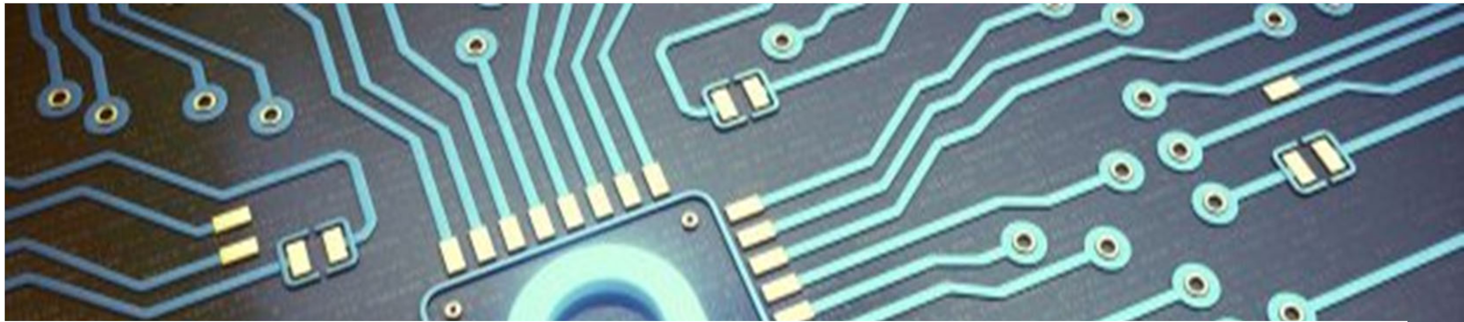
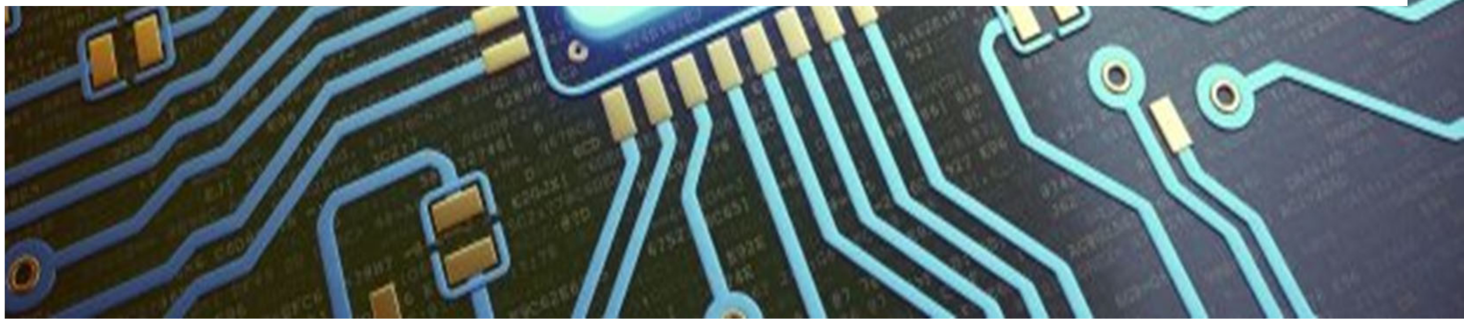
LLEIDA TECH
ARTIFICIAL INTELLIGENCE & OPTIMIZATION CONGRESS



A team orienteering problem for improving the routes of trucks collecting livestock animals for the abattoir



