Tradeoffs in implementation of SDGs: how to integrate perspectives of different stakeholders?

Method: multi-criteria optimization

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Some challenges in implementing SDGs

SDGs are the globally accepted goals, but will be realized locally.

Diverse stakeholders: e.g., countries, regions, municipalities. Differing in their characteristics, responsibilities, and capabilities to meet them.

At least some coordination (e.g., in timing, allocation of resources) is needed in pursuing potentially conflicting SDGs.

Cooperation:
- fostered / enforced by central authority
- voluntary (no central authority)

How to implement them in a balanced way?

How to promote cooperation among stakeholders?
Outline

• Cooperation in presence of central authority:
  – Central planning and multi-objective optimization
• Voluntary cooperation:
  – Example: climate negotiations
  – Stakeholders and their utilities
  – Approaches to voluntary cooperation: fair allocation methods, bargaining games, Pareto rule
  – In search for fair solutions: back to multi-objective optimization
• Aggregating functions: formalization of notions of fairness
• Mapping the set of fair Pareto-optimal solutions
• Conclusions
SDGs from perspective of central planner

An authority acting as a central planner coordinating implementation of SDGs is immediately confronted with the following questions:

- How to track progress towards each particular SDG in a quantifiable way?
- How to appraise alternative policies of implementation of SDGs?
  - How to assess synergies and tradeoffs between SDGs?
- How to formulate balanced implementation strategies?

If there exist quantitative indicators of progress towards SDGs, it is possible to address these questions using the framework of multi-criteria optimization.
Multi-objective optimization problem

- Let $X$ be the space of all feasible options $x$.
- Let $f_i(x)$ be the $i$-th objective function (e.g., level of realization of the $i$-th SDG if $x$ is to be chosen).

Pareto-optimal solutions:
No possibility to further improve any objective without compromising the other(s).

Pareto-optimal solutions make utmost use of available options. It’s rational to restrict attention only to these solutions. But which solution represents a well balanced policy?
Finding balanced Pareto-optimal solution

Objective 2: SDG 2

- Build suitable **aggregated criterion** \( g(f_1(x), f_2(x)) \) encoding desired balance between objectives
- Rank Pareto-optimal solutions according to the value of the aggregated criterion
- Pick the solution which optimizes this aggregated criterion.

Pareto-optimal solutions

\( g = 1 \)
\( g = 4 \)
\( g = 7 \)
Challenges of voluntary cooperation

- Diverse stakeholders (e.g., countries):
  - Are motivated to cooperate with others by their self-interest (e.g., countries are primarily responsible for wellbeing of their citizens)
  - May invoke certain ethical notions (not necessarily shared by other stakeholders) to make case for their claims and interests.

- No authority able to impose a centrally developed policy or enforce coordination among stakeholders if it runs counter stakeholders’ interest.

- An impartial mediator helping to coordinate stakeholders’ actions may be appointed.

- ASSUMPTION: from now on we assume that stakeholders express their preferences towards outcomes of cooperation with use of their utility functions.
Problem: Climate treaty negotiations

- Nearly 200 countries signed the Paris agreement aiming at holding global warming below 2°C above the pre-industrial level.
- Countries contribute to collective climate action on a voluntary basis.
- Current countries’ pledges are insufficient to meet the 2°C target.
- Distributing the necessary collective mitigation efforts in a way satisfactory to all parties is of paramount importance.
Stylized example: Climate treaty negotiations

• Stylized example based on Barrett (2013). Countries negotiate the distribution of climate change mitigation burdens among them.

• To avoid catastrophic climate change, countries must collectively implement a minimal level of mitigation effort.

• Utility of country $i$ if the climate catastrophe is avoided:

\[
\text{initial wealth}_i + \text{benefits of mitigation}_i - \text{costs of mitigation}_i
\]

• In case of catastrophic climate change, the utility of all countries is zero.

• **Objective:** Distribute the required mitigation efforts in a way agreeable to all countries.
Fair allocation methods

- Assumptions about stakeholders:
  - Rational and concerned primarily with their individual interests
  - Share common social norms (not necessary ethically justifiable).
- Axioms: certain common sense conditions characterizing a desired costs / benefits allocation. These conditions may represent:
  - Social norms (e.g., proportionality, solidarity or no dictatorship)
  - Technical requirements (e.g., consistency, monotonicity).
- Objective: given the stakeholders’ preferences design an allocation rule satisfying the chosen axioms.
- Problems with this approach:
  - Virtually no reference to ethics or distributive justice. Fairness of a solution is a subjective impression of stakeholder.
  - Requirement of commonly accepted social norms.
Bargaining games

• Assumptions about stakeholders:
  – Rational: interested in ensuring profitable cooperation but also in maximizing their share in common gains.
  – No commonly shared social norms.
• Axioms: conditions characterizing the bargaining process and players’ behavior.
• Objective: predict the result of bargaining, i.e. find a strategy which any rationally calculating player would play.
• Problems with this approach:
  – Prediction is not a prescription.
  – Solution simply reflects the balance of bargaining power, and is virtually of no ethical value.
Pareto rule and unanimity

• Assumptions about stakeholders:
  – Rational and concerned primarily with their individual interests.
  – No commonly shared social norms.

