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Characterising economic trends by Bayesian stochastic model specification search

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ABSTRACT

A recently proposed Bayesian model selection technique, stochastic model specification search, is carried out to discriminate between two trend generation hypotheses. The first is the trend-stationary hypothesis, for which the trend is a deterministic function of time and the short run dynamics are represented by a stationary autoregressive process. The second is the difference-stationary hypothesis, according to which the trend results from the cumulation of the effects of random disturbances. A difference-stationary process may originate in two ways: from an unobserved components process adding up an integrated trend and an orthogonal transitory component, or implicitly from an autoregressive process with roots on the unit circle. The different trend generation hypotheses are nested within an encompassing linear state space model. After a reparameterisation in non-centred form, the empirical evidence supporting a particular hypothesis is obtained by performing variable selection on the model components, using a suitably designed Gibbs sampling scheme. The methodology is illustrated with reference to a set of US macroeconomic time series which includes the traditional Nelson and Plosser dataset. The conclusion is that most series are better represented by autoregressive models with time-invariant intercept and slope and coefficients that are close to boundary of the stationarity region. The posterior distribution of the autoregressive parameters provides useful insight on quasi-integrated nature of the specifications selected.

1. Introduction

Characterising the nature of the trends observed in economic time series is a widely debated topic in time series analysis. An issue that has attracted a lot of attention is whether the trend is best captured by deterministic or integrated stochastic processes.

The historically oldest approach is to view the trend as a deterministic, possibly unknown, function of time, and the deviations from trend as a stationary process (thus, the series is said to be trend-stationary). According to this interpretation, the trend is an entirely exogenous component, that can be estimated e.g. by global or local polynomial approximations.

An alternative view is that trends arise endogenously as a result of the persistent effects of economic shocks, that are cumulated in the level of the series. This behaviour is the characteristic property of the class of integrated, or unit root, processes. As the series can be made stationary after suitable differencing, it is also said to be difference-stationary. The distinction between what is permanent and what is transitory in economic dynamics has important implications for interpretation and policy.

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The econometric literature has envisaged formal statistical tests for discriminating the two trend generation hypotheses. Unit root tests, see Dickey and Fuller (1979) and Phillips and Perron (1988), test the null of integration versus a stationary alternative; on the contrary, stationary tests, see Nyblom and Makelainen (1983) and Kwiatkowski et al. (1992), test trend stationarity against the alternative of integration. The implications for the interpretation of macroeconomic dynamics were considered in a seminal paper by Nelson and Plosser (1982), in which they applied the Dickey–Fuller test on a representative set of annual U.S. macroeconomic time series, and were unable to reject the null of integration for most of the series.

A rich literature has discussed the limitations of the testing approach, see among others (DeJong et al., 1992; Schwert, 1989; Caner and Kilian, 2001; Pitarakis, in press; Fossati, 2012) has proposed refinements and enhancements. Important references are (Perron, 1989; Elliott et al., 1996; Ng and Perron, 2001) for unit roots tests, and (Leybourne and McCabe, 1994) for stationarity tests; see also Harvey (2001) for a review.

The Bayesian approach to unit root testing has been considered by De Jong and Whiteman (1991), Koop (1992), Sims (1988), Sims and Uhlig (1991), Phillips (1991), Schotman and van Dijk (1991), Phillips and Ploberger (1994), among others; the literature has focused on the selection of noninformative priors for the autoregressive coefficients and on assessing the sensitivity of model selection on the prior choice.

The problem of discriminating fixed trends from stochastically evolving ones has been addressed by Frühwirth-Schnatter (1995) and Koop and van Dijk (2000). The research question that we posit in this paper is similar to that of the two aforementioned articles, in that our ultimate aim is establishing which trend model appears to provide the most plausible explanation for the behaviour of economic time series. However, our approach is different as we capitalise on the recent developments in Bayesian model selection. In particular, we apply the stochastic model specification search recently proposed by Frühwirth-Schnatter and Wagner (2010)(FS–W henceforth).

The different trend models are nested inside a more general hierarchical state space model and are obtained by imposing exclusion restrictions, so that discriminating the trend hypothesis amounts to performing variable selection within the regression framework considered by George and McCulloch (1993), George and McCulloch (1997). We will argue that this approach can shed further light on the issue of characterising trends in macroeconomic time series. An application to seasonal time series can be found in Proietti and Grassi (2012).

There are two ways in which a difference-stationary process can arise: the first is explicitly from an unobserved components process adding up an integrated trend and an orthogonal transitory component, the second is implicitly from an autoregressive process with roots on the unit circle. In a strict sense, the Bayesian variable selection procedure applied in the paper will enable us to discriminate between a pure autoregressive process around a deterministic trend and a latent stochastic trend plus a stationary process. Insight that the process might be non-stationary arises as a by-product of the Gibbs sampler inspecting the draws of the autocorrelation coefficients.

The plan of the paper is the following. The next section introduces the approach in the simple case when we are interested in discriminating a fixed level versus a random walk level. Section 3 brings into the analysis a possibly stochastic drift. Model selection and estimation by Markov Chain Monte Carlo is discussed in Section 4. Illustrations are provided in Section 5 with respect to the traditional (Nelson and Plosser, 1982) dataset and other key macroeconomic time series. In Section 6 we draw some conclusions.

2. Discriminating level stationarity and random walk trends

Fig. 1 displays the quarterly series of U.S. average weekly hours worked (QHWorked) for the manufacturing sector and the quarterly CPI and core (ex. food and energy) inflation rate for the period 1960:1–2009.4 (Source: U.S. Census Bureau). These series have been extensively investigated in macroeconomic applications. For instance, as far as QHWorked is concerned, the order of integration of the series is a crucial issue, as the response of the labour market to technology shocks crucially depends on the stationarity of this series. Opposite conclusions are reached whether one uses differences or levels in a structural vector autoregressive model: in the former case (see Galí, 1999) technology shocks induce a short run reduction in hours worked; in the second, hours worked increase, see Christiano et al. (2003).

We present an approach based on Bayesian model selection to investigate the issue as to whether the long run evolution of hours and inflation is better characterised by a fixed level or a slowly evolving component driven by permanent shocks.

2.1. An encompassing model

Let us consider the following AR(p) model with time-varying intercept:

$$\begin{aligned} \phi(L)y_t &= \mu_t + \epsilon_t, \quad \epsilon_t \sim \text{NID}(0, \sigma_\epsilon^2), \quad t = 1, \dots, T, \\ \mu_t &= \mu_{t-1} + \eta_t, \quad \eta_t \sim \text{NID}(0, \sigma_\eta^2), \end{aligned} \tag{1}$$

such that $\phi(L)$ is a stationary AR polynomial, and ϵ_t and η_t are mutually uncorrelated at all leads and lags. Model (1) nests two trend generation hypotheses of interest:

(a) y_t is a level-stationary process. This occurs if $\sigma_\eta^2 = 0$, and $\phi(L)$ is a stationary polynomial, i.e. $\phi(z) = 0 \iff |z| > 1$.
(b) y_t is a difference stationary process. There are two ways by which difference stationary processes can arise as particular cases of (1).