Built Environment Systems Thinking
BSEER Workshop

Linking models to realities:
Model validation and credibility revisited

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Complex Built Environment Systems Platform Grant

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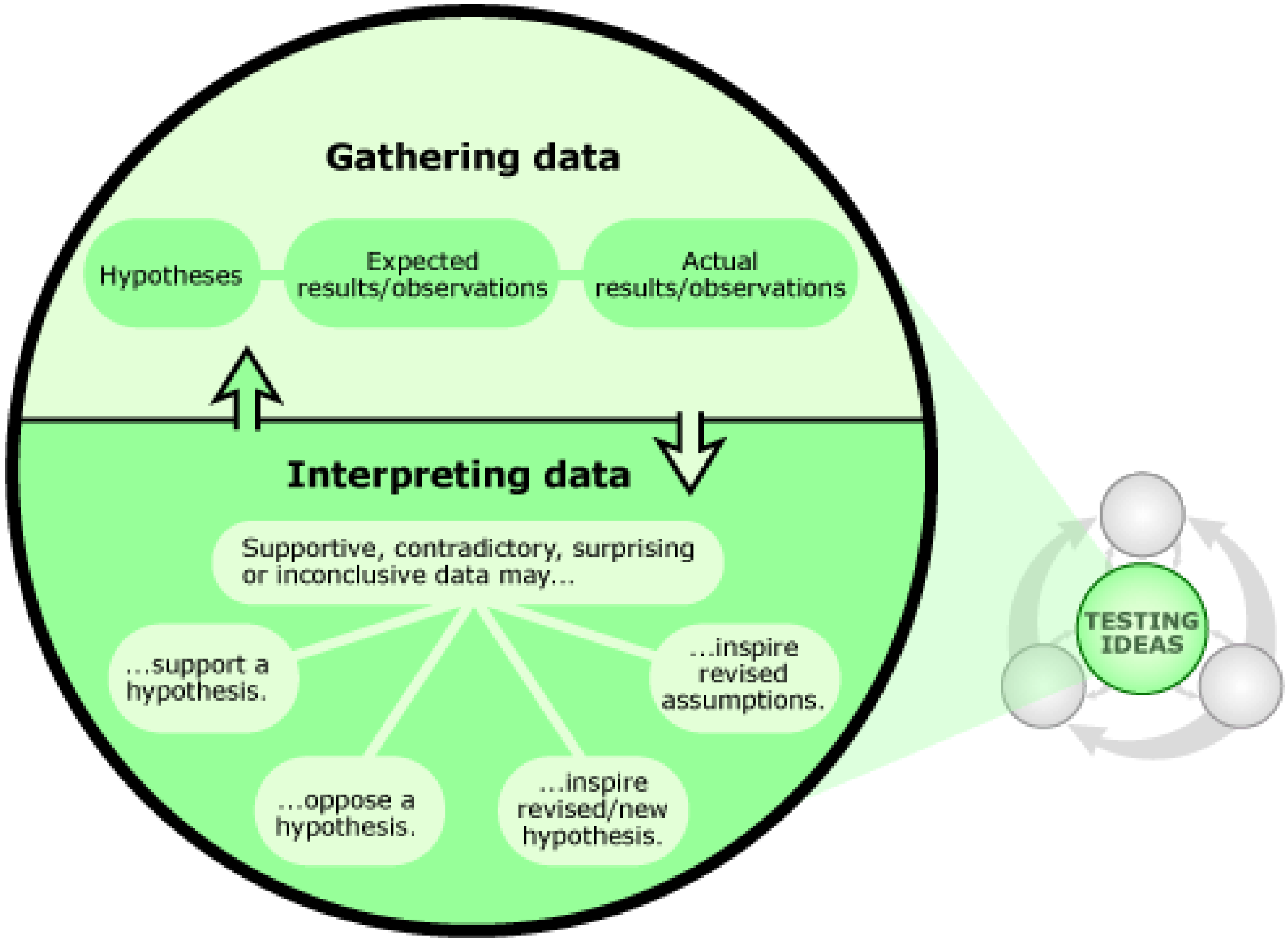
Concerns

- How do we ensure that we use the “right” model to aid decision-makers ?
- How does one ensure that one’s representation of the world corresponds to meaningful representations of the world?
- Are the recommendations that we give policy-makers based on our research methods and models meaningful or, even worse, potentially leading to bad outcomes ?

