Formal methods in the Philosophy of Science

Jan-Willem Romeijn
Faculty of Philosophy
University of Groningen
ESF initiative:
The architecture of science

Team A: Formal methods
Formal philosophy of science

Formal methods can clarify the practice of scientists and provide norms for good practice.

Good-old logic is no longer the toolkit of choice for philosophers of science.

Logic has seen major extensions and revisions in recent years.

High time for bringing logic back to the scene.
Outline of talk

1. The demise of logical methods
2. New methods: confirmation
3. New methods: statistics
4. New methods: uncertainty
5. Logic meets philosophy, again
The demise of logic

In early day philosophy of science, logical analysis played a key role, especially in confirmation theory.

Popper  Carnap  Hempel
The poverty of syntax

The logical analysis ran into a number of paradoxes.

The bottom line was that traditional logic cannot cope with the complexity, or with the semantic aspects of scientific modeling.
New methods: confirmation

Philosophers of science traditionally used classical deductive logic to capture confirmation.

\[ H \rightarrow E , \quad \neg E \quad \therefore \neg H \]

\[
\begin{array}{c|c}
H & \neg H \\
\hline
& \neg E
\end{array}
\quad \rightarrow \quad
\neg H \land \neg E
\]
Bayesian confirmation

Instead of truth valuations, we can also use a probability measure over an algebra to express confirmation.

\[
P(H) = P(\neg H) \\
P(E | \neg H) < P(E | H) = 1 \\
P(H|E) > P(\neg H|E)
\]
Using new logics?

Confirmation theory can be improved in various ways:

- Scientific models often concern causal relations. Causal hypotheses invite different confirmations.

- Issues are sometimes decided by the scientific forum, by voting or by consensus formation.

- In many instances of confirmation, logical and probabilistic knowledge must be combined.
3 New methods: statistics

Causal networks and Bayesian methods are having increasing impact on statistics in the social sciences.
Integrating logic and statistics

Often we also have logical constraints on parameters and interactions in the statistical model. How can we integrate the two?

linguistics

psychology
New methods: uncertainty

Additive normed measures are not the only tool for representing epistemic uncertainty.

\[ P(E | \neg H) < 1/2 \]

uncertain evidential bearing:

\[ 1/4 < P(E | \neg H) < 1/2 \]

uncertain about the evidence:

\[ P(E) > P(\neg E) \]
Models of agents

Alternative representations of uncertainty can be used in methodology, but also in scientific modeling itself.

- The uncertainty of economic agents and psychological subjects are perhaps better represented with other measures than probability.

- Different representations of uncertainty might mesh better with new models of how agents interact, e.g., alternatives to decision and game theory.
Logic meets philosophy, again

☆ Logic can provide new tools for the philosophy of science.

☆ We must be careful to give priority to the sciences, not to what tools happen to be around.

☆ To convince scientists of new methods, we need a killer application.
Thanks

opor
j.w.romeijn@rug.nl

http://www.philos.rug.nl/~romeyn

orp
J.W. Romeijn
University of Groningen / Philosophy
Oude Boteringestraat 52,
9712 GL Groningen
The Netherlands