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The Relationship between the Option-implied Volatility Smile, Stock Returns and Heterogeneous Beliefs

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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.

Keywords: Implied volatility, Smile slope, Heterogeneous beliefs

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.[1] 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 obscure the underlying relationship between the option prices and stock returns.

1. 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.

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.[2] 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 endusers of call options and pessimistic investors are natural endusers 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.[3]

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 between the return on a portfolio of high book-to-market stocks

2. 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.

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

and the return on a portfolio of low book-to-market stocks) and UMD (the difference between the return on a portfolio of stocks with high returns from t-12 to t-2 and the return on a portfolio of stocks with low returns from t-12 to t-2). Both equally-weighted portfolio returns and value-weighted returns are computed and regressed on four risk factors.

Our proxy for investor heterogeneous beliefs is the dispersion in financial analysts' earnings forecasts. Following Diether et al. (2002), the dispersion in financial analysts' earnings forecasts is measured as the standard deviation of forecasts for quarterly earnings scaled by the absolute value of the mean earnings forecast. The data on financial analysts' earnings forecasts are taken from the Institutional Brokers Estimate System (I/B/E/S) summary history dataset. Only the most recent statistical summary is adopted. To ensure the forecast is current, only the forecast period of one quarter (FPI=6) is selected. Firms with a zero mean forecast or without a standard deviation are excluded.

To further examine the predictability of the smile slope on future stock returns, we control for other explanatory variables and adopt the Fama–MacBeth two-stage regression approach. Our control variables include firm size (LOGSIZE), book-to-market ratio (B/M), lagged return (LAGRET), volatility premium (PVOL) and stock turnover (TURNOVER). LOGSIZE is the nature logarithm of the market capitalization as of the last day of previous month. B/M is the book-to-market ratio computed as book common equity value divided by the market capitalization of the last day of previous month. LAGRET is the previous month return. PVOL is the volatility premium, the difference between the implied volatility of ATM options (averaged using both puts and calls) and the stock return volatility each month computed using daily stock returns. TURNOVER is the monthly trading volume over number of outstanding shares.

2. Empirical results

Our sample includes options of 2510 firms from 1996 to 2008. Table 1 presents summary statistics for the implied volatility and smile slope for standardized options with 1 month to expiration with various deltas. The implied volatility of stock options exhibits a smile shape while the implied volatility of S&P 500 index options exhibits a skewed shape. Since deeper out of money options have steeper put slopes and more positive call slopes, we choose to report the results of the deepest OTM options (i.e. delta = −20 for puts and delta = 20 for calls). The results of options of other deltas are discussed in Section 3.

2.1. Summary statistics

Table 2 presents summary statistics for control variables. In our sample, the average daily open interests of OTM puts and OTM calls are 14,474 contracts and 15,401 contracts respectively. The average trading volume of puts and calls are 565 and 692 contracts respectively. There is greater open interest and trading volume for OTM calls than OTM puts. The mean firm size of our sample is about $1.9 billion, indicating that most of sample firm are medium and large firms. The average book-to-market value is about 0.521 and the average dispersion of financial analysts' earnings forecasts is 0.182. The average volatility premium is 1.6%. The average monthly stock turnover is 2%.

2.2. Put and call slopes and future stock returns

We conduct a portfolio-based analysis by assigning stocks into portfolios according to either the put slope or the call slope. To do this we regress the monthly excess return of each portfolio on the Carhart (1997) four factors. The portfolio return is computed as the equal-weighted or value-weighted (with weights based on the stock's market capitalization) average of all stocks in the portfolio. The risk-adjusted abnormal return is the return not explained by the four-factor model (i.e. alpha). Table 3 reports alphas of four-factor time series regressions. The results of equal-weighted average returns are shown in Panels A and B while results of value-weighted average returns are shown in Panels C and D.

In Panels A and C, portfolios are formed using the put slope. Portfolios with steeper put slopes have significantly lower risk-adjusted future returns for all four holding periods. Panels B and D show that portfolios with steeper call slopes have significantly higher risk-adjusted future returns only for shorter holding periods (1 month and 3 months). These results suggest that the predictability of the put slope lasts longer (at least 1 year) while the predictability of the call slope lasts for a shorter period (only three months). If investor pessimism is the result of bad news, then our results are consistent with the findings of Hong et al. (2000) that bad news "travels slowly".

2.3. Belief differences, the smile slope and stock returns

We next explore the role of heterogeneous beliefs in the relation between smile slope and stock returns. We first sort the sample into three groups based on the dispersion of financial analysts' earnings forecasts and then double sort on the put slope and the call slope respectively. Table 4 presents the risk-adjusted returns for the double-sorted portfolios using both equal- and value-weighted portfolios. Panels A and C report the results for put slopes, and show that in the lowest dispersion group, the return differentials between the steepest put slope quintile and the flattest put slope quintile are insignificant. The greater the dispersion of opinion about the stock value, the more significant the underperformance of stocks with steeper put slopes (more pessimism). Panels B and D look at call slopes: the significant outperformance of stocks with steeper call slopes (optimism) mainly exists in the medium dispersion group. The latter result is inconsistent with our hypothesis, which predicts the strongest relationship between call slope

Table 1. Summary statistics of implied volatility and smile slope. This table presents mean and standard deviation of implied volatilities and smile slopes of stock options and S&P 500 index option (SPX). The sample period is from January 1996 to December 2008. The sample includes 2510 firms. The implied volatility is the fitted implied volatilities of options with 1month to expiration and fixed deltas obtained from OptionMetrics. The last day of month is dropped. The smile slope is the difference between the implied volatility of OTM options and ATM options.

