Multi-Objective Optimization for Social Cost Benefit Analysis

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1. Introduction

"Imagine a tribe living on a small, forested, island..."

Social cost benefit analysis (CBA) is concerned with appraising the effects on society of potential government investments or projects.

Solutions should be measured in terms of a scalar **net benefit** (in cash terms), but many aspects of solution quality cannot readily be converted to a monetary equivalent.

MCDA should be useful here, but its application has been limited. In our paper, we reflect on our **real-world** experiences supporting CBA processes to identify why MCDA is not being used.

We use the device of **allegory**: a tribe choosing to build a new forge to smelt spears for hunters and scythe heads for gatherers.

2. On Governance

"... surely the thinkers knew nothing about either hunting or gathering?..."

Decision problems are situated in complex organisational and social contexts. Sustained engagement with **stakeholders** is important:

- Solution designers
- Individuals and organisations responsible for benefits delivery
- Budget holders
- Colleagues involved in the wider business case
- Assessors.

3. On Objectives

"... it was essential that the capacity of the hunters to catch and kill animals be included as an objective..."

Benefits maps visually map the flow of cause-and-effect from the **enablers** of a candidate solution, through the intermediate chain of **benefits,** to an organisation's **strategic objectives**.

Objectives are normally benefits towards the right on the map, but:

- Solution designers tend to argue for enablers to be chosen as objectives
- Stakeholders tend to argue for inclusion of any benefits for which they have ownership / responsibility.
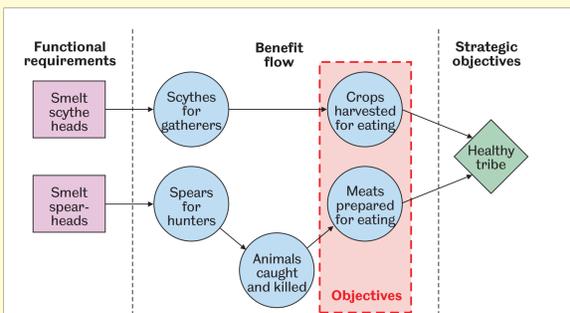
Figure 1: Forge benefits map

4. On Models

"... the thinkers asked the groups to indicate with shells how well the option would support the objectives compared to the current copper forge..."

Ideally we would like to use mathematical models to appraise candidate solutions against the objectives. However, for social CBA, such models are difficult to obtain:

- **Complexity** in the benefits map and associated social systems produces high levels of modelling **uncertainty**
- As analysts, we tend to have **limited resource** for model-building activities.

An alternative is to use **expert opinion** to score each canduate solution against each objective:

- Burden on experts limits scope for optimization
- Meta-modelling of expert opinion may be helpful.

	kill animals	harvest crops	feed tribe	blood sacrifices
no forge	0	0	0	0
no forge (mitigated)	1	1	1	2
scythe-only forge	0	4	2	5
scythe-only forge (mitigated)	1	4	3	6
scythe-and-spear forge	4	4	4	20

Table 1: Benefits and costs for forge options

5. On Preferences

"Tired and unhappy, the hunters and gatherers studied the pattern of twigs and leaves on the ground..."

We need to use **value judgments** to compare Pareto-optimal solutions. In social CBA these should be **societal** preferences

kill animals	harvest crops	feed tribe
1/3	1/3	1/3

Table 2: Swing weights for benefit objectives

- **Weighted-sum** approach is very common
- Elicitation using the **swing weights** method conflicts with regulatory requirements to publish weights in advance of solutions being known
- **Gaming** behaviour by stakeholders is an issue.

Figure 2: Forge options cost-benefit scatter plot

Preferences for benefits are often quantified - to produce a **benefit score** - then the trade-off between benefit score and cost is debated.
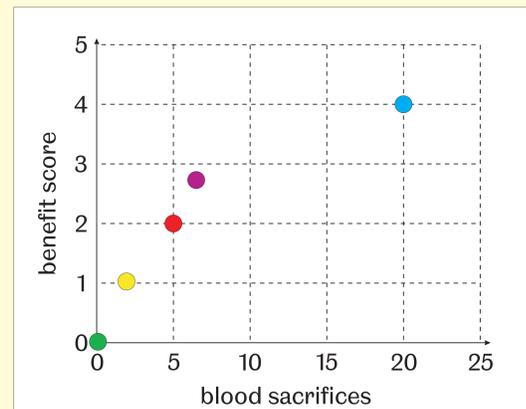
6. Conclusion

"The shaman had a notorious track record in under-estimating the number of blood sacrifices required to appease the gods..."

Government decision-makers are schooled and skilled in **rhetoric** - they are wary of formal analytical methods. To gain the confidence of decision-makers, MCDA must:

- Build more robust **models of social systems**
- Measure **societal preferences** that can resolve trade-offs
- Provide more **practical guidance and case studies** which demonstrate that the approach works well.