Extreme Asymmetric Volatility, Leverage, Feedback and Asset Prices

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Abstract

Asymmetric volatility in equity markets has been widely documented in finance, where two competing explanations, as considered in Bekaert and Wu (2000), are the financial leverage and the volatility feedback hypothesis. We explicitly test for the role of both hypotheses in explaining extreme daily U.S. equity market movements during the period January 1990 to September 2008. To this aim, we examine asymmetric volatility based on a novel model of market returns, conditional market volatility and volatility of volatility. We then test for extreme asymmetry and the distinct predictions of both hypotheses. Our results document significant extreme asymmetric volatility. This effect is contemporaneous, consistent with both hypotheses, and it is important for large market declines. We further derive aggregate asset pricing implications under extreme volatility feedback. Given our results, asymmetric volatility, which includes the effect of volatility feedback at extreme levels, is shown to play an important role in explaining substantial equity market declines. As large market declines can in part be attributed to feedback they are not fully inconsistent with rational asset pricing behavior given the absence of information on changes in market fundamentals. Our findings also underline that means which are directed to a stabilization of extreme conditional market volatility are an important task for market regulators. We argue that extreme asymmetric volatility represents a component of systemic market risk.

Asymmetric Volatility

- Three features:
  - (i)*negative* relation between past realized returns and conditional volatility
  - (ii)*positive* relation between conditional expected market returns and volatility
  - (iii)*asymmetry* in that (i) is more pronounced for negative returns

Model

The model of returns is

$$R_t = \mu + Y_t \sigma_t.$$

For volatility we assume

$$\Delta \ln \sigma_t = \sum_{j=1}^{p} \delta_j \Delta \ln \sigma_{t-j} + f(Y_{t-1}; \sigma_{t-1}) + Z_t \phi_t.$$

Innovations (Y_t, Z_t) drive the return-volatility model.

Dependence I

Asymmetric volatility

- time-varying nature of the correlation between realized returns and conditional volatility
- extreme leverage and feedback

Model of dependence in the innovations (Y_t, Z_t)

- multivariate GARCH: DCC Engle (2002) and Engle and Sheppard (2001)
- extreme value theory (EVT): bivariate GPD, e.g. Coles (2001)

Dependence II

Asymptotic dependence versus independence:

Consider the limiting conditional probability

$$\chi = \lim_{u \to \infty} P(Y > u | Z > u).$$

Two cases:

- $\chi = 0$: asymptotic independence,
- $\chi > 0$: asymptotic dependence.

Data Set

- S&P 500 closing prices yield a sample of R_t
- VIX market volatility index yields a sample of σ_t
- Period: January 2, 1990 to September 30, 2008
- $T = 4890$ daily observations
- Stress periods: 1997, 1998, 2000 to 2002 and 2008
- Model (2.1-3) yields sample of (Y_t, Z_t)
- Joint extremes of interest: $(Y, -Z)$ and $(-Y, Z)$

Empirical Results

Asymmetric volatility hypotheses results

- $\mathrm{H}_0^{(1)}$: $\overline{\rho} \geq 0$: *rej.: asy. vol.*
- $\mathrm{H}_0^{(2)}$: $(Y_t, -Z_t)$ asy. ind.: not rej.
- $\mathrm{H}_0^{(3)}$: $(-Y_t, Z_t)$ asy. ind.: *rej.: ex. asy. vol.*
- $\mathrm{H}_0^{(4)}$: $(-Y_{t-1}, Z_t)$ asy. ind.: not rej.
- $\mathrm{H}_0^{(5)}$: $(-Y_t, Z_{t-1})$ asy. ind.: not rej.
- $\mathrm{H}_0^{(6)}$: $(-Y_t, Z_t)$ sym. dep. rel.: not rej.
- $\mathrm{H}_0^{(7)}$: $\lim_{u\to\infty} P(-Y_t > u | Z_t > u) = 0$: *rej.: feedb.*

Conclusion

- New model: market returns and observable conditional volatility
- Test implications of leverage and feedback: large unexpected return and volatility shocks
- Extreme asymmetric volatility: documented component of systemic risk
- Large market declines: partly explainable via volatility feedback
- Stabilization of conditional market volatility: task for market regulators