A sugar distribution network: Designing and planning

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Tale of a battle!

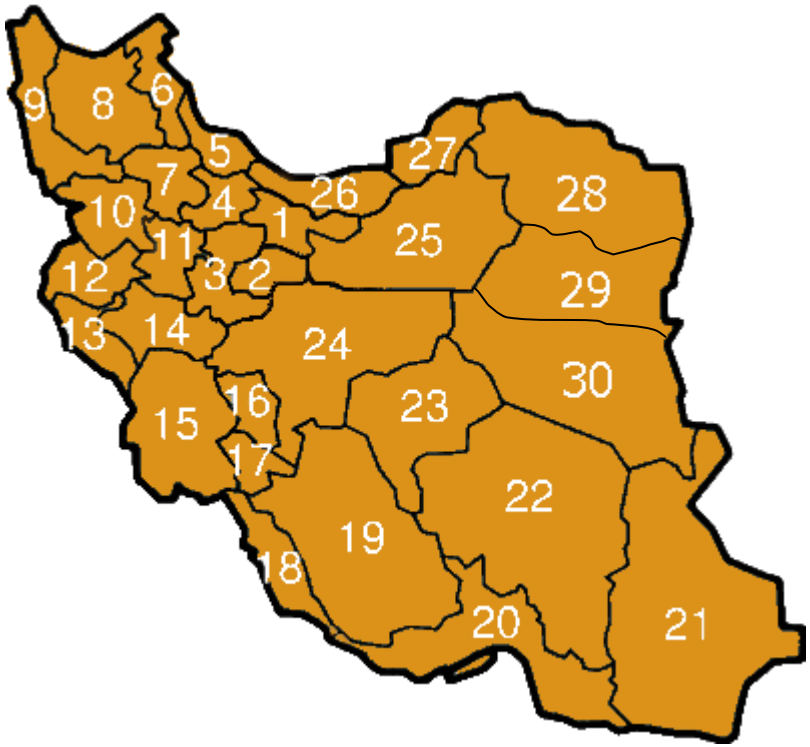
Angry producers **vs** **Naughty merchants**

Agenda

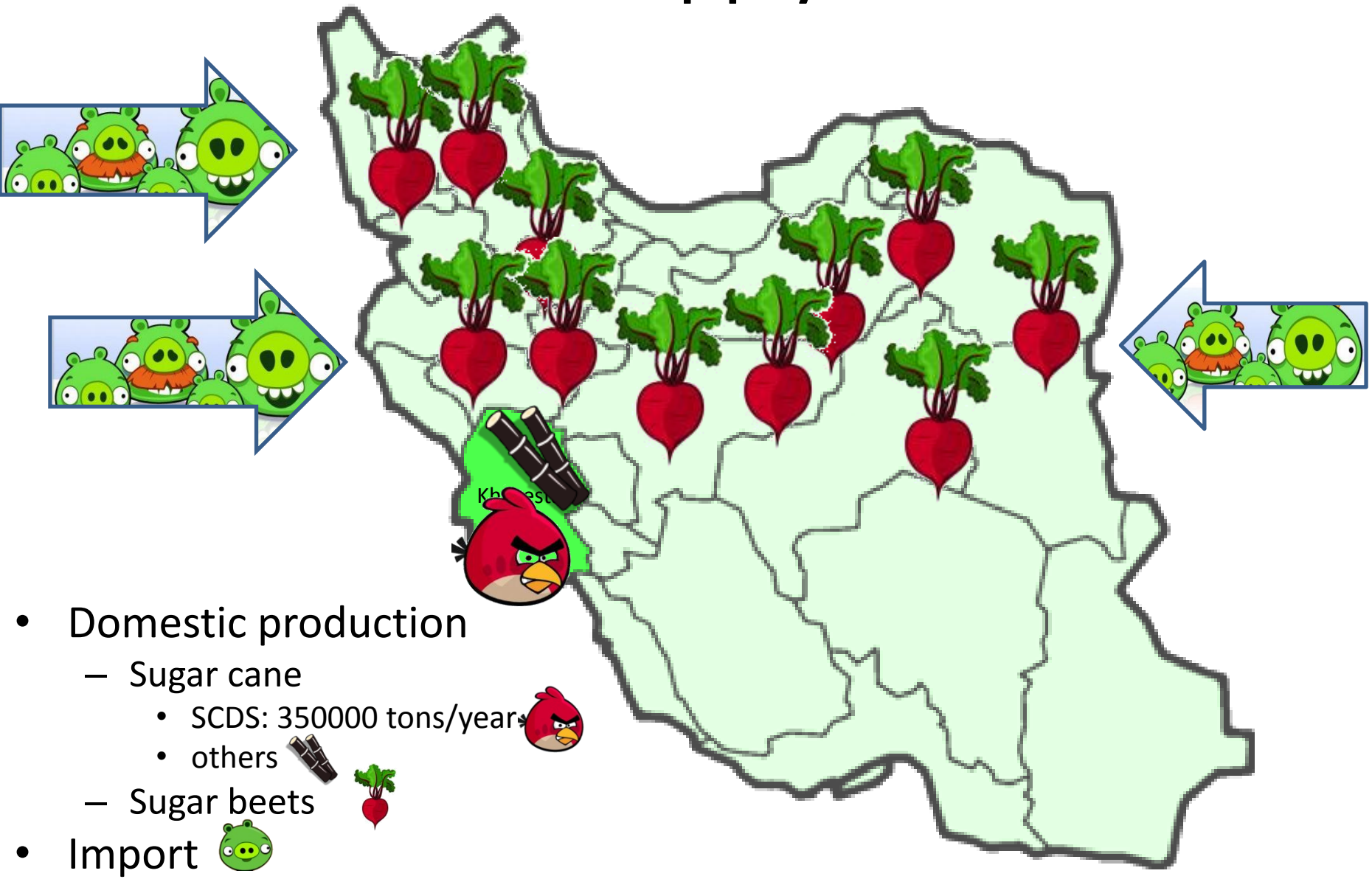
- The problem
- Classification of provinces and customers
- Distribution channels/methods
- Refinement/Distribution/Storage planning

