

Causality: Models, Reasoning, and Inference. By PEARL (JUDEA). (Cambridge and New York: Cambridge University Press, 2000. Pp. xvi+384. £25.00 hardback, US \$39.95 hardback. ISBN 0 521 77362 8.)

How does econometrics differ from statistics? In a recent paper, James Heckman (2000) argues that econometrics, unlike statistics, is primarily concerned with causes. Heckman revives an older tradition. The Cowles Commission in the late 1940s and early 1950s – and indeed, as Hendry and Morgan's (1995) anthology demonstrates, most early econometrics – was explicitly causal. The degree of

novelty of Heckman's insight is a measure of how far econometrics has drifted from its causal roots towards statistics. Although not an econometrician, in *Causality* Judea Pearl invites econometrics to reverse course. Pearl is a computer scientist at UCLA. His work is well known to practitioners of artificial intelligence, statistics, and non-economic social sciences. *Causality*, the masterwork and capstone to his research program, recently won the Lakatos Prize in the philosophy of science. Unfortunately, Pearl's work is little known to economists and econometricians.

In this book, Pearl vigorously opposes the attitude – ultimately traceable to the philosopher David Hume – that the most that we can learn from data are its associations summarised in the likelihood function and that, consequently, it is impossible systematically to infer or use causal relations. The great statistician R. A. Fisher famously argued that the available evidence could not prove that smoking causes lung cancer – a source of comfort to the tobacco companies for years. Even most statisticians reject this conclusion, but in fact Fisher was simply being honest: the standard tools of statistics are inadequate to causal analysis. It is common among both statisticians and econometricians to argue that causality is either too hard or too metaphysical a problem to be analysed.

Pearl is, in contrast, a causal optimist. He defends a notion of causal structure that goes beyond probabilistic association. Each link in a causal structure is 'a stable and autonomous physical relationship' (p. 22) that can be changed without changing other links. For Pearl 'the causal relationships [are] the fundamental building blocks both of physical reality and of human understanding of that reality... probabilistic relationships [are] but the surface phenomena of the causal machinery that underlies and propels our understanding of the world' (pp. xiii–xiv). Despite the gallant attempts of philosophers, causality cannot be reduced to probability. *Useful* probabilistic inferences carry an implicit causal structure. Pearl's aim is to make it explicit.

Pearl admires the econometrics of the Cowles Commission and, especially, the work of Herbert Simon. So, why did econometrics abandon causality and take a statistical turn? Pearl attributes much of it to an inadequate notation that made it hard to separate the statistical and structural properties of econometric systems. Pearl is a leader in the graph-theoretic approach to causal analysis, whose other contributors include Clark Glymour, Richard Scheines, Peter Spirtes and colleagues at Carnegie–Mellon University. In a causal graph, causal linkages are shown as arrows running from causal variables to effect variables. Econometric systems are easily rendered into causal graphs. The mathematics of graph theory allows the implication of a causal structure for probability distributions to be readily worked out. While the Carnegie–Mellon/Pittsburgh group has concentrated on the philosophical basis for these ideas and on practical implementation in the *TetradIII* software, Pearl stands in the forefront of the formalisation and mathematical development of the graph-theoretic approach.

The key notion is what Pearl calls *d-separation*, essentially the idea that a set of causes intervening between two variables or a set of parent causes of two variables induces a relationship of conditional independence between them. Elaborating on d-separation permits Pearl to develop powerful algorithms for inferring causal

structure from non-experimental data and for calculating the effects of interventions in one part of the causal structure on other parts (the *do-calculus*). Pearl demonstrates that these tools convey a deep, and often usefully simplified, understanding of important issues in econometrics such as instrumental variables, exogeneity, the relationship of non-experimental data to randomised experiments. Pearl displays an impressive breadth, providing fresh analysis to problems in experimental design, the philosophical account of counterfactual reasoning, legal analysis and the social sciences.

While a brilliant performance, *Causality* is not the last word on the subject – at least as it concerns economics. Most of the analysis is limited to *acyclical graphs* (or what econometricians would call *recursive structures*). Yet, traditionally, much of econometrics – as well as general-equilibrium theory – concerns simultaneous relationships. Pearl does provide some hints about the analysis of cyclical graphs, but there is more work to be done. More importantly, Pearl's notion of causality is strongly influenced by analogies with physical processes. I have argued elsewhere (Hoover, 2001, ch. 5) that these analogies are defensible – but not without modification. In particular, the graph-theoretic approaches to causality have yet to come to grips with the implications for empirical causal analysis of rational (and other endogenous) expectations, optimal control, and other characteristic ideas of economic choice and policymaking. These issues do not vitiate the approach, but they complicate it, and suggest that further development – and, in the meantime, special care – are needed.

Causality is not an easy book to read, but it repays careful study. I highly recommend it to econometricians and applied economists. Pearl appends an entertaining and informative lecture, 'The Art and Science of Cause and Effect,' as epilogue. This lecture was intended for the general audience and was delivered as the prestigious Faculty Research Lecture at UCLA in 1996. It is an excellent introduction to Pearl's point of view. The reader is recommended to start with the epilogue.

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References

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