Universitat Autònoma de Barcelona
Departament d'Economia i d'Història Econòmica

Three essays in nonlinear macroeconometrics

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“My interest is in the future because I am going to spend the rest of my life there”

C.F. Kettering

A Carmen y a mis Padres

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CHAPTER 1: Introduction

1 Importance of forecasting

Early detection of future economic changes is crucial for economic decisions to be optimal when future arrives. Let us imagine for a moment that certain economic agents could incorporate into their optimization programs perfect knowledge about the future economic events. Competitive firms could modify their purchase, production and retail decisions to exploit their competitive advantages leading their respective sectors. Policy makers could anticipate the consequences of setting monetary and fiscal policies to obtain efficiency in expansionary and contractionary policies, smoothness in stabilization policies, and maximum social welfare effects. Consumers could maximize utility under the absence of uncertainty reaching consumption paths that optimize their programs. Nothing to say about investment opportunities in financial markets.

Surely, this unrealistic assumption lead the reader to evaluate the importance of forecasting in economics. Unfortunately, this situation is similar to the assumption that economic agents own a crystal ball showing the future. This is of course far from the day-to-day process of forecasting: under the assumption that there are some patterns in the economic dynamic likely to appear into the future, forecasters use the information available at any point in time to recognize these patterns and to produce statements about the future. Both errors in recognizing the patterns and errors in assuming that the patterns will follow lead to difference between the original forecast and the final outcome, i.e. forecast errors.

Econometric forecasts try to minimize the forecast errors. There are many ways of producing forecasts but those based in time-series analysis have been by much the more used in the literature of forecasting. Box and Jenkins published in 1976 one of the more influencing books in econometrics stating a systematic analysis of linear ARIMA forecasts. The success of these linear models is due to their accuracy at forecasting univariate series even though their simple structure. The generalization of these models to a multivariate framework is firstly proposed by Sims (1980) who introduces the concept of vector autoregressive VAR specifications. The seminal paper of Engel and Granger (1987) introduces long-run restrictions to the VAR models.

All of these seminal studies share a common assumption: they assume that the relationships among the model's variables are linear which implicitly imposes symmetric restrictions. This is difficult to reconcile with the idea that markets economy are characterized by business cycles which are sequences of expansions and contractions in economic activity within which the economy presents different behavior.

During the 1990s, several nonlinear methods emerge to mitigate the symmetry problems of linear models. Among them, the Markov-switching (MS) models proposed by Hamilton (1989) and the Smooth Transition Autoregressive (STAR) models introduced by Teräsvirta (1994) have been the most treated in the current literature. Both models assume that the economy is characterized by different states, that there are an specific behavior in each of these states, and that there is a time-series variable that is able to locate the model among states. However, such variable is an unobserved series following an stochastic Markov process in MS models and an observed deterministic series in STAR models.

In order to obtain accurate and interpretable forecasts two open questions remain. First, due to the specific behavior of the economy within the business-cycles phases, is there any variable with the ability of anticipating the turning points of these swings? And second, due to the sophistication of the time-series analysis, are there simple and intuitive ways to illustrate the forecasting results to be used for practitioners, policy makers or simply non-technical users?

2 Business-cycles indicators

In the early 1940s the National Bureau of Economic Research (NBER), using both observed empirical behavior and theories of the business cycle, elaborated a system of indicators to signal turning points of business activity. The process of constructing these indexes has suffered several changes, however. First, there exist statistical revisions reflecting the collection of richer and more representative sources data samples when time passes. Second, the components that make up the index have been reselected and reweighted ex post leading to definitional revisions in the indexes. Finally, these indexes are issued by The Conference Board since October 1996.

The Conference Board issues three groups of indexes: leading, coincident and lagging indexes that are currently weighted averages of ten, four and seven series respectively. The leading indicators have designed to anticipate peaks and troughs in the business cycle. The coincident indicators are comprehensive measures of the economic performance, indicating the direction global movement of the economy. The lagging indicators are more sluggish in their reactions to the economic climate but they help to confirm diagnostics made by

coincident and leading indicators and they turn into very long-leading indicators when they are inverted.

3 Reaction to shocks

What is the relative importance of large and small, or positive and negative, shocks hitting the economy at any time? Are the effects symmetric over the business cycles? Are them permanent or become negligible after several periods? The Impulse-Response Functions (IRF) and the Variance Decomposition (VD) are a very easy and intuitive way of answering these questions.

