking limitations

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Methodology

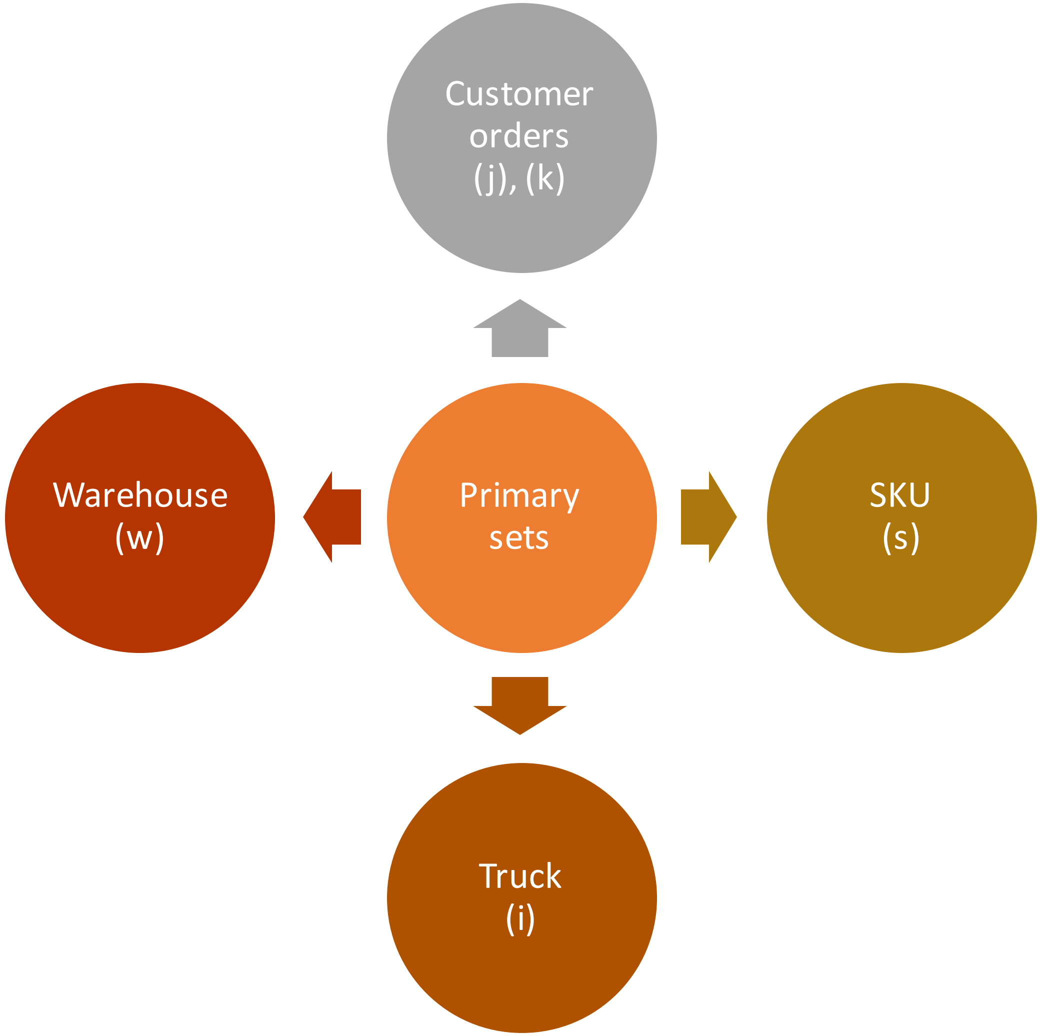
The model

A goal programming model is proposed to schedule the transportation of non-alcoholic beverages from the distribution centers to the points of sale through fleets of trucks with different characteristics

The goals

The goals include the fulfillment of the number of pending orders, the number of available trucks, the contractually bound capacity and the distance that trucks will travel to fill the orders