Scientific method at the core of the validation process

Model validation:

Whether the model is a "reasonable" representation of the system of interest / the target of the model (Rand and Rust 2011)



Source: Understanding science programme developed by University of California: https://undsci.berkeley.edu/article/0_0_0/howscienceworks_03

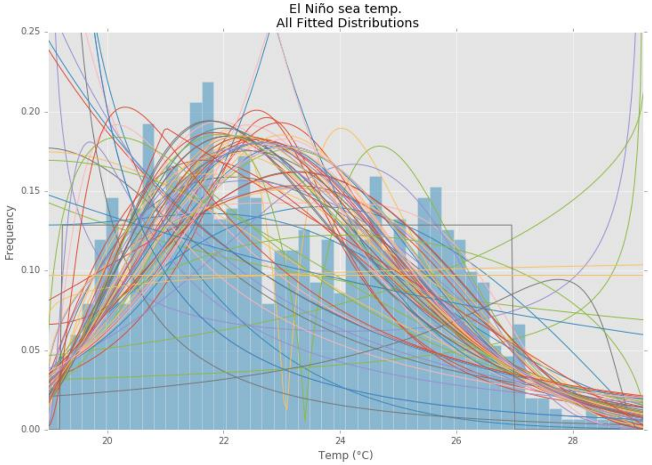
Standard (empirical) validation

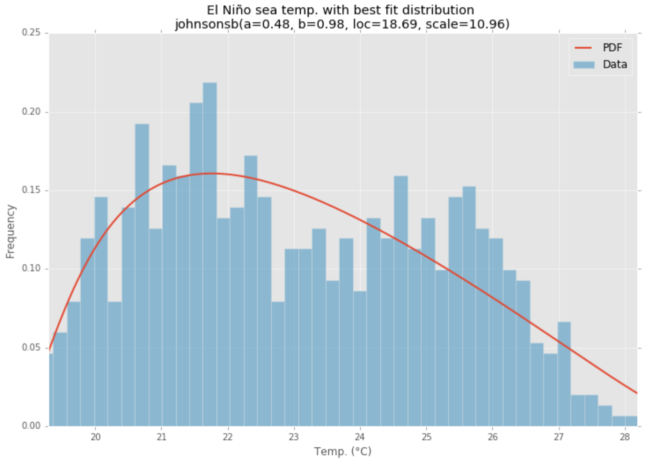
- *There is no objective validation or objective proof of a model* (Sterman 2000)

- Essence of the conventional scientific approach: basing all models and theories firmly on empirical data

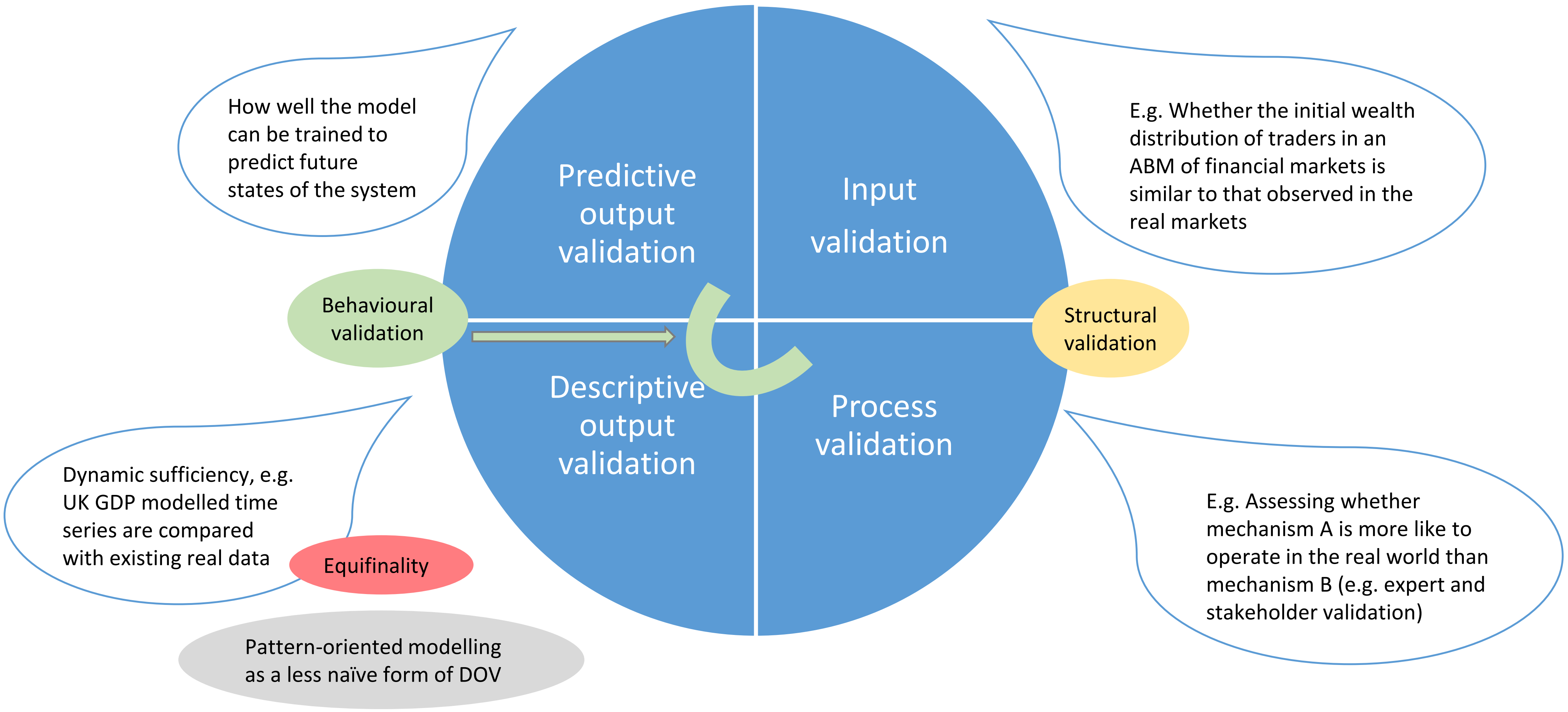
- Relevant validity test of a hypothesis: comparing its predictions with experience – fitting models to empirical data (e.g. predictive power; goodness of fit; model performance)

