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The information frown in option prices

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Abstract

In the S&P 500 options market, the information content of implied volatilities differs by strike in a frown pattern that is a rough mirror image of the implied volatility smile. Implied volatilities calculated from moderately high strike price options are both unbiased and efficient predictors of future volatility. Implied volatilities calculated from low and at-the-money strikes are biased and less efficient. This bias cannot be explained by market imperfections but is consistent with the hedging pressure argument of Bollen and Whaley [J. Finan. 59 (2004) 711] and Ederington and Guan [J. Derivat. 10 (2002) (Winter) 9]. We also find that a serious estimation bias results when the relations are estimated using panel data.

JEL classification: G13; G14
Keywords: Implied volatility; Volatility smile; Volatility forecasts; Volatility forecasting

1. Introduction

If markets are efficient and the option pricing model is correct, then the implied volatility calculated from an option's price should represent the market's best forecast of the underlying asset's future volatility over the remaining life of the option.

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This yields a couple of propositions which have been extensively tested and usually rejected. First, since they represent volatility over the same period, there should be no significant difference in implied volatilities calculated from options with the same expiry but different strike prices. However, contrary to this hypothesis, numerous studies have documented sizable and persistent cross-sectional differences, in a smile or sneer pattern. [1] Second, implied volatilities should be unbiased forecasts of future volatility and should fully impound all available information, including the asset's price history. However, numerous studies find that, when subsequent realized volatility is regressed on (1) implied volatility, and (2) measures of historical volatility, the coefficient of implied volatility is invariably less than one implying that implied volatility is a biased estimator and historical volatility often has a significant positive coefficient implying that implied volatility does not efficiently incorporate all information in the historical record. [2]

In this paper, we combine these two strands of the literature examining how the information in implied volatilities differs by strike price for options on S&P 500 futures. We find considerable differences. At low strikes, that is out-of-the-money (OTM) puts and in-the-money (ITM) calls, implied volatilities are biased and inefficient predictors of future volatility. The same holds to a lesser degree for at-the-money (ATM) strikes and very high strikes. However for moderately high strikes (OTM calls and ITM puts), implied volatilities are both unbiased and efficient. The most informative implied volatilities are those from strikes at approximately the smile's nadir. Since the information content of implied volatilities is roughly a mirror image of the smile, we refer to it as the "information frown".

These results have implications regarding the source of the smile. The primary theory of the smile is that it arises because implied volatilities are calculated using the wrong model – Black–Scholes. According to this theory, if implied volatilities were calculated using the correct model (such as one which incorporates jumps and/or stochastic volatility), implied volatilities calculated from different strikes would be the same but because they are calculated using a flawed model they differ. On the other hand, Bollen and Whaley (2004) and Ederington and Guan (2002c) argue that in the stock index options market implied volatilities differ because of hedging pressure. Specifically, they argue that demand for out-of-the-money puts to hedge against stock market declines pushes up implied volatilities on low strike options in the stock index options market. [3] If this hedging pressure theory is

[1] While this literature is voluminous, prominent examples include Black (1975), Rubinstein (1994), Heynen (1994) and Das and Sundaram (1999).

[2] See the excellent review of this literature by Poon and Granger (2003).

[3] If prices and implied volatilities of put options at low strikes are pushed up by demand from hedgers, this should provide an incentive for traders to sell these options and buy those at higher strikes with lower implied volatilities in a delta neutral ratio. For calls and puts at the same strike, riskless arbitrage is possible so hedging demand for puts should impact implied volatilities on calls equally. However, for options at different strikes, Ederington and Guan (2002c) show that the trading portfolio cannot be kept delta neutral and low risk without frequent trading whose transaction costs eat away the profits even if the portfolio is initially gamma as well as delta neutral.