	Delta	−0.20	−0.25	−0.30	−0.35	−0.40	−0.45	−0.50	0.50	0.45	0.40	0.35	0.30	0.25	0.20
Stock options															
Implied volatility	Mean	0.515	0.502	0.491	0.483	0.477	0.471	0.467	0.459	0.457	0.456	0.456	0.459	0.464	0.472
	STD	0.237	0.237	0.236	0.234	0.233	0.232	0.231	0.227	0.226	0.226	0.225	0.225	0.224	0.225
Smile slope	Mean	0.048	0.034	0.024	0.016	0.009	0.004	0.000	0.000	−0.002	−0.003	−0.003	0.000	0.005	0.013
	STD	0.050	0.041	0.033	0.025	0.017	0.009	0.000	0.000	0.009	0.018	0.026	0.034	0.043	0.053
S&P500 index options															
Implied volatility	Mean	0.237	0.226	0.217	0.210	0.204	0.199	0.194	0.194	0.189	0.185	0.181	0.177	0.174	0.171
	STD	0.090	0.087	0.084	0.081	0.079	0.076	0.074	0.074	0.072	0.070	0.068	0.066	0.065	0.063
Smile slope	Mean	0.043	0.032	0.024	0.016	0.010	0.005	0.000	0.000	−0.005	−0.009	−0.013	−0.017	−0.021	−0.024
	STD	0.020	0.016	0.012	0.009	0.006	0.003	0.000	0.000	0.003	0.005	0.007	0.010	0.012	0.015

Table 2. Summary statistics of control variables. This table presents summary statistics for control variables used. Our sample includes 2510 firms from 1996 to 2008. PUT OPEN INTEREST is the daily total open interest of all OTM put options averaged over a month. CALL OPEN INTEREST is the daily total open interest of all OTM call options averaged over a month. PUT VOLUME is the daily total trading volume of all OTM puts averaged over a month. CALL VOLUME is the daily total trading volume of all OTM calls averaged over a month. LOGSIZE is the nature logarithm of the market capitalization as of the last day of previous month. B/M is the book-to-market ratio computed as book common equity value divided by the market capitalization of the last day of previous month. LAGRET is the previous month return. PVOL is the volatility premium, the difference between the implied volatility of ATM option and the stock return volatility computed using daily stock returns. TURNOVER is the monthly trading volume over number of outstanding shares. DISPERSION is the dispersion in financial analysts' earnings forecasts, measured as the standard deviation of forecasts for quarterly earnings scaled by the absolute value of the mean earnings forecast.

	Mean	5 Percentile	25 Percentile	Median	75 Percentile	95 Percentile
PUT OPEN INTEREST (in thousands)	14.474	0.014	0.190	0.995	6.217	63.966
CALL OPEN INTEREST (in thousands)	15.401	0.048	0.371	1.461	7.055	61.987
PUT VOLUME (in thousands)	0.565	0.000	0.005	0.032	0.222	2.484
CALL VOLUME (in thousands)	0.692	0.001	0.010	0.052	0.294	2.882
LOGSIZE	21.383	19.078	20.276	21.238	22.352	24.127
B/M	0.521	0.082	0.238	0.396	0.619	1.185
LAGRET	0.005	−0.213	−0.064	0.005	0.071	0.219
PVOL	0.016	−0.118	−0.026	0.012	0.053	0.162
TURNOVER	0.002	0.000	0.001	0.002	0.003	0.006
DISPERSION	0.182	0.000	0.026	0.058	0.141	0.667

and future stock returns when dispersion of opinion is highest. Thus, it appears that the relationship between slope and future returns is different for puts and calls.

We next decompose the smile slope into systematic and idiosyncratic components with the hope of shedding some light on this puzzling result.

2.4. Systematic and idiosyncratic smile slope and stock returns

In this section, we decompose put and call slopes into their systematic components and idiosyncratic components. Table 5 Panel A presents the risk-adjusted returns of equally-weighted quintile portfolios sorted on either the systematic component or the idiosyncratic component of

Table 3. Portfolio risk-adjusted returns. This table presents risk adjusted returns (alphas) of the Carhart (1997) four-factor model for equal-weighted quintile portfolios formed on the smile slope. Each month stocks are assigned into five quintiles based on the magnitude of the put slope Panel A (C) or the call slope Panel B (D) as of the previous month,with Q1 as the smallest quintile and Q5 as the largest Quintile. After assigning stocks into portfolios, the mean portfolio monthly return is computed as the equal-weighted (value-weighted) average of returns of all stocks in the portfolio. Carhart (1997) four factor model is used to obtain risk-adjusted returns (alphas). The sample period is from January 1996 to December 2008. T-statistics (Newey–West adjusted) are in parentheses under estimates. *, ** and *** represent statistical significance at 10%, 5% and 1% respectively.

