Aalto University
School of Science

Path Dependence in Operational Research

How the Modeling Process Can Influence the Results

Tuomas J. Lahtinen, Raimo P. Hämäläinen
tuomas.j.lahtinen@aalto.fi, raimo.hamalainen@aalto.fi
Systems Analysis Laboratory, Department of Mathematics and Systems Analysis

EURO 2016, Poznan, 4.7.2016

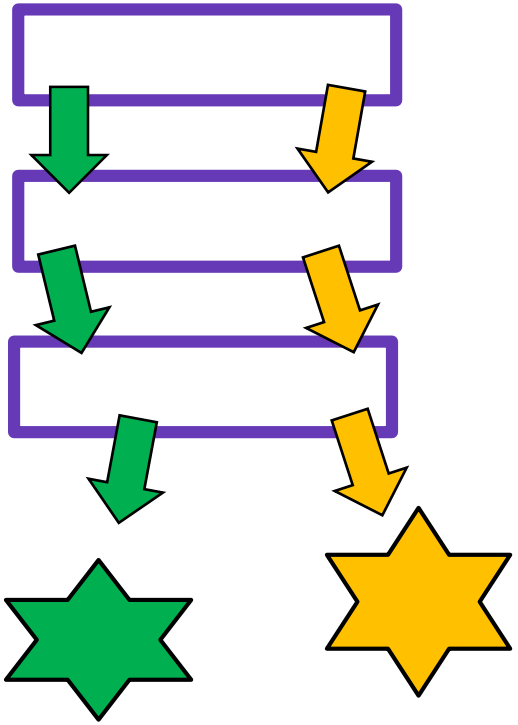
Systems Analysis Laboratory

A modelling process can be realized in different ways

Process descriptions and **best practices** provide instructions to be followed in modelling

The literature has not discussed that

a given process can be realized in different ways



Following a

best practice procedure does not guarantee a desired outcome

Path is a new and needed concept!

It refers to:

- the actual sequence of steps taken

in a modelling effort

- the trajectory of the problem solving process

formed by the interaction of

actors, praxis, methods and context

A key perspective in Behavioural Operational Research

(Hämäläinen et al. 2013, Franco and Hämäläinen 2016a, 2016b)

The steps where behavioral phenomena occur

are not isolated

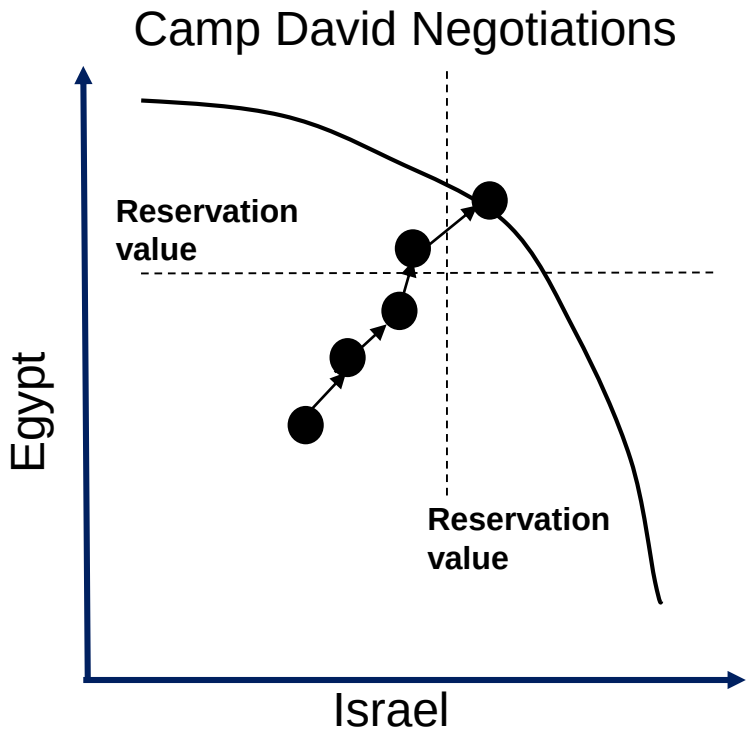
Idea of paths discussed in multi-criteria methods