- All models are simplified representations of reality, but there are different epistemological ways of relating one's model to reality
  - Simulation model validation has theoretical roots in Popper's falsificationism – provisional evidence validation / representation of reality
  - Many economists value rigour, clarity and parsimony, yet this kind of epistemology is not desirable in a normative sense or for policy advice (Lehtinen and Kuorikoski 2007)





Forms of model validation



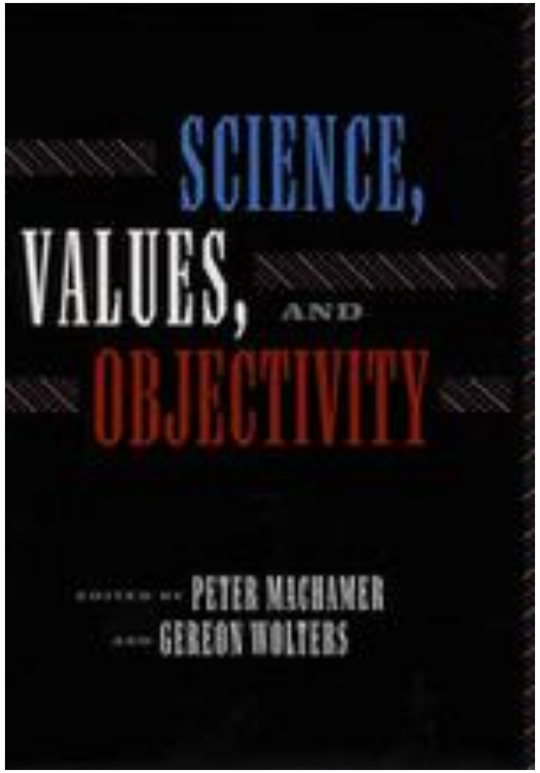
Source: Based on Tesfatsion (2017) and Gräbner (2018)

Challenging / evading standard validation: Increasing complexity, uncertainty and unpredictability

- Traditional validation is not readily applied or applicable to various types of models, e.g. in complexity science (CS) or systems thinking (ST)-based models
    - Calibrating the parameter space is extremely difficult and the implied causal structure is not tested (Batty and Torrens 2005)
    - Positivist physical models are usually validated for realism, but models of social systems may be validated for usefulness
- CS and ST: A model may be realistic if it can be adequately interpreted, understood and accepted by other points of view (process / structural validation)
- The fact that the model fits the data does not mean that the model is correct or reliable
- "We may be doomed to a world where only partial theories are possible, where all our understanding is contingent on what we observe over short periods of time and at particular instants." (Batty 2018)

Challenging / evading standard validation: The interplay between science and human values

- Logical positivism enforced a strict dichotomy between facts and values, between object and subject
- Scientific facts are not completely objective, they emerge from a Kuhnian paradigm (a constellation of human perceptions, values, ideologies, facts and actions)
  - The Lucas Critique influenced the values embedded in contemporary macroeconomics rather than resulting in scientific progress in a positivistic sense (Moss 2019)
- "All the matters pertaining to the sphere of feelings and values cannot undergo the more objective tests of validation typical of natural sciences, since there tends to be a strong personal and emotional involvement with the issues at hand" (Reardon 2015)



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Possible guiding questions for discussion

1) What type of model validation do you pursue and what are the main strengths and weaknesses?

