CAUSALITY AND ECONOMETRICS: SOME PHILOSOPHICAL UNDERPINNINGS

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CAUSALITY

Causality issues are crucial in economics since economics was born. Indeed, Adam Smith titled his work, published in 1776, *An Enquiry into the Nature and Causes of the Wealth of Nations.* Even before Smith, David Hume (1752) writes about the causal problem of the relationship between money and prices (predating the quantitative theory of money), and after Smith, David Ricardo and John Stuart Mill are explicitly involved in causality issues. Economics, like any modern science, makes use of causality notions in the sense of what Aristotle called *efficient cause* (Physica, B 194b, 29-32). That means that a cause produces or brings about its effect. In economic policy, one often uses causal terms to denote the possibility of controlling one variable (e.g. interest rates), in order to influence another one (e.g. national income). Causality issues are also relevant in the study of economic agents decisions. In this area economists often involve notions of causes, which Aristotle called *final causes* (*Physica*, B 194b, 33-35): if, for instance, a choice is taken in order to maximize the profit, "the end (*telos*), that for the sake of which a thing is done," is the cause.

The philosophical underpinnings of the approach to causal issues in economics are in the work of David Hume. In *An Enquiry Concerning Human Understanding* (1748, section VII, part II), Hume gives the following definition: "we may define a cause to be an object, followed by another, and where all the objects similar to the first are followed by objects similar to the second. Or in other words where, if the first object had not been, the second never had existed." According to Hume, causal events are ontologically reducible to non-causal events, and causal relations are not directly observable, but can be known by means of the experience of *constant conjunctions* (see *A Treatise of Human Nature* 1739-40, vol. I, book I, part III, section 2-6, 14, 15) and by the construction of general laws.

The problem of differentiating between causal relations and empirical regularities (measured in statistics by correlations) has been crucial in the development of econometrics. In contemporaneous econometrics one can finds three distinct methods to face the ontological and epistemological problem of causality.

The first one is the *probabilistic approach* to causality, which can be interpreted as a version of the probabilistic theory of causality, developed in philosophy of science by Patrick Suppes (1970), applied to econometrics. Suppes, on his turn, elaborates in probabilistic terms the first part of the definition given by Hume and quoted above. According to Suppes, an event A causes *prima facie* an event B if the conditional probability of B given A is greater than B alone, and A occurs before B. This approach has received a considerable attention in economics, where the relations among variables are essentially stochastic.

Clive Granger (1980, p.330) proposes the following definition of causality: a (time series) variable A causes B, if the probability of B conditional on its own past history and the past history of A (besides the set Ω of the available information) does not equal the probability of B conditional on its own past history alone. This definition, in the econometric literature referred to as *Granger-causality*, has been extensively applied in econometrics, because it has the advantage, as it has been emphasized by Granger himself, to be *operational*. This means that the definition contains in itself the method of its application. Indeed, statistical tests for Granger-causality are straightforward in standard macroeconometric models (especially in Vector Autoregressive models). But this definition is fraught with difficulties and paradoxes, which are analogous to the difficulties and paradoxes that have been raised in philosophy of science against Suppes's definition. Moreover, Granger-causality is more a definition of the incremental predictability between two time series variable, than a real definition of causality, which seems to be a somewhat stronger relation than predictability. Indeed, if A Granger-cause B, we cannot say that controlling A we influence B (see Leamer 1985, and Hoover 2001). (Granger himself is very careful to delimit his notion of causality, in order to distinguish it from controllability and exogeneity).

Hoover (2001) points out that there is a second approach to causal analysis commonly found in economics, which he calls the *structural approach* to causality. While the probabilistic approach aims to reduce causes to regularities (measured by probabilities), the structural approach maintains a realist ontology. The idea is that the existence of economic structures suggests that causal relations among economic variables are not entirely reducible to regularities. Probability conserves an important epistemological role: given the complexity of economic structures and the limits of the observer, the data generated by economic structures have to be measured by probabilistic tools.

We can interpret the *Cowles Commission* approach (see below) as the typical example of the structural approach to econometrics. In the Cowles Commission approach, the existence of economic structures is

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dictated by economic theory and the aim of probabilistic methods is that of measuring causal relations in an identified system of equations.