Raiffa (1982)

- Starting point matters in negotiation processes

French (1984)

- Anchoring to initial point in multi-criteria optimization



Korhonen, Moskowitz, Wallenius (1990)

- Reference points matter in multi-criteria optimization due to loss aversion

The whole modelling process creates a path

Forks where choices can strongly influence the path

- Who are included in the problem solving team?
- How is the problem framed?
- Which modelling approach is chosen?
- How the problem is decomposed into parts?
- How are data and preferences collected?
- How does the communication take place?
- ...

Path dependence:

Outcome depends on the path followed

Origins and drivers of path dependence in OR

- System
- Learning
- Procedure
- Behavior
- Motivation
- Uncertainty
- External environment

Can interact and occur together

Hämäläinen and Lahtinen (2016): Path Dependence in Operational Research - How the Modeling Process Can Influence the Results *Operations Research Perspectives, Vol. 3, pp. 14-20*.

Phenomena related to path dependence

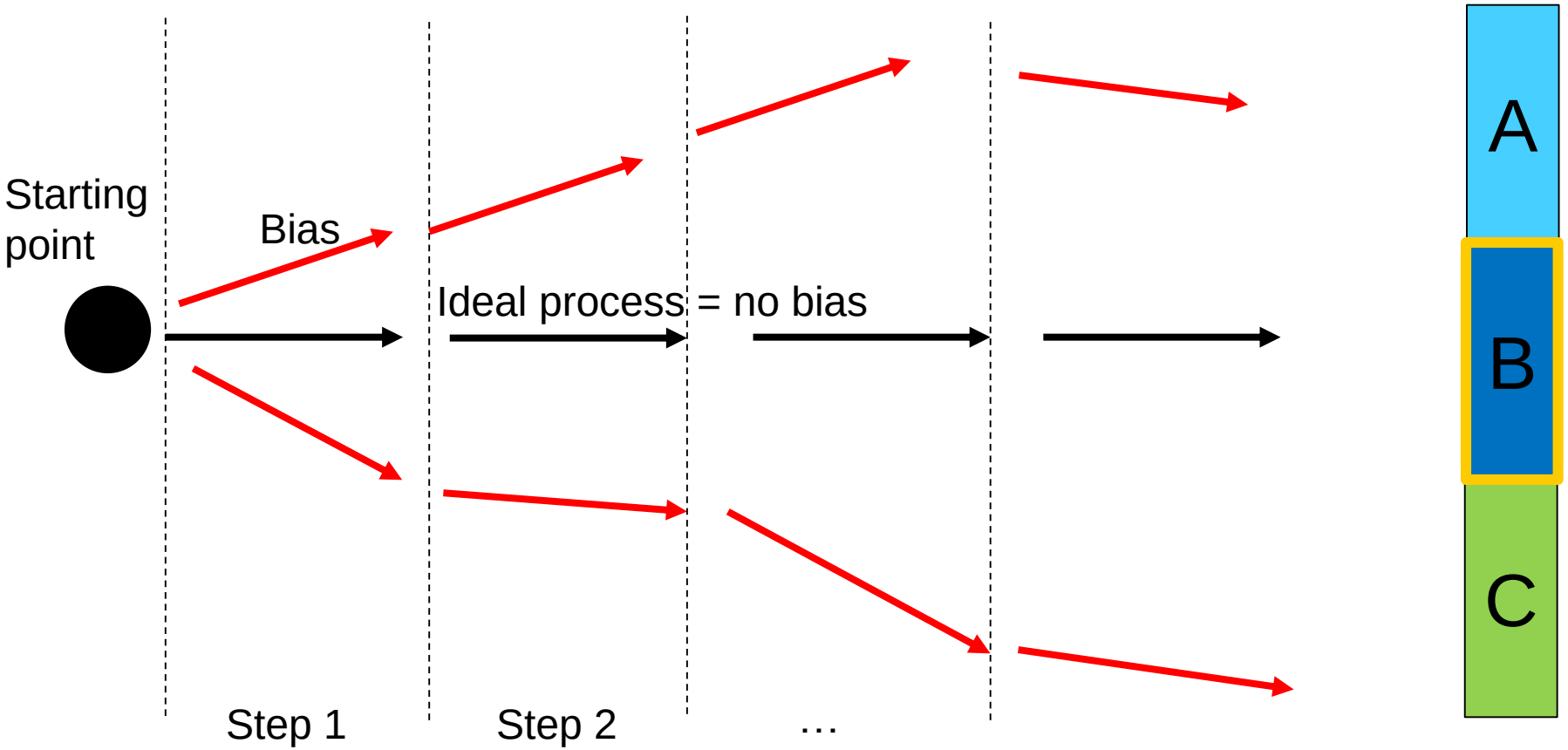
One can take a path which seems good but leads to an inferior outcome

