

VERIFYING AND VALIDATING SOCIAL SIMULATIONS

FRANK DIGNUM



UMEÅ UNIVERSITY



Universiteit Utrecht

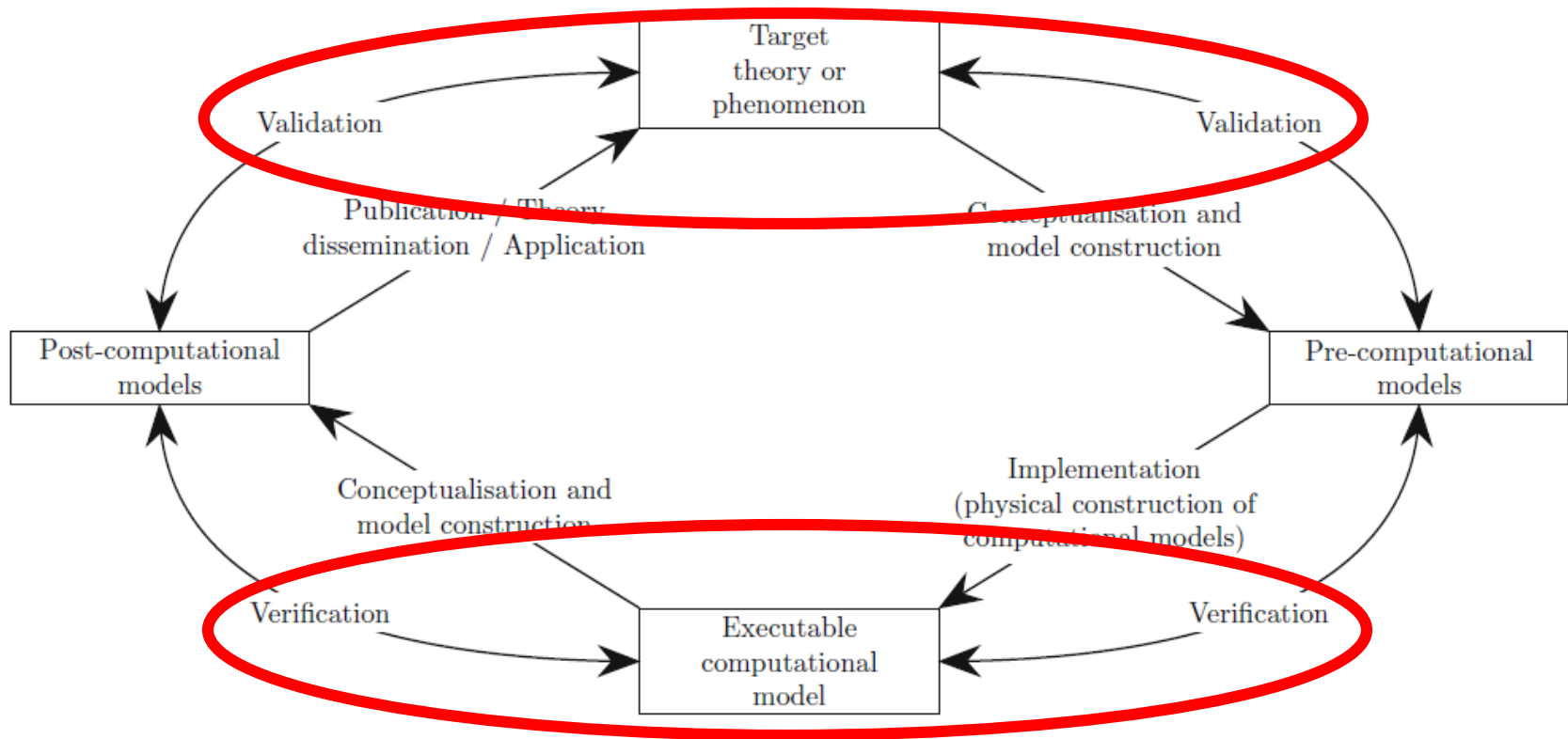


Definitions

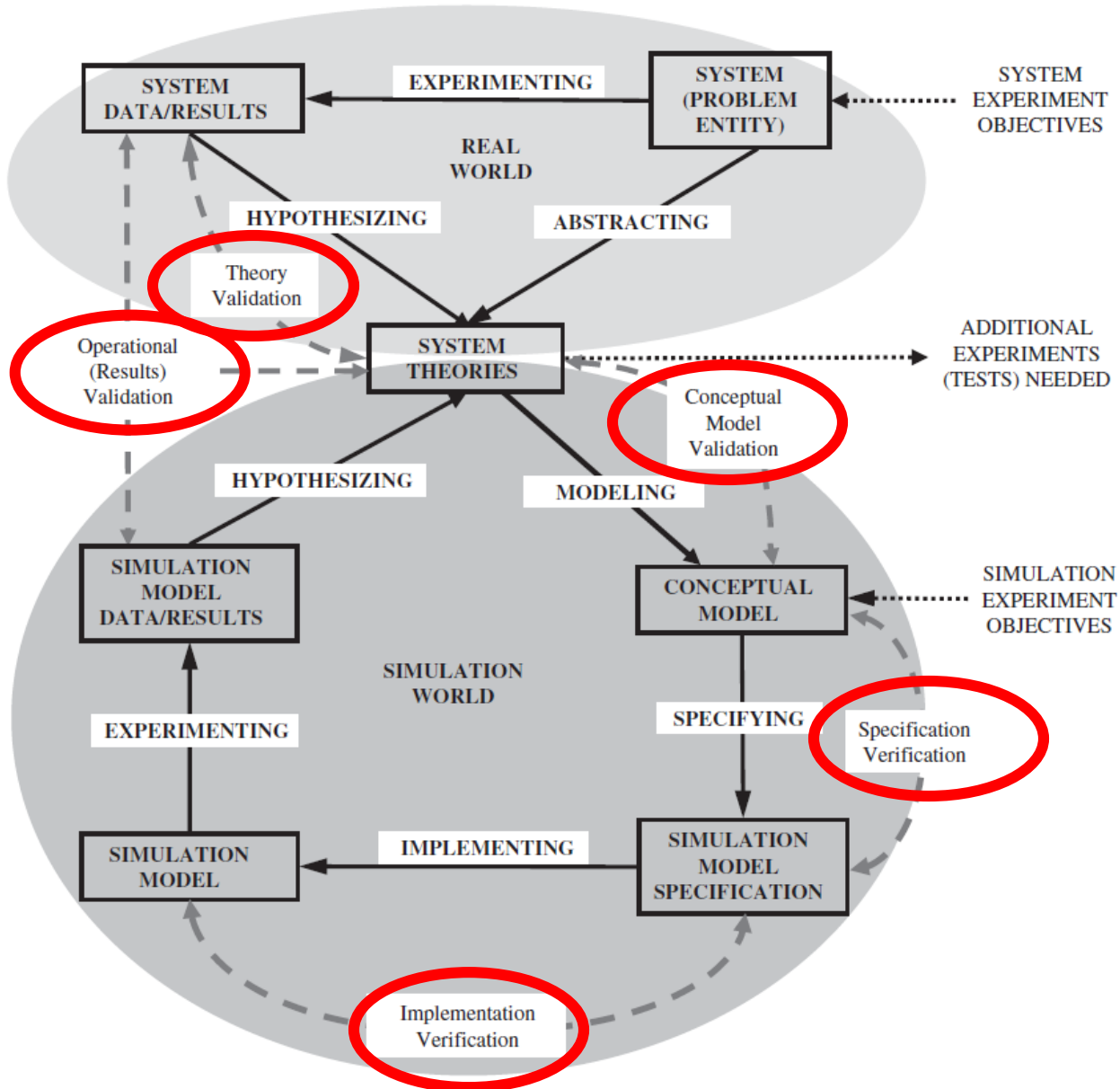
Verification: Are we building the simulation right?

Validation: Are we building the right simulation?

Verification and Validation



Verification and Validation



Verification

- a) **Hardly ever possible with simulations** For some pre-computational model definable as a set of input/output pairs *in a specified parameter range*, the corresponding executable model is *verified for the range considered* if the corresponding post-computational model expresses the same set of inputs/outputs for the range considered.
- b) For some pre-computational model defined according to the researcher and/or stakeholders' intentions *in a specified parameter range*, the corresponding executable model is *verified for the range considered* if the corresponding postcomputational model meets the researchers and/or stakeholders' expectations for the range considered.

