Resilience Informatics for Innovation

— Collective Decision-Making —

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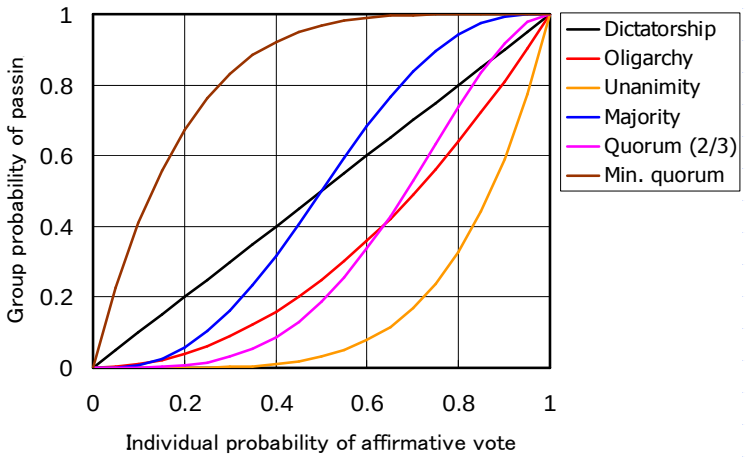
Collective decision-making and voting

- Collective decision-making
  - A group of humans makes a decision following some procedure
- Voting
  - Mapping from individual decisions to a group decision
  - Primary procedure for collective decision in a democratic society
  - Choices and individual decisions are unchangeable during the aggregation process.
  - No social influences are allowed during voting.

Voting schemes

- Dictatorship
  - A particular person overrules the decision.
- Oligarchy
  - The unanimity of a particular subgroup decides.
- Unanimity
  - The unanimity of all members decides.
- Quorum (Majority)
  - More than a particular portion of group decides.
- Minimum quorum (Eureka)
  - At least one affirmative vote decides.

Difference of voting schemes



Voting with multiple choices

- Majority model
  - The candidate that obtained the most votes wins.
- Proportional model
  - The probability of winning is proportional to the number of obtained votes.
- Equiprobability model
  - Random selection from those obtained votes.
- Average model
  - The medium candidate wins among those obtained votes.
- Eureka model
  - At least one correct vote passes.

General form of social decisions

- Social decision scheme by Davis (1973)

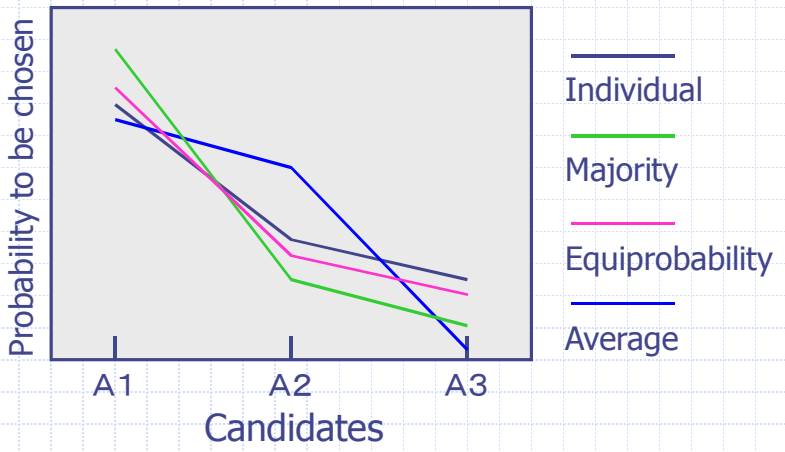
$$[P_1, P_2, \cdots, P_n] = [\pi_1, \pi_2, \cdots, \pi_m] \begin{bmatrix} d_{11} & d_{12} & \cdots & d_{1n} \\ d_{21} & d_{22} & \cdots & d_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ d_{m1} & d_{m2} & \cdots & d_{mn} \end{bmatrix}$$

P_i : Probability that the group chooses Item i

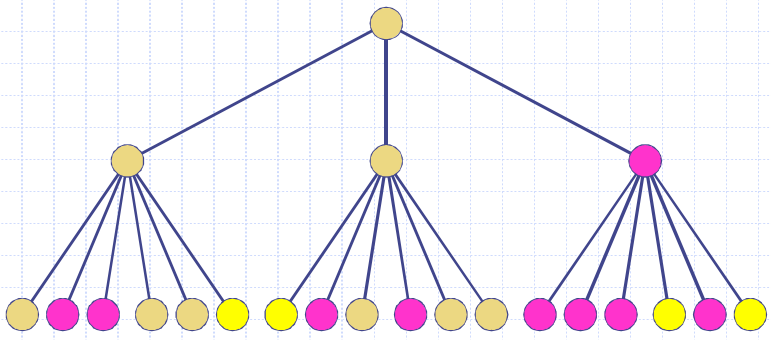
π_j : Probability that Pattern j of member choices obtains

d_{ji} : Conditional probability that the group chooses Item i, when Pattern j of member choices obtains

