AULA 8 – LOCALIZAÇÃO MULTI-CRITÉRIO

PRO 5807 – Logística e Cadeias de Suprimento

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1

Designing logistic systems with optimisation and multi-criteria decision analysis

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2

Motivation

- Willingness of decision makers to prefer, within certain limits, non-optimal solutions.
  - Logistic network design (location problems)
    - » Coffee producers cooperative
      - NPV 32.4 vs 29.1 US$ MM: + 11%
    - » CPG companies
      - Location software (CAPS, i2)
    - » Literature (Daskin, Klose & Drexl)
  - Considering qualitative attributes and preferences in a formal and rigorous way.
- Near-optimal solutions in the Capacitated Fixed Charge Facility Location problem (CFCFL) – Guazzelli & Cunha 2018
  - 20 best solutions gap < 1%

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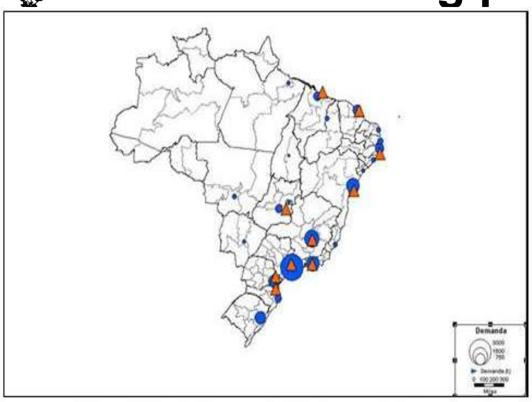
3

Locating plants



b) Potential sites placed on ten capital cities (orange triangles).

Regional demands.

A set of potential nodes (main States' capitals).

A subset of nodes should be selected to locate the plants.

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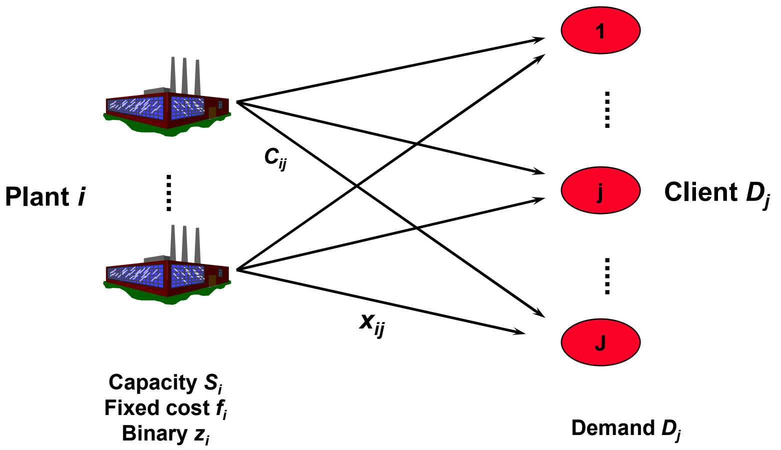
4

Single commodity, capacitated facility location problem (SCFL´)



SCFL’ formulation

(Aikins, 1985; Klose & Drexl, 2005)

OF: $\min C_L = \sum_{i \in I} \sum_{j \in J} c_{ij} x_{ij} + \sum_{i \in I} f_i z_i$

s.t.

$$\sum_{j \in J} x_{ij} \leq S_i z_i \quad , \forall i \in I$$

$$\sum_{i \in I} x_{ij} = D_j \quad , \forall j \in J$$

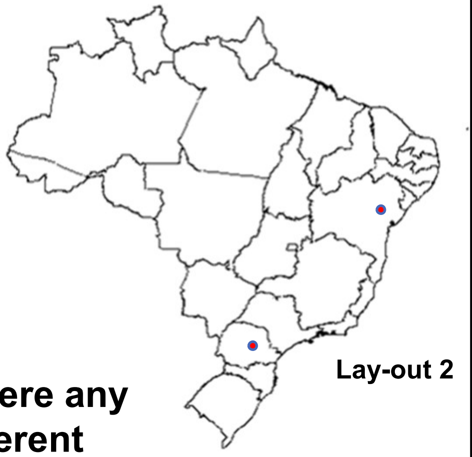
$$x_{ij} \geq 0 \quad , \forall i, j$$

$$z_i \in \{0,1\}$$

x_{ij} = flow between plant i and customer j

c_{ij} = unit production + distribution cost

2 layouts: very similar total costs



Are there any different benefits in these designs?