Primary sets



Secondary sets

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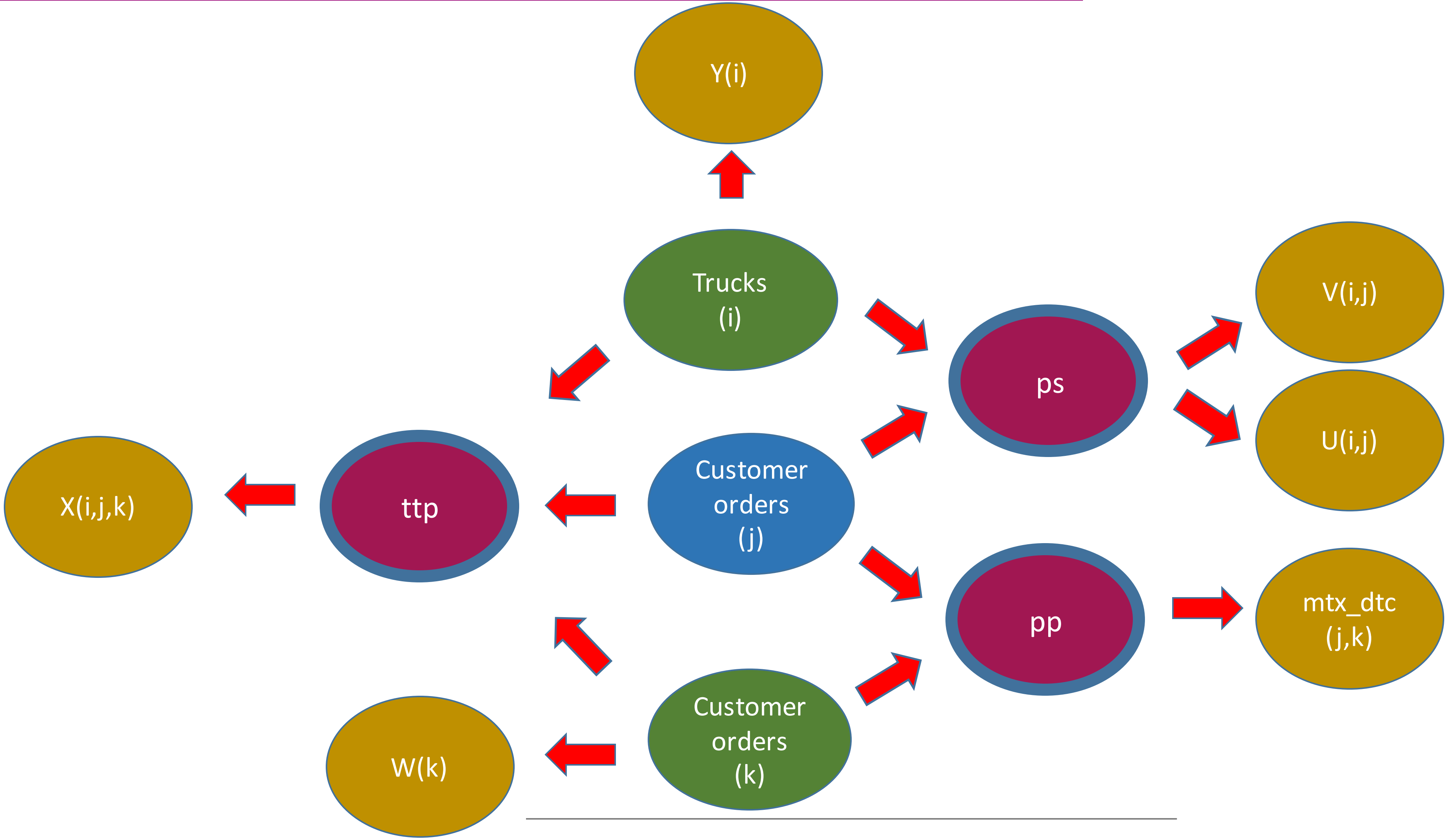

