From Models to Decisions
Project Abstract

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Many decisions in modern societies have a very complex scientific basis. Clinicians have to choose between different drugs for treating a patient. Central bankers have to forecast the evolution of financial markets, and to control the amount of money that circulates in a society. Physicists have to evaluate the impact of continued CO2 emissions for life on the planet. All these decisions are based on the forecasts of scientific models, and sometimes, their predictions reach a great degree of exactness (e.g., in identifying high-risk hospital patients and allocating resources efficiently).

However, why should we rely on such models when they are highly idealized and contain assumptions that are far from the truth? What is it that makes decisions based on them reliable and trustworthy? How do we factor in their intrinsic uncertainty? In short, how does science based on uncertain models contribute to good decisions?

Our project investigates the interface between modeling and decision-making. We develop an understanding of how scientific models function, how they advance our knowledge despite their intrinsic uncertainty, and how they are interpreted in a decision context. More specifically, we focus on the following three questions, which correspond to our main targets:

1. How can highly idealized and intrinsically uncertain scientific models be successful in prediction?

2. Why can we trust and accept scientific models in spite of their intrinsic uncertainty and how should we factor in this uncertainty?

3. How should we synthesize actuarial, model-based judgment with human expertise in making practical decisions?

In answering these three questions, our projects integrates foundational philosophical analysis (e.g., rational criteria for theory acceptance), formal and conceptual analysis, and case studies about construction and use of models in a number of relevant scientific disciplines like financial economics and evidence-based medicine.

The outcomes of our project explain the epistemic value of uncertain scientific models, and how they guide rational decisions. This is of utmost relevance in an age of science skepticism, where the authority of scientists (and the model-based predictions they make) is often challenged by claims that models are intrinsically uncertain and hence the policies adopted on their basis are not trustworthy (e.g., global warming, quantitative easing, and vaccination policies). The international reputation of our research team, its experience in interdisciplinary projects, and the collaborations with mathematicians, economists, and medical scientists within the affiliated institutions, guarantee that our research objectives can be met and will substantially advance the state of the art.

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The overall project is divided into three subprojects, each of which employs two postdoctoral researchers ("assegnisti di ricerca") and is coordinated by the leader of a local research unit. The subprojects correspond to three different stages on the path from models to decisions: (1) the construction of idealized models and the evaluation of their intrinsic uncertainty and (mis)match with reality; (2) the acceptance of a particular scientific model on a certain evidential basis; (3) the use of models in decision-making, including the cognitive pitfalls that arise when models represent uncertainty in probabilistic terms, and the problem of synthesizing model-based judgment and human expertise. The project PI (J. Sprenger/UniTO) is in charge of coordinating the project, keeping the parts coherent and synthesizing the results in a final book project.

In Subproject 1 (leader: G. Valente/PoliMi), we investigate how models are constructed in statistical physics and related disciplines with a strong decision component, such as climate science and econophysics. These models typically exhibit a high degree of idealization. We identify where exactly they mismatch reality, and what kind of predictive ambitions they can have.

In Subproject 2 (leader: G. Cevolani/Lucca), we use the truthlikeness criterion for model assessment for explaining the epistemic and predictive value of highly idealized models (i.e., models that are unable to fully describe the intended target system). We also apply our results to the case studies from climate science and financial economics addressed in Subproject 1: we show when one can rationally trust model predictions in those fields, and we explain how public policy decisions in those fields should factor in the relevant uncertainty.

Finally, in Subproject 3 (leader: C. Martini/UniSR) we investigate in a medical case study how model-based information interacts with clinical (expert) judgment to aid decision making, including the formulation and use of clinical guidelines. The case study will focus on off-label prescriptions and will be supported by the San Raffaele Hospital Research Centre.