By Lluis M. Pla

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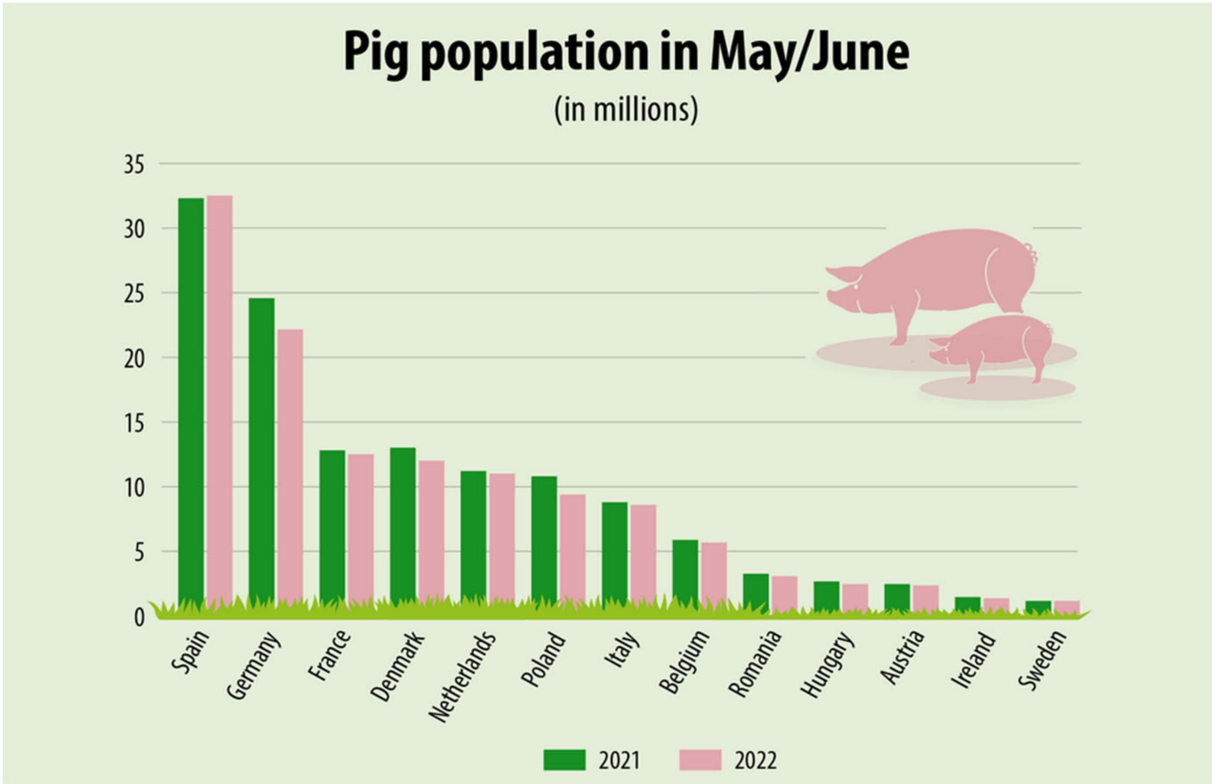