Demand

- 30 provinces
- 4 market segments
  - Households
    - Groceries
    - Small local super markets
  - Confectioneries/workshops
  - Small industries
  - Big industries (mostly soft drinks)
- Total demand
  - 1300000-1500000 tons/year

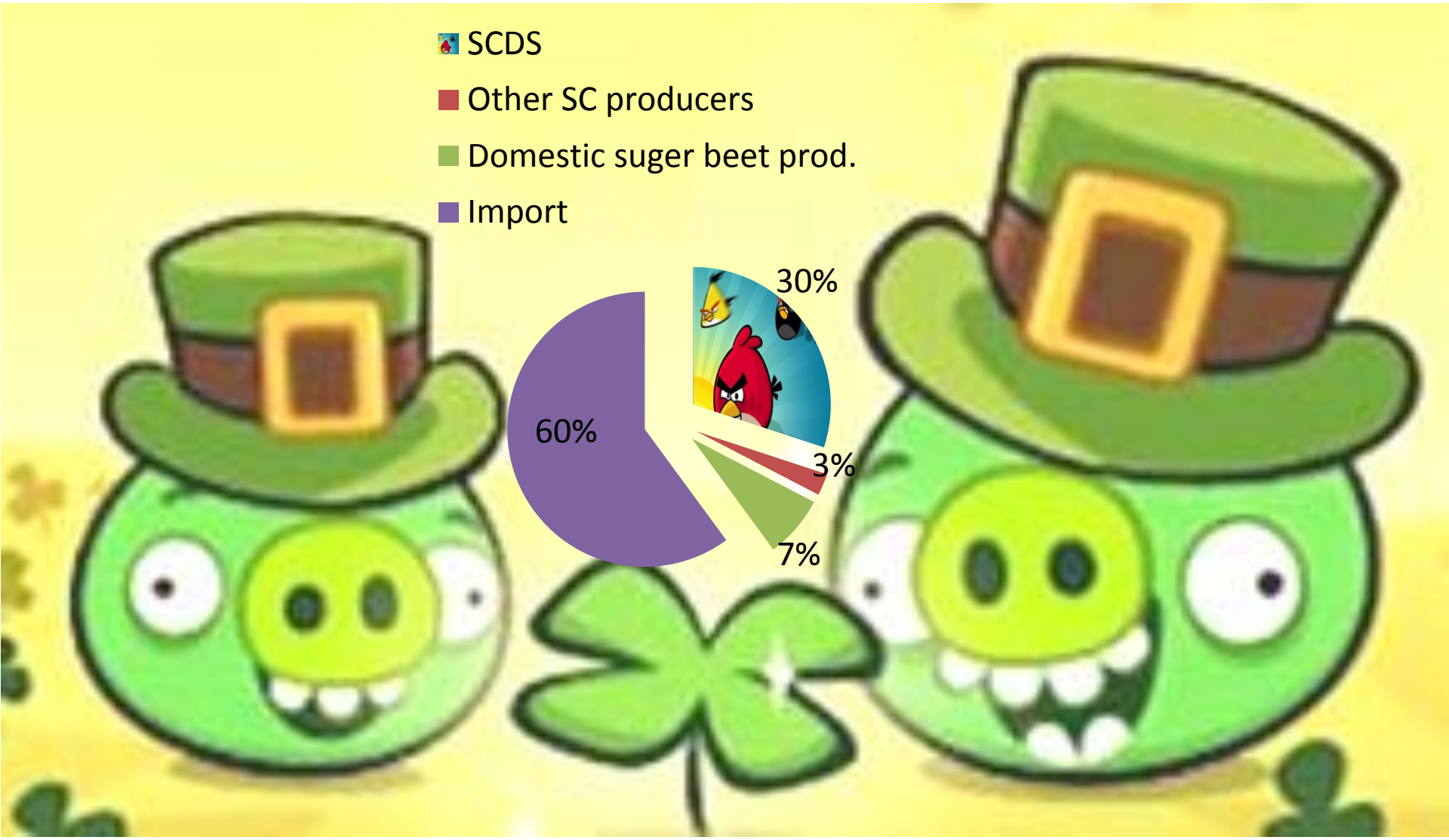


Supply



- Domestic production
  - Sugar cane
    - SCDS: 350000 tons/year
    - others
  - Sugar beets
- Import

Supply


SCDS
Other SC producers
Domestic suger beet prod.
Import
30%
60%
3%
7%

Strategy

- To be independent of the merchants (partly)
- To have own distribution network
- Closer contact with final customers

- Higher profit margin
- More competitiveness

Steps

- Classification of the provinces into sale regions
- Finding proper distribution methods for different market segments in the regions
- Assigning agents to the provinces
- Deciding on intermediate warehouses
- Operational production/distribution planning

Categorization of provinces

- Constructing sale regions
- Applying the same distribution method and organization for the provinces of the same region
- Goal : to put similar AND adjacent provinces in the same region

Steps

- Definition of indicators
- Data gathering
- Categorization algorithms
- Comparison of solutions of different categorization algorithms

Indicators

