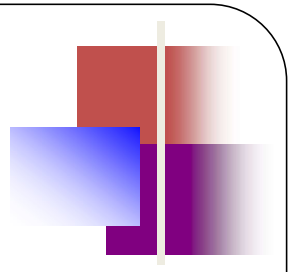


Second+third classes: Extension

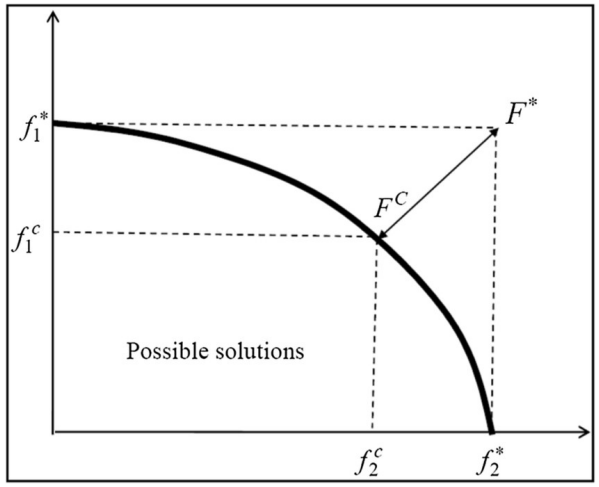
Irit Talmor (Ph.D)
Iritt@wgalil.ac.il

Reminder...

the application of science
to decision-making

WWII – the Battle of Britain
Where to locate the radar systems?