One can get stuck with the initial solution path

Early steps and framing can be critical

Biases and errors can accumulate (or cancel out)
Their overall effect matters!

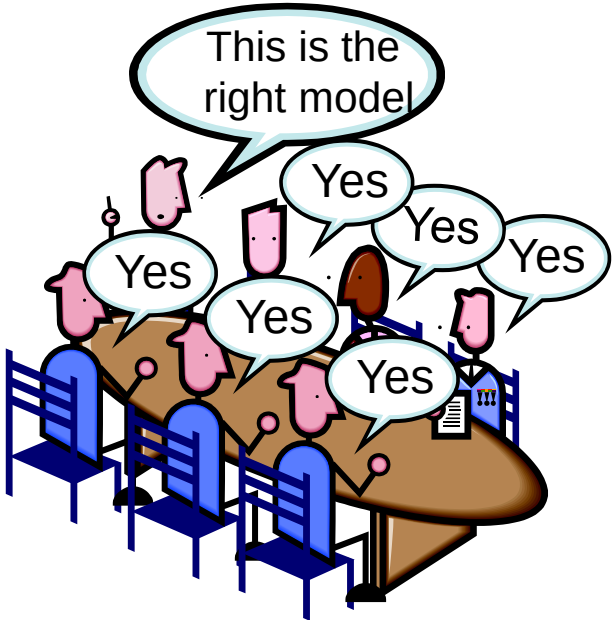
Accumulation of bias along the process



Getting stuck with one approach

- Man with a hammer syndrome
- Anchoring to initial thoughts
- Groupthink

  Cohesive group of modellers can endorse their solution without critical evaluation of alternatives
- Wishful thinking
- Confirmation bias
- Sunk cost effect



Awareness of path dependence

Challenges the modeling team to reflect on

The critical forks on the modelling path such as

- Who are included in the problem solving team?
- How data is collected?

What drives the team's behavior and choices?

Are we stuck with an inferior approach?

- Do we need to backtrack steps, or restart?

Procedures for coping with path dependence

- More than one problem solving process
- Adaptive problem solving
- Debiasing

More than one problem solving process

Multiple independent teams solving the same problem

- To consider alternative problem formulations and model structures

Devil's advocate team?

- To find and challenge crucial assumptions by primary team
- To perform worst case analyses

Adaptive problem solving

The desired path can change when we learn more

In policy problems there often is

- Incomplete information and uncertainty about the problem
- Changes in the problem environment