	Surface	Neighborhood
	Demand	Limits
	Sale plan	
Density of demand points	Geography/Demography	Similarity
Distance to khuzestan		
Border points and ports		
Ratio of sale plan to demand	Consumption and distribution pattern	
Density of industrial demand points		
Density of sale plan in the market segments		
Density of demand in market segments		
Consumption pattern in market segments		
Density of railway network	Transportation facilities, infrastructure and costs	
Density of road network		
Density of transportation companies		
Average road transport cost		
Density of sugar beet refineries	Facilities of sugar production and refinement	

Calculation of similarities

- Values of indicators for the provinces
- Giving weights to the indicators → AHP
- Normalized similarity of the provinces *m* and *n*

$$I_{mn} = \sum_i w_i \left[1 - \left(\frac{|a_{in} - a_{im}|}{a_i} \right) \right]$$

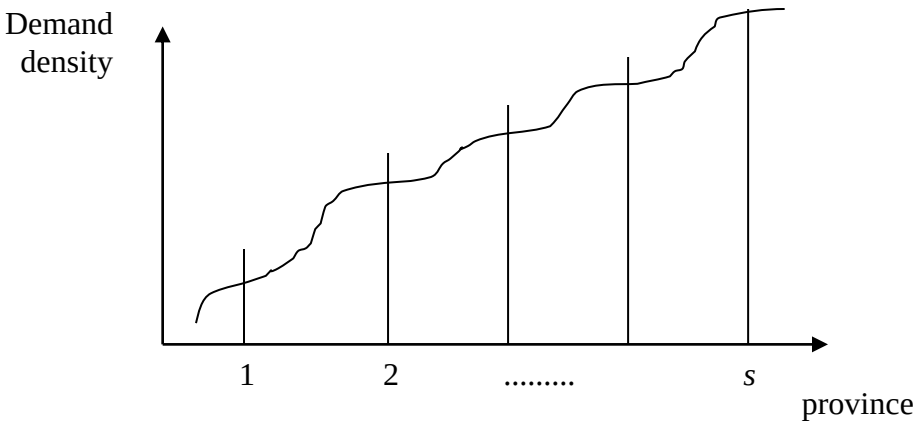
a_{in} Indicator *i* for the province *n*

w_i Weight of the indicator *i*

a_i Maximum gap between two provinces in the value of the indicator *i*

The first categorization algorithm

- Sort the provinces WRT demand density
  - Most important indicator
- Construct the cores of the regions
- Add neighbor similar provinces to the cores until constraints are violated

