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INTRODUCTION TO THE SPECIAL ISSUE: NONLINEAR MODELING OF MULTIVARIATE MACROECONOMIC RELATIONS

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1. INTRODUCTION

During the past decade, the popularity of nonlinear models in econometrics has been increasing quite rapidly. Nonlinear models are now widely used for modeling macroeconomic relationships, and they also are used frequently in financial econometrics. The most popular nonlinear models have been univariate. Threshold autoregressive, Markov switching autoregressive, and smooth-transition autoregressive models, just to name a few popular families of models, have been widely applied to modeling of macroeconomic series. Even nonlinear multivariate single-equation models have found application in areas where linear single-equation models traditionally have been used, such as modeling the demand for money, real exchange rates, consumption–income relationship, and house prices. Interest in nonlinearities in the Phillips curve also has grown recently.

Much less work has been done in nonlinear systems. The disequilibrium models whose development began in the early 1970's [see Fair and Jaffee (1972)] constitute an early exception. These models are aimed at describing situations in which there exist constraints in the market that prevent convergence to an equilibrium. Sticky prices (wages) or rationing of goods may serve as examples of phenomena that may cause permanent disequilibria in the markets. Disequilibrium models peaked in popularity in the 1980's. Recently, the increased interest in dynamic nonlinear models has resulted in new work on dynamic nonlinear systems and their application to macroeconomic problems. To provide an opportunity to discuss some of this research and pave the way for new developments, a workshop focusing on multivariate nonlinear models in econometrics was organized in Rotterdam, The Netherlands, September 17–18, 1999. This special issue of *Macroeconomic Dynamics* contains a selection of papers from that meeting.

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2. CONTENTS OF THIS SPECIAL ISSUE

The first paper, based on the opening lecture of the workshop by Clive Granger, contains an overview of nonlinear empirical macroeconometric models. This survey covers, with some exceptions pointed out in the article, both single-equation multivariate models and systems. First, Granger remarks that empirical evidence for nonlinearity in macroeconometric literature is not very strong. This he attributes to aggregation, which is discussed in a separate section. Even if micro relations were strongly nonlinear, aggregating them to macro level usually weakens the nonlinearity. Next, Granger considers vector autoregressive models and nonlinear error or equilibrium correction. He points out that threshold cointegration that recently has become a topic of considerable interest, may involve a disequilibrium-correcting term. This special issue contains an innovative paper on threshold cointegration by Ming Chien Lo and Eric Zivot, which is considered later.

The paper of Granger also draws attention to the modeling of asymmetric shocks and the work on generalized impulse response functions. In particular, he mentions the "floor and ceiling model" of output that goes back to Hicks as well as the, by now well-known, current depth-of-recession model. Granger also takes up regime-switching models in his overview and observes that most of the papers in that field make use of a model in which only the intercept is switching. This is indeed the most popular alternative in economic applications. Furthermore, Granger considers time-varying parameter models, common nonlinear factors, and forecasting with nonlinear models. Finally, he concludes that there is a major weakness in most if not all studies considered in his survey. They lack postsample evaluation, which Granger finds important because nonlinear models often may overfit the data. This postsample evaluation period should even be rather long because "nonlinear behavior" may occur rather infrequently in the series.

Obtaining reliable forecasts of recessions is important for policy makers and decision makers in business alike. In their paper, Heather Anderson and Farshid Vahid consider this problem. They apply Fair's (1993) definition of recession and define a loss function for evaluating the success of time-series models in correctly forecasting a recession. The economy in question is that of the United States, and the series to be forecast is the quarterly U.S. GDP. Anderson and Vahid are interested in the case in which the forecasts are conditional and based on a number of leading indicators. In particular, they want to investigate the usefulness of the interest-rate spread as a leading indicator of the U.S. GDP. The possibility of using changes in the money (M2) stock also is considered.

After a univariate analysis, Anderson and Vahid build bivariate systems of the GDP (in first differences) and the interest-rate spread. They consider both linear vector autoregressive and nonlinear smooth-transition autoregressive systems. They find that, in the linear case, inclusion of the interest-rate spread improves the predictive accuracy in forecasting recessions compared to the performance of univariate models. When linearity is tested against the smooth-transition alternative, it is soundly rejected for both equations of the system. Anderson and Vahid then specify and estimate a bivariate smooth-transition autoregressive system for the GDP first difference and the interest-rate spread. The results indicate that using this bivariate system for forecasting recessions increases the accuracy compared to that obtained with the linear bivariate system. Additional modeling experiments show that extending the system by including money (M2) does not improve the accuracy of recession forecasts any further. A general conclusion is that a bivariate nonlinear system gives fewer false warnings than a linear system, and Anderson and Vahid would encourage researchers to consider such system with an interest-rate spread for forecasting U.S. recessions.