How to Verify a simulation

- a) Formal software development methodology:
 - Ensures that implementation follows specification

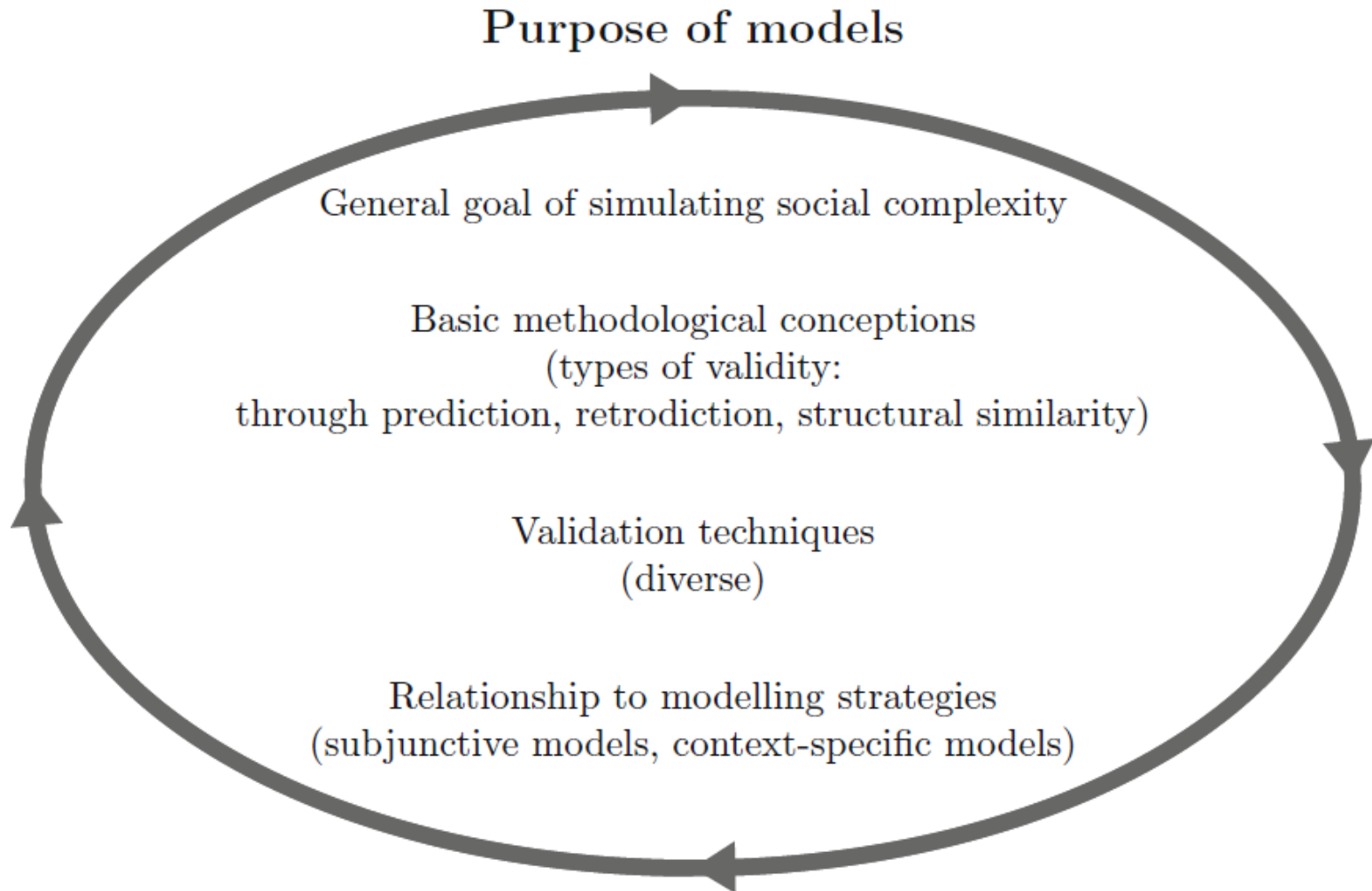
- b) Traces
 - Follow a specific variable or agent through the simulation