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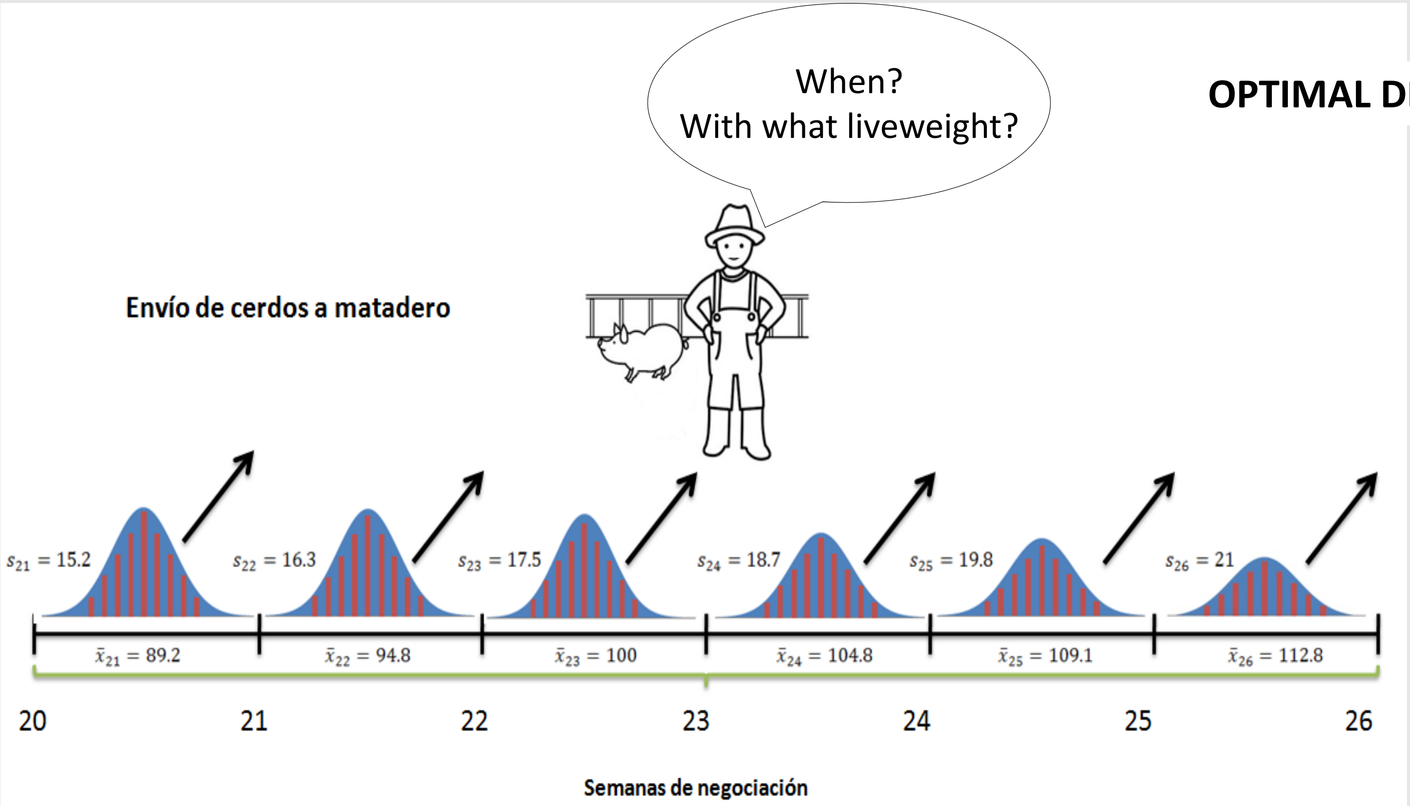
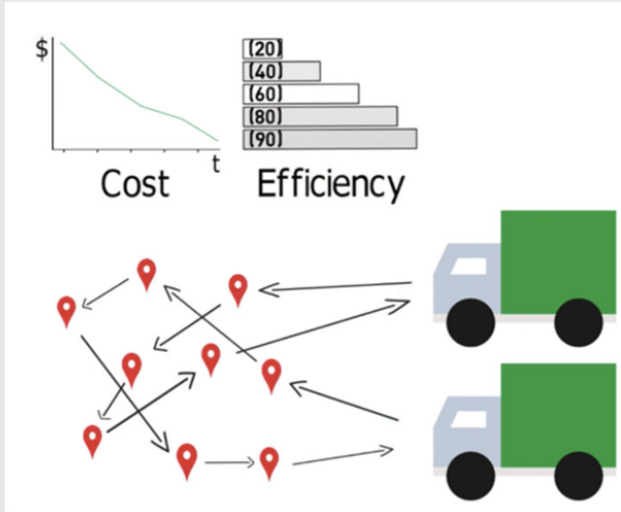