The IRF are the estimates of the impact of innovations on the model's endogenous variables. They tell us how structural shocks will affect any of the endogenous variables initially and after several periods. Along with the point estimates of the IRF it is usually presented confidence bands indicating how precise are the estimates in a statistical sense.

Another useful tool of examining the relative importance of unpredictable shocks to the endogenous variables in the model involves decomposing the variance of the forecast errors. This shows the percentage of the k-step ahead forecast error variance in each of the endogenous variables that is accounted for by each shock, that is, they investigate what is the dominate source of forecast errors.

4 Contribution

This dissertation is an attempt to contribute to this literature in many ways. Specifically, Chapter 2 extends to a multiple equation framework the STAR models in order to in-

vestigate the nonlinear interactions between output and the Composite index of Leading Indicators (CLI). Chapter 3 uses several linear and nonlinear specifications to extract an appropriate filter that convert the CLI issues into a more intuitive probability of being in recession one quarter ahead. Finally, Chapter 4 develops a framework to calculate IRF and VD in a framework of linear cointegrating relations but regime-switching cointegrating errors.

4.1 Chapter 2

I present in the second chapter the paper titled *Vector Smooth Transition Regression Models for US GDP and the Composite index of Leading Indicators.* In this paper I propose a VAR generalization of the STAR model that we call, by analogy, Vector Smooth Transition Regression (VSTR) models. Using maximum likelihood as the base for estimation, I adapt linearity and model selection tests as long as several tests to check the accuracy of the selected VSTR models, i.e., tests for serially independence of errors, tests of no remaining nonlinearity and tests of parameter constancy.

I apply this method to examine the nonlinear relationships between GDP and the CLI in the US economy. I find that linearity is rejected for several VSTR specifications that passes the accuracy tests fairly well. However, a logistic-VSTR is more accurate than any other specification both in anticipating growth specially during recessions. Moreover, I investigate the ability of these models to forecast the business-cycles phases. Interestingly, I point out that the information available in the transition function may be useful to elaborate real-time forecasts of the official NBER schedule.

4.2 Chapter 3

Following with the study of the ability of the CLI in forecasting output and recessions I take account of the paper *This is what the leading indicators lead* (jointly with Gabriel Perez-Quiros) in Chapter 3. The series of CLI issued monthly by The Conference Board is a nonintuitive series of thousands of numbers. But, Is this series a good tool to anticipate future changes in the business-cycles phases? What is the meaning of a zero rate of growth of the CLI? We show in this paper that the accuracy of a leading indicator is only as good as the efficiency of the filter used to extract its leading information. Thus, we propose an optimal filter to convert the series of CLI into more intuitive probabilities of being in recession one quarter ahead.

For this attempt, we use several methods to forecast both probability recessions and output in the US economy. Among them, we include linear models (AR, VAR), probit, VSTR, multiple equation MS and nonparametric techniques. We find that a combination of the information coming from the best model within recession (MS) and the best model within expansions (nonparametric) outperform any other specification both in-sample and in real-time analysis.

Using this filter, we point out the following interesting result. The same rate of growth of the CLI produces rather different signals about the probability of forthcoming recessions depending on the forecast period in consideration. To be concrete, our filter interpret a zero quarterly rate of growth of the CLI in 1990.4 (within a NBER recession) and 1997.4 (within a NBER expansion) as a probability of being in recession the next quarter of almost one and almost zero respectively. It has a very intuitive explanation: at each period our

filter evaluates the state of the economy prior to forecast a probability of recession.

4.3 Chapter 4

I include in the last chapter the paper *Nonlinear stochastic trends and economic fluctuations*. The classical Engle-Granger Vector Error Correction (VEC) representation assume that linear a combination of nonstationary variables may behave as an attractor, that is, the equilibrium errors or departures from the attractor present a stationary dynamics. In this paper I present both theoretical and empirical evidence that, even though I consider linear attractors, the equilibrium errors may follow a MS with the states referring to the business-cycle phases. This implies that the strength to which the deviations from the attractor vanish depend on the state of the economy.

I thus postulate a MS-VEC model to allow for the business-cycle dynamics of the equilibrium errors and we examine how these models are closely related with the assumption of nonlinear common trends. To analyze the dynamics of the system, we find an explicit expression of the IRF and VD within this nonlinear framework, and we propose a way of computing the respective confidence bands.

I apply these findings to analyze the effects of permanent shocks to output, consumption and investment. I show that both the short-run reaction to permanent shocks and the ability of such shocks to explain short-run variability of the variables depend on the state of the business cycles.