	Q1	Q2	Q3	Q4	Q5	Q5 − Q1
Panel A: Equal-weight portfolios sorted on put slope with delta = −0.20						
1-month return	0.89%***	0.29%*	0.16%	0.14%	0.22%	−0.67%***
	(3.97)	(2.11)	(1.09)	(0.80)	(1.35)	(−3.01)
3-month return	1.91%***	0.81%**	0.82%**	0.71%	0.62%	−1.29%***
	(4.45)	(2.45)	(2.25)	(1.56)	(1.49)	(−3.12)
6-month return	3.46%***	1.49%***	1.09%**	1.03%	0.93%	−2.53%***
	(5.35)	(3.35)	(2.19)	(1.60)	(1.29)	(−3.95)
12-month return	6.36%***	2.76%***	1.88%**	1.46%	1.42%	−4.94%***
	(3.87)	(2.88)	(2.18)	(1.35)	(1.26)	(−3.62)
Panel B: Equal-weight portfolios sorted on call slope with delta = 0.2						
1-month return	0.18%	0.20%*	0.37%**	0.41%**	0.54%**	0.36%*
	(0.03)	(1.72)	(2.45)	(2.27)	(2.52)	(2.06)
3-month return	0.54%	0.66%**	1.15%***	1.19%***	1.32%**	0.78%**
	(1.32)	(2.36)	(3.09)	(2.82)	(2.53)	(2.58)
6-month return	1.28%*	1.37%***	1.62%***	1.78%****	1.95%***	0.67%
	(1.69)	(3.27)	(3.23)	(3.38)	(2.83)	(0.89)
12-month return	3.55%**	2.24%***	2.92%***	2.86%**	2.30%*	−1.25%
	(2.36)	(3.04)	(3.04)	(2.52)	(1.91)	(−0.84)
Panel C: Value-weight portfolios sorted on put slope with delta = −0.20						
1-month return	0.22%***	0.15%	0.18%	0.14%	0.16%	−0.06%*
	(2.31)	(1.40)	(1.27)	(0.86)	(0.62)	(−1.81)
3-month return	1.87%***	0.53%**	0.55%*	1.03%***	0.08%	−1.79%***
	(2.56)	(1.58)	(1.91)	(3.34)	(0.13)	(−2.57)
6-month return	2.34%***	1.01%*	0.89%**	1.82%***	−0.25%	−2.59%***
	(4.06)	(1.87)	(2.03)	(3.15)	(−0.30)	(−3.84)
12-month return	3.45%***	1.81%**	1.96%**	1.91%*	0.83%	−2.62%**
	(2.36)	(2.24)	(2.08)	(1.94)	(0.82)	(−2.19)
Panel D: Value-weight portfolios sorted on call slope with delta = 0.2						
1-month return	−0.37%*	−0.08%	0.05%	0.16%**	0.23%	0.60%*
	(1.81)	(0.71)	(0.30)	(0.95)	(1.36)	(2.06)
3-month return	0.48%	0.60%***	0.66%**	0.86%**	1.12%***	0.64%*
	(0.94)	(2.67)	(1.98)	(2.31)	(3.12)	(1.64)
6-month return	0.77%	1.41%***	1.08%**	1.33%***	1.53%***	0.76%
	(1.31)	(3.96)	(2.31)	(2.87)	(2.93)	(1.38)
12-month return	3.17%***	2.69%***	1.97%***	2.82%***	1.54%*	−1.63%
	(3.09)	(3.46)	(2.71)	(3.54)	(1.94)	(−1.51)

Table 4. Risk-adjusted returns of portfolio double sorted on dispersion of analysts' forecasts and smile slope. Each month stocks are sorted into high, medium and low dispersion of opinion portfolios first and then assigned into five quintiles based on the smile slope as of the previous month, with Q1 as the smallest quintile and Q5 as the largest quintile. The dispersion of opinion is measured as the standard deviation of financial analysts' forecasts for quarterly earnings scaled by the absolute value of the mean earnings forecast. After assigning stocks into portfolios, the mean portfolio monthly return is computed as the equal-weighted (and value-weighted) average of returns of all stocks in the portfolio. Carhart (1997) four factor model is used to obtain risk-adjusted returns (alphas). The sample period is from January 1996 to December 2008. T-statistics (Newey–West adjusted) are in parentheses under estimates. *, ** and *** represent statistical significance at 10%, 5% and 1% respectively.

Panel A: Equal-weight portfolios sorted on put slope with delta = −0.20

	Q1	Q2	Q3	Q4	Q5	Q5 − Q1
Low dispersion						
1-month return	0.70% ***	0.59% *	0.44% **	0.66% ***	0.74% ***	0.04%
	(3.25)	(3.10)	(2.22)	(3.50)	(3.37)	(0.14)
3-month return	1.68% ***	1.54% ***	1.46% ***	1.67% ***	2.17% ***	0.49%
	(3.73)	(3.40)	(2.71)	(3.54)	(3.98)	(0.95)
6-month return	2.95% ***	3.19% ***	3.25% ***	3.42% ***	3.66% ***	0.71%
	(5.05)	(4.36)	(3.45)	(3.74)	(3.77)	(0.91)
12-month return	5.96% ***	6.04% ***	6.34% ***	6.66% ***	7.23% ***	1.27%
	(3.87)	(4.40)	(3.55)	(3.53)	(3.53)	(0.65)
Medium dispersion						
1-month return	0.45% *	0.47% **	−0.01%	−0.02%	0.10%	−0.35%
	(1.94)	(2.22)	(−0.07)	(−0.08)	(0.57)	(−1.25)
3-month return	1.25% ***	0.65%	0.33%	−0.10%	0.20%	−1.05% **
	(2.83)	(1.33)	(0.78)	(−0.27)	(0.64)	(−2.15)
6-month return	1.88% **	0.46%	−0.21%	−0.83%	−0.54%	−2.42% ***
	(2.32)	(0.67)	(−0.35)	(−1.35)	(−0.88)	(−3.64)
12-month return	3.42% *	0.78%	−0.67%	−2.59% ***	−2.29% *	−5.71% ***
	(1.72)	(0.61)	(−0.81)	(−3.24)	(−1.97)	(−4.45)
High dispersion						
1-month return	0.98% ***	−0.06%	0.00%	−0.04%	0.13%	−0.85% ***
	(3.33)	(0.32)	(0.01)	(0.15)	(0.57)	(−2.64)
3-month return	2.17% ***	0.48%	0.49%	0.18%	0.40%	−1.77% ***
	(3.49)	(1.02)	(0.95)	(0.28)	(0.72)	(−2.96)
6-month return	4.03% ***	1.49% **	0.24%	0.44%	0.56%	−3.47% ***
	(4.56)	(2.30)	(0.32)	(0.52)	(0.56)	(−3.67)
12-month return	7.17% ***	3.63% **	−0.05%	0.32%	−0.36%	−7.53% ***
	(3.17)	(2.26)	(0.03)	(0.23)	(0.27)	(−4.06)