OPTIMAL DELIVERY OF PIGS TO THE ABATTOIR



Rodriguez-Sanchez S, Plà-Aragonés L.M. and de Castro R. (2019) Insights to optimise marketing decisions on pig fattening farms. *Animal Production Science*.

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1. Deterministic OP
2. Dynamic probabilistic OP
3. The TOP
4. The TOP in agtriculture

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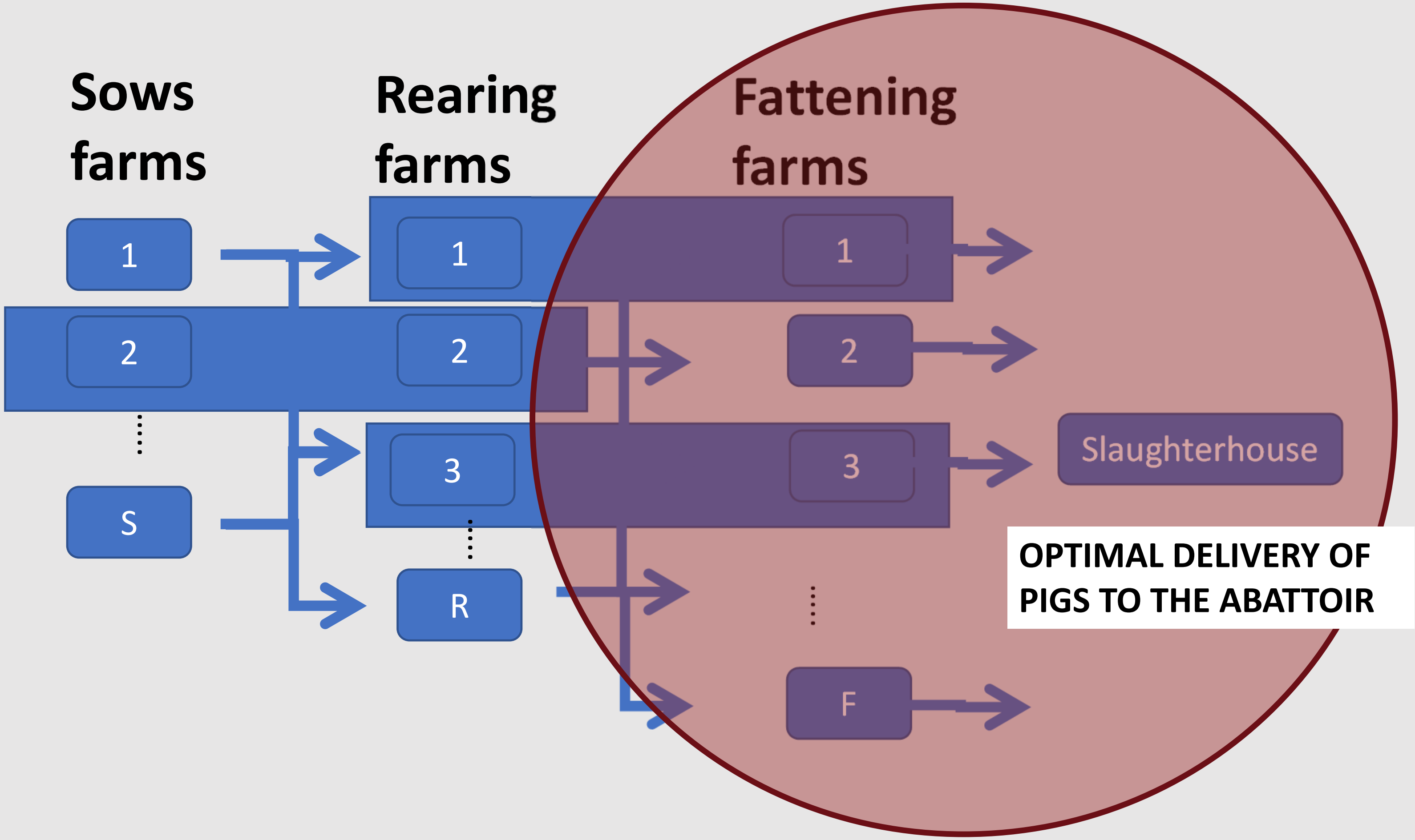

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	TOP
Objective Function	to optimize the routing of a fleet (team) who can collect rewards or profits by visiting a subset of locations within a limited time frame.
Emphasis	Orienteering aspect. The emphasis is on selecting the most profitable subset of locations to visit within a given time limit
Constraints	limited time available for visiting locations, limited capacity for collecting rewards
Context	tour planning, salesperson routing, and sightseeing route optimization

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$$\text{Maximize: } \sum_{d \in D} \sum_{(i,j) \in A} u_j \cdot x_{ij}^d \qquad (4.1)$$

Maximization of sum of profits collected

$$\text{s.t.: } x_{ij}^d \leq 1 \qquad \forall (i,j) \in A, \forall d \in D \qquad (4.2)$$

One visit at most

$$y_i^d - y_j^d + 1 \leq (1 - x_{ij}^d) \cdot |V| \qquad \forall i,j \in V, \forall d \in D \qquad (4.3)$$

Eliminate sub-tours

$$\sum_{i \in V} x_{ij}^d = \sum_{h \in V} x_{jh}^d \qquad \forall j \in V, \forall d \in D \qquad (4.4)$$

Flow balance

$$\sum_{j \in V} x_{0j}^d = \sum_{i \in V} x_{i0}^d = 1 \qquad \forall d \in D \qquad (4.5)$$

Departure and arrival nodes

$$\sum_{(i,j) \in A} t_{ij} \cdot x_{ij}^d \leq T_{max} \qquad \forall d \in D \qquad (4.6)$$

Travel distance

$$x_{ij}^d \in \{0,1\} \qquad \forall (i,j) \in A, \forall d \in D \qquad (4.7)$$

Integrallity

$$y_i^d \geq 0 \qquad \forall i \in V, \forall d \in D \qquad (4.8)$$

Tour connectivity

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$$\text{Maximize: } \sum_{d\in D}\sum_{(i,j)\in A}\Big(\sum_{p\in P} b_{e_jp}\cdot s^d_{e_jp}\Big)\cdot x^d_{ij} \qquad (4.21)$$

$$\text{s.t.: } x^d_{ij} \le 1 \qquad \forall (i,j)\in A, \forall d\in D \qquad (4.22)$$

$$y^d_i - y^d_j + 1 \le (1 - x^d_{ij})\cdot |V| \qquad \forall i,j\in V, \forall d\in D \qquad (4.23)$$