Decide checkpoints where process can be revised

- Take into account learning, intermediate results, new data

Debiasing

Reduce effects of cognitive biases in preference elicitation and expert judgment

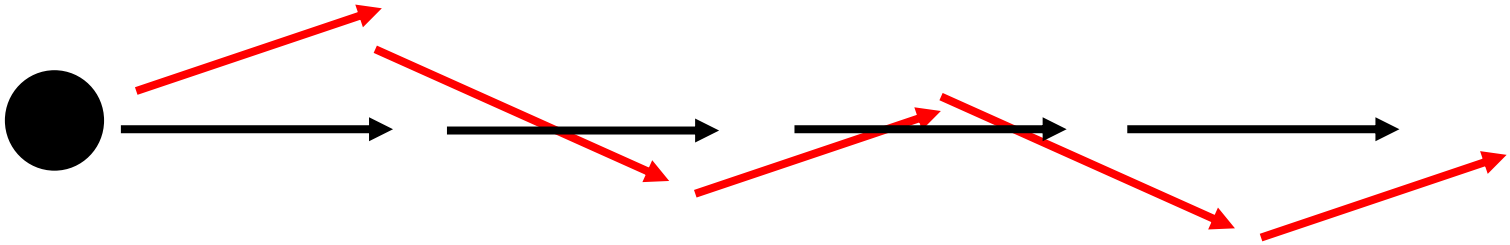
Approaches suggested in the literature:

- Reframe questions, train decision makers, calibrate judgments (see, e.g. Montibeller, von Winterfeldt 2015)

Lahtinen, Hämäläinen (2016):

- Design elicitation process so that effects of biases cancel out
- **Possible only if the mechanism of bias is well understood**

Effects of biases can cancel out



Example of such procedures

- Even Swaps: Lahtinen, Hämäläinen (2016)
- Trade-off weighting: Anderson, Hobbs (2002)

Not always necessary to debias individual judgments

The path can be intentionally directed to support learning

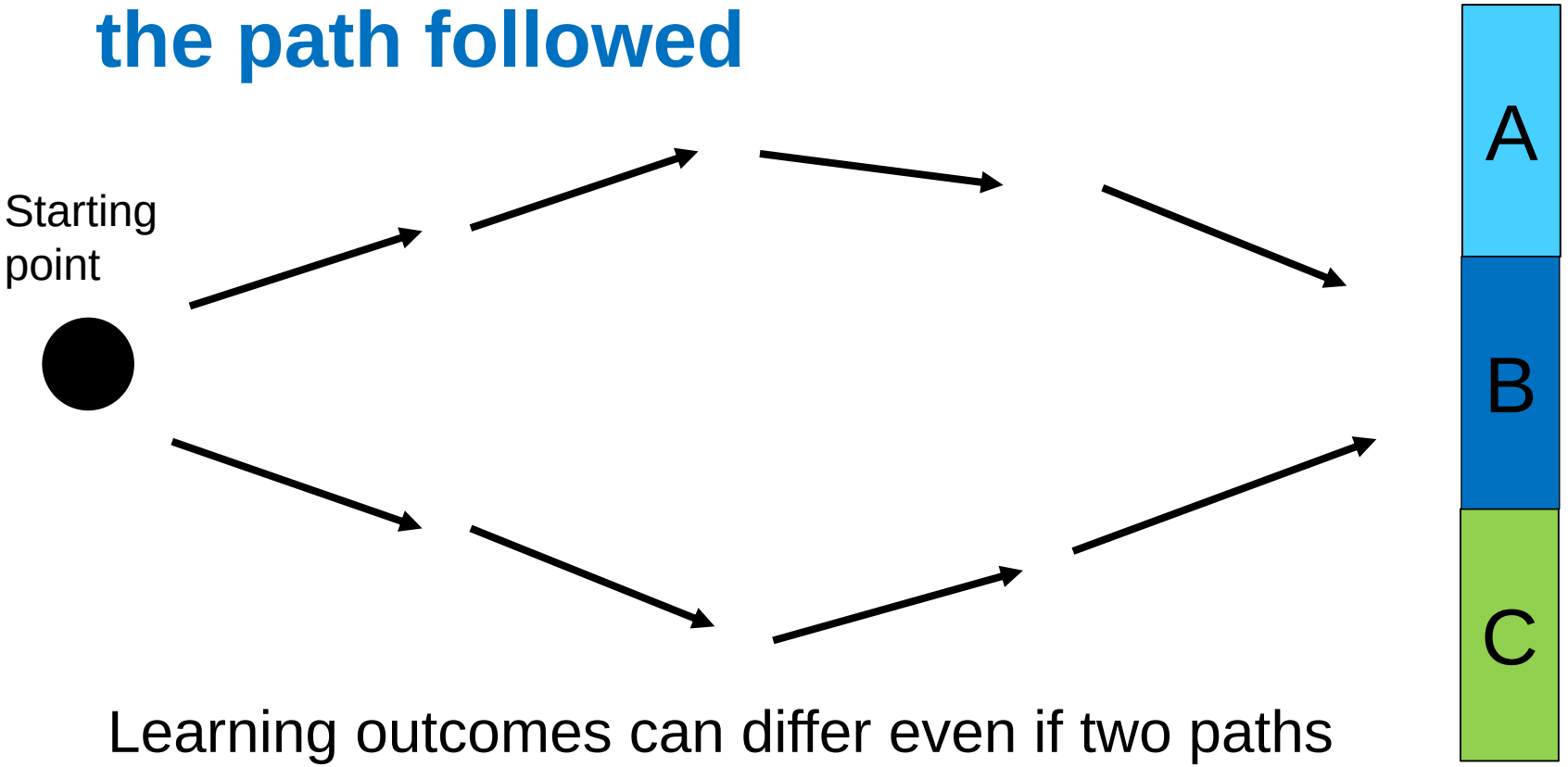
What happens if we take a different starting point?