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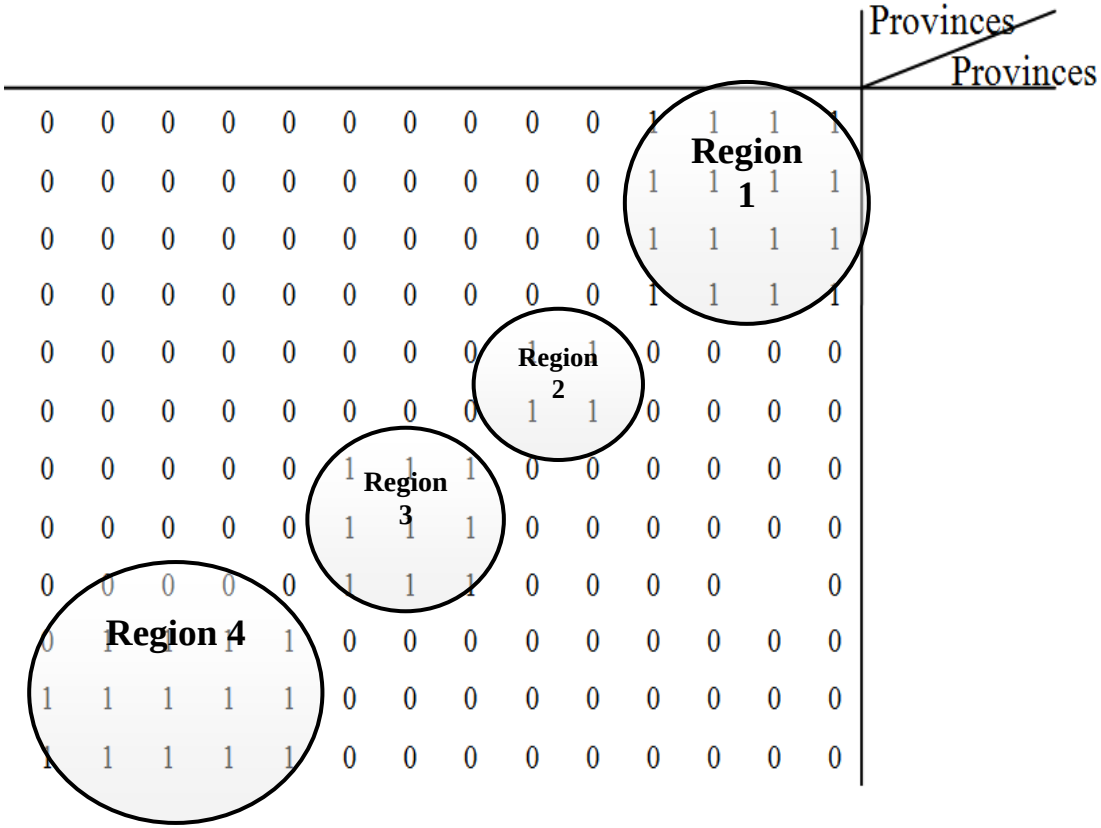
