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The relationship between the option-implied volatility smile, stock returns and heterogeneous beliefs☆

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ABSTRACT

We study the relationship between stock returns and the implied volatility smile slope of call and put options. Stocks with a steeper put slope earn lower future returns, while stocks with a steeper call slope earn higher future returns. Using dispersion of opinion as a proxy for belief differences, we find that the slope–stock return relation is strongest for stocks with high belief differences. The idiosyncratic component of the put slope fully explains the negative risk-adjusted stock returns. For the call slope, the idiosyncratic component dominates the systematic one, and explains the positive risk-adjusted returns.

1. Introduction

Recent studies document an empirical relationship between the implied volatility smile and stock returns. For example, Bali and Hovakimian (2009), Cremers and Weinbaum (2010), and Doran and Krieger (2010) study whether the implied volatility spread predicts future stock returns. Xing, Zhang, and Zhao (2010) finds stocks with steeper volatility smirks earn lower future stock returns and argue that this underperformance is because informed traders with negative news prefer to trade out-of-the-money put options. Yan (2011) finds a negative relationship between the slope of implied volatility smile and future stock returns, which he links to underlying jump risk. Conrad, Dittmar, and Ghysels (2013) also find a negative relation between implied volatility and returns in the cross section.

This study tests whether belief differences among investors are a determinant of the option–stock price relationship just described. We use as our starting point the conjecture of Xing et al. (2010) that pessimistic investor demand plays a role in the relationship between stock returns and implied volatility. This conjecture is consistent with the model of Garleanu et al. (2009) who show that end-demand for an option increases its price by an amount proportional to the variance of the unhedgeable part of the option. Greater end-user demand increases the expensiveness of the option, and this result is strongest when there is less option activity and less capacity for the option market maker to bear risk. Garleanu et al. (2009) also document a cross-sectional relationship between option prices and end-user demand.

Because investor demand affects option prices, and because the end-users of put and call options may be quite different, we hypothesize that distinguishing between the smile slope of calls and the smile slope of puts may be important. We define the smile slope of OTM puts as the implied volatility difference between OTM puts and ATM puts, henceforth, called the "put slope"; and the smile slope of OTM calls as the implied volatility difference between OTM calls and ATM calls, henceforth, called the "call slope". The first contribution of our study is to extend the empirical results cited above by measuring separately the cross-sectional relationship between future stock returns and the put and call slopes. [3] Using data on 2510 stocks from 1996 to 2008, we find stocks with steeper put slopes earn lower future returns while stocks with steeper call slopes earn higher future returns. Thus, the put slope and call slope predict stock returns in opposite ways. This suggests that common measures of implied volatility smile (which average or difference the implied volatility of puts and calls) may

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[3] A concurrent study by Ang, Bali, and Cakici (in press) examines the joint cross-section relationship between option implied volatility and stock returns. Their study looks at the role of belief differences in the context of stock returns predicting future changes in implied volatility. Their results highlight that significant cross-sectional variation in belief differences coincides with large changes in implied volatility. A desire for a better understanding of the precise nature of this empirical relationship helps motivate some of our empirical tests.

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obscure the underlying relationship between the option prices and stock returns.

We then explore the role played by belief differences in these documented patterns between stock and option prices. Belief differences among investors can affect both stock and option prices. For example, Miller's (1977) overvaluation theory predicts a negative relation between investor belief differences and stock returns, while the risk theory proposed by Williams (1977) predicts a positive relation between investor belief differences and stock returns.[4] Diether, Malloy, and Scherbina (2002) provide empirical evidence supporting the overvaluation theory, while Anderson, Ghysels, and Juergens (2005) present evidence supporting the risk theory. In short, the existing empirical evidence is sufficiently mixed that there exists little consensus about how belief differences are related to future stock returns.

Heterogeneous beliefs affect option prices and thus explain the volatility smile. Shefrin (2001) demonstrates that investor sentiment affects the pricing kernel in such a way that belief differences can lead to a volatility smile. Ziegler (2003) shows that belief differences impact equilibrium state-price densities, and may help explain the volatility smile. Bakshi, Kapadia, and Madan (2003) suggest that belief differences can affect risk-neutral skewness and option implied volatility, while Buraschi and Jiltsov (2006) develop a model to show that heterogeneous beliefs among investors can affect option prices and explain the option implied volatility smile. Empirical work by Friesen, Zhang, and Zorn (2012) confirms that the volatility smile and risk-neutral skewness reflect investor belief differences.

Because belief differences are linked to both stock and options markets, we hypothesize that belief differences may play a role in the observed relation between returns in the two markets. Again, we look at puts and calls separately because optimistic investors are natural end-users of call options and pessimistic investors are natural end-users of put options. Therefore, the put slope captures the valuations of the subset of pessimistic investors while the call slope captures the valuations of the subset of optimistic investors. Because stocks with more dispersion of opinion have steeper put and call slopes (Friesen, Zhang, & Zorn, 2010), we hypothesize that the relationship between smile slope and stock returns becomes stronger when investor belief differences are greater. Using the dispersion of financial analysts' earnings forecasts as a proxy for heterogeneous beliefs, we find a large and statistically significant negative relationship between the put slope and stock returns over 1-, 3-, 6- and 12-month horizons. However, this relationship is significant only for medium and high dispersion groups but not for low dispersion group. The relationship between the call slope and stock returns is much smaller in magnitude, is statistically significant only at the 3-month horizon, and is not driven by either high or low dispersion.