Panel B: Portfolios sorted on call slope with delta = 0.2

	Q1	Q2	Q3	Q4	Q5	Q5 − Q1
Low dispersion						
1-month return	0.62% ***	0.62% ***	0.56% ***	0.55% ***	0.80% ***	0.18%
	(2.77)	(3.39)	(3.24)	(3.23)	(3.50)	(0.67)
3-month return	1.82% ***	1.70% ***	1.62% ***	1.58% ***	1.79% ***	−0.03%
	(3.16)	(3.48)	(3.83)	(3.32)	(3.25)	(0.01)
6-month return	3.98% ***	3.39% ***	3.25% ***	3.19% ***	2.66% ***	−1.32%
	(3.71)	(4.31)	(4.51)	(4.50)	(3.55)	(1.49)
12-month return	8.58% ***	6.77% ***	6.58% ***	5.89% ***	4.49% ***	−4.09% **
	(3.34)	(4.09)	(5.27)	(3.93)	(3.60)	(2.02)
Medium dispersion						
1-month return	0.19%	0.12%	0.02%	0.30%	0.36% *	0.17%
	(−0.85)	(0.78)	(0.09)	(1.52)	(1.69)	(0.60)
3-month return	−0.47%	0.28%	0.50%	1.05% **	0.96% **	1.43% ***
	(−1.02)	(0.74)	(1.09)	(2.21)	(1.94)	(2.86)
6-month return	−1.26% *	0.36%	−0.57%	0.98%	1.25% *	2.51% ***
	(−1.90)	(0.61)	(−0.91)	(−1.28)	(−1.80)	(3.57)
12-month return	−1.64%	−0.04%	−1.55%	1.27%	0.59%	2.23% **
	(−1.18)	(−0.04)	(−1.38)	(−0.98)	(0.51)	(2.01)
High dispersion						
1-month return	0.35%	0.15%	−0.22%	0.44% **	0.28%	−0.07%
	(−1.06)	(0.78)	(0.94)	(2.04)	(1.12)	(0.17)
3-month return	0.49%	0.50%	0.75%	1.16% **	0.80%	0.31%
	(0.73)	(1.03)	(1.45)	(1.98)	(1.41)	(0.47)
6-month return	0.52%	0.71%	2.29% ***	2.29% ***	0.92%	0.40%
	(−0.52)	(−1.09)	(−2.77)	(−2.83)	(−1.23)	(0.46)
12-month return	1.08%	1.90%	2.77% *	4.26% **	0.66%	−0.42%
	(−0.68)	(1.32)	(1.70)	(−2.10)	(0.51)	(0.24)

Panel C: Value-weight portfolios sorted on put slope with delta = −0.20

	Q1	Q2	Q3	Q4	Q5	Q5 − Q1
Low dispersion						
1-month return	0.19%	0.29% *	0.24%	0.40% *	0.41% ***	0.22%
	(0.82)	(1.91)	(1.47)	(1.88)	(3.37)	(0.63)
Low dispersion						

Table 4. (*continued*)

Panel C: Value-weight portfolios sorted on put slope with delta = −0.20

	Q1	Q2	Q3	Q4	Q5	Q5 − Q1
3-month return	0.50%	1.00% ***	1.06% **	1.40% ***	0.97%	0.47%
	(1.06)	(2.75)	(2.56)	(3.02)	(1.58)	(0.77)
6-month return	1.20% *	1.82% ***	1.93% **	2.95% ***	1.96% *	0.76%
	(1.91)	(2.62)	(2.60)	(3.23)	(1.83)	(0.81)
12-month return	2.02% *	3.25% ***	3.86% **	6.96% ***	7.18% ***	5.16%
	(1.76)	(2.75)	(2.45)	(4.04)	(2.94)	(1.63)
Medium dispersion						
1-month return	0.21%	0.25%	0.01%	−0.02%	0.37%	0.16%
	(0.93)	(1.47)	(0.06)	(−0.09)	(1.15)	(−0.46)
3-month return	1.00% *	0.48%	0.42%	0.59%	0.32%	−0.68%
	(1.93)	(0.88)	(0.97)	(1.70)	(0.50)	(−0.96)
6-month return	2.28% **	0.53%	0.14%	0.86%	−1.23%	−3.51% ***
	(2.73)	(0.66)	(0.25)	(1.41)	(−1.03)	(−3.53)
12-month return	2.94% *	1.25%	2.90%	1.07%	−2.24%	−5.18% ***
	(1.74)	(1.03)	(−0.29)	(1.28)	(−1.25)	(−3.14)
High dispersion						
1-month return	0.50% *	−0.06%	−0.05%	−0.14%	−0.17%	−0.67% *
	(1.83)	(0.27)	(−0.23)	(−0.48)	(−0.43)	(−1.97)
3-month return	1.05% *	0.33%	0.26%	0.52%	−0.85%	−1.90% **
	(1.69)	(0.53)	(0.51)	(0.82)	(−0.95)	(−2.44)
6-month return	3.37% ***	2.05% **	0.04%	0.96%	−0.82%	−4.19% ***
	(4.38)	(2.26)	(0.05)	(1.03)	(−0.58)	(−3.93)
12-month return	6.35% **	2.22%	1.07%	1.09%	−1.22%	−7.57% ***
	(2.46)	(1.13)	(0.81)	(0.79)	(−0.80)	(−3.82)