Secondary sets

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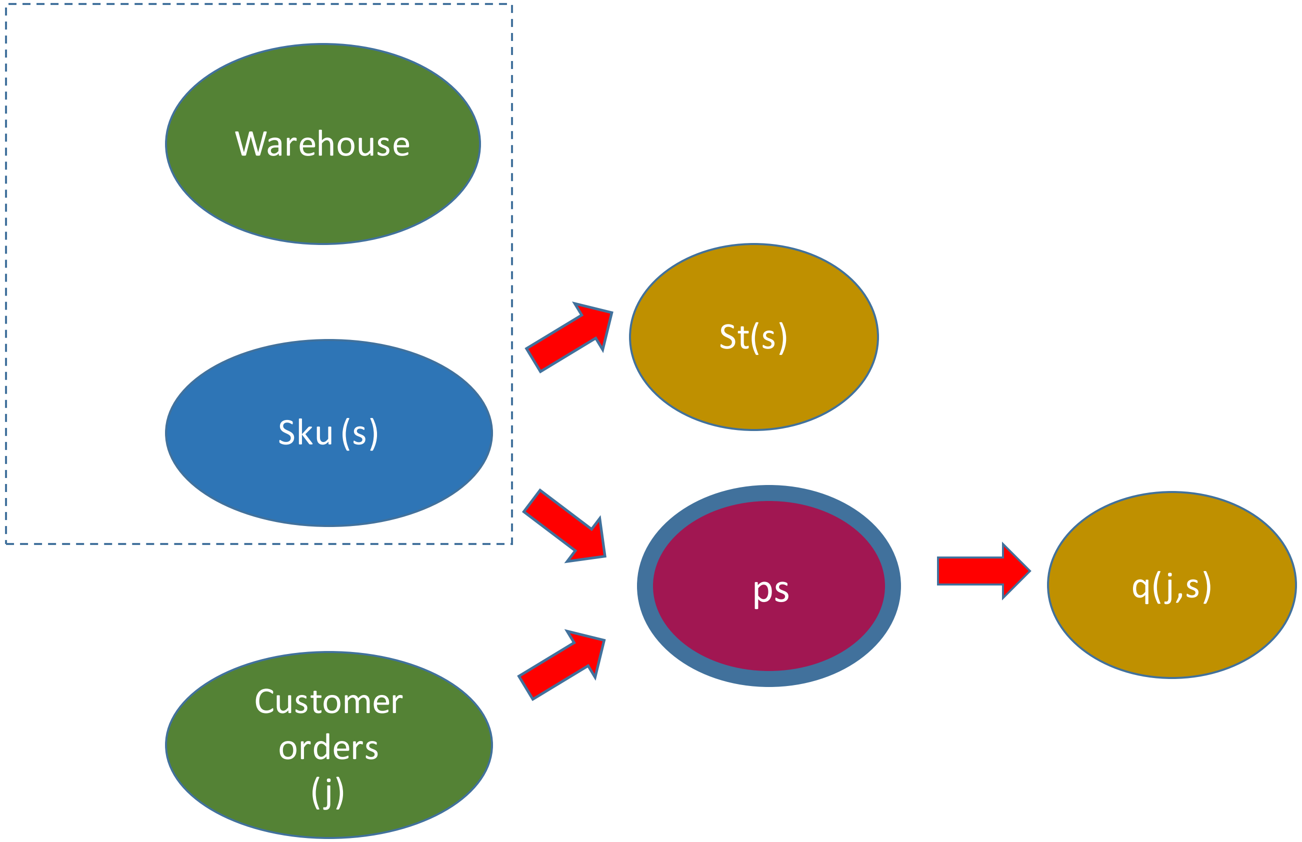

The objective

Goals

$$Min\ z = not\_attended + \frac{etrucks}{MinTrucks} + \sum_{i=1}^{m} e2cap_i + \frac{edst}{Max\_Dst}$$

.

$$\sum_{j=1}^{n} \frac{W_j}{n} + not\_attended \ = 1$$

Fullfilment

$$\sum_{i=1}^{m} Y_i + dtrucks - etrucks = MinTrucks$$

Number of trucks

The objective

Goals

$$\sum_{i=1}^{m} weight_i * V_{ij} + d1cap_i \ - e1cap_i = capacity_i * Y_i \ \forall\, i \ \in trucks$$

$$\sum_{i=1}^{m} \frac{d1cap_i}{LIM\_CAP * capacity_i} + d2cap_i - e2cap_i = Y_i \ \forall\, i \ \in trucks$$

