

Randomness and determinism in empirical sciences

Are the methodology of natural sciences equally valid in empirical sciences explaining and forecasting human behaviour?

Randomness and determinism

Outline of this presentation

- The status and properties of laws in science in general and the methodology to discover.
- A interpretation of laws in empirical sciences
- Sources and causes of randomness and complexity in "laws" in social sciences.
- Modeling and forecasting social behavior in the context of free decisions.
- Are mathematics & statistics adequate tools to fully account for the explanation of human decision making and behavior?

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- A quote attributed to Albert Einstein:
 - *"Not everything that can be counted counts and not everything that counts can be counted".*
- *Scientific research in the social, as well as many natural sciences, like (bio-) medical, meteorology, epidemiology and others) are imbued by statistical data analysis.*
 - *The increasing number crunching computing power of present day computers allow scientists to fine tune theories and validate ever more complex models.*
 - *Solving equation systems containing more than 100.000 variables and equations are no longer rare exceptions.*

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Features of the scientific method in general

- The overall endeavor of science is to find order and structure in the enormous diversity of facts and experiences.
 - This demands abstraction of the actual data and facts, transcending the individualized observations and unifying them in a coherent vision that describes joint features, offers causal explanations and enables forecasting.
- A major apotheosis of scientific research is to find universal laws as the highest degree of unification of data and observations.
- The following question need to be addressed: what are basic properties of a law (of nature)

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Some features of laws (graduality)

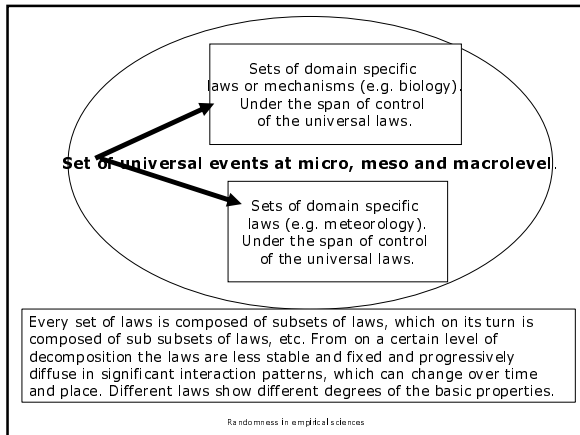
1. True: there are no repeated contradicting observations
2. Universal: apply everywhere in the universe
3. Absolute: appear not to be affected by any interactions arising outside them.
4. Stable: essentially unchanged since first discovered.
5. Normally simple: one or a few mathematical equations suffice to describe them.
6. If not 100% accurate, they can be considered as approximations of more accurate laws – that can still be unknown -.

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Span of control of laws.

- One way to express the degree of absoluteness/universality of a law is using the concept "*span of control.*"
- *The span of control is the range of events that are governed by (or obeying) that law.*
 - One event can be subdued to many laws.
- Span of control enables ranking of laws.
 - Such a ranking also enables to classify laws as coordinated or subordinated with respect to each other.

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Interpretation of “laws” in empirical research

- There is a trend in empirical social sciences - we restrict to economics - to borrow and apply theoretical approaches from natural sciences
- However, empirical research faces some problems that are less prominent present in experimental sciences, like physics or genetics.
 - This is the high degree of randomness.

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Meaning of laws in empirical research

- Although (social economic) models focus on structural relationships – and try to leave the noise of random effects out – the transformation to a testable quantifiable hypothesis, is where the random effects creep in and can have potentially significant biasing effects on the estimation and interpretation of the structural relationship.
 - Example: a arbitrary hypothesis would read

$$Y_i = a_0 + a_1 * X_{1i} + a_2 * X_{2i} + a_3 * X_{3i} + \epsilon_i$$

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- The best estimation result of a structural equation is obtained by regressing on the population data.
 - Because population data are ordinarily not available or only at extremely high costs, econometricians – professionals in statistical estimation and regression analysis - recur to sample data.
- However a sample is by its very nature part of the whole (population) thereby creating random effects.
- Every new sample - even under constant population parameters - results in different sample statistics.

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- The uncertainty due to sampling is overcome by validating the assumed population relationship against the criteria of *statistical significance*.
- A hypothesized parameter in the equation, modeling an economic relation or social behavior, is accepted or rejected on grounds of statistical significance.
 - Two main types of (correlated) errors are rejecting a correct hypothesis and accepting an erroneous hypothesis.

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From explaining to forecasting: a big leap

- Forecasting on the basis of the estimated relationship inferred from historical data is surrounded with even greater uncertainty than the explained variation of past data.
 - The independent variables are normally also uncertain and affected by exogenous influences.
 - This problem affects especially the reliability of time series forecasts used to reveal trends over time.

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Statistical significance and causal relation.

- Statistical significant relations do not imply cause and effect relations of the phenomenon under study.
 - The dependent and an independent variable can be interchanged and still maintaining a statistical significant relation
 - However cause and effect are swapped.

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Complex social models and freedom

- Most phenomena of human and social behavior are complex: different causes contribute – although not equally - to joint effects and in many cases they themselves are correlated.
 - The interaction density – with features similar to network patterns - between all variables is high.
 - Single equations are inadequate to analyze it and a system of equations are used to model them.
- The degrees of freedom of a simple closed system behavior diminish by adding exogenous factors. The system transforms in an entangled and intertwined interaction pattern.

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Determinism, conditioning & freedom

- In the majority of social phenomena and human behavior there are more decision options than interactions conditioning the options. Future outcome of human behavior and decisions become unpredictable and forecast reliability depends on the number of conditions (or interaction density) imposed on the variables in the model.
- This unbalance between options and interactions is one of the main sources for the unpredictability of human decision making and the futures outcome (realizations) of those decisions!

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Math & Stat: queen or servant in (social) sciences?

- If mathematical models fail to explain adequately cause and effect, what use do they have?
- This refers to the classical and ongoing debate about the status of mathematics in science.
 - Mathematics are by its very nature an abstraction, intellectually inferred from the order and relations mankind has observed in (im)material phenomena.
 - However math & stat do not have the famous last words in the final and overall interpretation of natural events and even less about human life.
- In my opinion: they are a servant, but an extremely valuable and indispensable one.
 - They need a coach to give it meaning (theory).

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Some conclusions:

- Conclusion: Do social models offer conclusive evidence for either social or biological determinism in human behavior and decision making, either at the individual and the collective level? Answer: No!
- Do they point to conditioning or limiting impact by external interactions/stimuli on human freedom? Answer: Yes!
- Look behind quantitative data to acquire real knowledge and insight in a unified view on the universe.
 - *Closing note: "As far as the laws of mathematics refer to reality, they are not certain: and as far as they are certain, they do not refer to reality".*

Quote from A. Einstein in "Geometry and Experience", January 27, 1921.
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