How our view about the problem changes if we use another model?

Backcasting (Robinson 1982)

Working backwards from an envisioned outcome to figure how that outcome can be reached

Learning outcomes can also depend on the path followed



Learning outcomes can differ even if two paths have the same starting point and the same result

Conclusions

The term path captures a relevant concept in OR –

the actual realization of the modelling process

Path dependence is a real phenomenon

Originates from: Human interaction with the methods, problem, and the context

Challenges us to reflect on the forks ahead, and the path taken

Important in prescriptive decision support for major policy problems such as climate policy

Presentation based on the following papers and references therein

Lahtinen TJ, Hämäläinen RP (2016)
Path dependence and biases in the even swaps decision analysis method,
European Journal of Operational Research, special issue on Behavioural OR.

Hämäläinen RP, Lahtinen TJ (2016)
Path Dependence in Operational Research – How the Modeling Process Can Influence the Results, Operations Research Perspectives.

Available at http://sal.aalto.fi/publications/

References that are not included in the path dependence papers by Hämäläinen and Lahtinen

- Franco L.A., Hämäläinen R.P., 2016a. Behavioural operational research: Returning to the roots of the OR profession. European Journal of Operational Research, Vol. 249, Issue 3, pp 791-795.
- Franco L.A., Hämäläinen R.P., 2016b. Engaging with behavioural OR: On methods, actors, and praxis. Behavioural operational research: Theory, methodology and practice. Palgrave.
- Robinson, J. B. 1982. Energy backcasting: A proposed method of policy analysis. Energy policy Vol. 10, Issue 4, pp 337-344.

Some OR professionals recognized the idea of path dependence already early

Morris (1967)

- Discusses **the process of model development**

Little (1970)

