F-mix. I hope this brings about a debate over the tensions of Friedman's methodology in action and practice that produces less heat than light.

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Which structure do models represent?

Representation and structure in economics: the methodology of econometric models of the consumption function, by Hsiang-Ke Chao, London and New York: Routledge, 2009, xiii + 161 pp., £70.00, ISBN 0-415-36283-0

The *semantic* or *model-based approach* is a philosophical view about the nature and function of scientific theories which has become increasingly popular in the methodology of economics. Some scholars have recently argued that this approach is able to provide fundamental insights to understand the role played by econometric models in connecting theoretical claims with empirical evidence (Davis 2000; Stigum 2003; Chao 2005). In his *Representation and Structure in Economics*, Hsiang-Ke Chao investigates further this issue by both offering a thorough discussion of the semantic approach and presenting accurate and illuminating case studies drawn from consumption studies.

The semantic approach is a reaction to the logical positivist conception of scientific theory ('the received view'). This latter view assumes that any scientific theory can be reconstructed as an axiomatic system within the framework of formal logic (first-order predicate calculus with quantifiers). It was to a large extent inspired by Whitehead and Russell's (1910) project to reduce mathematics to logic. The emphasis here is on the syntax in the sense that the theory is articulated by deriving logical consequences from the axioms. As logical positivists were also empiricists, 'correspondence rules' were

formulated that linked the predicates of the theory with observational terms, thereby providing an empirical interpretation for theoretical terms.

On the semantic conception, the focus shifts from the logico-deductive aspects of the theory to the interpretations satisfying a system of axioms. Thus, the term 'semantic' is used here as in model theory, a branch of mathematical logic which studies the connection between a formal language and its interpretations. Model theory was primarily developed by Alfred Tarski in the 1930s with the purpose of addressing questions concerning the foundations of mathematics. In this framework a model is an interpretation of a theory in which all valid sentences of the theory are satisfied. An interpretation, also referred to as a *structure*, is defined in a set-theoretical manner, since it is formalized as a couple $<A, R>$ containing a set of elements A and a set of n-ary relations R. According to the promoters of the semantic conception, this approach can be applied to empirical sciences as well. From this perspective, a theory is an abstract system which has to be specified through models, which satisfy (or realize) the theoretical definitions. Models have to mirror some structure of reality but maintain a certain degree of autonomy.

Chao presents a very clear introduction of the semantic conception in its relation with mathematical logic and discusses different versions of this approach, which correspond to different ways of conceiving the relationship between model and data. He also makes clear the advantages that this conception offers for the analysis of empirical economics. Economists, as is well known, are the people of models. Defining what constitutes a model and what distinguishes it from a theory has always been quite controversial. However, one of the clearly recognized functions of models is their capacity of representing selected aspects of the world in isolation. Economists are very keen to use models, because these permit them to study the isolated phenomena through the lenses of theoretical principles, such as, for example, rationality and equilibrium, which are hardly applicable directly to the data. In general theoretical principles do not perfectly match complex phenomena, so that models provide the researcher an intermediate level between theory and data.

The focus of the book is on econometrics. Here model is still a key notion, but the meaning is slightly different from the one found in theoretical economics. An econometric model represents certain properties of the data using the theory of probability. In contrast to a statistical model, which solely describes probabilistic dependencies among the data, an econometric model incorporates certain restrictions dictated by the economic theory. In many cases these restrictions allow the researcher to claim that certain probabilistic dependencies are signs of actual causal influences.

As there are different versions of the semantic view, so too are there different methodologies of econometrics. Again, it is the variety of approaches to the theory–data confrontation that makes the difference. Another key notion used in econometrics is that of structure. A structure is a stable system of relations among a set of objects (p. 1). A structure is strictly associated with a model, because an econometric model aims at representing and measuring a structure. Thus, as argued by Chao, a model is more concrete than a structure, since the latter is usually hidden or not directly observed, while the former is directly built by the researcher. Different approaches to econometrics are interpreted as different views on what a structure is and how it relates to theory. Chao classifies the main macro-econometric approaches – Cowles Commission, vector autoregressive (VAR), New Classical, and London School of Economics – according to whether the theory view is accepted or rejected and whether the invariance view is explicitly or only implicitly endorsed. In the Cowles Commission approach, for instance, the structure articulated in the econometric model is specified by economic theory or *a priori* information. Chao calls this approach *theory view*. At the same time the Cowles Commission put much emphasis

on the notion of invariance: a structural relation must be stable to the changes of other elements. This position is referred to as the *invariance view*. The VAR approach, on the other hand, rejects the theory view and accepts the invariance view only implicitly.

Chao then presents specific examples of consumption studies to show how they relate to different versions of the semantic approach, except one – Milton Friedman's study of the permanent income hypothesis – which represents an application of the 'received view'. Friedman's case study is included not just because it is one of the most influential investigations on consumption. It permits Chao to elucidate how the semantic approach (represented by the other case studies) differs from the received view in the actual practices of economics.