One vs. many criteria



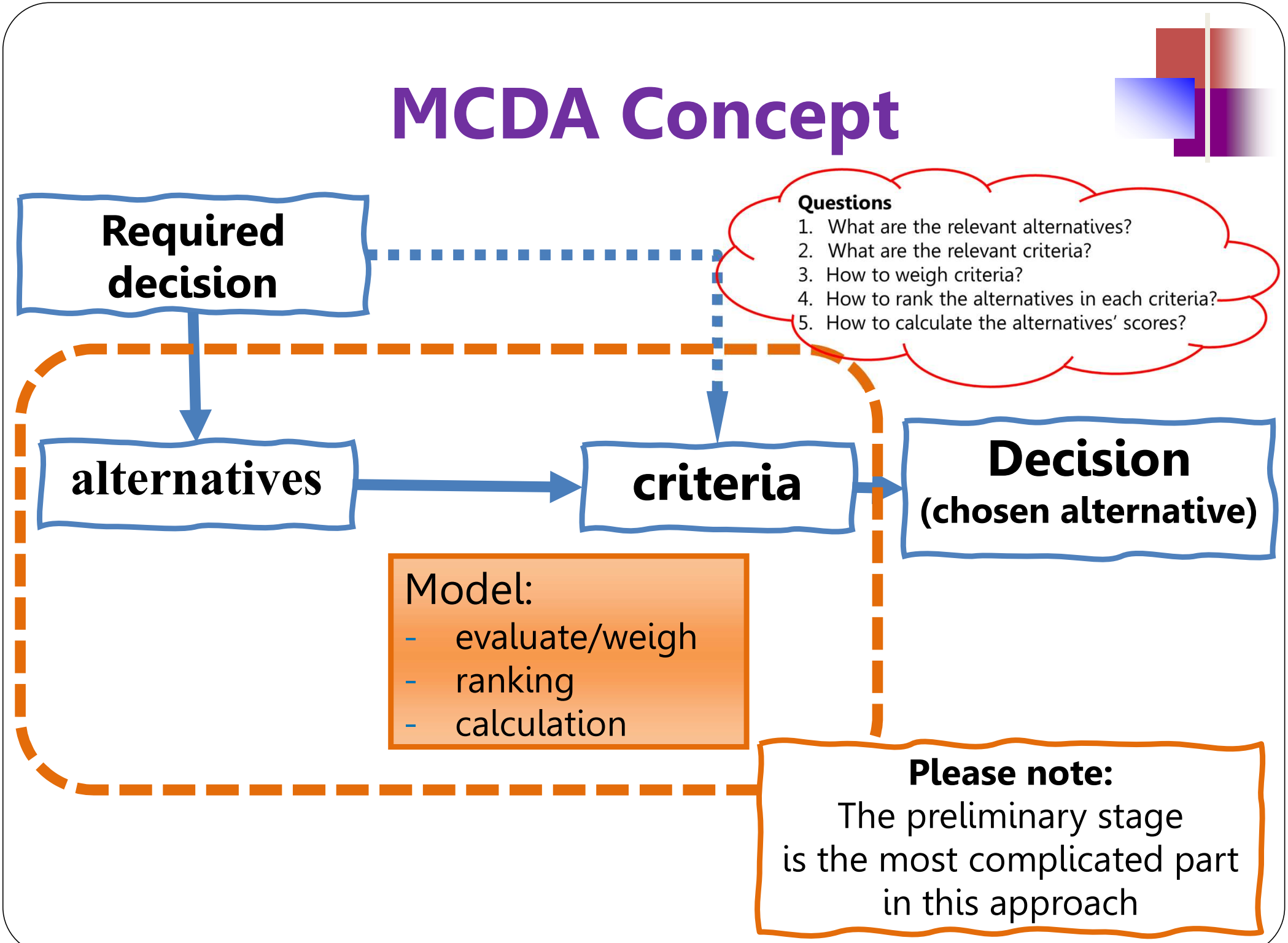
Ideal vs. compromise decision

Objective vs. subjective solution

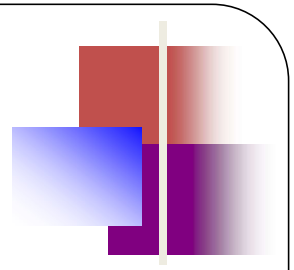
MCDA (or MCDM)

multi-criteria decision analysis (making)

MCDA Concept



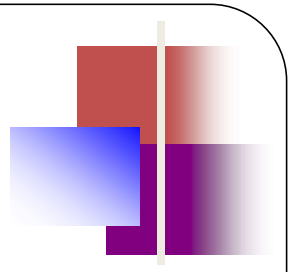
Structure of class



- MCDA – real-world case

  (using statistical data)
- AHP (technique)

  (using subjective preferences)
- Workshop



Using MCDA
for allocating budget of a political campaign

Background (1)

Israeli government system

- A parliamentary democracy with a multi-party system.
- Three branches: legislative, executive, judiciary
- Designed to ensure a separation of powers, accountability, and representation of diverse political viewpoints, including minorities.
- The **legislative** branch is vested in the unicameral parliament, the **Knesset**.

Background (2)

Israeli electoral system

- nationwide proportional representation
- A barrier: threshold requirement: 1%→1.5% → 2% → 3.25%
- State's funding: depends on achievements.

Background (3)

The pre-elections political campaign of a new party

vs.

marketing campaign for a new commercial product

huge efforts = ≠ degree of freedom

Background (4)

	large, established party	small, new party
Has a steady core of loyal voters who always vote for it	✓	✗
can present proof of tangible results to actual and potential constituents	✓	✗
has a steady federal budget to support its activities	✓	✗

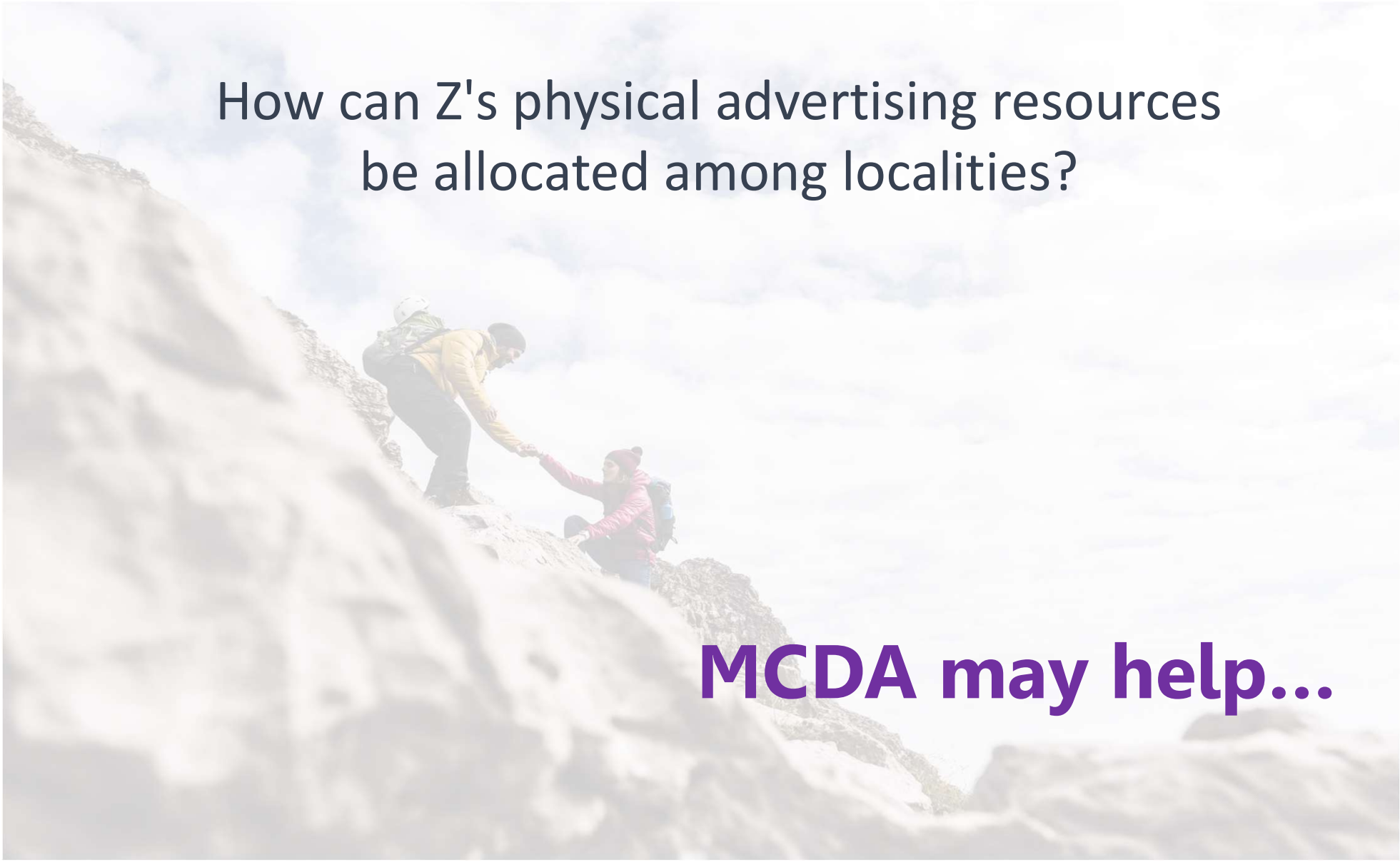
It is critical for a new party's advertising campaign to be precise and targeted.