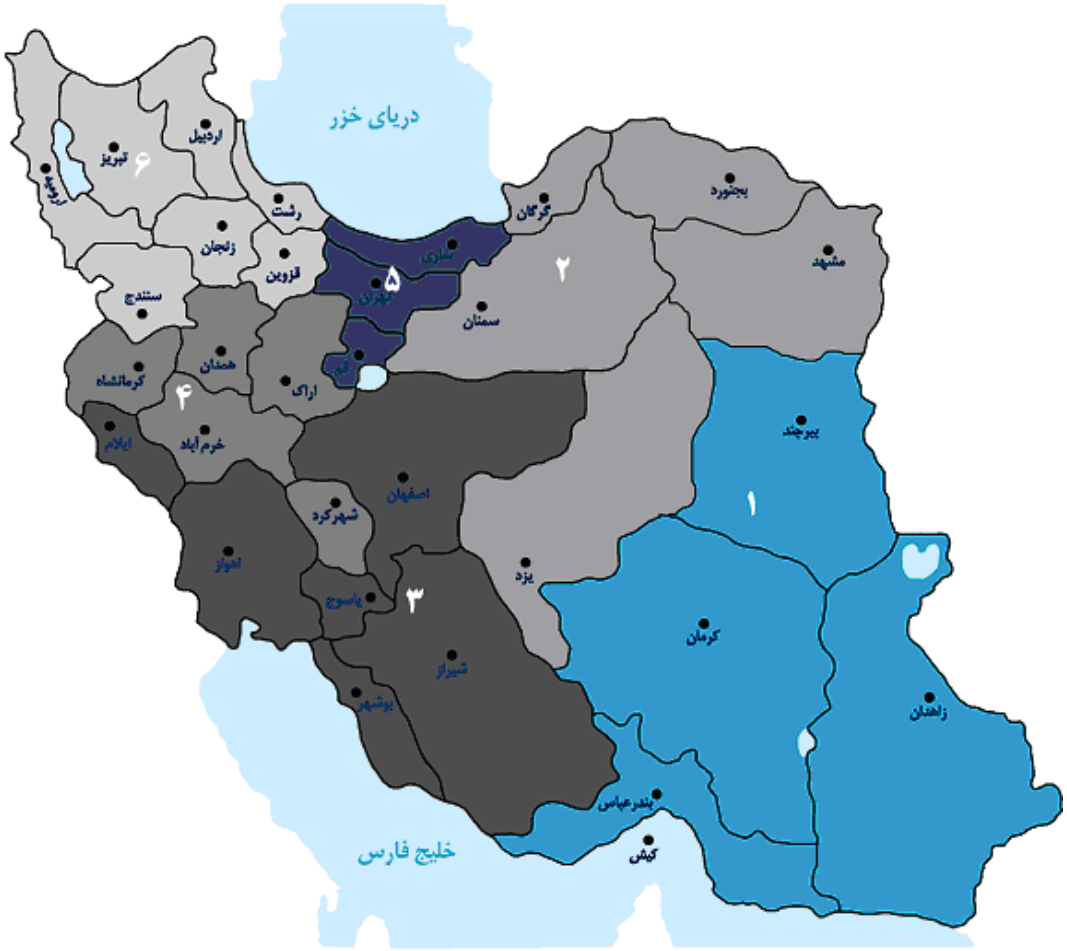
The second categorization algorithm