- c) Structured walk through
 - Use an expert to go through the simulation step by step to see whether it works as expected

Validation

Software validation checks that the software product satisfies or fits the intended use (high-level checking), i.e., the software meets the user requirements, not as specification artifacts or as needs of those who will operate the software only; but, as the needs of all the stakeholders (such as users, operators, administrators, managers, investors, etc.). There are two ways to perform software validation: internal and external. During internal software validation, it is assumed that the goals of the stakeholders were correctly understood and that they were expressed in the requirement artifacts precise and comprehensively. If the software meets the requirement specification, it has been internally validated. External validation happens when it is performed by asking the stakeholders if the software meets their needs. Different software development methodologies call for different levels of user and stakeholder involvement and feedback; so, external validation can be a discrete or a continuous event. Successful final external validation occurs when all the stakeholders accept the software product and express that it satisfies their needs. Such final external validation requires the use of an [acceptance test](#) which is a [dynamic test](#).

Validation is related to model purposes



Validation is related to model purposes

1. Prediction →

simulation generates the **right** result given some input

2. Explanation →

an **acceptable** explanation is obtained from the simulation for the phenomena generated

3. Theory exposition →

a structural or mechanical **similarity** exists between the theory and simulation

4. Illustration →

the simulation shows a **clear picture** of the phenomena investigated

5. Analogy →

an **equivalent** mechanism is observed in the simulation as in reality or other model

6. Description →

the simulation generates the required emergent phenomena in **sufficient** detail and accuracy

Purpose of Validation

The purpose of validation is to assess whether the design of micro-level mechanisms, put forward as theories of social complexity validated to arbitrary levels, can be demonstrated to represent aspects of social behaviour and interaction that are able to produce macro-level effects either

- (i) broadly consistent with the subjacent theories; and/or
- (ii) qualitatively or quantitatively similar to real data.

Types of Validity

1. Predictive

2. Retrodictive

3. Structural similarity

Predictive Validity problematic in simulations

- Models of social complexity usually show nonlinear effects in which the global behaviour of the model can become path-dependent and self-reinforcing, producing high sensitivity to initial conditions, which limits the use of predictive approaches.
- Many social systems show high volatility with unpredictable events, such as turning points of macroeconomic trade cycles or of financial markets that are in practice (and possibly in principle) impossible to predict.
- Many social systems are not amenable to direct observation, change too slowly, and/or do not provide enough data to be able to compare model outcomes. Most involve human beings and are too valuable to allow repeated intervention, which hinders the acquisition of knowledge about its future behaviour. Policies based on false predictions could have serious consequences, thus making the purpose of prediction unusable.
- What simulations are useful to predict is only how a target system might behave in the future qualitatively. Prediction does **NOT** validate the **mechanism** with which this accomplished!

Retrodictive Validity in simulations

Underdetermination: Given a model able to explain a certain record of behaviours or historical data, there will always be a different model yielding a different explanation for the same record.

Insufficient quality of data: In many cases it is impossible to obtain long historical series of social facts in the target system. In the social sciences the very notion of social facts or data is controversial, can be subjective, and is not dissociable from effects introduced by the measurement process. Moreover, even when data is available it may not be in a form suitable to be matched to the bulk of data generated by simulation models.

