

Book reviews<sup>1</sup>

**Causality: Models, Reasoning, and Inference, Judea Pearl; Cambridge University Press, Cambridge, UK, 2000, pp. 384. ISBN 0-521-77362-8.**

This is, in some sense, more of a philosophical book about reasoning and making inference in scientific and other inquiries in life. Many readers (like myself) who subscribe to or even are skeptical about the philosophic foundation of science would love this book, appreciate and relish the discussions. On the contrary, those who are simple practitioners of scientific tools with no objection or criticism might find this book very abstract with less substance or even boring in an extreme frame of mind. However, in my opinion, this book is very much thought provoking and valuable addition to the scientific community. The author, Judea Pearl is not only an expert but also well known for creating novel ideas in cognitive system analysis and artificial intelligence. I had an opportunity of listening his presentation, a few years ago, in this topic. I, then, was very skeptical of his views but now, after reading this book, have become convinced of the importance of his views on causality concept. The main theme in the book is causation.

What is this celebrated (at least in this book) but somewhat nebulous notion called causality? Unlike the probability, which connotes doubt or lack of regularity, causality describes a real or seeming influence of one entity on another. The causality occurs in marketing research, economic doctrines, physical laws, artificial intelligence, medical investigations, and in computing sciences. The author well explains, in the section titled “Epilogue”, the history of this neglected, mysterious and difficult notion. Many philosophers, founding leaders of statistical science like Karl Pearson and Ronald Fisher, and astronomers like Galileo all had difficulty in pinning down the exact definition and properties of this idea called causality.

To motivate the readers on causality, the author starts with a Bible story as follows. When God questioned Adam and Eve whether they ate the forbidden fruit from the tree, both answered that it was due to an ill advise from the evil serpent. While God wanted the fact, but Adam and Eve felt a need to explain. This story clearly implicates that the causal explanation is simply human-made concept. In the pursuit of cause versus effect, *why* is not merely second to the *how*, but the *why* is totally superfluous as it is subsumed by the *how*.

The other noteworthy example the author very successfully employs is the following. The rooster crows in constant conjunction with the sunrise, yet it does not cause the sunrise. The rubric underlying this example echoes that the spurious correlation does not imply the causation. As the author well points out, this meaning came through loud and clear in the well known Francis Galton’s words: “...a category broader than causation, namely correlation, of which causation was only the limit...”. Karl Pearson, a leader in statistics exterminated the causation concept before it had a chance to take root but Ronald Fisher, another leader of statistics used randomization idea to legitimize the causal concept. Another citation by the author about the causation is from a statistician Terry Speed who acted as an expert witness in the O. J. Simpson murder trial in which Speed declared: “Considerations of causality should be treated as they have always been treated in statistics: preferably not at all but, if necessary, then with very great care”. In summary, the causation is much harder to measure than the correlation. The author first asks while statisticians are not easily deterred by difficulties, why then the causality has been expelled much from scientific inquiries and then eludes the reason for it to the inability of probability to accommodate this concept. The author argues that however the past had been, while the future is to be more computer science

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<sup>1</sup> Material to be included in this section can be submitted to: Prof. K.J. Cios, Computer Science and Engineering Dept., University of Colorado at Denver, Campus Box 109, 1200 Larimer Street, Denver, CO 80217-3364, USA. Email: [kcios@carbon.cudenver.edu](mailto:kcios@carbon.cudenver.edu)

oriented, the causal concept is a necessity. In this argument, the author employs an example with artificial intelligence as follows: “If the grass is wet, then it rained. And, if we break this bottle, the grass will get wet. Should the computer conclude that it rained if we break this bottle”? There are several examples from Computer Science in the Section titled “Epilogue” to illustrate the importance of causal concept in this computing age.

There are 10 chapters covering Introduction to Probability, Graph Theory, Mathematical Statistics, Bayesian Ideas, Counterfactuals, Structural Models, Stable Distributions, Controlling Confounding Bias, Calculus of Intervention, Causality Models in Social Science and Economics, Simpson’s Paradox, the Logic of Structure-Based Counterfactuals, the so-called Imperfect Experiments, the Probability of Causation with Interpretation and Identification, the Insufficiency of Necessary Causation, the Causal Beams, and the Substance-Based Causation. There are some unusual notations.

Several noteworthy items in the book are: (1) the excellent interpretation of symmetric, decomposition, weak union, contraction, intersection properties of conditional independence in probability, (2) easy to follow description of graph theory concepts, (3) direct quotes from historical literature like Shakespearian Hamlet to set the stage for illustration, (4) a thorough explanation of Simpson’s paradox in statistics, (5) examples for counterfactuals, and (6) good exposure to identifiability under monotonicity and exogeneity. In my opinion, the description of art and science of cause and effect could have been placed in the introduction rather than in the epilogue as the description is well motivating. The classic photos and pictures in the epilogue are very impressive.

The book is readable without probability or statistics background. The book does not have any exercise or problems to work and, hence, might not be suitable to be a textbook in a course. However, this book is very valuable in graduate level teaching with supplementary material. The readability is not going to be fast as the text is full of thought provoking and controversial ideas. It is a well-composed and written book. The bibliography is exhaustive and up-to-date. I enjoyed thoroughly reading the material in the book. I would highly recommend this book to both theoretical and applied scientists.

**Ram Shanmugam**

*University of Colorado, USA*

*E-mail address: rshanmug@carbon.cudenver.edu*