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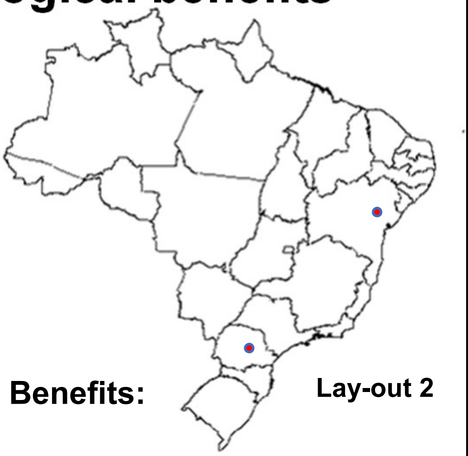
7

2 layouts: topological benefits



Topological Benefits:
- **resilience**
- **regional coverage**
- **etc.**

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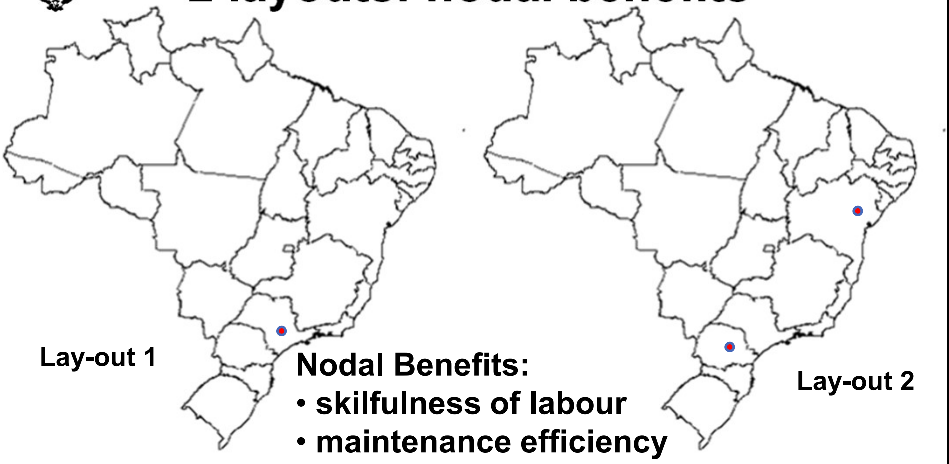
8

2 layouts: nodal benefits



Nodal Benefits:
- skilfulness of labour
- maintenance efficiency
- availability of logistic services
- etc.

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9

From the location problem

Decisions about Logistic Systems,

at strategic level,

may involve considering

several benefits.

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10

From the location problem

- We suggest that they may be classified as:
  - Topological benefits - a subset of the network's systemic properties which attempt to reflect the decision-makers' concerns about the topology of the network.
  - Nodal benefits - benefit dimensions for each potential site of the network, which the decision-makers are concerned with and are properties of the network's elements.

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11

Three ways of considering benefits

- Informal analysis (optimisation followed by an informal analysis of benefits for a small set of designs)
- Monetisation (benefits are monetised and included in the optimisation model)
- Pricing out (assessing how much the DM is willing to pay for each extra benefit)
- Multi-criteria analysis (the value of each node is assessed)
- Multi-Criteria Value Optimisation (the value of each design on each benefit is computed and the overall value of the network is optimised).

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12

MC Value Optimisation – Location Problem

- Minimise Total Logistic Cost
- Select nodes with highest individual benefits (e.g., Infra-Structure, Logistic Services, etc.) – Nodes' Benefits
- Find configurations with the best topological (network) structure – Topological Benefits

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13

Facilities Location with Multiple Objectives

- **Measuring Nodes' Benefits** (discrete alternative MCDA methods, such as AHP – e.g. Yurimoto & Masui (1995))
- **Measuring Topological Benefits** (Goal Programming or Multi-Objective Optimisation – e.g. Yurimoto & Masui (1995))
- **Measuring both Types of Benefits** (e.g., Topsis for Nodes' Benefits and Multi-Objective Optimisation for costs vs benefits – e.g. Farahani & Asgari (2007))

