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Predicting Markov volatility switches using monetary policy variables

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Abstract

This paper presents a procedure to analyze the reaction of stock market returns and output growth volatility to monetary policy. In particular, we study whether shifts in the variance of returns and GDP growth can be predicted by changes in a monetary policy indicator. An empirical application to US data is examined and discussed.

Keywords: Monetary policy; Stock prices; Output growth; Volatility; Markov switching

JEL classification: C32; G15

1. Introduction

Many economists have argued that it is important to understand how policy actions affect changes in asset prices and financial markets in general, as they have a causal effect on the behavior of households, firms and generally speaking the broader economy. Following this line of research, many papers have studied the interactions between stock markets and interest rate policy using very high frequency data [see e.g. Rigobon and Sack (2003)].

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In this paper we choose to study the low frequency relationship between monetary interventions and, the stock market and the output growth volatility. We examine the reaction of stock market returns and GDP growth volatility to monetary policy. In particular, we raise the question of whether shifts in the unconditional variances of stock market and output growth can be predicted by changes of a monetary policy indicator such as the interest rate. These are changes that seldom take place in the sample and they are big enough to allow us to consider that economic conditions are different under the different characterizations of the economy. Our aim is to assess whether monetary variables affect (or help to predict) big changes in the state of the economy.

We extend the multivariate parameterization of the Markov switching model used in Ravn and Sola (1995) and Sola et al. (2002) by making the transition probability matrix time varying as in Diebold et al. (1994) and allow the probabilities to be a function of the monetary variables. We find that monetary variables such as the interest rate and the spread between long and short term bonds have power to predict changes in the volatility of both GDP growth and asset returns.

2. The econometric model

Consider the following model for the 2×1 vector $z_t=[x_t,y_t]'$,

$$z_t = \mu + \Phi_{s_t} u_t \tag{1}$$

where $\mu=[\mu_x,\mu_y]'$ and u_t is a Gaussian process with zero mean and positive-definite covariance matrix Σ; $\{s_t\}$ is modelled as a Markov chain on $\{1, 2, 3, 4\}$, independent of $\{u_t\}$, with s_t indicating the state that the system is in at date t. The time series $\{z_t\}$ satisfies therefore a four-state Markov process

$$z_t|(s_t = s) \sim N(\mu, \Omega_{s_t}), \tag{2}$$

for $s=1, 2, 3, 4$, with $\Omega_{s_t}=\Phi_{s_t}'\Sigma\Phi_{s_t}$. Accordingly, the variance–covariance matrices are:

$$\Omega = \left\{ \Omega_{s=1} = \begin{bmatrix} \sigma^2_{x\mathrm{h}} & \sigma_{x\mathrm{h},y\mathrm{h}} \\ \sigma_{y\mathrm{h},x\mathrm{h}} & \sigma^2_{y\mathrm{h}} \end{bmatrix}, \quad \Omega_{s=2} = \begin{bmatrix} \sigma^2_{x\mathrm{h}} & \sigma_{x\mathrm{h},y\mathrm{l}} \\ \sigma_{y\mathrm{l},x\mathrm{h}} & \sigma^2_{y\mathrm{l}} \end{bmatrix}, \right.$$
$$\left. \Omega_{s=3} = \begin{bmatrix} \sigma^2_{x\mathrm{l}} & \sigma_{x\mathrm{l},y\mathrm{h}} \\ \sigma_{y\mathrm{h},x\mathrm{l}} & \sigma^2_{y\mathrm{h}} \end{bmatrix}, \quad \Omega_{s=4} = \begin{bmatrix} \sigma^2_{x\mathrm{l}} & \sigma_{x\mathrm{l},y\mathrm{l}} \\ \sigma_{y\mathrm{l},x\mathrm{l}} & \sigma^2_{y\mathrm{l}} \end{bmatrix} \right\}, \tag{3}$$

where the indices h and l refer to high or low volatility. The transition matrix is a 4×4 matrix, Π (with elements $\pi_{ij}=Pr(s_t=i|s_{t-1}=j)$, $i, j=1, 2, 3, 4$), where each column sums to unity and all elements are nonnegative. To assess the links between output growth/stock returns and macroeconomic variables, we generalize the model in Eqs. (1)–(3) by allowing the transition probabilities to vary over time.

In particular, we assume that each volatility follows an independent regime-shifting process[1] and, following Diebold et al. (1994), we allow the transition probabilities to be time varying:

$$\Pi_t = \begin{pmatrix} \pi_t^{x\mathrm{h}}\pi_t^{y\mathrm{h}} & \pi_t^{x\mathrm{h}}(1-\pi_t^{y\mathrm{l}}) & (1-\pi_t^{x\mathrm{l}})\pi_t^{y\mathrm{h}} & (1-\pi_t^{x\mathrm{l}})(1-\pi_t^{y\mathrm{l}}) \\ \pi_t^{x\mathrm{h}}(1-\pi_t^{y\mathrm{h}}) & \pi_t^{x\mathrm{h}}\pi_t^{y\mathrm{l}} & (1-\pi_t^{x\mathrm{l}})(1-\pi_t^{y\mathrm{h}}) & (1-\pi_t^{x\mathrm{l}})\pi_t^{y\mathrm{l}} \\ (1-\pi_t^{x\mathrm{h}})\pi_t^{y\mathrm{h}} & (1-\pi_t^{x\mathrm{h}})(1-\pi_t^{y\mathrm{l}}) & \pi_t^{x\mathrm{l}}\pi_t^{y\mathrm{h}} & \pi_t^{x\mathrm{l}}(1-\pi_t^{y\mathrm{l}}) \\ (1-\pi_t^{x\mathrm{h}})(1-\pi_t^{y\mathrm{l}}) & (1-\pi_t^{x\mathrm{h}})\pi_t^{y\mathrm{l}} & \pi_t^{x\mathrm{l}}(1-\pi_t^{y\mathrm{h}}) & \pi_t^{x\mathrm{l}}\pi_t^{y\mathrm{l}} \end{pmatrix}. \tag{4}$$

[1] This simplifies the parameterization of the model.