Models in Knowledge Production

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Abstract

The thesis attempts to analyze models as a particular class of representation in natural and social sciences. Their uniqueness arises from a structural correspondence between the model and its target, defined in particular contexts. We attempt to (i) sketch a history of models in knowledge production and (ii) understand how they function. Models are employed to perform descriptive and prescriptive roles; we explore the extremes where description and prescription overwhelm one another, respectively.
We move into insurance modeling as a central example in our thesis. We focus only on the aspect of risk transfer marked by contractual obligations. In the four-hundred year of its history, we see it evolve from striking a bargain to a mathematically robust enterprise. The evolution happens in conversations between disciplines such as mathematics, astronomy, economics, and sociology under the larger context of statecraft and population management.

Models

- *Model* originates from *modelle*, *modulus*, and *modelle*, carrying meanings of measure, standard, and mold.
- The functions of a model can be broadly categorized as description, prescription, and prediction.
- A model presupposes a target, whether material or immaterial.
- A model can be described as a fixed arrangement of parts that give rise to a regularity (Cartwright). Thus, it has a structural correspondence with its target.

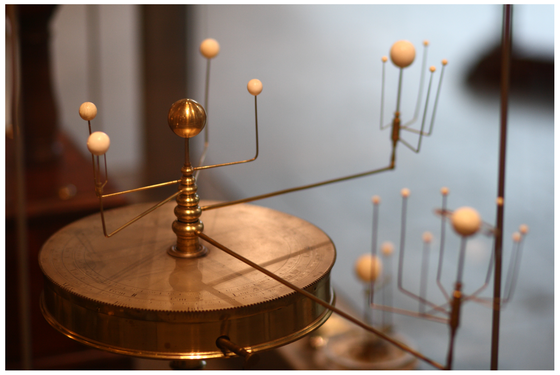


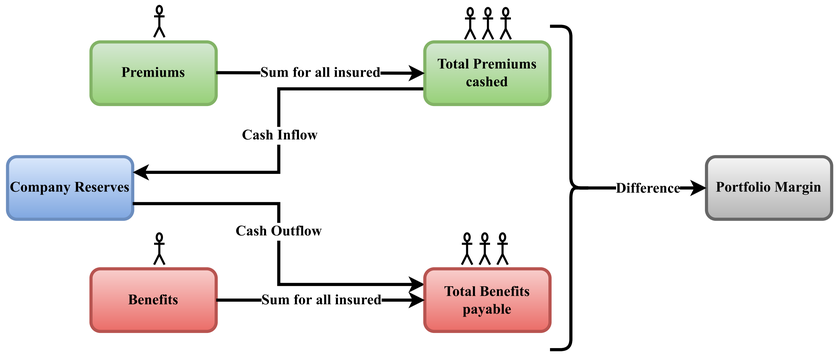
Fig. 1: Source: Wikipedia

A Sketchy History of Models

- Newton's *Principia* laid the foundation for models in sciences.
- Development of statistics and emergence of energetics as the unifying principle in physics elevated models as a form of proof.
- Neoclassicals carried models over to economics.
- The invention of computers expanded the possibilities of models and led to the emergence of disciplines oriented towards computation and modeling.

Insurance in the Western World

- Insurance predates probability and actuarial mathematics.
- It was prevalent in the sea-faring cities like Venice and Genoa since the mid-fifteenth century. It appears like a bargaining activity that went on up to the early-eighteenth century.
- Models in insurance come in only when the general population is pulled into the fold of insurance; initially through life insurance, and later through other forms of insurance.



- During the mid-eighteenth century, many crucial theoretical breakthroughs took place in probability and statistics:
  - Bayes' response to Hume's skeptical challenge to induction in form of conditional probabilities provided a rational foundation to statistical inference.
  - Gauss, Laplace, and Legendre, while working with astronomical data, came up with the solution to the determination of the best fit curve.

  These enabled the insurer to perform *rational* calculation of premiums by projecting into the future through appropriate time discounting.
- Since the mid-nineteenth century, demands for universal life, health, disabilities, and old-age insurance subsidized by the state had come up in the backdrop of the new manufacturing process that accompanied the industry. Models of social insurance came up in response to the revolutions, wars, and financial crisis::
  - The first instance of social insurance was instituted in Germany in 1884, complementing the anti-socialist laws.
  - A socialist form of social insurance was implemented in USSR after the Bolshevik Revolution.
  - USA instituted the Social Security Act (1935) and the UK instituted the National Health Services (1948); both in response to economic crisis and war.

Future Work

- To develop a comprehensive history of models:
  - The eminence of models through conversations between natural and social sciences.
  - The evolution of model from a tool of experimentation to a form of establishing truth.
- To write the history of insurance in India through the history of the institutions surrounding it, namely, the Indian state, its banking sector, and the market.

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References

[1] Nancy Cartwright. "Models: The Blueprints for Laws". In: *Philosophy of Science* 64 (1997), pp. 292–303.

[2] Sabine C.P.J. Go. "The Amsterdam and Rotterdam Insurance Markets in the Sixteenth to the Eighteenth Century: Inertia versus Adaptability". In: *International Journal of Maritime History* 23.2 (2011), pp. 85–110.

[3] Craig Turnbull. *A History of British Actuarial Thought*. 1st ed. Palgrave Macmillan, 2017.

[4] Aiqun Hu and Patrick Manning. "The Global Social Insurance Movement since the 1880s". In: *Journal of Global History* 5.1 (2010), pp. 125–148.

[5] Paul P. Rogers. "The Structure of Soviet Insurance". In: *The Journal of Risk and Insurance* 32.2 (1965), pp. 237–254.