2) What are the implications of interdisciplinary collaboration, increasing complexity and (awareness of) uncertainty), and changing human values for model validation?

3) Should we shift from model validation based on accurate prediction to model plausibility / credibility based on pattern prediction, credible assumptions and model robustness?

Image source: RePrac Research Methods: https://reprac.co.nz/research-methods-positivism-v-s-post-positivism/

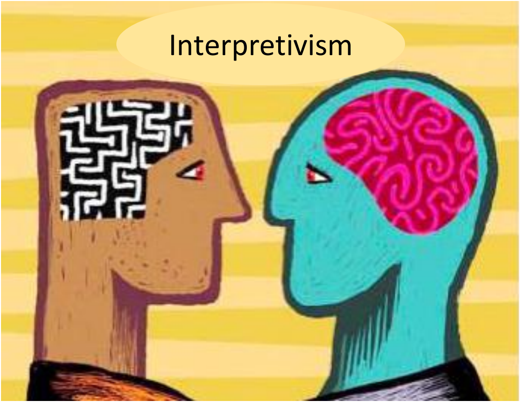

Image source: Based on Louise Chan et al (2016) slides available at: https://www.slideshare.net/sykeshea/interpretivist-paradigm-ctl-1018-lesely-louisa-noelle?from_action=save

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Some additional slides

Verificationism versus Falsificationism

Verificationism	Falsificationism
Objective truth and definite verification	Scientific theories can never be truly confirmed but temporarily accepted
Objective validation	Provisional validation
True predictions	Predictions can never be proven true
General laws	No definite general “correct” model or “right” theory
Rejects hypotheses as universal generalisations	Allows hypotheses as universal generalisation
Only empirically verifiable statements are cognitively meaningful	Provisionally true until falsified by evidence
Logical positivism: Intuition, ethics, aesthetics meaningless	Acknowledges the role of values, ethics, aesthetics in shaping knowledge

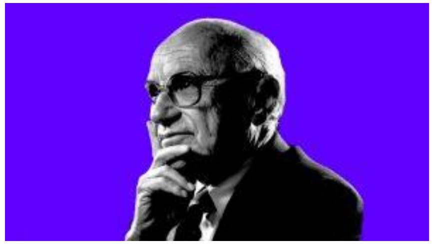
Circular reasoning and input-output validation

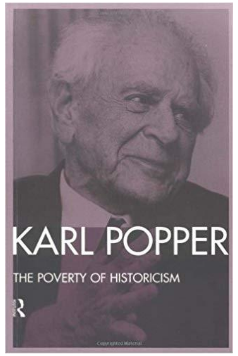
- Some models (e.g. standard optimisation equilibrium economic models) are not falsifiable in their totality, have assumptions departing from reality, aim to design and control the future
- Damaging focus in positive social sciences (e.g. dominant mainstream economic views) on logical argumentation and internal consistency, rather than exploring how realistic the underpinning assumptions are (Blackford 2017)
- Standard validation is problematic or ignored when applied in social sciences / economics:
    - Positive versus normative economics (“what is” versus “what should be”)
    - Conventional economic models are typically normative, and their assumptions often not tested against economic realities (Blackford 2017)
    - Calibration versus estimation

Some barriers to empirically validating social/economic models

"There is a property common to almost all moral sciences, and by which they are distinguished from many of the physical; this is, that it is seldom in our power to make experiments in them" (Mill 1844)

