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Modelling breaks and clusters in the steady states of macroeconomic variables

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ABSTRACT

Macroeconomists working with multivariate models typically face uncertainty over which (if any) of their variables have long run steady states which are subject to breaks. Furthermore, the nature of the break process is often unknown. Methods are drawn from the Bayesian clustering literature to develop an econometric methodology which (i) finds groups of variables which have the same number of breaks and (ii) determines the nature of the break process within each group. An application involving a five-variate steady-state VAR is presented. The results indicate that new methodology works well and breaks are occurring in the steady states of only two variables.

1. Introduction

Macroeconomists working with multivariate models such as VARs face a myriad of modelling choices. Traditionally, such choices have involved restrictions on parameters. For instance, cointegration, lag length selection or the economic theory used by DSGE modellers all involve restrictions on the coefficients of a VAR (or similar multivariate time series model). However, the increasing realisation of the importance of parameter change has led macroeconomists to work with more parameter-rich models which allow for such a change. Examples include time-varying parameter (TVP) VAR models (see, among many others, Cogley and Sargent, 2001, 2005 or Primiceri, 2005), multivariate Markov switching models such as Sims and Zha (2006) or structural break VAR models such as Jochmann et al. (2010). For related work in the financial econometrics literature, see, e.g., He and Maheu (2010).

Often the researcher is unsure of the nature of parameter change (e.g. is it associated with VAR coefficients or the error covariance matrix? Is it associated with time such as in a structural break model or does change occur over the business cycle? etc.). Multivariate time series models such as VARs are parameter-rich even with constant parameters. Allowing for parameter change in VARs increases the number of parameters to be estimated. This raises worries about over-fitting and over-parameterisation. The presence of model uncertainty relating to time-variation in parameters greatly exacerbates these worries.

The present paper is motivated by these considerations. Faced with uncertainty over the nature of parameter change, we want an econometric method which will discover its nature in a data-based fashion. And faced with over-fitting, we want to do this in as parsimonious manner as possible. In many cases, this latter goal can be achieved by focussing on economically important parameters. For instance, a VAR may have hundreds of parameters (or even more, see Banbura et al., 2010).

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These parameters control the dynamics (short-run and long-run) of the variables in the model as well as the economic relationships of interest to the macroeconomists (e.g. impulse responses are functions of VAR coefficients and the error covariance matrix). But VAR coefficients are hard to directly interpret and allowing for parameter change in all of them can lead to a very parameter-rich model. When considering ways of allowing for parameter change, the researcher may wish to focus on some economically meaningful function of the parameters (e.g. allowing for only the monetary transmission mechanism to change). And it is typically most important to model parameter change in the economic feature under study. For instance, in a study of the monetary policy transmission mechanism it is very important to correctly model parameter change in this relationship, but it may be less important to correctly model parameter change in other parts of the model.

In this paper, we develop an econometric methodology which is more parsimonious than other approaches (such as TVP-VARs) and uncovers parameter change of an unknown sort in features of economic importance. We focus on the long run steady states of VAR dependent variables (although the general ideas can be adapted to any feature of interest). These are features that have a straightforward economic interpretation and theoretical macroeconomic models such as DSGE models typically have strong implications for long run steady states. We extend the steady state VAR of Villani (2009) to allow for the steady states to change over time. Of course, it would be straightforward to adapt any of the existing modelling approaches described above (e.g. Markov switching or structural break models) so as to apply only to the steady states. However, such an approach would assume all of the steady states change in a particular way (e.g. a structural break model would imply that they all change at the break time). The econometric methodology developed in this paper (drawing on ideas from the Bayesian clustering literature, see Tadesse et al., 2005) is more sophisticated than this. It determines (in an automatic, data-based fashion) which variables exhibit breaks in their steady states (i.e. some variables can exhibit breaks and others not) and the nature of the break process (e.g. it can estimate structural breaks which occur at a point in time or parameter change over the business cycle or anything else).

The paper is organised as follows. The next section of this paper describes the modelling framework and provides a general outline of the Markov chain Monte Carlo (MCMC) algorithm used to estimate the model. Full technical details on prior, posterior and MCMC algorithm are provided in the Technical Appendix. The third section of the paper illustrates the usefulness of our methods in an empirical application relating to one presented in Del Negro and Schorfheide (2008). We use a five-variate VAR and find that breaks exist in the steady states of some of the series but not others.

2. Modelling framework

Bayesian VAR analysis traditionally works with a VAR of the form:

$$A^{\dagger}(L)y_t = \mu^{\dagger} + \varepsilon_t,$$

where y_t is an $n \times 1$ vector of dependent variables for $t = 1, \ldots, T$, ε_t is $N(0, \Sigma)$ and $A^{\dagger}(L) = I - A_1^{\dagger}L - \cdots - A_p^{\dagger}L^p$ is a polynomial in the lag operator. Conventional Bayesian VAR approaches such as the Minnesota prior (see Doan et al., 1984) place a prior on the parameters in $A^{\dagger}(L)$ and $\mu^{\dagger}$. This parameterisation can be hard to directly interpret (e.g. $\mu^{\dagger}$ is not the unconditional mean of the series). In contrast to this, the steady state VAR (see Villani, 2009) can be written as

$$A(L)(y_t - \mu) = \varepsilon_t. \tag{1}$$

This specification for the VAR has the advantage that μ is the unconditional mean of y_t and, thus, can be interpreted as the steady state of y_t. As argued in Villani (2009), the steady state is often something that researchers have strong prior beliefs about (unlike $A_1, \ldots, A_p$). Thus, it may be preferable to focus prior elicitation efforts on μ. The parameters in $A(L)$, controlling the short run dynamics for deviations from steady states, may be of less interest to the macroeconomist. For instance, DSGE modellers often have strong prior information about steady states and elicit their priors in terms of such structural parameters (see, among many others, Smets and Wouters, 2007; Del Negro and Schorfheide, 2008). A drawback of the steady state VAR relative to the traditional VAR is that MCMC methods must be used. However, the gain in interpretability and the ability to elicit priors directly off the parameters with an economic interpretation are large benefits which may outweigh this drawback.

In empirical macroeconomic work, it is likely that the steady states of some variables remain constant over time, while others change at a particular point in time (i.e. structural breaks might occur), while others might change in some other fashion (e.g. they may differ between expansions and recessions). However, the researcher is typically unsure about which of these possibilities holds for which variable. Unless n is small, the number of modelling choices can be daunting. In this paper, we draw on ideas from the Bayesian clustering literature (see, e.g., Tadesse et al., 2005) to propose a modelling framework which allows us to group the dependent variables into clusters which have the same structure. For instance, one cluster might have constant steady states, another cluster might include dependent variables whose long run steady states exhibit a break, etc. This grouping is done in an automatic data-based manner.

Since the contributions of this paper relate to μ, we will draw out the basic intuition of our methodology ignoring the role of $A(L)$ and the error covariance matrix. Of course, in our empirical application $A(L)$ will be included as well as a time-varying error covariance matrix. Complete details of the full model are given in the Technical Appendix.

Accordingly, let us begin with a simple model:

$$y_t = \mu_1 + \varepsilon_t, \tag{2}$$

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