$$\sum_{i\in V} x^d_{ij} = \sum_{h\in V} x^d_{jh} \qquad \forall j\in V, \forall d\in D \qquad (4.24)$$

$$\sum_{j\in V} x^d_{0j} = \sum_{i\in V} x^d_{i0} = 1 \qquad \forall d\in D \qquad (4.25)$$

$$\sum_{(i,j)\in A} t_{ij}\cdot x^d_{ij} \le T_{max} \qquad \forall d\in D \qquad (4.26)$$

$$\sum_{d\in D} s^d_{e_jp} \le N_{p_j} \qquad \forall j\in V, \forall p\in P \qquad (4.27)$$

$$\sum_{j\in V}\sum_{p\in P} s^d_{e_jp} \le N^d_{max} \qquad \forall d\in D \qquad (4.28)$$

$$s^d_{e_jp} \ge 0 \qquad \forall j\in V, \forall p\in P \qquad (4.29)$$

$$x^d_{ij} \in \{0,1\} \qquad \forall (i,j)\in A, \forall d\in D \qquad (4.30)$$

$$y^d_i \ge 0 \qquad \forall i\in V, \forall d\in D \qquad (4.31)$$

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Algorithm 4.1 Algorithm adapted to the delivery of pigs to the abattoir

Data : $BR, maxSave, nodes, dMat, elapsed$

$sol \leftarrow genInitSol(maxSave, nodes, dMat)$

$eff\_list \leftarrow create\_eff\_list(sol)$

$eff\_list \leftarrow sort(eff\_list)$

while $elapsed < T_{max}$ **do**

  $new\_sol \leftarrow merge(BR, maxSave, nodes, dMat, eff\_list)$

  if $new\_sol > sol$ **then**

    $sol \leftarrow new\_sol$

  end if

end while

Print the best solution sol

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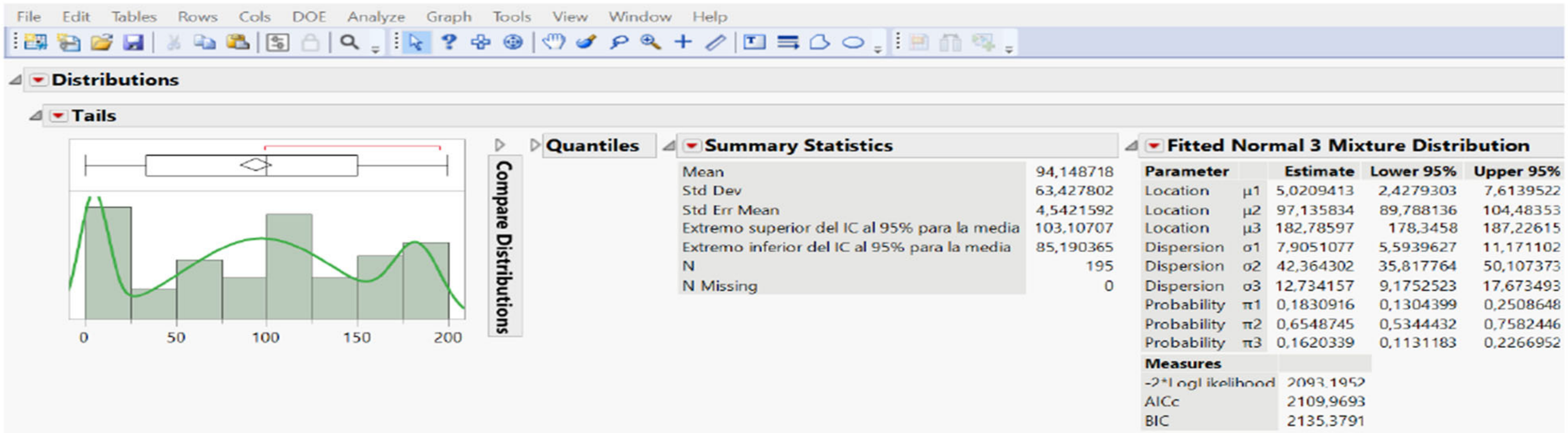

Figure 4.1: Distribution of farms around a geographical area.

Truck load	Cost	Reward	Routes
200	1,541.4	17,119	92
300	1,515.4	25,519	89
400	1,549.0	33,919	87

Table 5.1: Main results of the base case.