Panel D: Value-weight portfolios sorted on call slope with delta = 0.2

	Q1	Q2	Q3	Q4	Q5	Q5 − Q1
Low dispersion						
1-month return	0.67% ***	0.40% **	0.04%	0.34% *	0.31%	−0.36%
	(2.87)	(2.31)	(0.17)	(1.66)	(1.32)	(1.06)
3-month return	1.38% **	1.06% ***	0.93% **	1.09% **	0.89% **	−0.49%
	(2.52)	(3.01)	(1.99)	(2.24)	(2.28)	(0.88)
6-month return	2.75% ***	2.45% ***	2.16% ***	2.18% ***	1.87% ***	−0.88%
	(3.40)	(3.20)	(2.79)	(2.69)	(3.30)	(1.05)
12-month return	7.51% ***	5.12% ***	4.60% ***	5.57% ***	2.93% ***	−4.58% **
	(3.96)	(3.46)	(3.50)	(4.19)	(3.38)	(2.02)
Medium dispersion						
1-month return	0.27%	0.06%	0.13%	0.44% **	0.35%	0.08%
	(0.97)	(0.38)	(0.60)	(2.08)	(1.43)	(0.06)
3-month return	−0.36%	0.27%	0.74%	1.50% ***	1.08% **	1.44% *
	(−0.67)	(0.77)	(1.58)	(2.86)	(2.50)	(1.73)
6-month return	−0.51%	0.56%	0.19%	1.36% *	1.94% ***	2.45% ***
	(−0.58)	(0.61)	(−0.29)	(−1.90)	(−3.22)	(3.11)
12-month return	−0.02%	0.87%	0.43%	1.46%	1.36%	1.38% **
	(−0.01)	(−0.90)	(−0.36)	(−1.30)	(1.35)	(2.22)
High dispersion						
1-month return	0.07%	−0.47% *	−0.48% *	−0.29%	0.26%	0.19%
	(−0.21)	(1.83)	(1.68)	(1.02)	(1.08)	(0.45)
3-month return	−0.46%	−0.33%	0.78%	0.28%	1.20% **	1.66% **
	(−0.55)	(−0.59)	(1.14)	(0.47)	(2.57)	(2.23)
6-month return	0.25%	0.01%	1.91% **	1.57% **	0.96%	0.71%
	(0.19)	(0.02)	(2.31)	(2.06)	(1.21)	(0.69)
12-month return	0.25%	0.11%	1.52%	2.11%	2.18% *	1.93%
	(0.19)	(0.08)	(0.80)	(1.14)	(1.72)	(1.28)

the put slope (Panel C presents similar results using value-weighted portfolios). Analogous results using call slopes are reported in Panels B and D. All risk-adjusted returns are alphas from the four-factor model described earlier. Results show that the systematic component of the put slope does not predict future stock returns while the idiosyncratic component of the put slope has a significant, inverse relation with future stock returns. For calls, the systematic component of the call slope predicts lower future stock returns while the idiosyncratic component of the call slope predicts higher future stock returns. In the context of the results from the previous table, which show a positive relation between the overall call slope and stock returns, these results indicate that idiosyncratic component of the call slope dominates the systematic component in terms of predicting future stock returns. They also suggest that looking simply at the smile slope may be inadequate, as the individual components may have offsetting effects on future stock returns.

2.5. Belief differences and the idiosyncratic and systematic components of smile slope

The focus of this section is the idiosyncratic component of smile slope, which may proxy for differences in opinion at the firm level. We are particularly interested in the relation, if any, between this measure of heterogeneous beliefs about firm-level information, and future firm-level

Table 5. Portfolio risk-adjusted returns based on systematic or idiosyncratic components of smile slope. This table presents risk adjusted returns (alphas) of the Carhart (1997) four-factor model for equal-weighted quintile portfolios formed on the systematic component or idiosyncratic component of smile slope. Each month stocks are assigned into five quintiles based on the magnitude of the put slope (Panel A) or the call slope (Panel B) as of the previous month, with Q1 as the smallest quintile and Q5 as the largest Quintile. After assigning stocks into portfolios, the mean portfolio monthly return is computed as the equal-weighted (and value-weighted) average of returns of all stocks in the portfolio. Carhart (1997) four factor model is used to obtain risk-adjusted returns (alphas). The sample period is from January 1996 to December 2008. T-statistics (Newey–West adjusted) are in parentheses under estimates. *, ** and *** represent statistical significance at 10%, 5% and 1% respectively.

Panel A: Equal-weight portfolios sorted on put slope with delta = −0.20

	Q1	Q2	Q3	Q4	Q5	Q5 − Q1
Systematic component						
1-month return	−0.05%	0.44% ***	0.50% ***	0.62% ***	0.19%	0.24%
	(0.31)	(3.00)	(2.79)	(3.45)	(1.15)	(−1.23)
3-month return	0.06%	1.48% ***	1.27% ***	1.47% ***	0.56%	0.50%
	(0.17)	(3.66)	(2.95)	(3.17)	(1.29)	(−1.25)
6-month return	0.35%	2.17% ***	2.12% ***	2.55% ***	0.79%	0.44%
	(0.62)	(4.09)	(3.51)	(3.56)	(0.98)	(−0.67)
12-month return	1.72%	3.98% ***	3.18% ***	4.03% ***	0.91%	−0.81%
	1.183.87	(4.15)	(3.32)	(2.93)	(0.62)	(−0.63)
Idiosyncratic component						
1-month return	0.67% ***	0.40% **	0.29% *	0.22% *	0.12%	−0.55% ***
	(3.28)	(2.51)	(1.83)	(1.66)	(0.76)	(−2.67)
3-month return	1.54% ***	1.19% ***	1.07% **	0.57% *	0.47%	−1.07% ***
	(3.36)	(3.03)	(2.55)	(1.78)	(1.23)	(−2.59)
6-month return	3.02% ***	1.90% ***	1.87% **	0.85% *	0.35%	−2.67% ***
	(3.99)	(3.32)	(3.23)	(1.66)	(0.53)	(−4.04)
12-month return	5.04% ***	3.42% ***	3.37% **	2.17% **	−0.16%	−5.20% ***
	(2.98)	(3.06)	(3.06)	(2.11)	(0.19)	(−3.94)

