The Stock Market Volatility and Regime Changes: A Test in Econometrics

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Abstract

This paper applies the Markov switching heteroscedasticity model to stock return for India. The Markov switching model in our study takes into account the chance of regime shift, a possibility outside the purview of the GARCH model. Our finding tells us that the high variance of the transitory component tends to be short lived. Although parameters estimating the impact of time-varying expected returns and the delivery system are in some cases qualitatively different between the regimes, the differences do not produce significant changes in our model of stock returns.

Index terms— arch process, garch process, markov switching.

1 Introduction

lthough the ARCH process controls the short-run dynamics of stock return, the long-run dynamics are controlled by regime shifts in unconditional variance, while an unobserved Markov switching process drives the regime changes. **??**amilton and Susmel (994) propose a switching ARCH model in which they allow the parameters of the ARCH process to come from one set of several different regimes. 1 Regime switching models can match the tendency of financial markets to often change their behavior abruptly and the phenomenon that the new behavior of financial variables often persists for several periods after such a change. While the regimes captured by regime switching models are identified by an econometric procedure, they often correspond to different periods in regulation, policy, and other secular changes 2,3 t u Suppose the variable is governed byt t t v u ? =**(1)**

Where { v t } is an i. i. d sequence with zero mean and unit variance. The conditional variance of t u is specified to be a function of its past realizationg = 2 ?

(2 - t t u , u 1 ? . . .)**(2)**? + ? = = = p 1 i 2 1 - t q 1 i t u a 2 ? 2 t i b 2 ? ?**(3)**

This is a Gaussian GARCH (q p

) specification introduced by Belterstev (1986). When p = 0it becomes ARCH (q) specification of Engle **??**1982). The popular approach to modelling sock volatility is the autoregressive conditional heteroscedasticity (ARCH) specification introduced by these authors. These authors argue that the variance ratio test that is often used for analyzing mean reversion 4 may need to be Author: Professor, Business, Southern University at New Orleans & Mathematics, University of New Orleans. e-mail: adas2@cox.net 1 Contagion plays a crucial role in the short-term transmission of a currency crisis. Its effects rely primarily on liquidity effects experienced by international investors. Thus, the drop in asset values after the Russian crisis represented a capital loss for investors, with the ensuing liquidity problems being countered by a reallocation of their respective portfolios 3 The notion of regimes is closely linked to the familiar concept of good and bad states or states withlow versus high risk, but surprising and somewhat counterintuitive results can be obtained from equilibriumasset pricing models with regime changes. Conventional linear asset pricing models imply a positiveand monotonic risk-return relation. In contrast, changes between discrete regimeswith different consumption growth rates can lead to increasing, decreasing, flat or nonmonotonic riskreturnrelations as shown by, e.g., Backus and Gregory (1993), **??**hitelaw (2000), **??**ng and Liu (2007),and Rossi and Timmermann (2011). 4 After the seminal studies by Summers (1986), **??**oterba & Summers (1988), an ongoing debate has emerged in the literature as to whether stock prices and stock returns are mean-reverting or not. The substantial amount of recent publications in this field (Goyal & Welch 2008, Spierdijk et al. (2012) illustrates that the meanreverting behavior of stocks is still an important issue 2 For example, interest rate behavior markedly changed from 1979 through 1982, during which the Federal Reserve changed its operating procedure to targeting monetary aggregates. Other regimes identified in interest rates correspond to the tenure of different Federal Reserve Chairs..

2 Keywords: arch process, garch process, markov switching.

Abstract-Often it is assumed that ? u t (0, 1) and that g (.) depends linearly on the past squared realization of u . modified to take into account the changes in variance due to changes in regimes 5 II.

3 The Model

.The cause of the debate lies in the fact that testing for mean reversion is inherently difficult due to a lack of historical data on stock prices. Accurate estimation of the degree of long-run mean reversion requires very long stock price series, which are not available. For example, if stock prices were to revert back to their fundamental value every twenty years, one would need at least 1,000 to 2,000 yearly observations to obtain reliable estimations. Moreover, the likely structural breaks during long sample periods further complicate statistical analysis of mean reversion (Spierdijket al. 2012). These methodological difficulties explain why mean reversion is a controversial issue in the economic literature.

Analyses suggest that the speed at which stocks revert to their fundamental value is faster in periods of high economic uncertainty, caused by major economic and/or political events. The highest mean reversion speed is found for the period including the Great Depression and the start of World War II. Furthermore, the early years of the Cold War and the period containing the Oil Crisis of 1973, the Energy Crisis of 1979 and Black Monday in 1987 are also characterized by relatively fast mean reversion.

We will to begin with assume that the return series is drawn from a mixture of normal distributions as in Kim and Nelson(1998). These authors have shown that the Markov switching heteroscedasticity model of stock return is a good approximation of the underlying data generating process. This leads us to formulate the return series as follows:t t t x m r + = ?**(4)**m t + = µ ? (t t , 1) Q Q ? ? 1 0 + (5) t 2t 1 0 1 - t t) h h (x x ? ? ? + + =**(6)**

WhereN t ? ? (0, 1)

In this model we use t

x to represent the temporary part of the return and not the prices directly.

We include ? simply reflecting the fact that the temporary component of the return could be auto correlated. t The parameters 1 h and 1 Q help us identify any shift in variance during periods of uncertainty. The estimation of this model would allow us to comment on the time series behavior of the return volatility and how this is influenced by the switching probability of the transitoy component.