Achieving this goal is not a simple task...

Frame

- 40 parties competed in Israel's 2019 election
- 29 of them were new
- "Zehut" ("Z") was one of them
- Although "Z" was unknown and resource-poor at the beginning of the campaign,
  its strategic team was determined to maximize the party's achievements in the elections

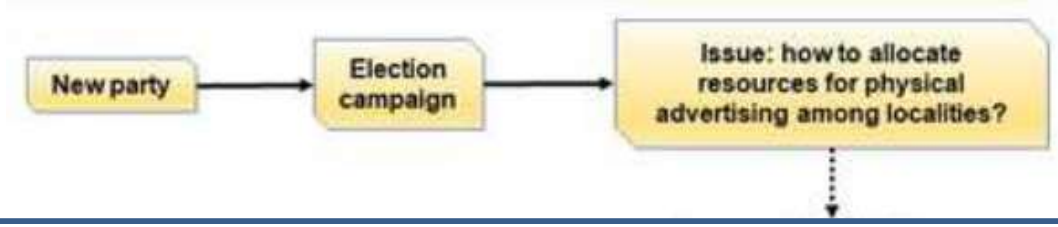
Decision required



How can Z's physical advertising resources be allocated among localities?

MCDA may help…

Steps of the MCDA process



Integrated MCDA Process

Step 1
Filtering localities (Pareto principle)

Step 2
Deciding on the criteria for comparing the localities

confidential Input data

Step 3
Assigning weights to each of the criteria

Public input data

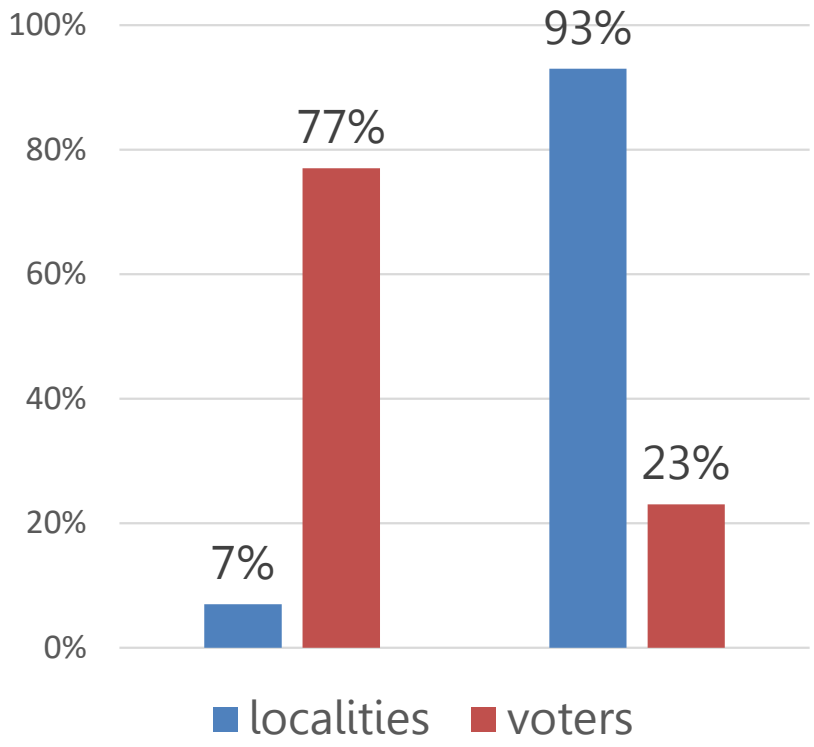
Step 4
Calculating the nominal and normalized scores of these criteria, for each locality.