•Badri et al. (1998).A multi-objective model for locating fire stations. European Journal of Operational Research 110 (1998) 243-260
•Farahani & Asgari (2007). Combination of MCDM and covering techniques in a hierarchical model for facility location: A case study. European Journal of Operational Research 176 (2007) 1839–1858
•Yurimoto & Masui (1995). Design of a decision support system for overseas plant location in the EC. Int. J. Production Economics 41 (1995) 411-418

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14

MSCFLP' (multi-criteria, single commodity, capacitated facility location problem')

OF: $Max\ V = w_L v_L + w_B [w_T v_T + w_N v_N]$

s.t.

$$\sum_{j \in J} x_{ij} \le S_i z_i \quad , \forall i \in I$$

$$\sum_{i \in I} x_{ij} = D_j \quad , \forall j \in J$$

$$x_{ij} \ge 0 \quad , \forall i, j$$

$$z_i \in \{0,1\}$$

$$v_L = f(C_L)$$

$$v_T = \sum_{m \in M} w_{T_m} v_{T_m}$$ M = number of topological criteria

$$v_N = \sum_{p \in P} w_{N_p} v_{N_p}$$ P = number of node benefit criteria

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15

Node criteria

$$v_N = \sum_{p \in P} w_{N_p} v_{N_p} = \sum_{p \in P} w_{N_p} \left[\frac{\sum_{i \in I} v_{ip} z_i}{\sum_{i \in I} z_i} \right]$$

Turning it into a constraint...Or running for a given set of nodes ON

$$\sum_{p \in P} w_{N_p} \left[\frac{\sum_{i \in I} v_{ip} z_i}{\sum_{i \in I} z_i} \right] \ge \underline{v}_N$$

$$\sum_{p \in P} w_{N_p} \sum_{i \in I} v_{ip} z_i - \underline{v}_N \sum_{i \in I} z_i \ge 0$$

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16

MC Value Optimisation -Example

- **Designing a logistic network (location and allocation) for a snacks company**
  - **Based on actual figures**
- **Set of alternative sites**
  - **10 potential sites**
- **Clients**
  - **23 Brazilian States (accessible by road)**
  - **Demand = f (population, per capita consumption)**
- **Costs:**
  - **Variable costs: transportation, transshipment, production**
  - **Fixed costs: investment, overhead**

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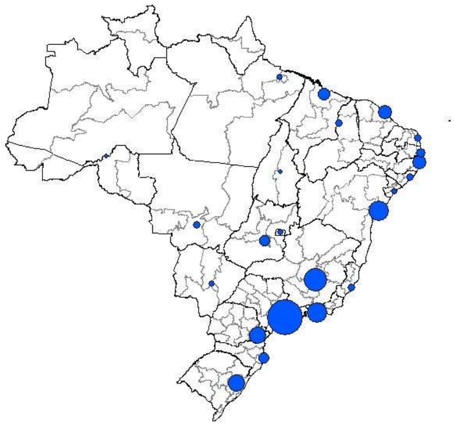
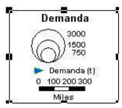
17

Demand





Demand D_j = population x per capita

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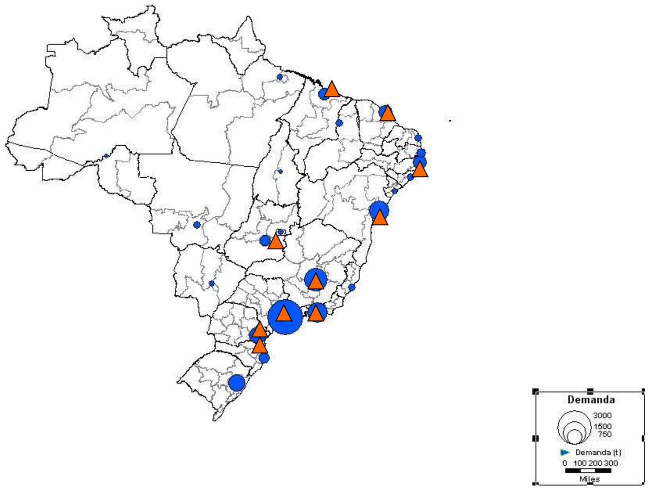
18

Demand and alternative sites



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19

Qualitative criteria

- Topological criteria
  - Resilience
  - Regional presence
- Node criteria
  - Maintenance
  - Planning permission
  - Logistic services
  - Skilled labour

