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Modelling nonlinear economic relationships. (English) Zbl 0893.90030

Advanced Texts in Econometrics. Oxford: Oxford University Press. x, 187 p. (1993).

This book provides a clear and useful review of the state of the art on nonlinear modelling in econometrics. It can be divided into four parts: the foundations for the theory of testing nonlinearities and of model specification (Chapters 1-5), that theory itself (Chapters 6-8), a few empirical applications (Chapter 9), and an outline of a strategy for building nonlinear models (Chapter 10).

Chapter 1 raises several choices in modelling the economy: single dependent variable versus multivariate systems, discrete versus continuous time series data, deterministic versus stochastic series, parametric versus nonparametric models, and linear versus nonlinear approaches. Particular nonlinear models include nonlinear AR (NLAR), nonlinear MA (NLMA), threshold AR (TAR), and smooth transition AR (STAR) models. The chapter then extends the concepts of stationarity, invertibility, ergodicity, heteroscedasticity, stability, memory length, aggregation, and exogeneity to nonlinear models as a basis for discussion in the following chapters.

Chapter 2 presents nonlinear models from a mathematical-statistical viewpoint. Models are regarded as approximations to differentiable nonlinear functions, and hence the number of coefficients increases rapidly with the order of the approximation. Conversely, lower-order expansions may lead to misspecified models that are useless for forecasting and nonsensical economically. Models are obtained from Taylor series and Volterra expansions and may be state-affine, state-dependent, or doubly stochastic. The chapter also examines frequency- and time-domain measures, such as the bispectrum, cross-bispectrum, and auto- and cross-correlations, which are used for detecting nonlinearities and for detecting the existence of a relationship. Flaws in these measures lead to alternative but simple statistics such as the maximum correlation coefficient, the maximum mean correlation, and the maximum regression coefficient. More sophisticated alternatives appear in Chapter 6.

Chapter 3 describes several nonlinear models inspired by economic theory: the savings function, Desai's application of the prey-predator model to the labor market, Cobb-Douglas and CES production functions, the translog cost function, and switching regimes. The chapter also considers bifurcations and chaotic processes and tests thereof, noting that high-dimensional chaos can be difficult to distinguish from stochastic process.

Chapter 4 proceeds to multivariate analysis, describing purely nonlinear time series models, such as NLVAR(p) and NLMA(q), and bilinear models and models based on switching regimes, such as STAR, exponential STAR (ESTAR), smooth transition regimes (STR), and logistic STR (LSTR). Models for higher-order moments such as conditional variances are also considered: in particular, ARCH, GARCH, and random coefficient models.

Chapter 5 provides a concept of memory length for linear processes and its generalization for nonlinear processes. Examples are given of nonlinear processes preserving their memory length under particular transformations. The chapter then extends the concept of cointegration to nonlinear models, defining attractors and nonlinear ECMs and showing how they can be estimated and test.

Chapter 6, "Linearity Testing", is pivotal in this book. It collects tests against nonlinearity, both those for testing whether a linear model represents a suitable specification of the DGP, and those for testing whether the assumed nonlinear features in the data have been appropriately captured by a nonlinear model. Lagrange multiplier (LM) tests predominate – unsurprisingly so, as the alternative hypothesis is typically much more difficult to estimate than the null hypothesis. LM statistics are formulated for a general nonlinear model with a parameterized nonconstant conditional variance and with nonparameterized or ignored heteroscedasticity. Special cases examined include several variants of STR models. Tests against an unspecified nonlinear alternative are also feasible and include RESET, expansion-based, neural network, and BDS tests, as well as many constancy tests using re-arranged observations. Gourieroux and Monfort's definition of locally equivalent alternatives and the definition of a test's asymptotic relative efficiency highlight alternative ways of deriving and evaluating the test procedures.

Chapter 7 considers how to specify a nonlinear model after a nonlinearity test has rejected a particular

linear relationship. First, this chapter discusses estimation of nonparametric and semiparametric models, which might be considered if a particular nonlinear specification has not been decided upon at the outset. Then, the chapter examines the specification, estimation, and evaluation of parametric models, focusing on the STR, bilinear, and neural network models discussed previously. Evaluation of nonlinear models ties back to Chapter 3 (p. 31): the model should be consistent with economic theory, data admissible, flexible in functional form, congruent with the data, and computationally attractive. Estimated parameter values should be economically sensible. Tests of data congruency include checks against autocorrelation, ARCH, nonnormality, and nonlinearities in the residuals of the nonlinear model. Additional tests focus on long-run dynamic properties and the nonlinear model's forecasting performance relative to that of linear models.

Chapter 8 analyses a few methods for forecasting with nonlinear models. It examines preservation of nonlinearities after aggregation, looks at the nonlinearity of business cycles, and considers how a combination (either linear or nonlinear) of forecasts from a range of nonlinear models may obtain a better forecast than an individual model can provide.

Chapter 9 provides empirical applications of the methodology put forward in Chapter 7. Nonlinear univariate econometric models are built for four-quarter growth rates of industrial production in several OECD countries. Estimated linear models are tested for and found to have nonlinearities, and a choice is made between LSTAR and ESTAR models. The chapter also develops an STR model relating U.S. GDP to an index of leading indicators, finding mixed evidence for the STR model against a linear ECM model. Finally, Chapter 10 proposes a strategy for building nonlinear models.

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