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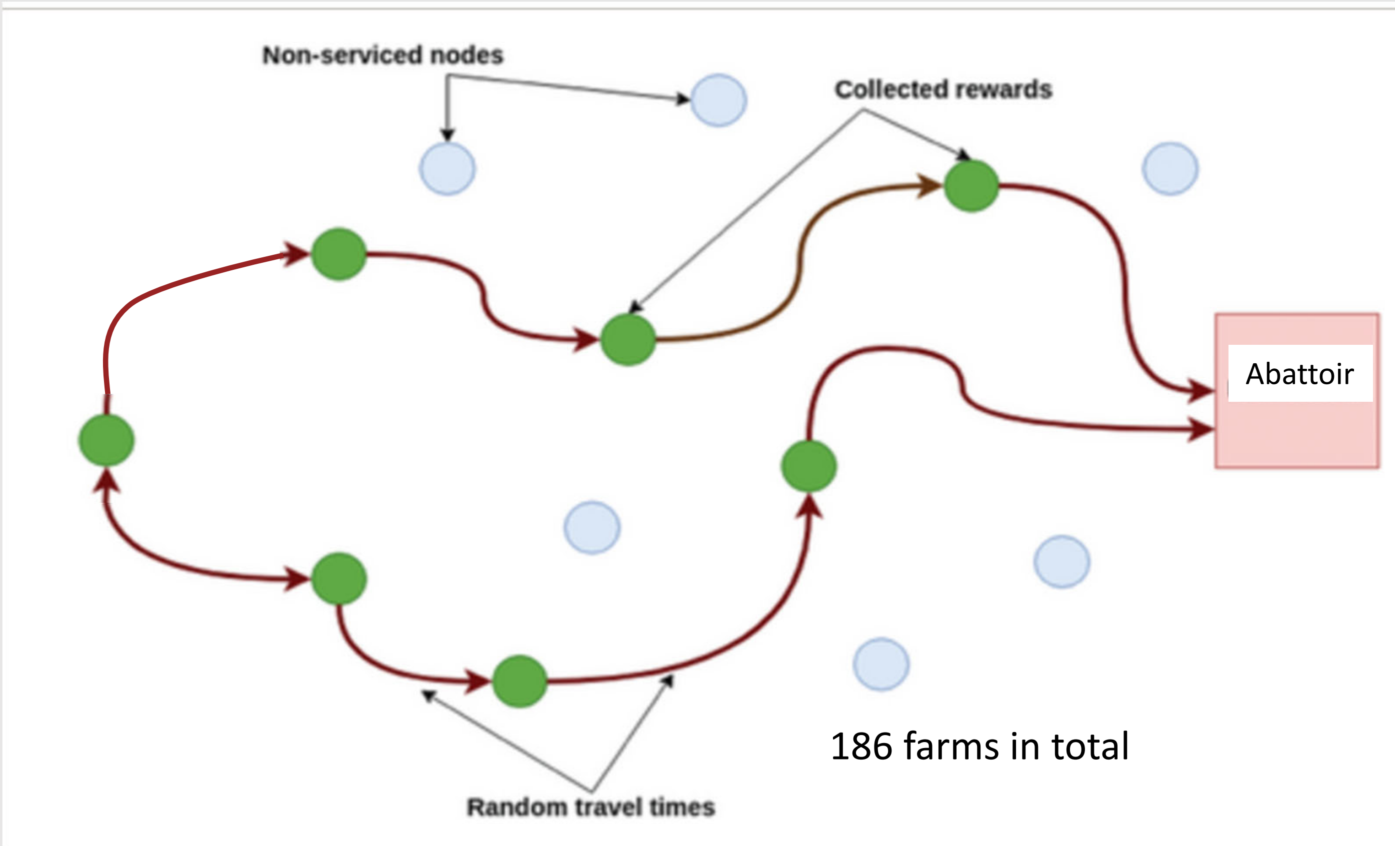

One abattoir
5.000 carcasses daily

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	σ=**5**	σ=**25**	σ=**45**	σ=**65**	σ=**85**
μ=**9**	1823	2641	3856	6074	7588
μ=**29**	5407	6160	7030	7357	9321
μ=**49**	9324	9524	10001	9544	11572
μ=**69**	12892	13240	13244	13869	12439
μ=**89**	16577	16551	17708	17457	15390
μ=**109**	20403	20538	19780	19703	17949
μ=**129**	24126	23939	23693	21576	19555
μ=**149**	27755	27586	25961	23744	21034
μ=**169**	31486	30352	27056	25692	23136
μ=**189**	34790	30110	27624	26136	24843

