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How asymmetric is U.S. stock market volatility?

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Abstract

This paper explores differences in the impact of equally large positive and negative surprise return shocks in the aggregate U.S. stock market on: (1) the volatility predictions of asymmetric time-series models, (2) implied volatility, and (3) realized volatility. Following large negative surprise return shocks, both asymmetric time-series models (such as the EGARCH and GJR models) and implied volatility predict an increase in volatility and, consistent with this, ex post realized volatility normally rises as predicted. Following large positive return shocks, asymmetric time-series models predict an increase in volatility (albeit a much smaller increase than following a negative shock of the same magnitude), but both implied and realized volatilities generally fall sharply. While asymmetric time-series models predict a decline in volatility following near-zero returns, both implied and realized volatility are normally little changed from levels observed prior to the stable market. The reasons for the differences are explored.

JEL classification: G10; G13; C22

Keywords: Asymmetric volatility; Implied volatility; GARCH; EGARCH

1. Introduction

This paper examines how asymmetric the volatility responses to surprise return shocks are for the aggregate U.S. stock market—specifically whether volatility rises or falls following large positive return shocks and how volatility behaves following near-zero

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returns. We examine and compare the behavior of three volatility measures: (1) the predictions of asymmetric time-series models, such as the EGARCH and GJR models, (2) implied volatility, specifically the Chicago Board Option Exchange's VIX index, and (3) realized volatility.

It is well established that positive and negative return shocks have differing impacts on aggregate U.S. stock market volatility in that volatility tends to be much higher following negative return shocks than following positive return shocks of the same magnitude. This has been documented repeatedly by estimations of asymmetric time-series GARCH-type models, such as Nelson's (1991) EGARCH model and the GJR model of Glosten et al. (1993). Asymmetry has also been found in the behavior of implied volatility. However, the extent of this asymmetry and its exact form for the aggregate U.S. stock market are not settled. While researchers universally find that volatility increases sharply following large negative returns, its behavior following positive and near-zero returns is less clear. Although estimations of asymmetric GARCH-type models consistently predict an increase in volatility following large positive return shocks (albeit much less than following a negative return shock of the same magnitude), numerous studies report that implied volatility declines.[1]

Extant time series and implied volatility studies are not necessarily in conflict since they differ in several dimensions. First, the horizons differ. While the asymmetric GARCH model predictions are generally for a short horizon, such as the next day, the usual implied volatility metric, the CBOE's VIX index, measures implied volatility over the next month. Second, the markets differ. Until September 2003, the VIX measured implied volatility on the S&P 100 index while most asymmetric GARCH estimations are for a broader index. Third, data periods vary.

Hence our first task is to compare changes in asymmetric GARCH model forecasts and implied volatility following positive and negative shocks where the forecast horizons, market index (S&P 500), and data periods are identical for both the GARCH model estimations and implied volatility. Consistent with previous studies, we find clear inconsistencies between the volatility predictions of the asymmetric GARCH models and implied volatility. While the time-series models, specifically Nelson's (1991) EGARCH model, the GJR model of Glosten et al. (1993), and Engle and Ng's (1993) partially nonparametric model, predict a small volatility increase following large positive surprise returns, implied volatility generally falls. No such discrepancy is observed following large negative surprise returns when the asymmetric GARCH models predict a volatility increase and implied volatility rises by roughly the same amount.

These results raise a number of issues that have not been addressed in the literature to date. One, since the asymmetric GARCH and implied volatility forecasts differ following positive but not negative shocks, do they differ (and if so how) following periods without return shocks, i.e., stable markets? Here we find that while the asymmetric time-series models predict a decline in volatility following days with small (or near-zero) surprise returns, implied volatility tends to be little changed. Two, and most important, when the asymmetric GARCH and implied volatility forecasts differ, which is correct? In other words, how does realized volatility behave? On this question, we find that the behavior of realized volatility basically corresponds to that predicted

[1]As discussed more fully in Section 3, these include Fleming et al. (1995), Bates (2000), Poteshman (2001), Pan (2002), Low (2004), Bollerslev and Zhou (2006), and Denis et al. (2006).