Preference exaggeration by voting

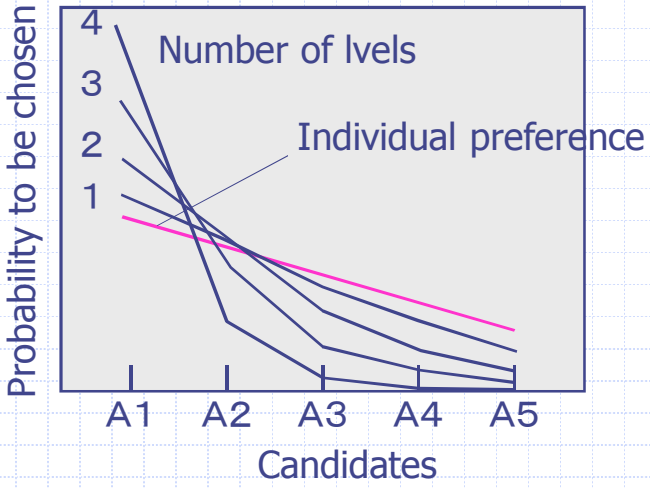


Hierarchical voting (representative)



- The majority at the top may not be so at the bottom (US election in 2000)

Preference exaggeration by hierarchical voting



Various voting systems

- Single voting
- Runoff voting
- Pairwise method (Condorcet method)
  - Every option is compared pairwise one by one at a time, and an option defeated every other is called Comdorcet winner.
- Ranked voting method (Borda method)
  - Following the individual preference, 1st, 2nd, ..., n^{th} option get $n-1$, $n-2$, ..., 0 score. One with the highest score wins.

Paradox of voting

1. x > y > z
2. x > y > z
3. x > y > z
4. y > z > x
5. y > z > x
6. z > y > x
7. z > y > x

- Single
  x > y > z
- Pairwise
  y > z > x
- Single disapproval
  y > z > x

Paradox of voting (2)

1. x > y > z
2. x > y > z
3. x > y > z
4. y > z > x
5. y > z > x
6. y > z > x
7. z > x > y

- Runoff
  x > y > z
- Pairwise
  x > y, y > z, z > x
- Runoff disapproval
  y > z > x

Paradox of voting (3)

	3pt.	2	1	0
1.	x	y	a	b
2.	x	y	a	b
3.	y	a	b	x

Bx = 3+3+0 = 6
By = 2+2+3 = 7
Ba = 1+1+2 = 4
Bb = 0+0+1 = 1

- Ranked
  y > x > a > b
- Single
  x > y > a > b
- Pairwise
  x > y > a > b

Paradox of voting (4)

Party X Bill A > B > C
Party Y Bill B > C > A
Party Z Bill C > A > B

- Vote from Bill A ⇒ Bill B
- Vote from Bill B ⇒ Bill C
- Vote from Bill C ⇒ Bill A

Requirements for democratic decision

- Non-dictatorship
  - A particular person cannot overrule the outcome.
- Transitivity of preference
  - If A > B and B > C, then A > C.
- Pareto efficiency (Unanimity)
  - If A > B for everybody, then A > B should result.
- Universal admissibility
  - Members can freely choose any preference.
- Independence of irrelevant alternatives
  - The social ranking of A and B depends just on member rankings of A and B.

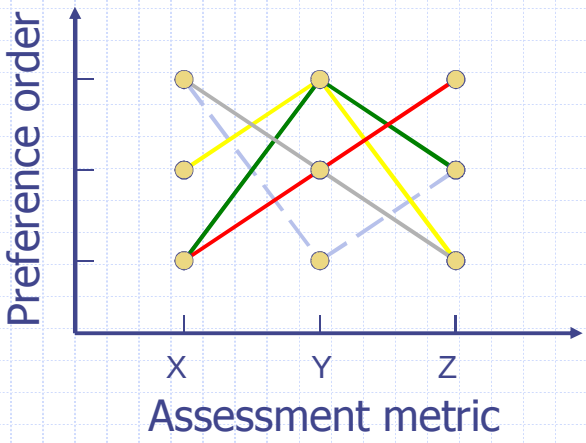
Arrowôs impossibility theorem

- No preference aggregation rules (social welfare functions) exist that satisfy the following criteria.
  - Non-dictatorship
  - Transitivity of preference
  - Pareto efficiency
  - Universal admissibility
  - Independence from irrelevant alternatives

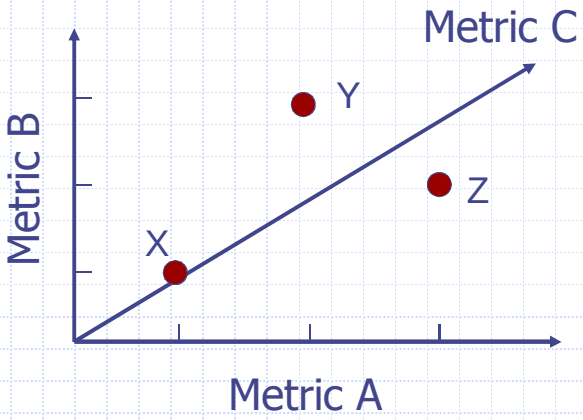
Escape from Arrowôs theorem

- Restriction of preference
  - Prohibit irrational or unfair preference
- Structurization of aggregation process
  - Preparing a binary vote by deliberation
- Relaxing the determinateness of vote
  - Redefining assessment criteria of candidates
  - Introduction of new candidates

Single peaked preference



Redefining assessment criteria



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