- **Model needs to be adjustable** in case we learn more about the problem

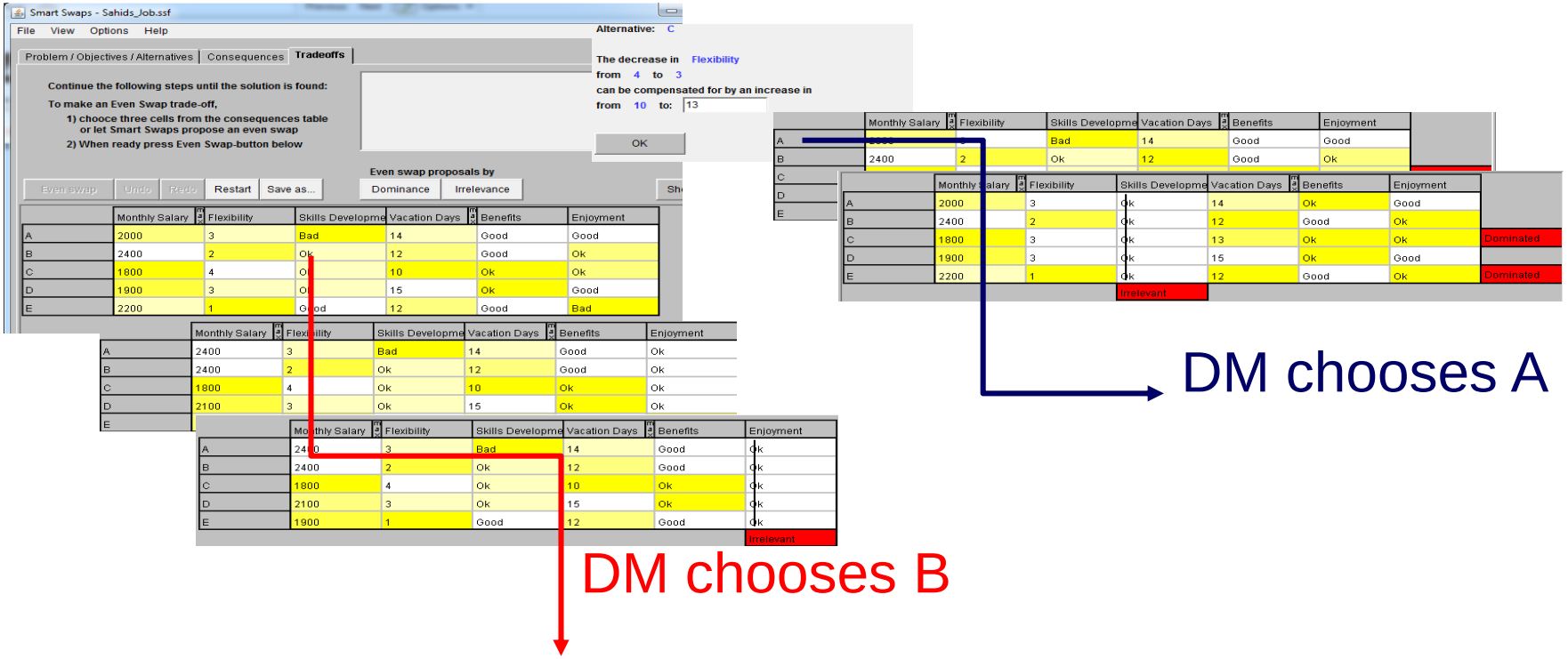
Landry et al. (1983)

- **Multiple ”valid” models** with different outcomes can be built **for the same problem**

Accumulation of bias in the Even Swaps process

Lahtinen and Hämäläinen (2016):

Accumulation of loss aversion and scale compatibility biases creates path dependence in Even Swaps



Example of cancelling out bias

Assume

- ”Real weights” are $W_1 = W_2 = W_3$
- Thus $\frac{W_1}{W_2}$ should be 1
- But… measuring stick bias doubles weight in trade-off assessment: $\frac{W_1}{W_2} = 2$

Elicitation 1:

$\frac{W_1}{W_2} = 2, \frac{W_2}{W_3} = 2$ => Derive weight ratios 4 : 2 : 1

Example of cancelling out bias

Assume

- ”Real weights” are $W_1 = W_2 = W_3$
- But… measuring stick effect doubles weight in trade-off assessment: $\frac{W_1}{W_2} = 2$

Elicitation 1:

$\frac{W_1}{W_2} = 2, \frac{W_2}{W_3} = 2$ => Derive weight ratios 4 : 2 : 1

Elicitation 2:

$\frac{W_1}{W_2} = 2, \frac{W_2}{W_3} = 2, \frac{W_3}{W_1} = 2$ => Estimate weight ratios 1 : 1 : 1