Step 5
Arriving at a single final score for each locality
To get the ranking list

Step 1

Filtering localities (Pareto principle)

Total	1195	4050K (*)
Number of voters in locality	**No. Of localities**	**Total Number of voters (app.)**
250K<voters	2	520K
100K<voters≤ 250K	6	750K
50K<voters≤ 100K	8	580K
10K<voters≤ 50K	54	1300K
voters≤ 10K	1115	900K



A great opportunity to promote "Z" !

(*) out of 5 million eligible voters

Step 2

Deciding on the criteria for comparing the localities

confidential Input data

- Preliminary research:
  in-depth interviews (1,007 people) and six focus groups

→ Characterizing the potential voters:

- Young
- Educated
- Earn an average income.
- Emigrated from the former Soviet Union

We used these characteristics as criteria in our model

Other attributes were not found to be meaningful in this context

(→ Decisions about the slogans and campaign topics)

Step 3

Assigning weights to each of the criteria

- To avoid biased judgment, we set the weights in two stages:
  - Stage 1: ranking the criteria qualitatively
  - Stage 2: choosing 3 simple and easy to understand weighting techniques according to Barron & Barrett (1996):
    - Equal weights (EW) — 25%, 25%, 25%, 25%
    - Arithmetic sequence weights (ASW) — 40%, 30%, 20%, 10%
    - Rank-order centroid (ROC) — 52%, 27%, 14%, 6%

Barron, F., & Barrett, B. (1996). Decision Quality Using Ranked Attribute Weights. *Management Science*, 42(11):1515-1523.

Step 3

Assigning weights to each of the criteria

- To avoid biased judgment, we set the weights in two stages:
  - Stage 1: ranking the criteria qualitatively
  - Stage 2: choosing 3 simple and easy to understand weighting techniques according to Barron & Barrett (1996):
    - Equal weights (EW)

25%, 25%, 25%, 25%

$$w_j = \frac{1}{N}$$

    - Arithmetic sequence weights (ASW)

40%, 30%, 20%, 10%

$$w_j = \frac{N - j + 1}{\sum_{k=1}^{N} k} = \frac{2(N - j + 1)}{N(N + 1)}$$

    - Rank-order centroid (ROC)

52%, 27%, 14%, 6%

$$w_j = \frac{1}{N} \sum_{k=j}^{N} \frac{1}{k}$$

Barron, F., & Barrett, B. (1996). Decision Quality Using Ranked Attribute Weights. *Management Science*, 42(11):1515-1523.

Step 3

Assigning weights to each of the criteria

#	Criterion	Definition	Equal weights (EW)	Arithmetic sequence weights (ASW)	Rank order centtroid (ROC)
1	Age group	Rate of people ages 20-34 in locality	25%	40%	52%
2	Country of origin	Rate of people in locality who are immigrants from the former Soviet Union	25%	30%	27%
3	Educational level	Rate of highly educated people in locality	25%	20%	15%
4	Income	Gap, in absolute value, between the nationwide average income and locality's average income	25%	10%	6%

Step 4

Public input data

Calculating the nominal and normalized scores of these criteria, for each locality

- Creating nominal score table:
  - CBS → demographic and socioeconomic attributes

הלשכה המרכזית לסטטיסטיקה
Central Bureau of Statistics
دائرة الإحصاء المركزية

- Normalizing scores for each locality j in each criterion i

$$\begin{matrix} normalized\ score \\ of\ the\ i\ \ criterion \\ in\ the\ j\ locality \end{matrix} = \frac{nominal\ score\ of\ locality\ j\ in\ criterion\ i}{maximal\ nominal\ score\ in\ criterion\ i}$$

Step 5

Arriving at a single final score
for each locality
To get the ranking list

We used the classic and popular weighted sum (WS) model:

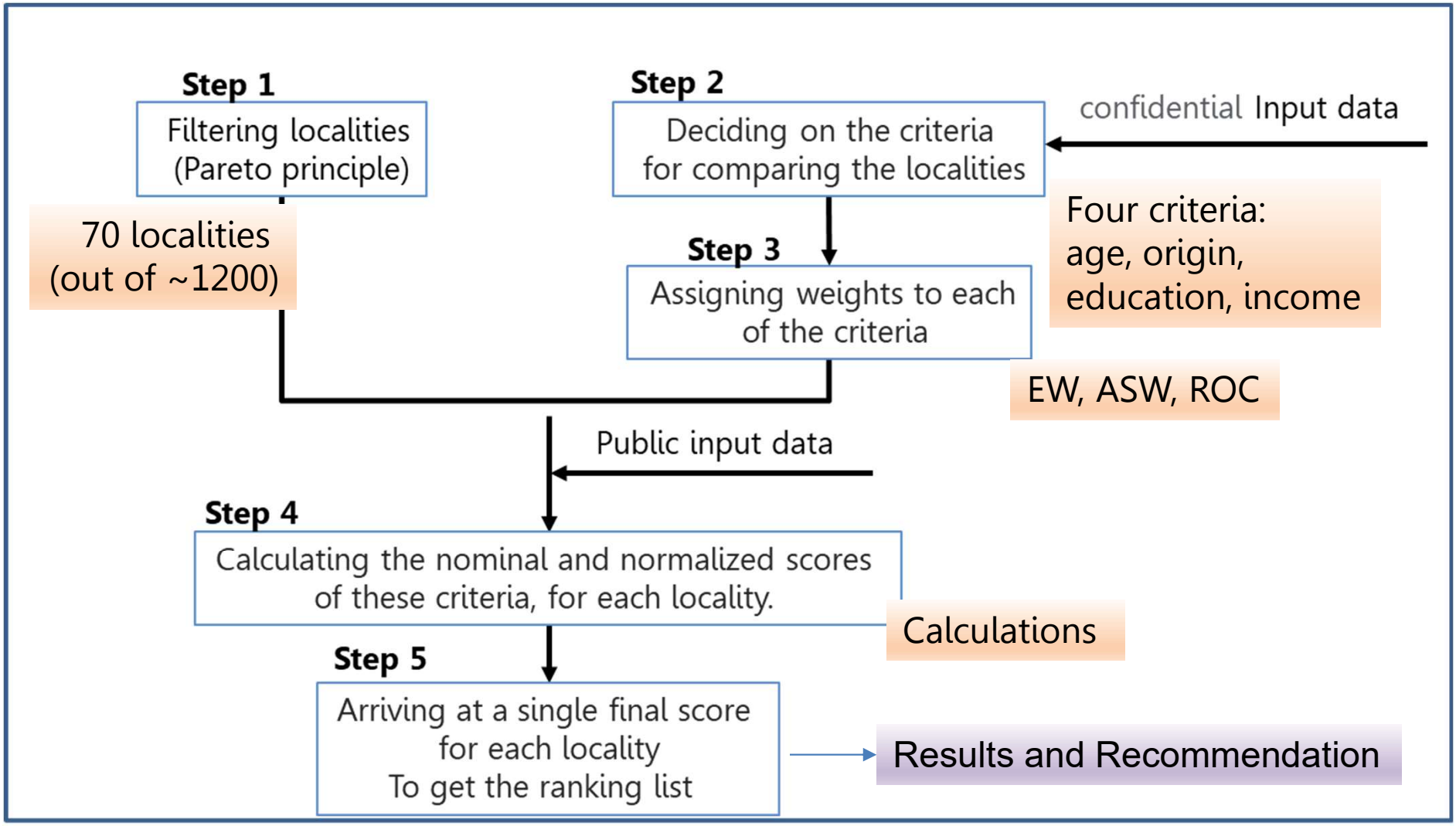
$final\_score\_of\_locality\_j$ = sumproduct(criteria weights, normalized scores)

Example:

locality	Normalized scores				EW	ASW	ROC
	Age group: 20-34 (%)	Country of origin: Former Soviet Union (%)	Higher education (%)	Income			
Tel Aviv-Jaffa	1.00	0.38	0.76	0.81	73.8%	74.8%	77%

EW	25%	25%	25%	25%	$25\% \cdot 1 + 25\% \cdot 0.38 + 25\% \cdot 0.76 + 25\% \cdot 0.81 = 73.8\%$
ASW	40%	30%	20%	10%	$40\% \cdot 1 + 30\% \cdot 0.38 + 20\% \cdot 0.76 + 10\% \cdot 0.81 = 74.8\%$
ROC	52%	27%	15%	6%	$52\% \cdot 1 + 27\% \cdot 0.38 + 15\% \cdot 0.76 + 6\% \cdot 0.81 = 77\%$

