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A dynamic factor approach to nonlinear stability analysis ☆

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Abstract

A method of principal components is employed to investigate nonlinear dynamic factor structure using a large panel data. Imposing a common factor structure has practical merit in reducing dimension for the nonparametric stability analysis of a large system. Under some conditions, replacing unobservable common factors by principal components in the nonparametric estimation is theoretically justified. The validity of this approach is also supported by simulation analysis even if the true lag order of the autoregressive process of a common component is unknown. When the method is applied to the U.S. business cycles, the class of nonlinearity that can generate endogenous fluctuation or chaos is not supported by the data.

JEL classification: C14; C33

Keywords: Chaos; Dynamic factor model; Lyapunov exponents; Nonparametric regression; Principal components

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1. Introduction

Traditionally, we treat expansions and contractions of the economy as a result of exogenous random shocks explained by a change in policy, a change in demand, technological change, or other supply shocks. An alternative view is to consider the endogenous aggregate fluctuation via a chaotic system, or a simple nonlinear deterministic system that can have stochastic-like unpredictable behavior. One of the most convenient empirical methods for considering two competing views of the business cycle is to compute a stability measure called the largest Lyapunov exponent. The Lyapunov exponent measures the sensitive dependence on initial conditions and is often employed to define a chaotic behavior in either a deterministic or stochastic nonlinear system (Eckmann and Ruelle, 1985; Nychka et al., 1992). A chaotic system has a positive Lyapunov exponent, while an exogenous system with a unique and globally stable steady state has a negative Lyapunov exponent.

In practice, the nonparametric regression method is often employed to compute Lyapunov exponents of an unknown nonlinear autoregressive (AR) model. Such a nonparametric Lyapunov exponent estimator was first considered by Eckmann and Ruelle (1985) and Eckmann et al. (1986). Its statistical properties are later examined by McCaffrey et al. (1992), Whang and Linton (1999), and Shintani and Linton (2004). By applying this nonparametric method to the GDP series from OECD countries, Shintani and Linton (2003) found that the Lyapunov exponents were significantly negative for most cases, which supported the exogenous view of a business cycle as opposed to the chaotic view. This approach was also applied to foreign exchange rates by Dechert and Gençay (1992), monetary aggregates by Serletis (1995) and Barnett et al. (1995), and the stock return series by Abhyankar et al. (1997) and Shintani and Linton (2004). However, one potential drawback of the approach employed in these studies is that only a univariate time series could be considered in each estimation. If the true system consists of N equations, the theoretical result known as Takens (1981) embedding implies that $2N+1$ lags are required in the estimation of a univariate nonlinear AR model. Thus, even with a moderately large N, the accuracy of the full nonparametric estimation cannot be expected due to the 'curse of dimensionality' problem of Bellman (1961).

The main objective of this paper is to consider an alternative approach to conducting a test regarding the stability of the multivariate nonlinear system with a large N. Instead of running a nonparametric regression using each individual economic time series, we consider a multiple time series generated from a dynamic factor model with a common factor following a nonlinear process. Imposing such a common factor structure in a system of equations, by construction, achieves dimensional reduction, and thus the nonparametric estimation is less subject to a high-dimensionality problem. For this reason, this approach seems to have a practical merit in a stability analysis of business cycles.

The dynamic factor model, originally considered by Sargent and Sims (1977) and Geweke (1977), has long been employed in macroeconomic analysis, including the construction of business cycle indexes, the analysis of stock price dynamics and