- Entry-to-entry multiplication of similarity and neighborhood matrices
- Diagonalization of the produced matrix
- Regions: blocks around the main diagonal

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Comparison of categorizations

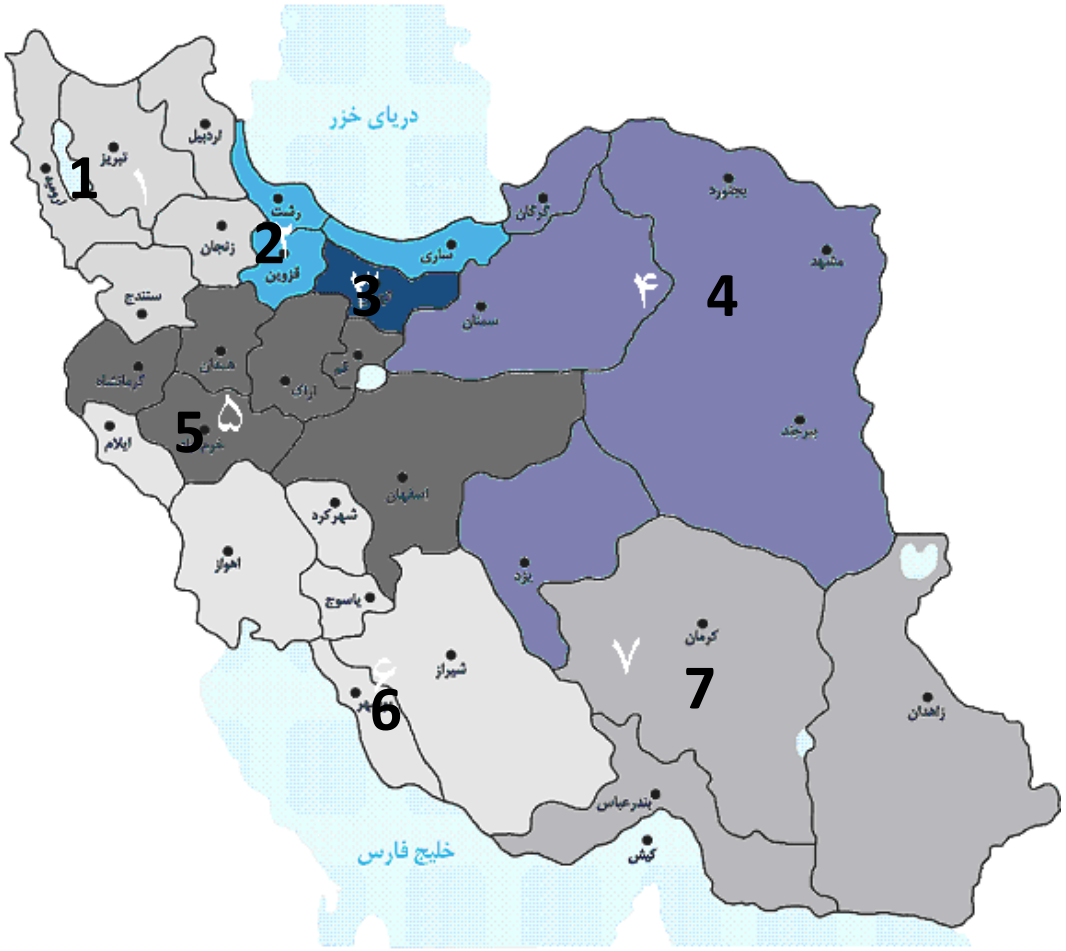
- Generating new categorizations by interviews and exchanging provinces between neighbor regions
- Criterion of utility: average of average similarity of the provinces of the regions