Validity through structural similarity

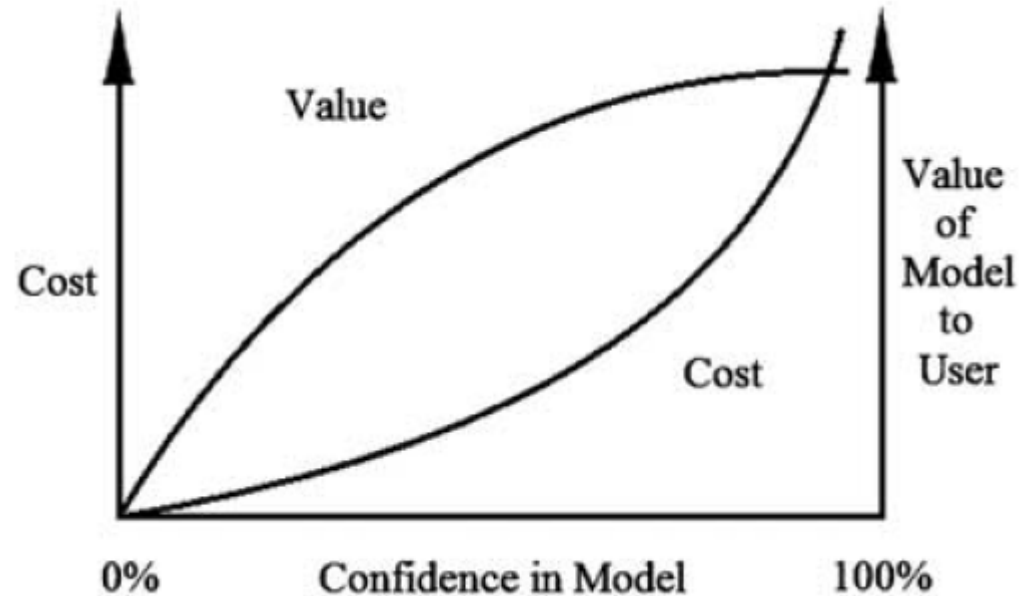
- **Micro-level similarity**
- **Macro-level similarity**
- **Aspect similarity**
- **Process similarity**
- **Mechanism similarity**
- ...

Validation techniques

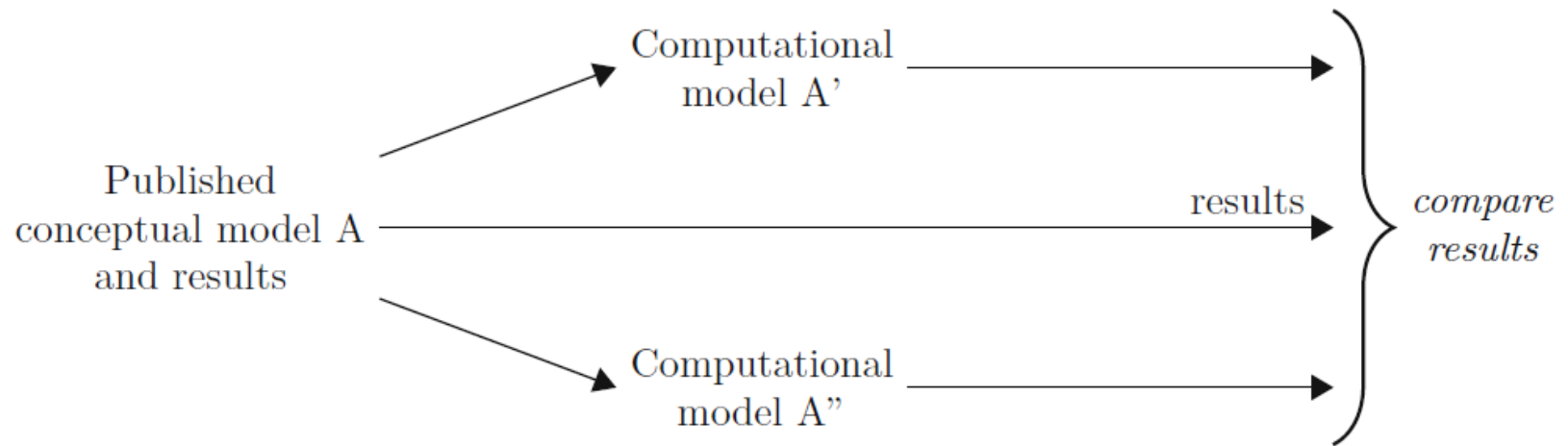
- **Face validity**
- **Turing test**
- **Historical validity**
- **Event validity**
- **Validity of simulation output**
- **Solution Space Exploration**
- **Participatory Approaches for Validation**