Table 5.2: Reward expressed in number of pigs transported

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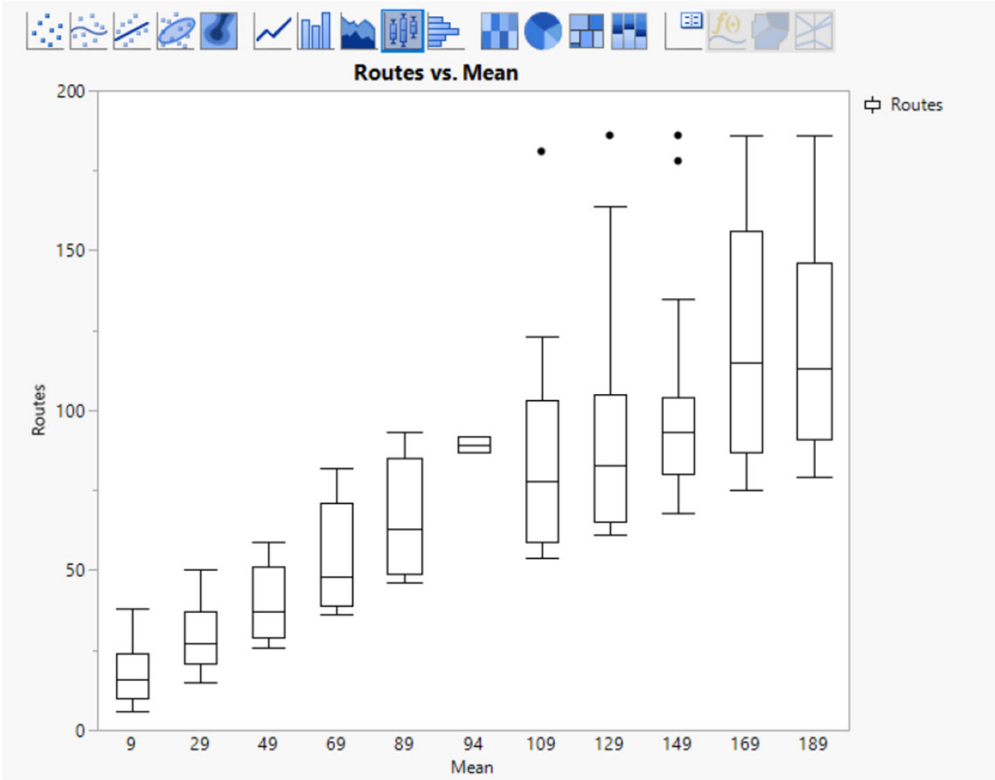
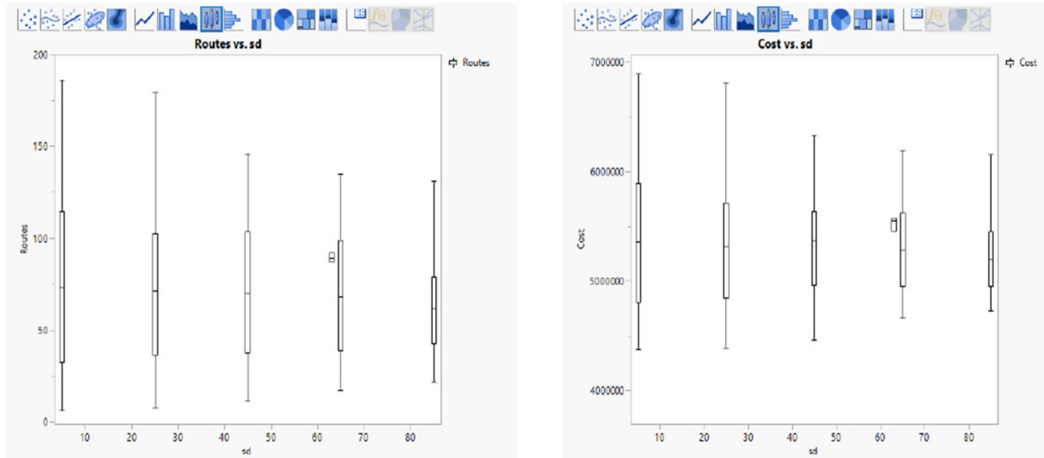


Figure 5.4: Boxplot of routes by mean number of pigs per farm.



(a) Number of *Routes* by *sd*.

(b) *Cost* by *sd*.

Figure 5.5: Results of *Routes* and *Cost* by standard deviation (*sd*).