$$\frac{\sum_{i=1}^{n} \frac{2\sum_{j=1}^{N_i-1}\sum_{k=j+1}^{N_i} I_{jk}}{N_i * (N_i - 1)}}{n}$$

N_i: number of provinces in region i

n: number of provinces

Final regions



Choosing distribution methods

- Best distribution method for each (region,segment)
- Classification of 8 original market segments into 4
- Data gathering in 7 sample cities from the 7 regions

Possible distribution methods/channels

- Distribution company
  - Establishing a new one
  - Contract with existing companies

- Via syndicates

- Direct sale

- Via agents
  - Big
  - Small

- Via merchants
  - Keeping a part of current quota
  - Distribute the rest by new methods

Standards for distribution quota and storage capacity set according to:

- distribution power
- financial factors
- organizational needs
- reliability requirements

Min quota

Max quota

Procedure of choosing distribution methods

- Definition of comparison indicators
- Removal of infeasible methods w.r.t. limiting (constraint-like) indicators
- Making compensatable (objective-like) indicators independent: 21 initial indicators → 14 independent indicators
- Giving weight to objective-like indicators
- Evaluation of each indicator for each (region,segment)
- Normalization and summarization of indicators
- Ranking distribution methods

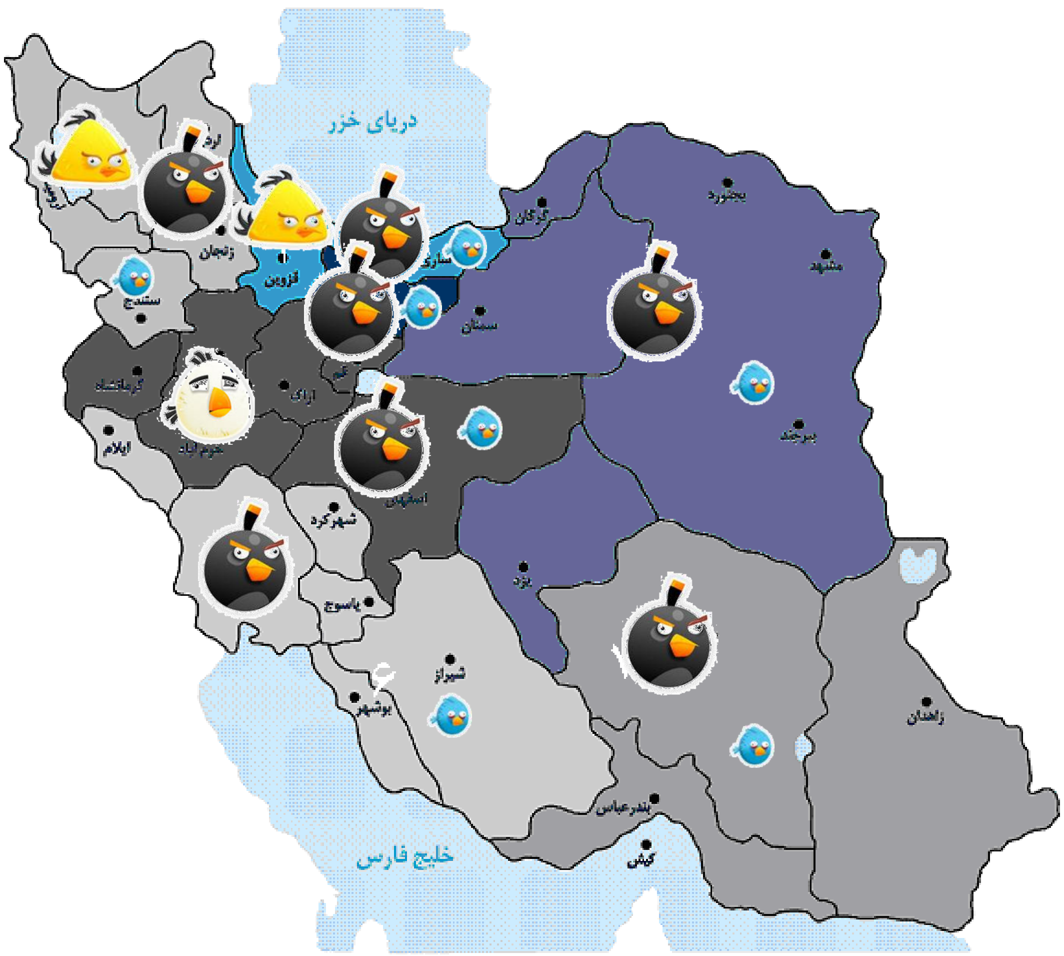
Comparison indicators

Class	Indicator	Compensatable /Limiting	Qualitative /Quantitative
Distribution capacity	Lead time	C	Quantitative
	Flexibility of purchasing methods	C	Qualitative
	Closeness to final customer	C	Quantitative
	Effect on demand	C	Qualitative
	Applicability to the market segment	L	Qualitative
Financial	Investment return period	Both	Quantitative
	NPV	Both	Quantitative
	Initial investment needed	C	Quantitative
Non-financial	Compatibility with strategies	L	Qualitative
	Negative effects in the market	C	Qualitative
	Durability	C	Qualitative
	Effect on the bargaining power of the customers	C	Qualitative
	Needed organization	C	Qualitative

Results

Market segment → Region ↓	Households	Workshops	Small industries	Big industries
1) North-west	Small agents	Small agents	Direct sale Big agents Small agents	Big agents
2) North	Small agents	Small agents	Direct sale Big agents Small agents	Big agents
3) Tehran	Small agents	Small agents	Big agents Direct sale Small agents	Big agents
4) North-east	Small agents	Small agents Via syndicates	Big agents Direct sale Small agents	Big agents
5) Centre	Small agents	Via syndicates Small agents	Big agents Direct sale Small agents	Big agents
6) South-west	Small agents	Small agents	Big agents Direct sale Small agents	Big agents
7) South-east	Small agents	Small agents	Big agents Direct sale Small agents	Big agents