To further test our hypothesis about belief differences, we follow Yan (2011) and decompose the smile slope into systematic and idiosyncratic components. An et al. (2014) find that the change in the idiosyncratic component of implied volatility is the source of stock return predictability. Their findings are consistent with a belief-differences hypothesis such as ours. We find that the predictable relationship between the put slope and future stock returns is completely determined by the idiosyncratic component of the put slope. For the call slope, the idiosyncratic component dominates the systematic component, and explains the documented positive relationship between call slope and future returns. For the put slope, this predictability exists only when investor belief differences are large. This is not true for the call slope, which suggests that the call slope and put slope may be influenced by different factors.

One interpretation of the idiosyncratic and systematic components of smile slope is that the systematic component reflects market-wide dispersion in beliefs, while the idiosyncratic component reflects disagreement among investors at the firm-level. The finding that firm-level idiosyncratic slope predicts future stock returns is consistent with earlier studies which find that the implied volatility smile is related to firm-level belief difference variables (Friesen et al., 2012). While our empirical results are independent of the interpretation one ascribes to them, we note that belief differences need not be interpreted as "irrational", nor do they necessarily lead to any sort of "over-reaction".

The remainder of this paper is organized as follows. Section 1 describes our data, variables and empirical methodology. Section 2 presents empirical results. Section 3 discusses our robustness checks and Section 4 concludes.

1.1. Data and methodology

We obtain option data from OptionMetrics. Similar to Yan (2011), we use the fitted implied volatility for 1-month maturity as our variable of implied volatility. OptionMetrics computes the fitted implied volatility for various maturities and option deltas based on the binomial model of Cox, Ross, and Rubinstein (1979) and kernel smoothing technique. We choose the maturity of 1 month to correspond to our portfolio formation frequency. We average the daily fitted implied volatility retrieved from the OptionMetrics over the month to obtain a monthly measure. The smile slope is measured as the difference in the implied volatility between OTM options and ATM options. We measure smile slope for OTM puts and OTM calls separately. The put (call) slope is calculated as the difference between the implied volatility of OTM puts (calls) and the implied volatility of ATM puts (calls). OptionMetrics provide the fitted implied volatility for various option deltas and we only use OTM and ATM options, that is option deltas are −0.50, −0.45, −0.40, −0.35, −0.30, −0.25, −0.20 for puts and 0.50, 0.45, 0.40, 0.35, 0.30, 0.25 and 0.20 for calls. To avoid the possibility that the implied volatility slope measures introduces a look-ahead bias into our results, we skip the last day of the month when computing average implied volatilities.[5]

We follow previous studies (e.g. Yan, 2011) to decompose the smile slope into systematic and idiosyncratic components using the smile slope of S&P 500 index option to proxy for the market smile slope. The put (call) slope of stock options is regressed on the put (call) slope of S&P 500 index options with a maturity of 1-month to obtain the systematic and idiosyncratic component of the smile slope. We interpret the systematic component of smile slope as a reflection of market-wide dispersion in beliefs, while the idiosyncratic component reflects disagreement among investors at the firm-level.

We also obtain control variables of open interest and option volume from OptionMetrics. Put (call) open interest is computed as the daily total open interest of all OTM puts (calls) averaged over a month while put (call) option volume is computed as the total trading contract of all OTM puts (calls) averaged over a month.

Return data are obtained from the Center for Research in Security Prices (CRSP). We adopt the portfolio-based analysis by assigning stocks into quintile portfolios based on the put and call slopes respectively. Each month stocks are sorted based on the smile slope and then assigned into five quintile portfolios. To perform the multifactor time-series tests, we adopt the Carhart (1997) four-factor model. We obtain the monthly data for the Fama–French three factors and momentum factor from Kenneth R. French's web page: market risk premium (Rm-Rf), SMB (difference between the return on a portfolio of small stocks and the return on a portfolio of large stocks), HML (difference

[4] Miller (1977) argues that market prices are bid up by optimistic investors in the presence of short-sales constraints, so that stocks with a greater divergence of opinion earn lower future returns. Williams (1977) argues heterogeneous beliefs reflect uncertainty and thus proxy for a risk factor, so that future returns should be positively related to belief differences. Diamond and Verrecchia (1987) and Hong et al. (2000) argue that heterogeneous beliefs will not affect stock prices in the presence of rational arbitrageurs or market-makers, though Shleifer and Vishny (1997) discuss the practical limits to arbitrage.

[5] For robustness we have also conducted our analysis without skipping the last day, and the results are essentially the same.