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Stock market volatility and equity returns: Evidence from a two-state Markov-switching model with regressors

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ABSTRACT

This paper proposes a two-state Markov-switching model for stock market returns in which the state-dependent expected returns, their variance and associated regime-switching dynamics are allowed to respond to market information. More specifically, we apply this model to examine the explanatory and predictive power of price range and trading volume for return volatility. Our findings indicate that a negative relation between equity market returns and volatility prevails even after having controlled for the time-varying determinants of conditional volatility within each regime. We also find an asymmetry in the effect of price range on intra- and inter-regime return volatility. While price range has a stronger effect in the high volatility state, it appears to significantly affect only the transition probabilities when the stock market is in the low volatility state but not in the high volatility state. Finally, we provide evidence consistent with the 'rebound' model of asset returns proposed by Samuelson (1991), suggesting that long-horizon investors are expected to invest more in risky assets than short-horizon investors.

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1. Introduction

Markov switching models have been extensively used in studies involving stock market returns, interest rates, foreign exchange rates, and return volatility forecasts. Researchers employ these regime switching techniques to account for specific features of macro-economic and financial time series such as the asymmetry of economic activity over the business cycle (Hamilton, 1989) or the fat tails, volatility clustering and mean reversion in stock prices (e.g., Cecchetti et al., 1990; Schaller and van Norden, 1997; Turner et al., 1989), interest rates (e.g., Ang and Bekaert, 2002; Gray, 1996; Hamilton, 1988), foreign exchange rates (e.g., Bollen et al., 2000; Dueker and Neely, 2007; Engel, 1994; Engel and Hamilton, 1990), and for improving volatility forecasts (e.g., Haas et al., 2004; Klaassen, 2002). The appeal of Markov switching models is that they give rise to parsimonious representations of state space models by letting the mean, variance as well as the dynamics of the series depend

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on the realization of a finite number of discrete states. They are particularly suited in situations where there are large changes in market volatility.[1]

In this paper we propose a two-state Markov switching model for stock market returns in which the state-dependent mean and return volatility as well as the transition probabilities of regime-switching are allowed to respond to changes in market information. We use this model to investigate the relationship between expected returns and market volatility accounting for shifts in investment opportunities linked to state-dependent changes in market volatility. In particular, we examine the explanatory and predictive power of price range and trading volume for return volatility. Our findings indicate that equity market returns are negatively correlated with volatility and that the effect of price range is asymmetric across the two regimes. However, we find no evidence that trading volume innovations are a significant determinant of state-dependent volatilities. Furthermore, although either the low expected return and high volatility state or the high expected return and low volatility state are persistent over short periods, our findings indicate a higher incidence of regime shifts between the two states over longer horizons. These results are consistent with the rebound model of mean-reverting asset returns proposed by Samuelson (1991), implying that long-horizon investors are expected to invest more in risky assets than short-horizon investors.

The time series of stock returns typically demonstrates several stylized facts characterizing the distributional and temporal properties of financial returns series; namely, leptokurtosis and asymmetry in the distribution, volatility clustering, structural breaks, and long memory. Markov switching models where the distribution of stock returns for a given period is a mixture of normals are capable of describing these stylized facts (Bulla and Bulla, 2006; Ryden et al., 1998). Turner et al. (1989) were the first to apply a Markov mixture of normal distributions to study the relation between the market risk premium and variance of stock returns using monthly excess returns on the S&P 500 index. They used a two-state Markov model characterized by two constant state-dependent expected returns and variances where the state dynamics are governed by a two-state first-order Markov chain with constant transition probabilities.

Extending the Turner et al. (1989) model, Schaller and van Norden (1997) include the price–dividend ratio as a determinant of both state-dependent expected returns and associated transition probabilities. Using monthly excess returns on the S&P 500 index, they provide robust evidence of Markov switching behavior for stock market returns. In particular, they report strong asymmetry in the effect of the price–dividend ratio on future expected returns; in the low-return state this effect is about four times larger than in the high-return state. On the other hand, they find that the price–dividend ratio has no significant effect on transition probabilities.

Our model for stock market returns is closest to the models considered by Schaller and van Norden (1997) and Turner et al. (1989), but with some important differences. We extend these models by incorporating regressors in the state-dependent volatilities through a link function, which allows us to directly assess sources of persistence on state-dependent volatilities. We use this model to produce new evidence on the relationship between market volatility and expected returns. In particular, we study the effect of two important volatility determinants; namely, price range and trading volume assessing their importance in terms of both explanatory power and predictability for return volatility.

The paper is organized as follows. Section 2 presents the proposed two-sate Markov switching model for stock market returns. Section 3 discusses the estimation method and volatility forecast performance measures. Section 4 describes the data, while Section 5 reports the empirical results. Finally, Section 6 presents conclusions.

2. The econometric model

Consider a stock portfolio. The return on the portfolio y_t for a period t has a mixed distribution of two normal densities with state-dependent expected returns and volatilities: (μ_{1t},σ_{1t}) if $S_t=1$ and (μ_{2t},σ_{2t}) if $S_t=2$ respectively, where the expected returns μ_{1t} and μ_{2t} may be affected by an $(m_1\times 1)$ vector of regressors, $x_{\mu,t}$, with two $(m_1\times 1)$ vectors of parameters, α_1 and α_2, through a linear link function $\mu_{jt}=\alpha'_j x_{\mu,t}, j=1,2$. The volatilities σ_{1t} and σ_{2t} may be affected by an $(m_2\times 1)$ vector of regressors, $x_{\sigma,t}$, with two $(m_2\times 1)$ vectors of parameters, β_1 and β_2, through an exponential link function $\sigma_{jt}=\exp(\beta'_j x_{\sigma,t}), j=1,2$. S_t is the state variable governed by a two-state first-order Markov chain with transition probabilities, $p_{ij}(t)$, associated with an $(m_3\times 1)$ vector of regressors, $x_{S,t}$, with two $(m_3\times 1)$ vectors of parameters, φ_1 and φ_2, through a logit link function

$$\begin{aligned} p_{11}(t) &= P(S_t = 1|S_{t-1} = 1\,) = \mathrm{logit}\left(\varphi_1{}' x_{S,t-1}\right) p_{12}(t) = P(S_t = 2|S_{t-1} = 1) = 1-p_{11}(t) p_{22}(t) = P(S_t = 2|S_{t-1} = 2) \\ &= \mathrm{logit}\left(\varphi_2{}' x_{S,t-1}\right) p_{21}(t) = P(S_t = 1|S_{t-1} = 2) = 1-p_{22}(t). \end{aligned} \tag{1}$$

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[1] More recent research has employed regime-switching vector autoregressions to capture the richer dynamics of bond and stock returns and their predictors (Guidolin and Timmermann, 2007; Henkel et al., 2011) and Markov-switching multifractals to model regime switching at low, intermediate and high frequencies (Calvet and Fisher, 2004, 2007). Markov-switching multifractal models compare favorably with standard volatility models both in- and out-of-sample yet their attractiveness stems from parsimony as they are able to capture the distributional nonlinearities of financial data with a very limited number of parameters. They permit estimation of switching models with an arbitrary large number of states thereby addressing some of the practical limitations encountered in the application of standard Markov-switching models (Calvet and Fisher, 2004). Most applications of multifractals involve univariate switching models as an extension to multivariate specifications would add considerable complexity to the parameter optimization problem.

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