Panel B: Equal-weight portfolios sorted on call slope with delta = 0.2

	Q1	Q2	Q3	Q4	Q5	Q5 − Q1
Systematic component						
1-month return	0.95%	0.62% ***	0.35%**	0.19% **	−0.41% **	−1.36% *
	(5.15)	(4.02)	(2.09)	(1.08)	(−3.97)	(−6.63)
3-month return	2.68%	1.79% **	1.22% ***	0.24%	−1.09% **	−3.77% **
	(4.99)	(4.31)	(2.83)	(0.59)	(−3.40)	(9.52)
6-month return	5.08% *	3.50% ***	2.10% ***	−0.27% ****	−2.41% ***	−7.49% ***
	(5.26)	(5.74)	(3.48)	(−0.58)	(−5.37)	(11.56)
12-month return	10.09% **	6.05% ***	3.61% ***	−1.04%	−4.87% *	−14.96% ***
	(3.68)	(5.46)	(3.01)	(−0.84)	(4.52)	(10.56)
Idiosyncratic component						
1-month return	−0.22%	0.09%	0.46% ***	0.55% ***	0.81% ***	1.03% ***
	(−1.38)	(0.73)	(3.30)	(3.39)	(3.57)	(6.63)
3-month return	−0.94% ***	0.32%	1.32% ***	1.79% ***	2.35% ***	3.29% ***
	(−2.49)	(1.05)	(3.68)	(4.44)	(3.94)	(7.32)
6-month return	−2.07% ***	0.56%	2.37% ***	3.31% ****	3.80% ***	5.87% ***
	(−4.53)	(1.25)	(4.30)	(5.26)	(4.68)	(8.97)
12-month return	−3.65% ***	1.18%	4.05% ***	6.15% ***	6.09% ***	9.74% ***
	(−2.99)	(1.31)	(3.75)	(4.94)	(4.35)	(7.97)

Panel C: Value-weight portfolios sorted on put slope with delta = −0.20

	Q1	Q2	Q3	Q4	Q5	Q5 − Q1
Systematic component						
1-month return	−0.08%	0.06%	0.26% *	0.21%	0.04%	0.12%
	(−0.45)	(0.46)	(1.66)	(1.43)	(0.22)	(−0.54)
3-month return	0.28%	0.33%	0.20%	0.58%	0.08%	−0.20%
	(0.73)	(1.05)	(0.57)	(1.58)	(0.17)	(−0.42)
6-month return	0.64%	0.00%	0.57%	0.52%	0.82%	0.18%
	(0.90)	(0.01)	(0.79)	(0.69)	(0.97)	(−0.24)
12-month return	1.41%	0.82%	1.81%	0.89%	2.48%	1.07%
	(1.00)	(0.85)	(1.44)	(0.55)	(0.62)	(−0.89)
Idiosyncratic component						
1-month return	0.60%*	0.11%	0.30% ***	0.19%	0.02%	−0.58%*
	(1.93)	(0.77)	(2.66)	(1.44)	(0.08)	(−1.67)
3-month return	1.00% **	0.83% **	1.33% ***	0.65% ***	−0.04%	−1.04% ***
	(2.25)	(2.15)	(4.69)	(2.81)	(−0.89)	(−2.59)
6-month return	1.21% **	1.20% ***	2.71% ***	1.42% ***	−1.40% *	−2.61% ***
	(2.20)	(3.32)	(5.05)	(3.96)	(−1.84)	(−3.40)
12-month return	2.28% ***	2.10% **	3.08% **	3.44% ***	−1.27%	−3.55% **
	(2.44)	(2.18)	(5.41)	(5.43)	(−1.44)	(−2.50)

Table 5. (*continued*)

Panel D: Value-weight portfolios sorted on call slope with delta = 0.2	Q1	Q2	Q3	Q4	Q5	Q5 − Q1
Systematic component						
1-month return	0.26% **	0.22% **	0.00%	−0.23%	−0.46% **	−0.72% ***
	(2.06)	(2.01)	(0.03)	(1.23)	(−2.72)	(−3.59)
3-month return	0.76% **	0.56% **	0.52% *	−0.46%	−0.92% **	−1.68% ***
	(2.00)	(2.25)	(1.67)	(0.97)	(−2.50)	(4.73)
6-month return	1.63% **	1.21% ***	0.64%	−1.12% *	−1.73% ***	−3.36% ***
	(2.47)	(2.77)	(1.36)	(−1.87)	(−3.28)	(6.98)
12-month return	4.06% ***	2.92% ***	0.97%	−2.29% *	−3.36% ***	−7.42% ***
	(3.32)	(3.59)	(0.90)	(−1.70)	(2.95)	(8.58)
Idiosyncratic component						
1-month return	−0.47% **	0.08%	0.40% ***	0.20%	0.39% *	0.86% ***
	(−2.56)	(0.56)	(3.02)	(1.64)	(1.82)	(3.02)
3-month return	−1.49% ***	0.12%	0.87% ***	1.20% ***	1.79% ***	3.28% ***
	(−3.04)	(0.41)	(3.54)	(4.15)	(3.84)	(6.44)
6-month return	−3.13% ***	0.42%	1.92% ***	2.06% ****	3.03% ***	6.16% ***
	(−3.71)	(0.95)	(4.41)	(3.41)	(4.95)	(7.94)
12-month return	−4.56% **	2.01% **	4.20% ***	3.79% ***	4.52% ***	9.08% ***
	(−2.24)	(2.11)	(5.34)	(3.75)	(4.95)	(6.83)

stock returns. Because the systematic component of the put slope is unrelated to stock returns, we don't report the results (all of which are statistically insignificant and available upon request). Table 6 reports results for the systematic component of the call slope. The negative relation between the systematic component of the call slope and future stock returns exists in both lower and higher group of opinion dispersion. Thus, dispersion of opinion does not appear to be related to the relationship between the systematic call slope and future stock returns.