Solution Space Exploration

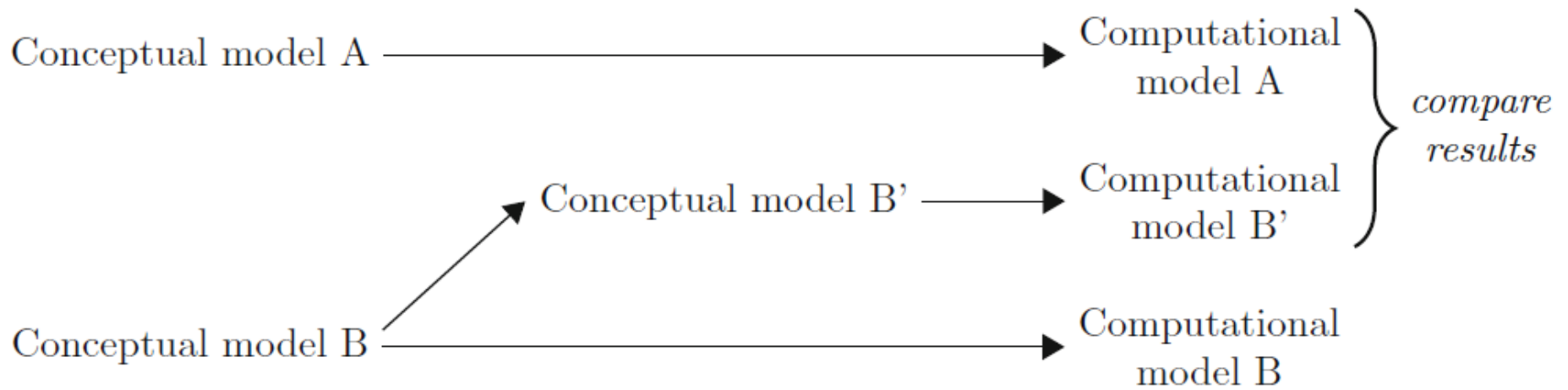
- Optimization
- Calibration
- Uncertainty analysis
- Sensitivity analysis