Philip Rothman, Dick van Dijk, and Philip Hans Franses return to an old problem of causality between money and output. The empirical analysis is carried out using U.S. series. The authors do not exclude the possibility that the relationship between money and output is nonlinear. They consider a two-equation system containing an equation for money and another one for input. In doing that, they do not exclude the possibility that the relationship between money and output is nonlinear. They rely on a vector smooth-transition regression and, because their system contains equilibrium correction terms, call their model a smooth-transition vector error correction (STVEC) model. Rothman and colleagues apply a rolling window when they analyze their time series. Thus they use a fixed number of observations for estimation, move that observation window over time, and leave a fixed number of observations for forecasting a number of periods ahead. This leads to a large number of “ex-post out-of-sample” forecasts. The purpose of the forecasting exercise is to investigate the question of Granger causality between money and output. The results of their linearity tests against the STVEC model indicate nonlinear Granger causality from money to input. But then, Rothman and colleagues also apply the Granger’s original definition and consider the causality out of sample through the above-mentioned forecasts. One of their main findings is that forecasts from STVEC models are no more accurate than the ones from linear models. This outcome is discussed in detail in the article.

The law of one price or purchasing-power parity is an economic theory that has been thoroughly investigated over the years. Despite its intuitive appeal, this law has not found empirical support in many studies. Recently, nonlinearity due to adjustment costs has been put forward as a possible explanation of this counterintuitive result. Ming Chien Lo and Eric Zivot consider the law of one price, using threshold cointegration as their tool. Their data set consists of monthly U.S. consumer price indices that represent 43 categories of goods for 29 cities. This makes it possible to consider the law of one price at a rather disaggregated level. The authors define a multivariate (in practice, bivariate) threshold cointegration model in order to investigate the law of one price in that framework. This model, called a threshold vector error correction model, is a special case of the general vector threshold autoregressive model of Tsay (1989).

In the theoretical part of their article, Lo and Zivot consider tests of no cointegration against linear cointegration and threshold cointegration and tests of linearity after determining that cointegration is present in the data. They also discuss specification testing in detail and report results from a large number of small-sample size and power simulations. In the application, Lo and Zivot consider pairs of cities and prices and apply a bivariate threshold cointegration model. They find evidence for threshold cointegration in goods that are relatively homogeneous. On the other hand, the distance between the cities generally does not seem to affect the speed of adjustment, although one might expect that to be the case. The authors have applied threshold cointegration models that assume symmetric bands and identical adjustment speeds for both cities. They conclude, however, that the adjustment speeds may be different and suggest that less restrictive models may give more informative estimates. The work of Lo and Zivot therefore opens up interesting possibilities for further research in this area.

Nonlinearity and occasional structural breaks are two features that can occur in empirical macroeconomic data. Indeed, there may be various reasons for the presence of such breaks, such as oil crises, institutional factors, or simply changes in data collection techniques, and it seems relevant to explore these, perhaps even before considering a nonlinear model. One reason may be that a nonlinear model imposes certain structures on the out-of-sample forecasts, while taking care of structural breaks somehow adjusts the direction of the mean or trend line. Because linear multivariate models may be easier to analyze in various empirical situations, it seems worthwhile to see if such models can be generalized by allowing for nonlinear trending patterns. Antti Ripatti and Pentti Saikkonen put forward such an analysis by focusing on vector autoregressive models with nonlinear time trends in the cointegrating relations. They discuss the relevant asymptotic theory for estimation and statistical inference. Upon applying their model to interest-rate data for Finland, they find that allowing for a smooth level shift improves on an earlier model. In that model, the possibility of such a shift had been ignored, and this had led to a model with a missing cointegration vector.

The concept of Granger causality is an important one in econometrics and has been popular in the linear framework. However, in the context of nonlinear models, the concept can become a little more difficult to operationalize. One alternative may be to consider the concept for actual out-of-sample forecasts. In their article, John Chao, Valentina Corradi, and Norman Swanson develop simple (nonlinear) out-of-sample predictive ability tests of the Granger noncausality null hypothesis. They use various Monte Carlo simulations to illustrate the potential usefulness of their approach. The empirical illustration considers an (approximately) linearized version of the model used in the article by Rothman et al. One of the interesting findings is that, based on in-sample data, money seems to cause output, but, in terms of out-of-sample forecasting, this evidence disappears.

The last paper in this special issue aims at correlating fluctuations in financial returns and volatility with business-cycle fluctuations. Marcelle Chauvet and Simon Potter construct an unobservable dynamic factor model to approximate the market risk premia, where the first two moments are driven by a latent two-state Markov variable. Their approach has an interesting consequence, which is that investors are allowed to respond to changes in risk in an asymmetric fashion, depending on their perception of the actual business cycle. An important empirical finding is that, around peaks, and in a limited period thereafter, the relation between returns and risk is negative, whereas it is positive in the period toward the next trough.

3. FINAL REMARKS

We hope that the reader will enjoy this special issue. The articles are of high quality and present solutions to interesting problems in quantitative dynamic macroeconomics. We wish to thank the Editor of *Macroeconomic Dynamics*, Bill Barnett, for the opportunity to put this issue together. We are also very grateful to a number of referees who have spent valuable time reviewing the manuscripts and providing the authors with many relevant and useful suggestions.

The conference is Rotterdam was well attended by over 40 researchers. Organizing the meeting would not have been possible without financial help from a number of sponsors. In particular, we would like to thank Tinbergen Institute Rotterdam, Erasmus Center for Financial Research, Erasmus University Trustfund, Netherlands Organisation for Scientific Research, Econometric Institute Rotterdam, and Rotterdam Institute for Business and Economic Studies, for their generous support. Finally, we specifically wish to thank Elli Hoek van Dijke and Herman van Dijk, who genuinely substituted for the local organizer during the entire conference when Cedric J. Franses, who was born right before the first session, stole his attention.

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