Truck capacity

$$\sum_{i=1}^{m} \sum_{j=1}^{n} \sum_{k=1\,/\,j\neq k}^{n} mtxdst_k \ * X_{ijk} + ddst - edst = Max\_Dst$$

Distance

The constraints

$$\sum_{k=1}^{n} X_{i0k} = Y_i \ \forall \ i \ \in trucks$$

$$\sum_{k=1}^{n} X_{ik(n+1)} = Y_i \ \forall \ i \ \in trucks$$

$$\sum_{k=1}^{n} X_{i(n+1)k} = 0 \ \forall \ i \ \in trucks$$

$$X_{i0(n+1)} = 0 \ \forall \ i \ \in trucks$$

Trucks constraints: start point, routes, points

The constraints

$$\sum_{k=1}^{n}\sum_{i=1}^{m} X_{ijk} \leq 1 \; \forall\, j \; \in point\_of\_distribution \setminus \{0, n+1\}$$

$$\sum_{j=1}^{n}\sum_{i=1}^{m} X_{ijk} \leq 1 \; \forall\, k \; \in point\_of\_distribution \setminus \{0, n+1\}$$

$$\sum_{j=1/j\neq k}^{n} X_{ijk} = \sum_{j=1/j\neq k}^{n} X_{ikj} \; \forall\, i \; \in trucks, k \; \in point\_of\_distribution \setminus \{0, n+1\}$$

Route constraints - points

The constraints

$U_{ik} \leq U_{ij} + 1 - (n+2)(X_{ijk} - 1)$ ∀ i ∈ trucks, (j,k) ∈ $point\_of\_distribution$ x $point\_of\_distribution$ / j≠k

$U_{ik} \geq U_{ij} + 1 + (n+2)(X_{ijk} - 1)$ ∀ i ∈ trucks, (j,k) ∈ $point\_of\_distribution$ x $point\_of\_distribution$ / j≠k

$\sum_{j=1}^{n} weight_j V_{ij} \leq capacity_i Y_i$ ∀ i ∈ trucks

Balance constraints

The constraints

$$\sum_{j=1\,/\,(j,s)\in ps}^{n} q_{js}W_j \le st_s \;\forall\, s \in sku$$

Inventory constraints

$$W_k = \sum_{i=1}^{m}\sum_{j=1}^{n} X_{ijk} \;\forall\, k \in point\_of\_distribution \setminus \{0, n+1\}$$

Process

Data

The input was the structure of the trucks, orders, products and coordinates of the point of sales in a Latin American city

Data

Table 1

Types of container used in the SKU of the simulated orders

Container	Quantity SKU	Percentage SKU
Packaging board	7	15.9%
Glass	10	22.7%
PET	23	52.3%
Metal	4	9.1%
Total	44	100.0%

Source: author's own elaboration.