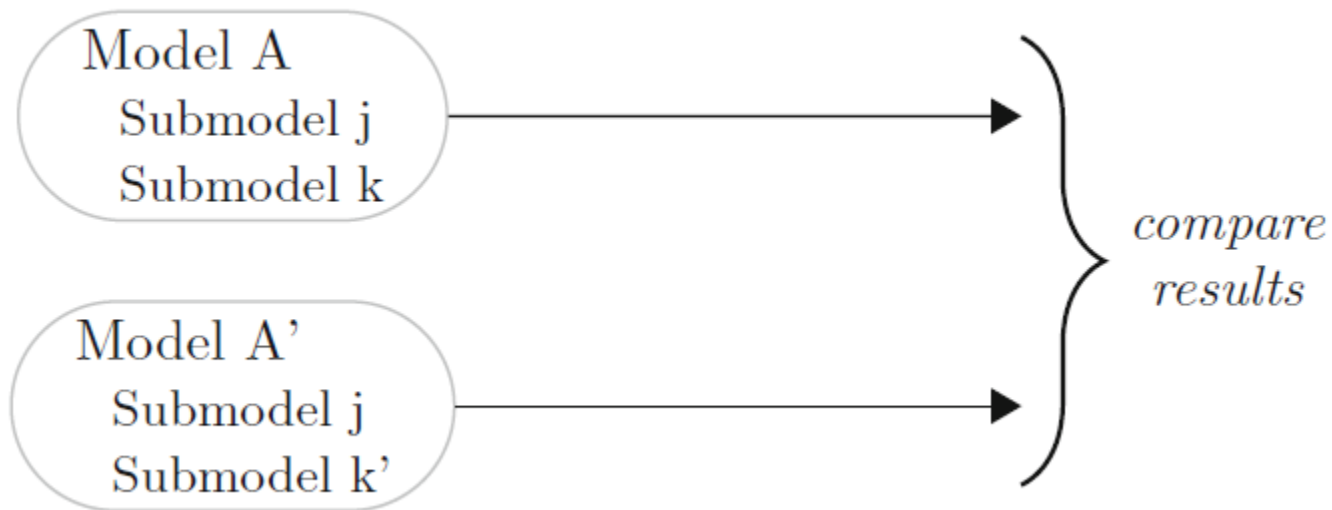
Replicating and comparing models



Aligning models



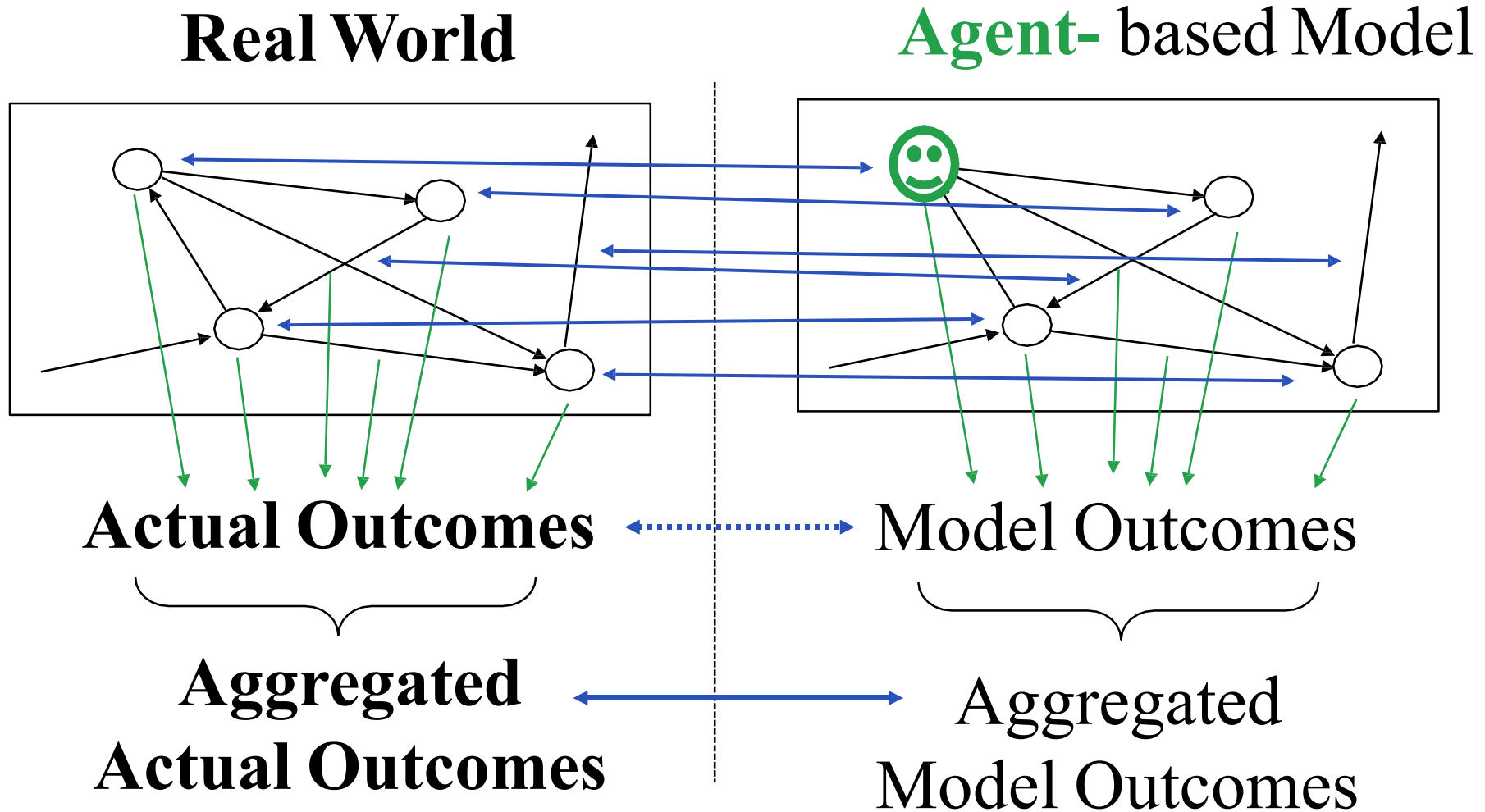
Comparing sub-models



Replicability

- Stochasticity is a problem for replicability
- When are two simulations equivalent?
 - Numerical identity
 - Relational alignment
 - Distributional equivalence

Validation, Verification and ABM



KISS vs KIDS

- **Keep it Simple Stupid**
 - Top-down approach
- **Keep it Descriptive Stupid**
 - Bottom up approach
- **No agreed upon methodology that is “best”**



The End