The process flow



Results and Recommendation

- **18 localities**
  were ranked in the top15
  of at least one technique
  (12 localities
  were ranked in top15
  of all three techniques)

- Recommendation:
  focus party's efforts
  On these 18 localities
  ("focused list")

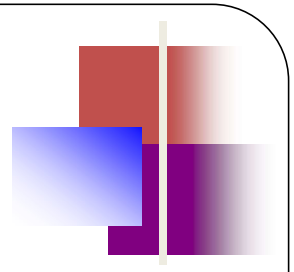
Ariel
Arad
Ashdod
Ashkelon
Bat Yam
Beer Sheva
Carmiel
Eilat
Hadera
Haifa
Kiryat Gat
Kiryat Yam
Maalot-Tarshiha
Nazareth Illit
Nesher
Netanya
Sderot
Tel Aviv-Jaffa

Epilog

- The elections were held on April 9th, 2019.
- None of the 29 new parties that competed won Knesset seats.
- Zehut, that started its campaign with only 0.4% support, ended up with 2.74% of the votes.
- It was close, but not enough. (2nd place in the "losers list")

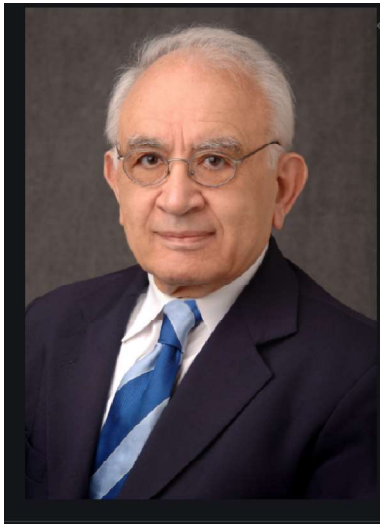
	Sub list (top 70)	Focused list (top 18)
votes percentage ≥ 3.25%	17 (24%)	9 (50%)
votes percentage ≥ 2.74%	45 (64%)	16 (89%)

The model provides a simple, valid tool
for making data-driven decisions about allocating resources
that can be easily updated for future election campaigns



Analytical Hierarchy Process (AHP)

AHP - background



- Developed by Prof. Thomas Saaty
- AHP is a structured and organized technique for making complex multidimensional decisions, based on mathematics and psychology
- It is useful in various fields – government, management, economy, industry…
- Two main reasons for its strength:
  - Transparency and clarity
  - The integration of subjective assessments, including human weaknesses, in the solution process

AHP – technique steps

- Evaluate preference for each pair of criteria (and/or pair of alternatives in each criteria), using a numeric scale ranging from 1 to 9

Degree of preference	**Equal**	**Moderate**	**Strong**	**Very strong**	**extreme**
Numeric value	1	3	5	7	9
Mid values may be chosen: 2, 4, 6, 8					

- Create a pair-preference matrix as follows:
  if criterion i is preferred to criterion j by p,
  then write p in cell (i, j), and $1/p$ in cell (j, i)
  [fill 1 in cells (i, i)]
- Normalize values to calculate weights
- Check inconsistency ratio (CR) – the upper threshold is 10%

Implementation

Steps 1+2: evaluate preferences and create preference matrix

	Age group	Country of origin	Educational level	Income
Age group	1	5	9	7
Country of origin	1/5	1	5	3
Educational level	1/9	1/5	1	1/3
Income	1/7	1/3	3	1

Degree of preference	**Equal**	**Moderate**	**Strong**	**Very strong**	**extreme**
Numeric value	1	3	5	7	9
Mid values may be chosen: 2, 4, 6, 8					

implementation

Steps 3+4: normalize, calculate weights and check consistency

- We can do it ourselves

	Age group	Country of origin	Educational level	Income
Age group	1	5	9	7
Country of origin	1/5	1	5	3
Educational level	1/9	1/5	1	1/3
Income	1/7	1/3	3	1

sum	1.454	6.533	18	11.333

	Age group	Country of origin	Educational level	Income
Age group	0.688	0.765	0.5	0.618
Country of origin	0.138	0.153	0.278	0.265
Educational level	0.076	0.031	0.055	0.029
Income	0.098	0.051	0.167	0.088