Process

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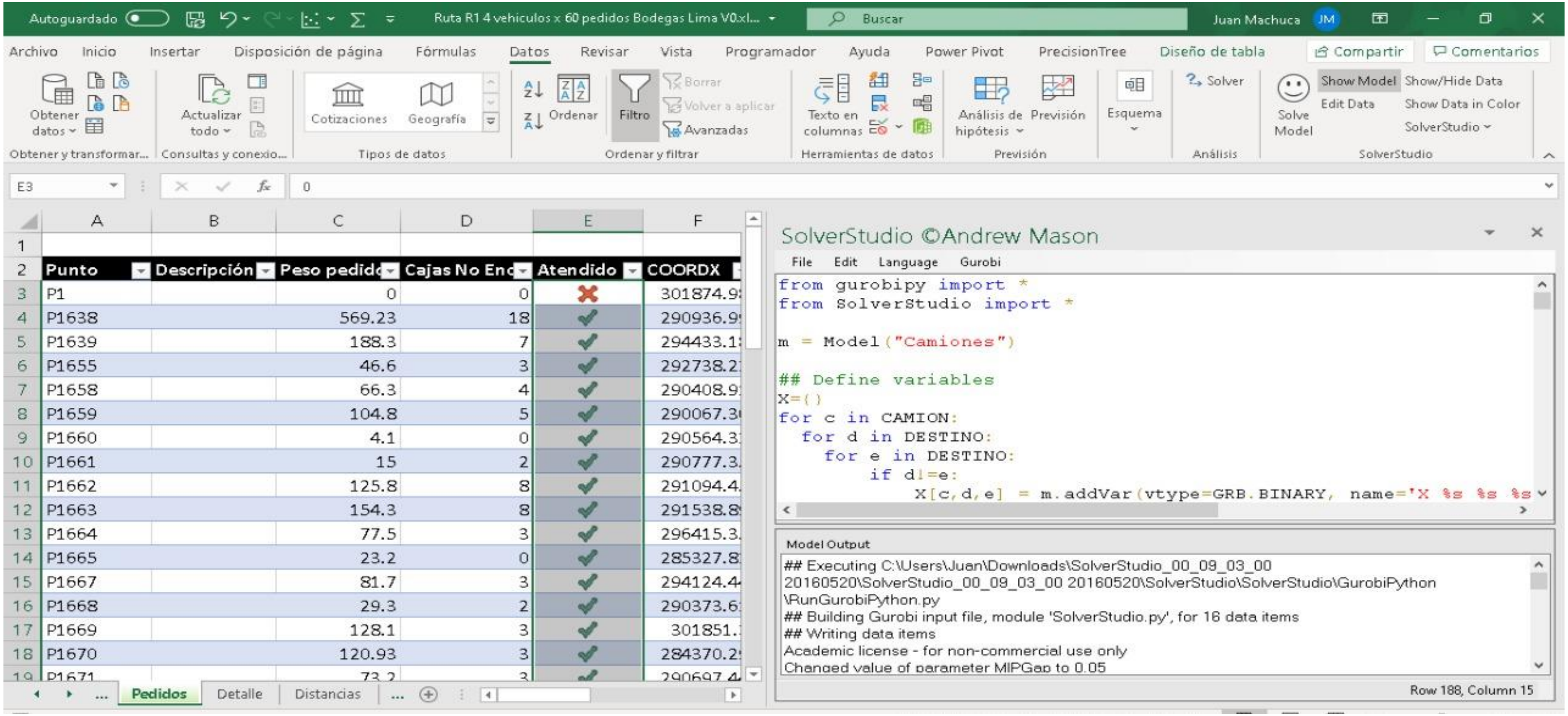

Process


```
NOATENDIDOS= m.addVar(obj=1000, name='NOATENDIDOS')
ECAMIONES= m.addVar(obj=1, name='ECAMIONES')
EDST= m.addVar(obj=1, name='EDST')

m.update()
m.setObjective(ECAMIONES+NOATENDIDOS*1000+ EDST+ quicksum(D2CAP[i] for i in CAMION)  );

m.modelSense = GRB.MINIMIZE
#familia 1
for i in CAMION:
    m.addConstr(quicksum(X[i,DESTINO[0],k] for k in DESTINO
            if DESTINO.index(k)!=0 and DESTINO.index(k)!=len(DESTINO)-1)==Y[i]);
for i in CAMION:
    m.addConstr(quicksum(X[i,k,DESTINO[len(DESTINO)-1]] for k in DESTINO
            if 0!=DESTINO.index(k) and len(DESTINO)-1!=DESTINO.index(k))==Y[i]);
```

Results

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Results – Order point of sales