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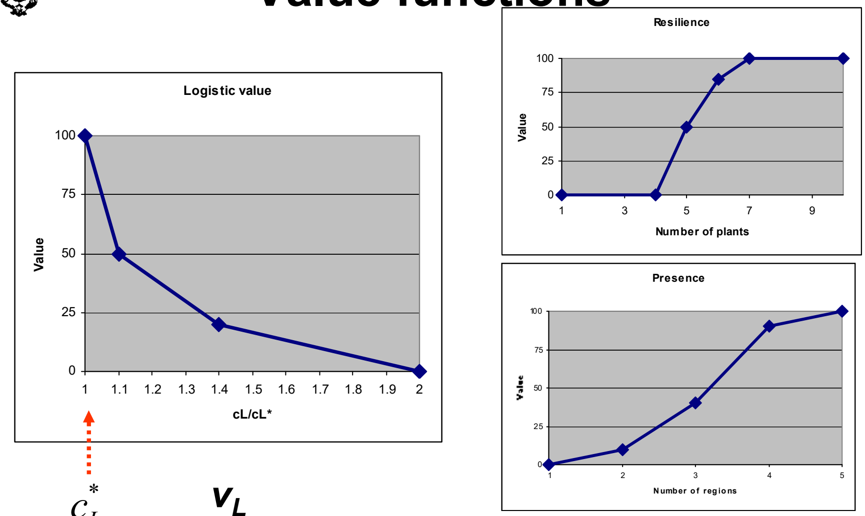
20

Value functions



c_L^* $\boldsymbol{V_L}$ $\boldsymbol{V_T}$

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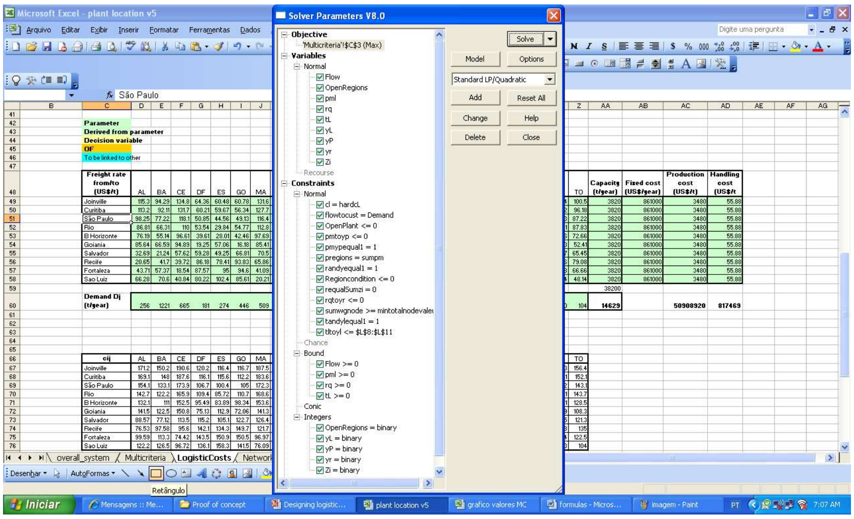
21

Plant location - DSS



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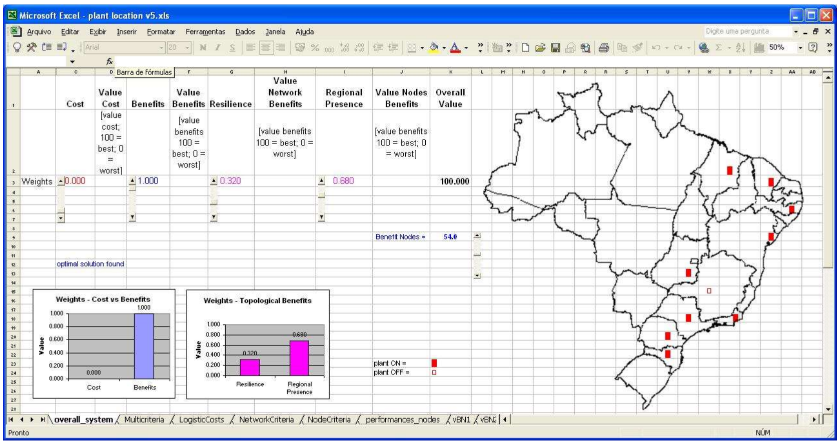
22

Projeto de rede multi-critério



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23