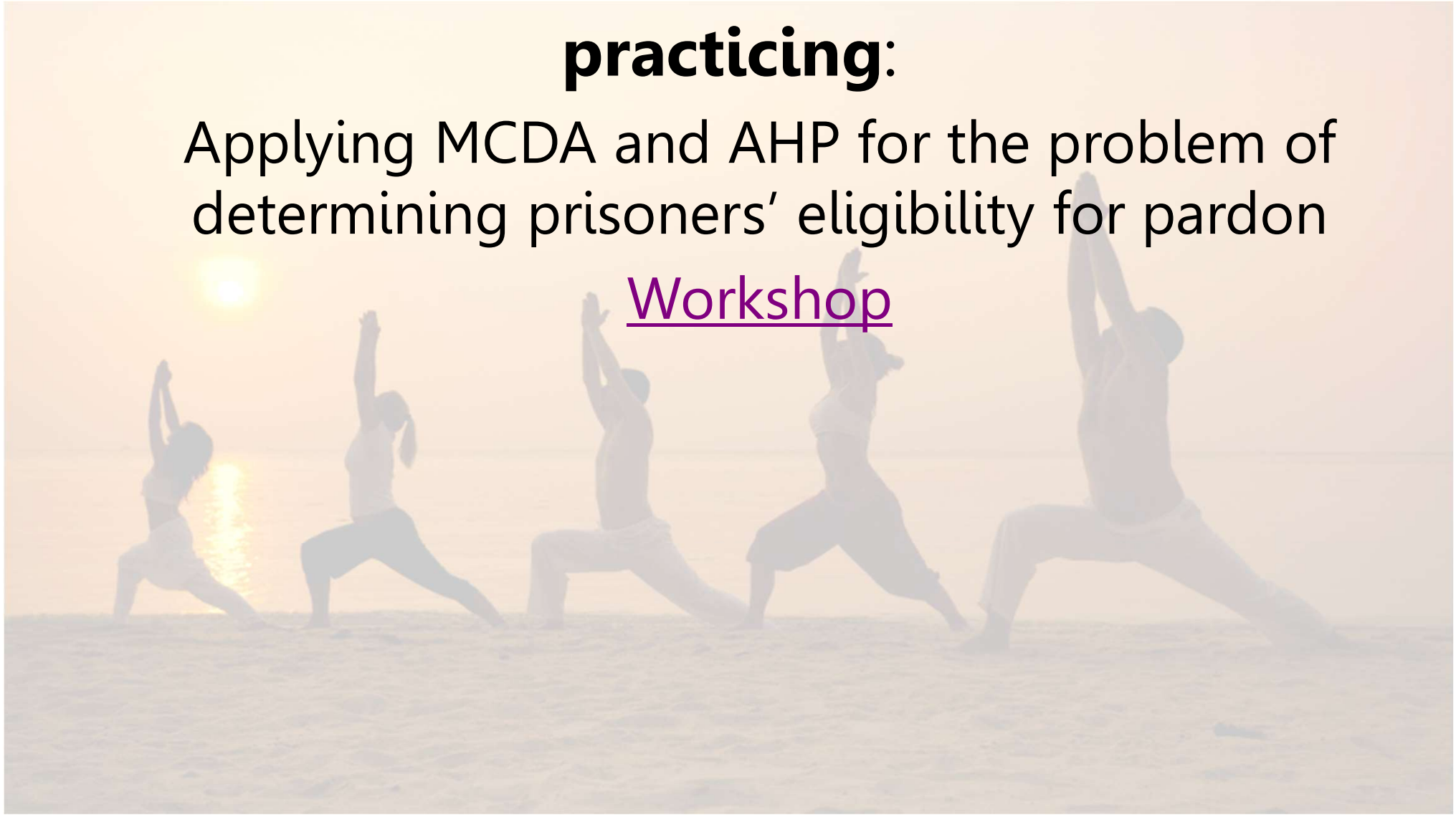
- Or we can use an AHP calculator…

https://bpmsg.com/ahp/ahp-calc.php

Weights!
65%
20.7%
4.8%
9.5%

CR =6.3% ✓

What's next?