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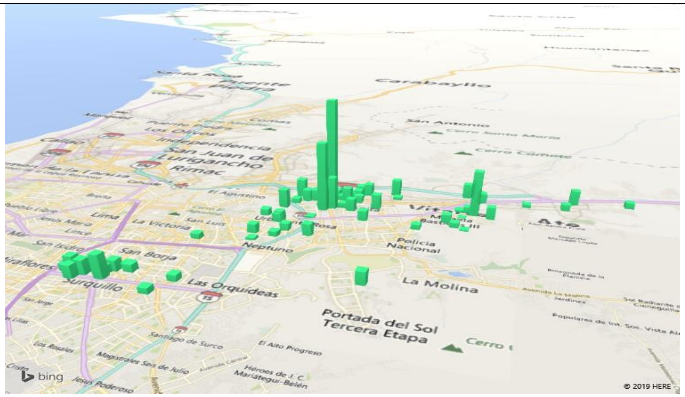
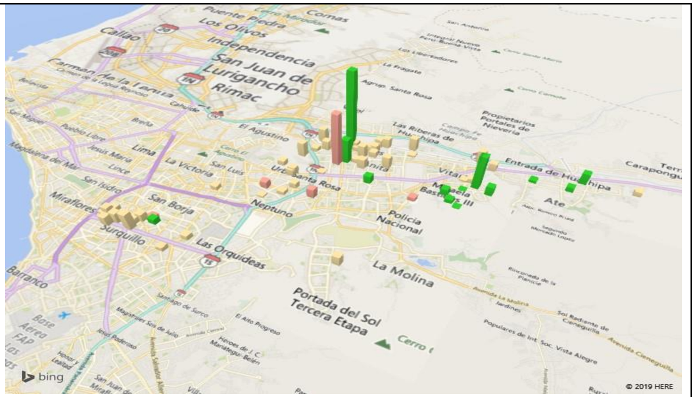
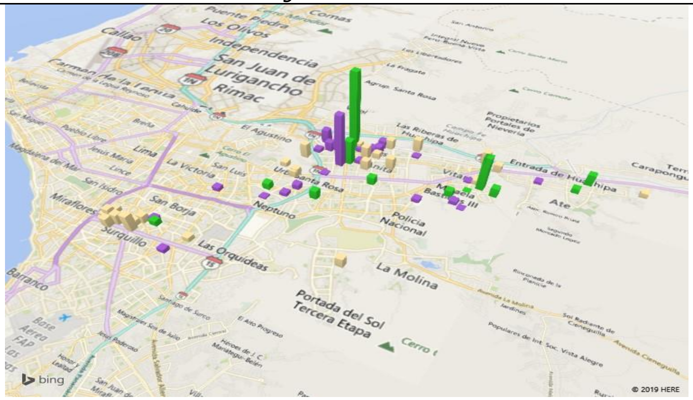


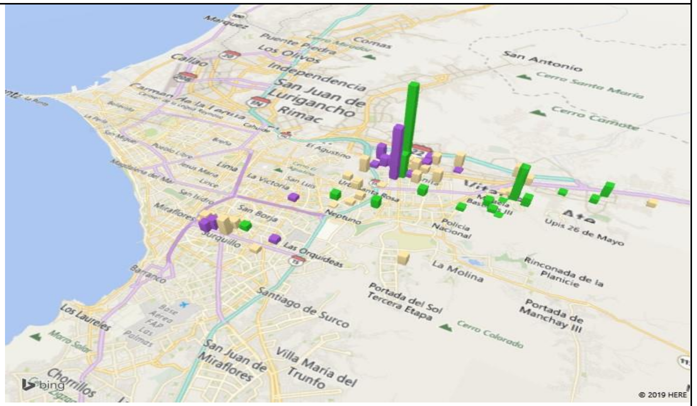
Points of delivery



Route with 20% GAP



Routes with 10% GAP



Routes with 5% GAP

Source: author’s own elaboration.