Table 7 presents results for the idiosyncratic component of the put and call slope, respectively. The idiosyncratic component of the put slope is unrelated to equal-weighted and value-weighted risk-adjusted stock returns in the low dispersion of opinion group, but is associated with lower risk-adjusted stock returns in the high dispersion of opinion group. On the other hand, the idiosyncratic component of the call slope is associated with higher equal-weighted and value-weighted risk-adjusted returns in all dispersion of opinion groups and is stronger for the higher dispersion group.

Table 7 results confirm that stocks with steeper put slopes earn lower future stock returns. This underperformance, which can last for up to 1 year, exists only when there is high dispersion of opinion about the value of the stock. Furthermore the ability of the put slope to predict risk-adjusted stock returns is due to the idiosyncratic component of the slope. In contrast, stocks with larger call slopes earn higher future returns, but the call slope predictability lasts for a shorter period of time (about three months) than the put slope predictability (about 12 months). Thus, the systematic component of the call slope is associated with lower risk-adjusted stock returns while the idiosyncratic component is associated with higher stock returns. Between the two components of the call slope, the idiosyncratic component dominates the systematic component, and the overall relation between the call slope and future returns is positive.

The put-slope results are most consistent with a belief difference interpretation, since the results are statistically significant only when dispersion of opinion is high. One interpretation of our results is that pessimism leads to higher prices of OTM puts and higher risk-adjusted stock returns, while optimism causes the prices of both OTM calls and stocks to be bid up. A caveat is in order: the call-slope results are only weakly consistent with the theory that optimism contributes to the observed relation between call-slope and stock returns, since the predictable relationship exists for both high and low dispersion of opinion. At the same time, the results in Table 7 leave out a number of control variables known to affect stock returns, and it is possible that the dispersion of opinion variable is capturing multiple effects.

To examine this hypothesis more closely,we use the Fama–MacBeth method to conduct cross-sectional regressions to control for variables that are shown in previous studies to be associated with stock returns, including firm size, book-to-market ratio, past stock return, volatility premium and stock turnover. Table 8 presents the cross-sectional regression results of stock returns on the idiosyncratic component of the smile slopes of puts with the delta of −0.20 and calls with the delta of 0.20.[4] Coefficients on the put slope are negative and significant for 1-month, 3-month, 6-month and 12-month returns. The coefficients on the call slope are positive and significant, for 1-month, 3-month, 6-month and 12-month returns. Among control variables, volatility premium is significantly positively related to returns of all holding periods. Turnover is also positively related to stock return. Dispersion of opinion is significantly negatively related to 1-month and 3-month returns, consistent with the prediction of Miller (1977) overvaluation theory. It appears that in Table 8, the dispersion of financial analysts' earnings forecasts was picking up some of the information contained in the new control variables, and once we include these variables in our regression, the dispersion shows up as a significant variable: the slope–return relationship is stronger when dispersion of opinion is high. These results are consistent with story in which investor optimism is correlated with higher prices of OTM calls and higher future stock returns.

3. Robustness checks

To investigate the robustness of the results presented in the previous section, several dimensions are examined and results are discussed in this section.

First, we examine different option deltas. To save space, tables are not reported but will be provided at request. We find that the deeper the OTM options used, the more significant the predictability of the smile slope on future stock returns. The negative predictability of the put slope on future stock returns is significant for all option deltas, but is most significant and has the largest return differentials for the deepest OTM deltas (i.e. delta = −0.20). The positive predictability of the call slope on future stock returns is insignificant for deltas of 0.45, 0.4 and 0.35 but is significant for delta of 0.3, 0.25 and 0.2 and the results are most pronounced when delta is 0.2.

4. We also conduct regression for put slope and call slope separately. The results are consistent with results combining put slope and call slope.

Table 6. Portfolio risk-adjusted returns based on systematic components of call smile slope. Each month stocks are sorted into high, medium and low dispersion of opinion portfolios first and then assigned into five quintiles based on the systematic component of call slope as of the previous month, with Q1 as the smallest quintile and Q5 as the largest Quintile. After assigning stocks into portfolios, the mean portfolio monthly return is computed as the equal-weighted (and value weighted) average of returns of all stocks in the portfolio. Carhart (1997) four factor model is used to obtain risk-adjusted returns (alphas). The sample period is from January 1996 to December 2008. T-statistics (Newey–West adjusted) are in parentheses under estimates. *, ** and *** represent statistical significance at 10%, 5% and 1% respectively.