In some parts of the book the reader may have the feeling that some connections between empirical studies of consumption and philosophical approaches are artificial juxtapositions. Indeed, apart from some anecdotal evidence, it is hard to believe that applied economists were directly influenced by specific philosophic approaches in any of the analysed cases. However, that feeling is not fully justified. Chao does not claim that the economic studies on consumption were directly inspired by philosophical stances. His aim is only to demonstrate that a particular philosophical view is able to clarify a particular empirical approach and vice versa, in agreement with a naturalistic methodology of science.

The first two case studies concern Richard Stone's and Trygve Haavelmo's empirical investigations on the consumption function (Stone 1954a; Stone 1954b; Haavelmo 1947a; Haavelmo 1947b; Girshick and Haavelmo 1947). Both studies are related by Chao to what he calls 'the general account of the semantic view' (p. 10). Namely, these studies are interpreted as endorsing the basic tenet of the semantic approach, i.e. focus on models as tools for representing and measuring structures. Stone's analysis of the demand system, conducted in the 1950s, was focused on microeconomics and cross-sectional data, while Haavelmo's empirical investigations, carried out at the end of the 1940s, concerned macroeconomics and time series data. Stone found a middle way between the theoretical and empirical strands of demand analysis. The theoretical strand refers to the tradition, which Chao traces back to Pareto, Walras, Marshall and Hicks, of deriving demand curves from utility-maximizing behaviour, in a manner consistent with the deductive approach of the received view. The empirical strand focuses on the statistical analysis of the relationship between prices and quantities, and between expenditures and income. The pioneer of this latter tradition is Ernst Engel, whose work in the middle of the nineteenth century paved the way for searching robust empirical regularities in consumption behaviour without much use of *a priori* theory. Stone created a model (the 'linear expenditure system') which satisfied a set of conditions derived by the theory of demand, the so-called 'Slutsky conditions'. Thus, Stone's linear expenditure system was aimed at representing the structure of the neoclassical theory of demand (based on utility maximization and equilibrium). But at the same time, it is also a model of the data, because it is articulated in a system of equation which can be estimated using simple regression techniques. This approach is consistent with the semantic view, according to Chao, because it conceives of models as crucial devices to bridge theory and data. Chao underlines the fact that the hypothetico-deductive method is eschewed by Stone, since the estimated system of equation is not derived by a set of axioms and then tested against the data. Instead the model is articulated in order to represent simultaneously theory and data, by maintaining a certain autonomy from both these two levels.

Haavelmo's econometric approach is also related by Chao to the semantic view. Haavelmo made some important contributions to estimating the marginal propensity to

consume in the US. At the same time, he was the pioneer of the Cowles Commission approach. In his methodological work he discussed at length the notions of structure, invariance and measurement. His mentor Ragnar Frisch claimed that an economic structure should be measurable, linked to economic theory, and invariant ('autonomous'). Haavelmo downplayed in part the role of theory by pointing out that invariance was the most important characteristic of structure. This view is related to Haavelmo's probabilistic methodology. Haavelmo was confident of the possibility of using statistics to capture autonomous structures. Background theory plays undoubtedly an important role in articulating the economic structure, especially its deterministic part. But the structure of a set of economic processes contains a stochastic part as well. By looking at the statistical property of the random part of the error terms the researcher should be able to tell whether the estimated structure is autonomous or not.

Invariance, in Haavelmo's view, comes in degrees, in a similar vein to Woodward (2003). Structural equations are statistical laws, i.e. laws that hold, on average, in the population. Chao is careful to report Haavelmo's claim that not all statistical laws are structural equations. An important average law, well studied also at the time of Haavelmo's analysis, is the Engel law: the richer a family is, the smaller is, on average, the budget share allocated to food. Engel curves measure the functional dependence of expenditure devoted to some commodity on income. Haavelmo pointed out that such curves have a low degree of invariance, in particular they are not invariant 'under transformation of the income distribution' (cit. at p. 63). According to Haavelmo, in other words, Engel curves cannot be used to measure the marginal propensity to consume (i.e. the elasticity of aggregate consumption to aggregate income), since aggregate income is not exogenous. Changes in income cause a change in the joint distribution of income and in other variables (e.g. family size, age, and location) that affect expenditure. Haavelmo proposed to measure the marginal propensity to consume by building a complete model of the Keynesian economy that includes investment, so that income is treated as endogenous. The model is formalized as a system of simultaneous equations which is estimated by indirect least squares. Thus, although an important data-driven component enters in Haavelmo's definition of structure (statistical autonomy), he still conceives structure as representing theory, in particular Keynesian economic theory.

Because Haavelmo underlined the importance of representing and measuring structure, Chao argues that he adheres to the semantic approach. Chao points out that Haavelmo is a realist about entities: economic structures are conceived of as really existing in the world. But how do we know that a particular structure, such as the one representing Keynesian theory, and not another one is the true structure of the world? Haavelmo gave much importance to statistical estimation and testing, but the structure of the economy was dictated by *a priori* theory. Yet, it may be the case that competing theories express alternative structures, both compatible with the data. Chao mentions this problem of identification in several parts of the book. The impression is, however, that he is more concerned to demonstrate the analogies between economic investigation and the semantic approach than to underline some of the difficulties that this approach inevitably encounters.