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Results

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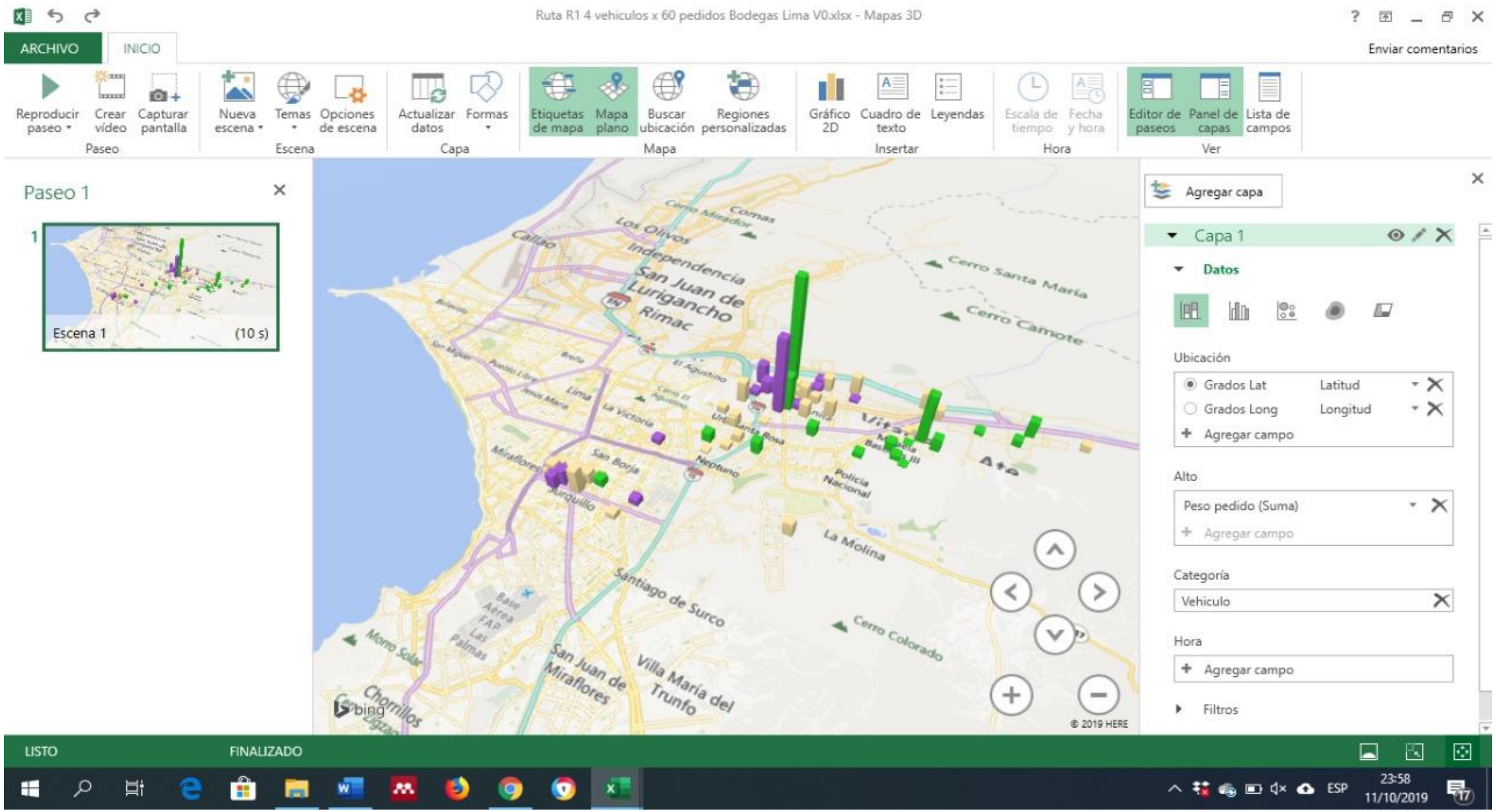

Results

Table 2

The meeting of goals with sufficient inventory

Points of delivery	Vehicles assigned	% of orders filled	% of capacity used	Route Distance (km)
10	1	100	23	15.9
20	1	100	56	23.6
30	1	100	50	24.6
40	1	100	66	26.6
50	1	100	88	29.4
60	2	100	78	33.2
70	2	100	79	36.6

Source: author's own elaboration.

