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A quantile approach to US GNP

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Abstract

In this paper we fitted a quantile self-exciting threshold autoregressive (QSETAR) time series model to the growth rate of real US GNP. We also presented a forecasting method for QSETAR models. This forecasting method makes it possible to obtain the predictive quantiles and predictive distribution function of x_{t+m} given x_t for $m>0$, and hence any quantities of interest can be derived. Therefore, this new approach allows us to study the US GNP from a distribution point view, rather than from a mean point of view. The results obtained in this paper show that the method works very well in practice.

Keywords: Bayesian inference; Predictive quantiles; Predictive density functions; QSETAR model; US GNP

1. Introduction

A Self-Exciting Threshold Autoregressive (SETAR) time series model was first proposed by Tong and Lim (1980).

Let ξ_{it} be a sequence of independently identically distributed (iid) Gaussian random variables with mean zero and variance σ_i^2, let $-\infty=r_0<r_1<\ldots<r_w<\infty$ be threshold values, and let $\Omega_i=(r_{i-1},r_i]$, $i=1,\ldots, w$, and $\Omega_{w+1}=(r_w,\infty)$. Then a SETAR model is defined by:

$$x_t=\sum_{i=1}^{w+1}(\beta_{i0}+\beta_{i1}x_{t-1}+\ldots+\beta_{ip}x_{t-p}+\xi_{it}))\ I_{[x_{t-d}\in\Omega_i]}, \tag{1}$$

where β_{ij}, $\sigma_i>0$ and $d>0$ are the parameters of the model, with d being called the delay parameter. The order of the model is p, and $I_{[x\in\Omega_i]}$ is an indication function of the event $x\in\Omega_i$, where Ω_i is the i^{th} regime of the SETAR model.

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This model says that the time series at time t follows different autoregressions according to the thresholds and the delay parameter. For example, in modelling currency exchange rate, the thresholds may represent intervention levels, and the delay parameter d, say $d=1$, indicates that the most recent exchange rate is important for deciding the current intervention level of a central bank.

Since Tong and Lim's work (1980), this model has been applied to many time series in economics. For example, Kräger and Kugler (1993) estimated SETAR models for five currency exchange rates. In all cases they found significant threshold effects on the exchange rates. Clements and Smith (2001) evaluated forecasts from the two SETAR models proposed by Kräger and Kugler (1993). Peel and Speight (1998) fitted SETAR models for five of the G7 economies, namely Canada, Germany, Japan, the UK and the US. They reported that except for Canada, the fitted SETAR models imply asymmetric dynamics, are able to account for all nonlinear structure in the data, and provide sizable reductions in residual variances. Peel and Speight (2000) also estimated SETAR models for unemployment rates for Germany, Japan, the UK and the US. They found that those SETAR models provide superior one-step-ahead forecast and exhibit predictive accuracy in the sense of parameter and residual variance stability. More recently, Feng and Liu (2003) employed a SETAR model to Canadian GDP data and studied the out of sample forecasting ability of the SETAR model. They found that the SETAR model performs well with respect to the out of sample forecasting performance. The US GNP time series has also been studied by a number of researchers. For example, Beaudry and Koop (1993), Brunner (1992) and Teräsvirta and Anderson (1992). Tiao and Tsay (1994), and Potter (1995) studied the properties of US GNP by using SETAR time series models. They found that the response of output to shocks at different stages of the business cycle is asymmetric.

However, SETAR models can only be used to describe the conditional mean behaviour of a time series x_t. It would be very interesting to study the quantiles and hence the whole distribution of x_t conditioning on the history of the data. In this paper we will study the quantiles and the distribution of the growth rate of US real GNP by using Bayesian quantile regression methods.

Quantile regression is an important statistical technique which offers a mechanism for estimating models for full range of conditional quantile functions. Compared with the estimation of conditional mean functions, quantile regression is capable of providing a more complete statistical analysis of the stochastic relationships among random variables. Furthermore, quantile regression method is very robust to outliers which is another feature often reported in literature.

Some work on quantile autoregression methods in time series can be found in the literature. For example, Weiss (1987) discussed how to estimate nonlinear dynamic models using least absolute error estimation, and Koenker and Xiao (2004) studied statistical inference in quantile autoregression models when the largest autoregressive coefficient may be unity. Koenker and Xiao (2006) considered quantile autoregression models in which the autoregressive coefficients can be expressed as monotone functions of a single, scalar random variable. Cai (2005) presented a Bayesian approach to QSETAR time series models. In this paper we apply the methodology to the growth rate of US GNP and also develop a new forecasting method for QSETAR models.

The arrangement of the paper is as follows. In Section 2 we describe the QSETAR model and the Bayesian method for estimating the parameters. The details about the fitted QSETAR model to the growth rate of US GNP data are given in Section 3. In Section 4 we present a new forecasting method for QSETAR models and apply the method to the fitted QSETAR model. Finally, some comments and conclusions are given in Section 5.