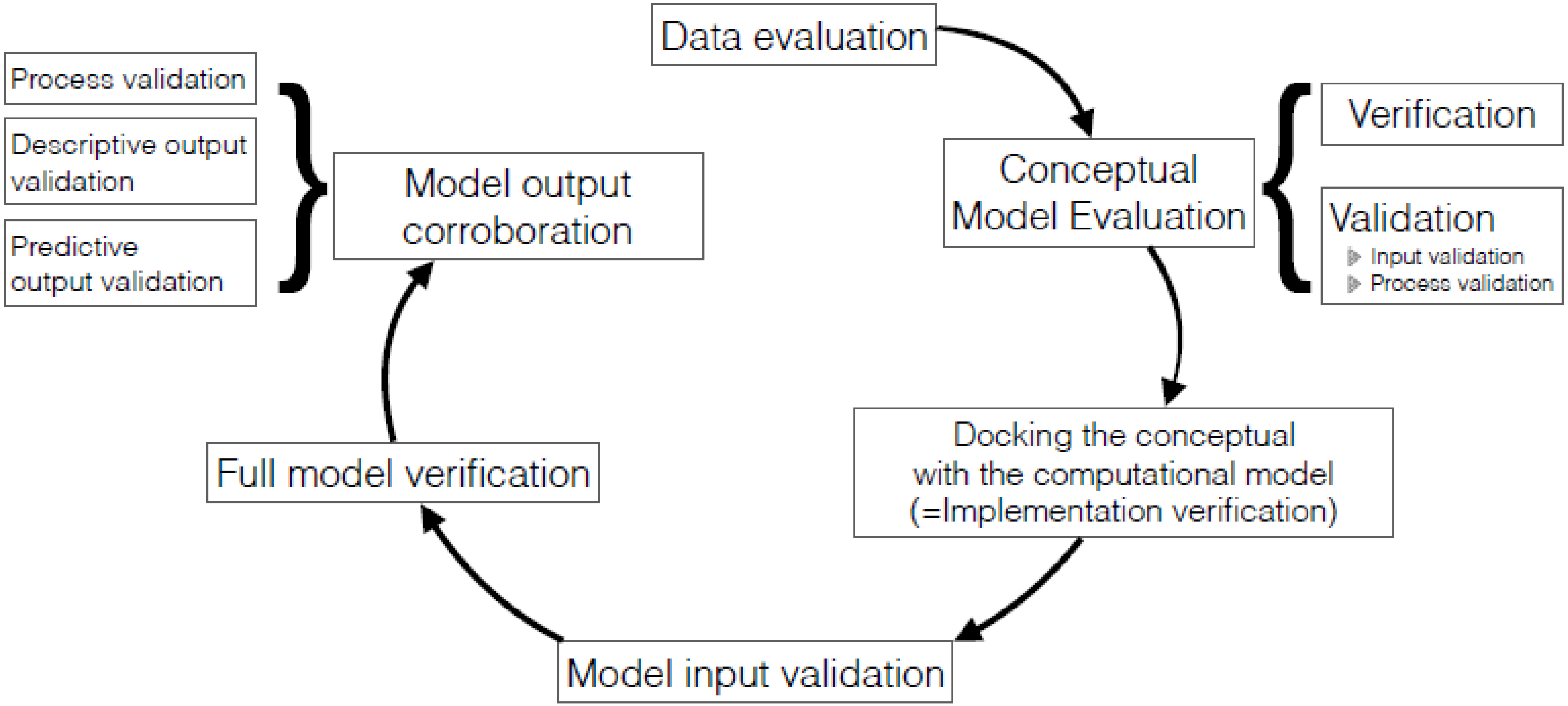
"The necessity of relying on uncontrolled experience rather than on controlled experiment makes it difficult to produce dramatic and clear-cut evidence to justify the acceptance of tentative hypotheses. […] More than other scientists, social scientists need to be self-conscious about their methodology." (Friedman 1953)





"… here [in economics], the parameters are themselves in the most important cases quickly changing variables. This clearly reduces the significance, interpretability, and testability of our measurements." (Popper 1957)

Epistemological considerations for a model evaluation framework



Source: Gräbner C (2018) "How to relate models to reality? An epistemological framework for the validation and verification of computational models, Journal of Artificial Societies and Social Simulation 21(3) 8

Newtonian/positivist science	Complexity science	Postmodernism/ poststructuralism
Realist ontology Determinism Discrete entities and events Linear causality Total predictability	**Realist ontology** Co-existence of determinism and indeterminism Nonlinear relations Limited predictability Reality as an emergent whole Simple–complex: blurred Phase transitions Self-organization Co-evolution	**Nominalist ontology and epistemology** Dissolution of subject–object distinction Dissolution of subject No objective reality or knowledge Knowledge as a language game No form of knowledge has epistemological privilege
Positivist epistemology Subject–object distinction Objective knowledge Correspondence theory of truth Fact–value distinction Universal laws Instrumentalism	**Postpositivist epistemology** Subject–object distinction: problematic Endophysical (contextual) nature of knowledge Limited generalizations, or laws of complexity Instrumentalism	
Methodology Reductionist/analytical models Deductivism Primacy of quantification	**Methodology** Holistic methods (simulations) Some use of analytical and deductive methods Qualitative and quantitative methods	**Methodology** Deconstruction

Source: Morçöl G (2001) "What is complexity science? Postmodernist or postpositivist?", Emergence 3(1): 104–19