Results

The solutions allowed the scheduling of orders that had specific transportation units assigned with a graphical route

Results

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The percentage of filled order will improve the decision making process when the time for a route design is limited

Conclusions

Conclusions

- We propose a model to design the shortest routes that can be used in an heterogeneous fleet with known capacities
- The results show that it is possible to find a solution when the process time depends on the number of delivery points

Conclusions

- One of the main contributions of the goal programming model proposal is that allows to manage the priorities in a distribution planning
- As future research, we propose other constraints such as route options, time windows, among others

Conclusions

Managerial implications

The points of distribution can be supplied by located warehouses	The results facilitate coordination within the stakeholders

Research implications

The model combines multiple operational goals	We can optimize considering the preventive and response stage

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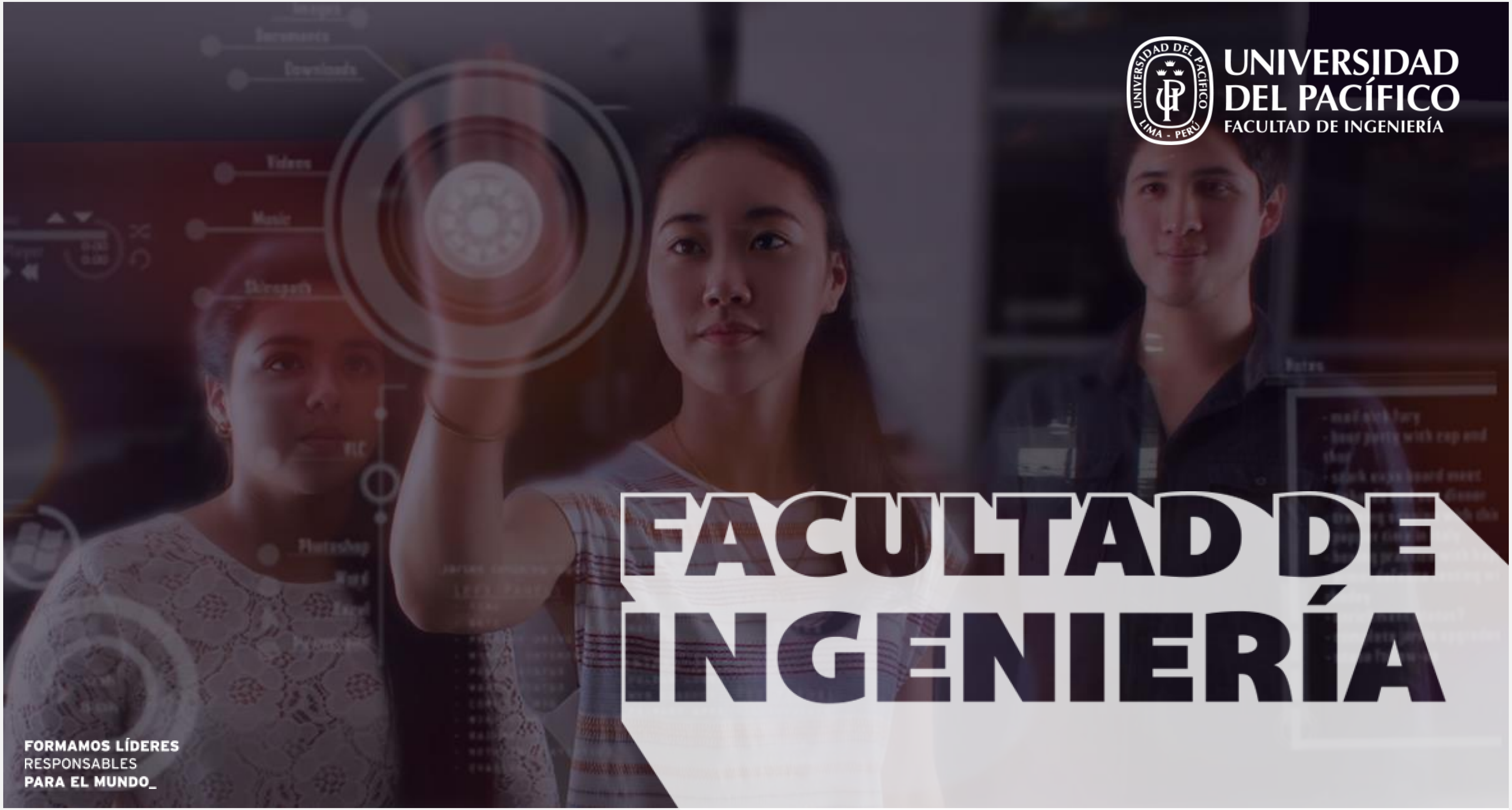
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