• Pareto rule:
  – If all stakeholders are indifferent about two alternatives then the group is indifferent too.
  – If at least one stakeholder prefers \( x \) to \( y \) and all others consider \( x \) to be at least as good as \( y \) then \( x \) is to be selected.

• Pareto rule rules out alternatives which are not unanimously acceptable.
Pareto rule and unanimity (cont.)

Pareto non-dominated solutions: unanimously better than \( x \)

Problems with Pareto rule:
- Unanimity is an extremely conservative approach
- Avoids confronting individual preferences with questions of justice.
- May lead to grossly unfair solutions.

Pareto rule implies that Pareto-optimal solutions (having no unanimously better alternatives) should be pursued, but Pareto rule alone does not ensure cooperation.
Question: Which Pareto-optimal solution is likely to be accepted by all stakeholders?

Answer:
• Chose appealing notion of fairness
• Build suitable **aggregated criterion** $g(u_1, u_2)$ encoding desired notion of fairness
• Rank Pareto-optimal solutions according to the value of the aggregated criterion
• Pick the solution which optimizes this aggregated criterion.
Ethical aspects and mathematical formalism

Ethical aspects of a solution (qualitative)

**Value** to be promoted

- e.g., equity

**Fairness principles**

- e.g., Rawlsian principles of fairness:
  
  Every stakeholder has a right to maximize his utility as long as it is compatible with the alike rights of other stakeholders.
  
  Inequalities in outcome are unjustifiable unless they are more beneficial to worse-off than to better-off individuals.

Mathematical formalism: Aggregating functions (quantitative)

**Aggregating function** encoding the value

- e.g., inequality measure as a formula

**Conditions** imposed on aggregating functions

- e.g., conditions characterizing a fair aggregating function:
  
  Impartiality: Permutation of arguments does not change the function’s value.
  
  Pigou-Dalton condition: Reducing inequalities is preferable and justified, as long as it does not change stakeholders’ order according to their utility levels.
Stylized example: Fair distribution of burdens

Fair solutions lie in this area

Four fair rational aggregating functions (increasing, symmetric, and satisfying Pigou-Dalton condition):

• **Ordered weighted average (OWA)**
  \[ \sum_i w_i u_{(i)}, \quad w_1 > \ldots > w_n > 0, \sum_i w_i = 1 \]
  \( w_i \) and \( u_{(i)} \) are the weight and utility of \( i \)-th worst-off stakeholder

• **Generalized weighted mean (GWM)**
  \[ \left( \sum_i w_i u_i^p \right)^{1/p}, \quad -\infty < p < 1 \]
  Interpretation: Degree of “egalitarianism”
  \( w_i \) and \( u_i \) are the weight and utility of \( i \)-th stakeholder

• **Distance to a reference point** \( u^R \)
  \[ \left( \sum_i |u_i - u_i^R|^p \right)^{1/p}, \quad 1 < p < \infty \]
  Interpretation: Degree of “egalitarianism”
  \( u_i^R \) is the \( i \)-th coordinate of the reference point \( u^R \), \( u_i \) is the utility of \( i \)-th stakeholder

• **Underachievement function**
  \[ \text{mean}(u) - \alpha \times \text{standard deviation}(u) \]
  \( u = (u_1, \ldots, u_n) \), \( u_i \) is the utility of \( i \)-th stakeholder
Stylized example: Preliminary conclusions

- Optimal solutions considered to be fair are confined to a relatively small section of the Pareto front.

- Within fair solutions, the **tradeoff between equity and efficiency is key**.

- Optimizing different types of aggregating functions gives very similar results, close to the set of generic solutions balancing equity and efficiency.

- Hypothesis: fair rational and Pareto optimal solutions can be obtained by optimizing OWA with decreasing weights.
Conclusions

• Multi-objective optimization is helpful in:
  – Designing centrally planned (or coordinated) implementation policies
  – Proposing Pareto-optimal solutions fostering voluntary cooperation

• It is possible to associate mathematical formalism with ethical notions of fairness and justice

• Fairness is the tradeoff between perfect equality (egalitarian solution) and maximal efficiency (utilitarian solution)
Thank you for your attention