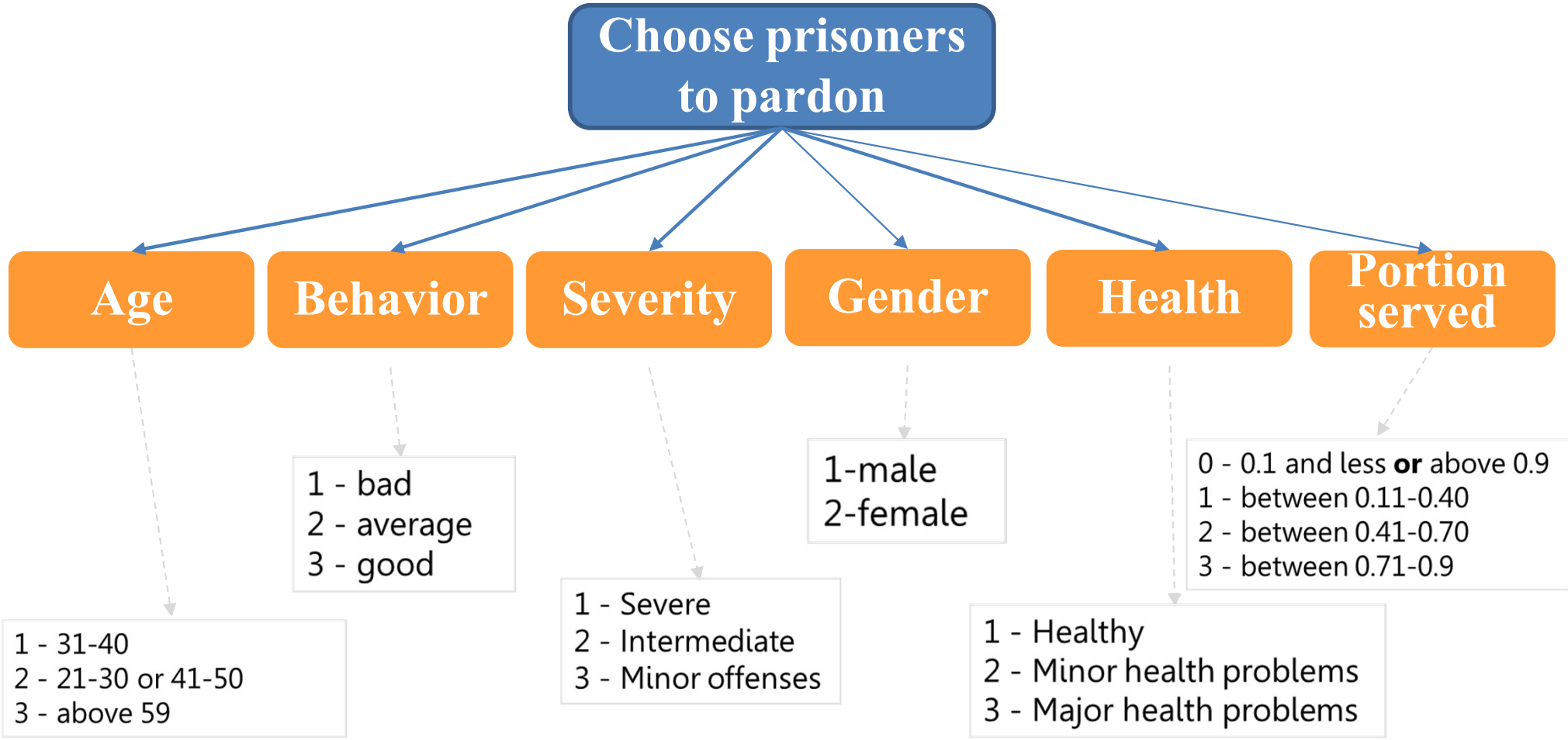


practicing:

Applying MCDA and AHP for the problem of determining prisoners' eligibility for pardon

Workshop

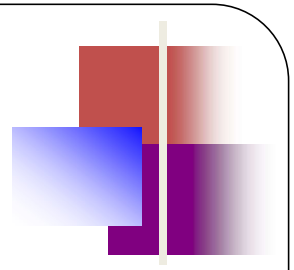
Workshop
Suggestion of a scale



Let's start by determining the weights of the criteria...

... continue with ranking the alternatives in each criterion.

Be aware to normalize the values in each criterion before the final scoring



Self-work

Results

- Let’s check who the lucky prisoners are…

all groups results

summary

- **We saw**:
  - Applying MCDA approach using objective prioritization
  - An implementation of AHP technique

- **You practiced**
  MCDA and AHP for the problem of
  determining prisoners' eligibility for pardon

Operations Research is useful and effective tool

It Can be applied to a wide range of issues and dilemmas

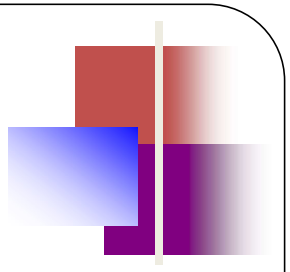
A short survey

The purpose of this survey is to gather feedback on the short course you have just completed. Your input is valuable to me, as it will help me improve and better meet the needs of my students.

Please take a few moments to complete this survey.

Your feedback is greatly appreciated!

https://forms.gle/od15UcAHakyKSdYJ8



Irit Talmor (Ph.D)
Iritt@wgalil.ac.il

Operations Research
Understand → Analyze → Decide!