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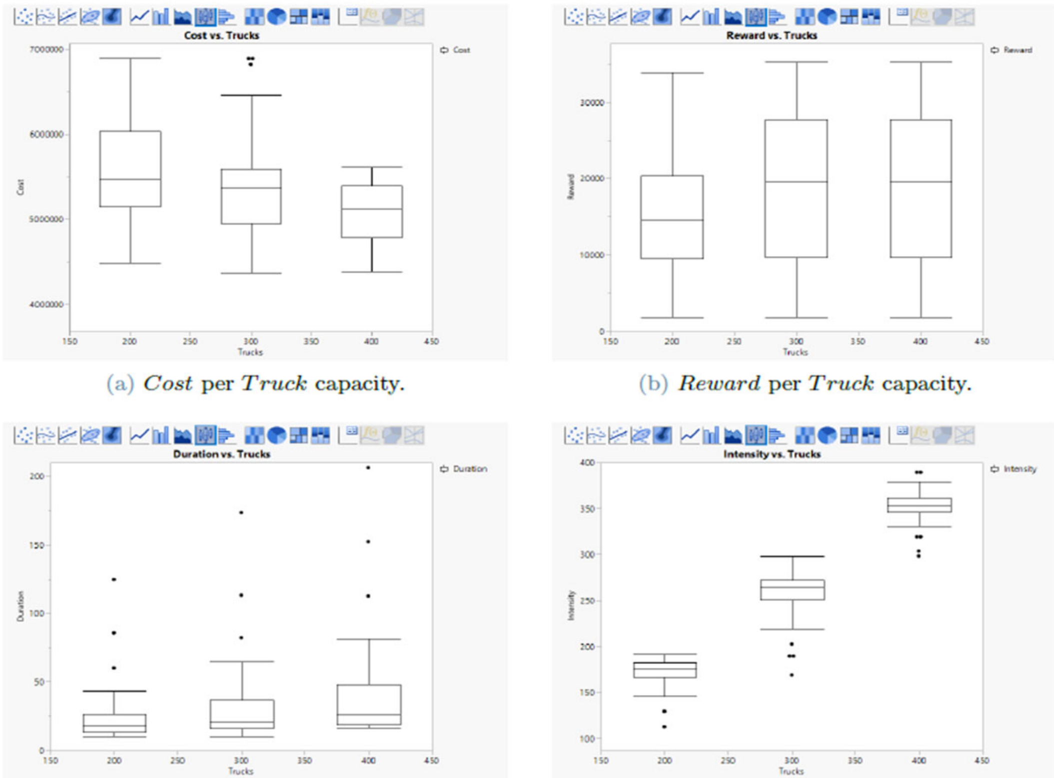

(a) *Cost* per *Truck* capacity.

(b) *Reward* per *Truck* capacity.

(c) *Duration* per *Truck* capacity.

(d) *Intensity* per *Truck* capacity.

Figure 5.7: Results of *Cost* (5.7a), *Reward* (5.7b), *Duration* (5.7c) and *Intensity* (5.7d) per *Truck* capacity.

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1. The TOP allows PSC managers better coordinate abattoir-farms operations
2. The proposed metaheuristic solves the TOP efficiently for practical use
3. The alpha value (PJH) was adapted to the case study
4. Biais randomized values were used to generate efficient lists

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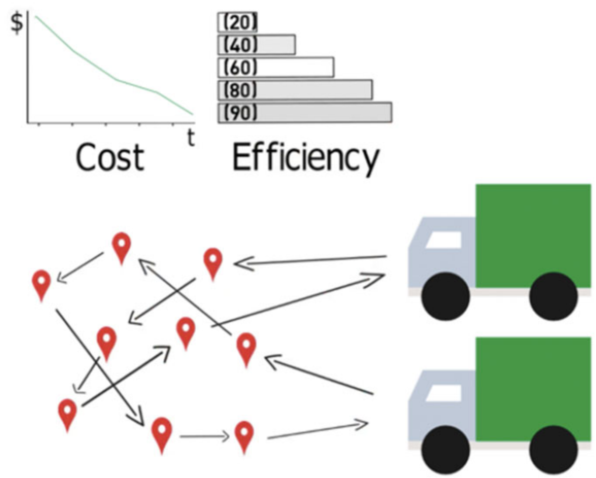
1. Solve the multi-period problem
2. Introduce uncertainty in the growth of pigs
3. Introduce uncertainty in sales' prices
4. Propose a Simheuristic approach to solve the problem



Thanks for your attention!

Questions…?