The two Markov switching variables are independent of each other and the respective transition probabilities are defined as.(rob 1t = ? ? 0 1 - 1t = ? 0) = 00 ? , (**8**)prob (t = 1 ? 1 = 1 - 1t ? 1 = 01 ? (9) 2t (rob ? ? = 0 1 - 2t ? = 0) = 00 q , (**10**)(rob 2t = ? ? 1 1 2 ? t = 1) = 11 q (11)

In order to estimate such a model that involves unobserved components and is subject to Markov switching shocks, we use the procedure used by **??**im and Nelson. (1999). 6 This involves generating a probability weighted likelihood function and a recursive algorithm to update the probabilities as new observations become available. This has been written with computer programming in mind. The parameters to be estimated are, therefore, The Stock Market Volatility and Regime Changes: A Test in Econometrics 5 The standard sensitivity analysis shows that the choice of the variance ratio may have substantial impact on investment decisions. If the variance ratio is high -meaning that stock prices are strongly mean-reverting -stocks become relatively less risky in the long run, making it optimal to invest a relatively large share of wealth in stocks. However, if the true variance ratio is lower than the assumed value, the perceived risk exposure is lower than the actual risk exposure. Hence, too much wealth is allocated to stocks, resulting in a non-optimal overexposure to risk. 6 The Markov switching ARCH features and Markov switching autoregressive features could, in principle, be combined into a single univariate specification, through using such a large set of parameters to describe the non-linear dynamics of a single series might pose numerical problems for finding a global maximum of the likelihood function. Moreover, goven the limited predictability of stock returns, it is surely a mistake to overparameterize the mean. By the same token, evidence of the ARCH effects in industrial production is rather weak. By contrast, the tendency of stock market volatility (as distinct from the mean) to exhibit variation and the periodic shifts in mean output growth associated with economic recessions, are fairly significant and well-documented features of these two series The goal of the paper is not to capture the nature of the link between a process for industrial production and a process for stock returns.

[? µ ? ? ? ? , h , h , q , q , , , . , 0 00, 11 0 00 1 1 11] (**12**)

The stock price index is obtained from the Morgan Stanley Capital International Index, MSCI's All Country World Index (ACWI) is the industry's accepted gauge of global stock market activity. Composed of over 2,400 constituents, it provides a seamless, modern and fully integrated view across all sources of equity returns in 46 developed and emerging markets. The company has used eight factors in developing its indexes: momentum, volatility, value, size, growth, size nonlinearity, liquidity and financial leverage.

The rate of return on stocks for India is calculated asx t = (1 - t t P - P) x 100 / 1 ? t P

where t P IV.

4 Results

Table **??**.2 shows the parameter estimates of the Markov switching heteroscedasticity model for the sample for our given time 7 . The results are computed using the algorithm used by Kim and Nelson (1998). The initial values for the filter are obtained from the observations on January 1980 ending through December 1980.

The Stock Market Volatility and Regime Changes: A Test in Econometrics 7 A key issue in regime switching models is whether the same regimes repeat over time, as in the case of repeated recession and expansion periods, or if new regimes always differ from previous ones. If "history repeats" and the underlying regimes do not change, all regimes will recur at some time. With only two regimes this will happen if 00 $p < 1$, $i = 0, 1$, Models with recurring regimes have been used to characterize bull and bear markets, calm versus turbulent markets, and recession and expansion periods. Alternative to the assumption of recurring regime is the change point process studied in the context of of dynamics of stock returns by Pastor and Stambaugh (2001) andPerez-Quiros, and Timmermann, A (2012) This type of model is likely to be a good approximation of regime shifts related to technological change. Our model has abstracted from such technological changes. Entries are P values for the respective statistics. The residuals in the portmanteau test is that the residuals are serially uncorrelated. The ARCH test residuals are for no serial correlation in the squared residuals up to lag 18. MNR is the Von Neuman ratio test using recursive residuals for model adequacy. If the model is correctly specified then Recursive T has a standard t-distribution. (Harvey (1990)). KS statistic represents the Kolmogorov Smirnov test statistic for normality. 95% confidence level in this test is .071 When KS statistic is less than 0.071 the null hypothesis of normality cannot be rejected at the given level of significance We also applied a pair of tests specifically designed for the recursive residuals produced by the state space system used in in this study. The first, the modified Von Neuman ratio, test against serial correlations of the residuals; the second, the recursive t test to check for correct model specification. The adequacy of the model is overwhelmingly supported. [1] [2]

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III. Data and Methodology

Table 1.2: Permanent and Transit
Equity Return (Markov Switching

p
P 00
q µ 11 1 0 ? ?

q

Mean(%)	Std dev	Skewness	Kurtosis	JB Test	1.786	7.453	2.312	9.654	.0000

(0.3461) 0.3214 -(3,4571) 2 6.783

(1 ?) of the permanent compone
volatility regime is also significant
find that the magnitude of the ove
permanent component during the
i.e., 0 ? + 1 ? says very little for

Figure 1: Table 1 . 1 :

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Portmanteau	0.412
ARCH	0.333
KS	0.013
RB Test	0.041
MNR	0.889
Recursive T	0.771

Figure 2: Table 1 . 3 :

.1 Conclusion

We applied the Markov switching heteroscedasticity model to stock returns in India. The modelling approach is superior to GARCH model. In particular, the Markov switching model explicitly considers the possibility of regime switch whereas the GARCH model does not. In terms of our estimate the high variance state of the transitory component lasts for an average of only 4 months.

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