Finally, there exist a counterfactual approach to causality. The philosophical underpinnings are in the second part of Hume's definition quoted above and in the work of David Lewis (1986). The idea is that the event X causes the event Y if and only if: (a) both X and Y happen; (b) if X had not been, then Y would not have happened. Paul Holland (1986) gives a statistical approach to causal inference based on this idea. The problem is that counterfactuals involve situations that we cannot observe. This problem would be not that big, if we dealt with an experimental science. Indeed Holland's method has been applied in microeconomics, where it is sometimes possible to realize credible "hypothetical experiments."

ECONOMETRICS

The *Econometric Society* was founded in 1933 with the aim of unifying the theoretical-quantitative approach with the empirical-quantitative approach to economics, analogously to what one finds in natural sciences (see Frisch 1933). The question about the relationship between theoretical properties and empirical-statistical properties, or, to put it in another way, the relationship between causes and correlations, is one of the crucial questions of methodology of econometrics. One can find at least three methodological approaches.

The first one is the *Cowles Commission* approach, named after the scientific commission founded in 1932 in the United States. Trygve Haavelmo, in the seminal paper *The Probability Approach in Econometrics* (1944) shows what are the necessary and sufficient algebraic conditions that make a system of equations *identified*. Identifying a system of equations means determining the causal (and probabilistic) structure which has generated the data. The identification problem derives from the fact the structure is in general under-determined by the statistical properties of the data. (This is a version of the induction problem: correlation is not causation). The solution proposed by the Cowles Commission consists in using the economic theory to specify a priori the causal structure. Statistical methods are applied to measure the strength of causal relations and, possibly, to test the restrictions derived from theory.

This approach has been subjected to two major criticisms. The first one comes from Robert Lucas (1976). Lucas claims that the structural parameters identified using the Cowles Commission method are not stable under change of economic policy. Indeed, if the econometric models estimated with the Cowles method were used to implement economic policy actions in a systematic way, the individuals would adapt their behavior in order to get the maximum advantage from the new policy. Hence, the equations used to predict the effects of the new policy would not be valid anymore, since they would neglect the intentional behavior of the individuals. According to Lucas, stable macroeconomic relations have to be derived from the choice and rational expectations of individuals. A new approach to macroeconomics micro-founded upon the hypothesis of rational expectations was born from this critique. In econometrics, this corresponds to derive from that hypothesis algebraic restrictions for the identification. However, what is object of criticism is more the economic theory extensively used until that time for the identification (i.e. Keynesian macroeconomics, which was the orthodox view until the beginning of the 1970s), than the methodological basis of the Cowles Commission.

The criticism moved by Christopher Sims in the seminal paper *Macroeconomics and Reality* (1980) is more radically directed to the method of identification pursued by the Cowles Commission approach. Sims claims not only that the theoretical restrictions used by the Cowles Commission for the identification are not well-grounded, but also that the structural equations are in principle not identifiable. Indeed, the interdependencies are so numerous that each variable should appear in each equation. (To put it in another way, the absence of purely exogenous variable impedes algebraically the solution of the identification problem). According to Sims, we should let the data speak, without imposing theoretical restrictions, at least as far as the estimation step is concerned. In fact, the models proposed by Sims, namely Vector Autoregression models (VAR), are shown to be extremely efficacious instruments to summarize the statistical properties of economic time series, but cannot be used for policy evaluation, because an estimated VAR is a reduced form model, and in this form cannot say anything about causal relations. Sims proposes to use VARs to identify the effects of structural economic shocks (instead of the structural parameters corresponding to the coefficients of the economic variables). But this task, even if less ambitious, asks the imposition of a priori restrictions as well. The use of a priori restrictions independent from the theory, proposed by Sims (1980), has been considered arbitrary and the program of an *atheoretical* empirical macroeconomics has been subjected to severe criticisms (see e.g. Cooley and Le Roy 1985). Large part of the literature about the so-called Structural VAR has been devoted to identify structural economic shocks, by appealing, in a way entirely consistent with the Cowles methodology, to restrictions derived from theory or from institutional knowledge (see e.g. Bernanke 1986).

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