Results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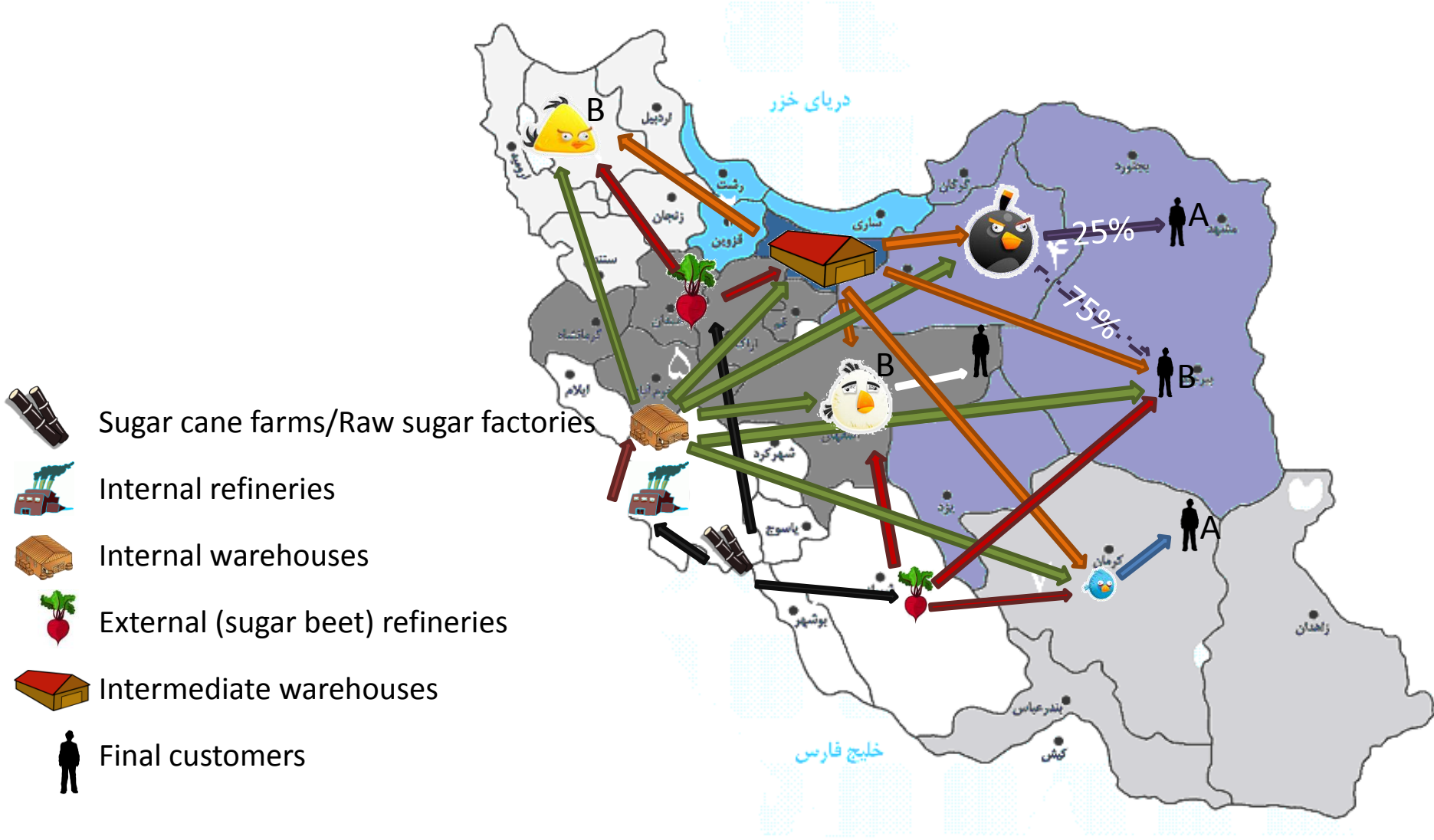
Planning of agents

- Decisions
  - Number of small and big agents in each province
  - Volume of sugar which agents of each province distribute
    - In the same province
    - In the other provinces of the region
- Objective: to minimize total transportation cost
  - Based on road mode (trailers)
- Constraints
  - Demand
  - Total volume of sugar which can be distributed by the agents of a province
    - Big agents: 150% of the demand
    - Small agents: 120% of the demand
    - A province may receive part of the needed sugar from other provinces
    - Agents located in each province may be more than what is needed there

Refinement/Distribution/Storage planning



Decisions

- Location and capacity of intermediate warehouses
- The amount of sugar to be refined in external and internal refineries in each month of the year
- Inventory of raw and refined sugar at the end of each month, in all of the storage points of the network:
  - [Internal] Warehouses of raw and refined sugar in Khuzestan
  - Warehouses of the external refineries
  - Intermediate warehouses of the company
  - Warehouses of the agents
- The amount of transportation of raw and refined sugar among storage points of the network and the customers
  - Customers:
    - Receiving sugar from the warehouse of the agent (Group A)
    - Receiving sugar without being stored in the agents (Group B)

Objective

- Minimize total cost:
  - Annual capital cost of the intermediate warehouses
  - Inventory holding cost at the internal (of the company in Khuzestan), external (refineries) and intermediate warehouses
  - Cost of refining in external refineries
  - Transportation cost of raw and refined sugar among storage point of the distribution network (factories in Khuzestan, external refineries, intermediate warehouses, agents and customers)
  - Loading and unloading costs of sugar through the process of transportation

Constraints

- Capacity of production and storage
- Demand satisfaction (sale plan)
- Balance relations of inventory and transportation at storage points of the network
- Initial conditions (inventory)

- Solver: LINGO 8.0

What happened at the end?

- Sad ending: the distribution sub-company failed

- The merchants dominate the market
  - Massive imports
  - Dumping prices
- Tactical/Operational planning cannot work when strategy is poor