



# Multicriteria Decisions in Complex Systems: A Dynamic Single-Agent Behavioural Approach

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# Overview

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- Individual decision making and complex systems
- A simple problem
- An evolutionary framework
- Conclusions and next steps

# Critique of Standard Utility-Based Static MCE Framework

- **Framing** of the problem **shapes** revealed **preferences**.
- **Decision** is not instantaneous but a **process** (time).
  - **Information** base may **change** during decision process.
  - **Preferences** may **change** driven by the attempts to reduce regret and cognitive dissonance.
- **Trade-offs** may be **acceptable or not**.
- Social systems are **complex and reflexive** - **novelty** emerges.
- Alternatives and criteria may be **interdependent**.

# A Simple Problem: House Search

Definition of the problem: Find house or flat to buy

Identification of ...

- Non-compensatory factors for decision- (criteria set 1):
  - metropolitan area of work pl.
  - no or very little traffic noise
  - (access to) garden
  - minimum one bedroom
  - monthly payment  $\leq$  £ 750
  - access to jogging area
  - travel time  $\leq$  20' public tr.
- Compensatory factors for decision (criteria set 2):
  - shops and restaurants nearby
  - efficient heating system
  - double glazing windows
  - modern kitchen
  - brightness of rooms
  - walking distance to train station
  - quality of drinking water etc.




# House Search - Decision process as a dynamic and hierarchical learning process

- (i) Find a set of **"good" alternatives** by applying the most important set of criteria (criteria set 1; **reference point approach**).
- (ii) **Some criteria** will carry a **limit** (e.g. price) and therefore serve from this limit as constraint. Apply **constraints**.
- (iii) Possibly learn that no alternative left; **release** least important constraint – **different type of alternatives** (or new information or new context); possibly other constraints added while others may be dropped. Weights of criteria may change with changing alternatives; **alternatives may increase** for some time instead of decreasing.
- (iv) Eventually a limited number of alternatives are left and **criteria are applied** after constraints are fulfilled (criteria set 2, then criteria set 1; need indifference/preference thresholds).

# Implications

- Important criteria (criteria set 1) applied first; may carry limit.
- Criteria are partly compensatory, but constraints do not allow for compensation between them or with criteria.
- If constraint cannot be fulfilled - released somewhat - possibly new alternatives; or abandon the decision problem at hand.
- Once constraints (or modified versions of initial constraints) fulfilled, less important criteria are applied (criteria set 2).
- Important criteria (criteria set 1) re-applied after constraints fulfilled and criteria set 2 applied.
- Weights, criteria and alternatives may change over time.

# Elements of Evolutionary Multi-Criteria Decision Framework

- Complexity and uncertainty: Focus on decision **process** (learning)
- Co-evolutionary approach:
  - Allow for **irreversibility and novelty**. 
  - Address potentially changing and **interdependent** criteria, weights and alternatives. 
- Hierarchical structuring: Allow for **lexicographic preferences**. 

# Path Dependence & Novelty

## Path-dependence -

- Set of dynamic processes where small events have long lasting consequences; can be modified, but only to a limited extent.
- Trajectory of a path-dependent process cannot be fully anticipated on basis of original events.
- Overlapping of irreversibility, indivisibility and structural action.
- Effects of past behaviour of agents on the structure of the environment and the Lamarckian survival of agents by learning and adaptation to the character of the environment.

Novelty may appear. Allow for expansion of decision space.



# Lexicographic Preferences

- Introduced by Carl Menger; concept of needs.
- In economic terms - elasticity of substitution between the two types of needs is zero.
- In multi-criteria terminology - the degree of compensability between the first and the second criteria set is zero.



# Interdependence

- Criteria, weights and alternatives are interdependent; there are complex feedback mechanisms between their variation and selection environment.
- If humans compare each action not only with the ideal/goal but also among themselves, this requires a new algorithm, e.g. re-compute the distances of all the remaining alternatives each time one is removed from the set of feasible actions.



# Conclusions

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Three main findings:

- (1) A hierarchical decision process with constraints applied before criteria, identified most suitable; repercussions on the role and characteristics of criteria and weights.
- (2) Elements of multi-criteria processes (criteria, weights, alternatives) were found interdependent; path-dependence; novelty, decision space can increase.
- (3) Evolutionary framework found more empirically founded and better applicable than standard framework.

Next steps