Chao regards Friedman's (1957) study of the permanent income hypothesis as an application of the received view. According to a popular reading of Friedman, a model is a tool for prediction, not for representation. But, as is well known, there are many interpretations of Friedman's methodology. Chao is very careful in providing an account of the different possibilities of reading Friedman. While he highlights the features that Friedman has in common with the logical-positivist view, he does not sufficiently consider some possible mismatches between Friedman's approach and the received view. For

instance, a crucial aspect of the received view is the emphasis on 'covering-law' explanation, which amounts to deductively systematizing the explanandum into the axiomatic structure of the theory. Friedman's approach to scientific explanation is actually at odds with this position. Probably because of his Marshallian methodology, which Chao rightly mentions (p. 6), Friedman attaches more importance to *mechanical* (or causal) rather than merely *nomological* patterns in a sound explanation. This is especially true in his applied works, where he considers permanent income as part of an unobserved mechanism which determines both consumers' choices and the demand for money.

Chao discusses two specific versions of the semantic view: Van Fraassen's (1980, 1989) constructive empiricism and Worrall (1989) structural realism. He then argues that van Fraassen's view is compatible with David Hendry's methodology of econometrics, also called London School of Economics (LSE) approach (cfr. Hendry 1995). The new classical Euler-equation analysis of consumption, on the other hand, is regarded as an application of Worrall's structural realism. The LSE approach differs from other methodologies for regarding econometric models not as direct representations of the theory, but as parsimonious descriptions of the data generating process (DGP). The DGP is an unobserved stochastic mechanism, which is assumed to have produced the data. Hendry has formalized a 'general-to-specific modelling strategy', which aims at characterizing a modelled DGP that is simpler than the real DGP but without loss of information relative to the questions of interest. The modeller starts with as broad a general specification of the DGP as possible and then searches over the space of possible restrictions to find more parsimonious specifications. At each step the validity of each reduction is statistically tested against alternative specifications.

Van Fraassen's version of the semantic view emphasizes the notion of empirical adequacy. A model should not aim to discover the truth concerning the unobservables. It is sufficient that it matches the phenomena. Van Fraassen is anti-realist about any claim concerning unobservable entities or processes. Since the LSE approach builds a model with the aim of representing the observed data, Chao argues that this approach is very much in tune with Van Fraassen's empirical stance. A case study of Hendry's empirical analysis of consumption is presented to sustain this claim. It is not clear, however, to what extent Hendry's methodology can be seen as anti-realist. The DGP is unobservable but refers to the actual structure of the economy. Ultimately, the similarity that Chao observes between Hendry's and Van Fraassen's approaches consists only in the primacy given to the empirical structure relative to the theoretical structure.

The opposite view which regards econometric models as structures of theory is represented, according to Chao, by the new classical Euler-equation approach primarily pursued in the work of Robert Hall (1978). Here, models formalize the theoretical structure about intertemporal optimizing behaviour and rational expectations. Implicit is a 'strong apriorism', that is a strong belief in the assumptions of economic theories. In the words of Chao '[i]f a model is not supported by empirical data when the model is considered as containing the true structure, we do not reject the model but instead construct a new model with the same true structure' (p. 127). Since the structure of intertemporal choices, formalized in the Euler equation, is preserved across different models, Chao claims that this is in tune with Worrall's structural realism. This is a methodological position which asserts that, even if successful theories are not an accurate description of the phenomena, the (mathematically expressed) structural content of theories describes true aspects of the world. This structure is retained across theory change. Chao is quite convincing in showing how the structural content of a theory is expressed in a mathematical form in the case of consumption. However, this begs the question of whether the structure captured by the

Euler equation is the right structure of the economy, or whether there are other structures which merit being captured by a system of equations.

In sum, this is a very rich book, where several philosophical approaches are discussed in parallel with econometric methods. The final message of the book is condensed in the following claim: 'in econometrics, especially in the cases discussed in this book: *models are representations; and more importantly, models aim to represent structures*'. Therefore, 'the semantic view or the model-based approach is useful to understand econometric methodology' (p. 134). Both claims are well sustained in the book. Yet, at the end of the nine chapters, the reader may have wished for stronger positions about issues that loom in the book's background, such as: which version of the semantic approach is more apt to study the consumption function? Which approach to consumption does better capture the structure of the world? And, more in general, if models represent structure but there are alternative structures to be represented (due to the presence of both alternative theories and diverse mechanisms in the reality), which structure should models represent? And how to adjudicate among models that represent alternative structures? The author seems to refuse to take a final position about these questions. This may be due to the fact that his focus is more on establishing parallelisms between econometric studies and philosophical approaches. On the other hand, those are issues that are quite difficult to settle and the book offers valuable and sound material which improves the possibility of tackling them.

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