Panel A: Equal-weight portfolios sorted on call slope with delta = 0.2

	Q1	Q2	Q3	Q4	Q5	Q5 − Q1
Low dispersion						
1-month return	1.19% ***	0.98% ***	0.55% ***	0.39%**	0.02%	−1.17% ***
	(4.76)	(5.08)	(2.89)	(2.19)	(0.12)	(4.36)
3-month return	3.34% ***	2.74% ***	1.79% ***	0.84% **	−0.19%	−3.53% ***
	(4.63)	(5.41)	(3.97)	(2.02)	(0.43)	(4.48)
6-month return	6.98% ***	5.17% ***	3.83% ***	1.64% ***	−1.13% ***	−8.11% ***
	(4.69)	(5.78)	(4.90)	(3.13)	(2.93)	(8.81)
12-month return	15.12% ***	11.13% ***	6.82% ***	2.57% **	−3.30% ***	−18.42% ***
	(4.30)	(4.94)	(4.62)	(2.49)	(4.11)	(8.79)
High dispersion						
1-month return	0.91% ***	0.37% *	0.22%	0.14%	−0.65% ***	−1.56% ***
	(2.91)	(1.73)	(0.84)	(0.58)	(3.75)	(−4.87)
3-month return	2.94% ***	1.16% **	0.83%	0.31%	−1.53% ***	−4.47% ***
	(3.38)	(1.98)	(1.38)	(0.62)	(−3.96)	(−7.62)
6-month return	5.26% ***	2.88% ***	1.56% *	0.30%	−3.25% ***	−8.51% ***
	(4.14)	(3.07)	(1.73)	(0.45)	(−5.01)	(−9.02)
12-month return	8.08% ***	5.55% ***	3.00% *	−0.40% ***	−5.58% ***	−13.66% ***
	(4.55)	(2.81)	(1.29)	(0.25)	(4.25)	(−8.33)

Panel B: Value-weight portfolios sorted on call slope with delta = 0.2

	Q1	Q2	Q3	Q4	Q5	Q5 − Q1
Low dispersion						
1-month return	1.19% ***	0.98% ***	0.55% ***	0.39% **	0.02%	−1.17% ***
	(4.76)	(5.08)	(2.89)	(2.19)	(0.12)	(4.36)
3-month return	3.34% ***	2.74% ***	1.79% ***	0.84% **	−0.19%	−3.53% ***
	(4.63)	(5.41)	(3.97)	(2.02)	(0.43)	(4.48)
6-month return	6.98% ***	5.17% ***	3.83% ***	1.64% ***	−1.13% ***	−8.11% ***
	(4.69)	(5.78)	(4.90)	(3.13)	(2.93)	(8.81)
12-month return	15.12% ***	11.13% ***	6.82% ***	2.57% **	−3.30% ***	−18.42% ***
	(4.30)	(4.94)	(4.62)	(2.49)	(4.11)	(8.79)
High dispersion						
1-month return	0.02%	−0.22%	−0.24%	−0.39% *	−0.86% ***	−0.88% **
	(0.07)	(−1.01)	(−0.79)	(−1.69)	(−3.83)	(−2.47)
3-month return	0.22%	−0.06%	−0.28%	−0.55%	−1.37% ***	−1.59% ***
	(0.28)	(−0.09)	(−0.51)	(−0.91)	(−3.26)	(−2.81)
6-month return	1.52% *	0.42%	−0.70%	−1.20% *	−1.67% **	−3.19% ***
	(1.64)	(0.46)	(−0.92)	(−1.72)	(−2.27)	(−3.83)
12-month return	1.68% ***	1.47% ***	−1.26% *	−1.99% ***	−1.42%	−3.10% **
	(4.55)	(2.81)	(−1.29)	(−0.25)	(−0.72)	(−2.21)

Second, we examine a different measure of smile slope. Following Toft and Prucyk (1997), the smile slope is scaled by the implied volatility of ATM options. Dennis and Mayhew (2002) argue that this measure is complex since it impounds information in both the implied volatility level and the smile slope. Using this alternative measure makes it hard to distinguish between the effects from the slope and those of the overall level of implied volatility. An et al. (2014) find changes in the implied volatility level (using ATM options) can forecast the cross-sectional stock returns: stocks with call options which have experienced large increases in volatilities over the past month tend to experience high expected returns over the next month while large increases in put option volatilities predict decreases in future stock returns. Our results using this alternative measure are not qualitatively different from results presented in the previous section.

Lastly, to test the robustness of our proxy for investor heterogeneous beliefs,we try another commonly used proxy—idiosyncratic volatility of stock returns. Shalen (1993) and others argue that stocks with higher divergence of opinion have higher idiosyncratic volatility. Using stock idiosyncratic volatility as the proxy for belief heterogeneity, we find results are similar to those based on the dispersion of financial analysts' earnings forecasts. This suggests that our study is robust for different proxies for investor heterogeneous beliefs.

4. Conclusion

Recent studies document an empirical relationship between the implied volatility smile and stock returns. In this study we test whether belief differences among investors are a determinant of the option–stock price relationship just described.

The first contribution of our study is that we test separately the cross-sectional relationship between the put slope and future stock returns and the call slope and future stock returns. We find stocks with steeper put slopes (i.e. OTM puts more expensive than ATM puts, indicating more pessimistic opinions) earn lower future stock returns, consistent with the finding of Xing et al. (2010). This underperformance is significant only when investors have greater dispersion of opinion about the value of the stock. Furthermore, it is the idiosyncratic component of the put slope that contributes to this predictability of the put slope on future stock returns. Our interpretation is that firm-level pessimism results in higher OTM put prices and lower future stock returns.

Stocks with larger call slopes (i.e. OTM calls more expensive than ATM calls, indicating more optimistic opinions) earn higher future returns. The call-slope results are consistent with a story in which investor optimism is correlated with higher prices of OTM calls and higher future stock returns. For the call slope, the idiosyncratic component

Table 7. Risk-adjusted returns based on dispersion and the idiosyncratic component of smile slopes. Each month stocks are sorted into high, medium and low dispersion of opinion portfolios first and then assigned into five quintiles based on the idiosyncratic component of smile slope as of the previous month, with Q1 as the smallest quintile and Q5 as the largest Quintile. After assigning stocks into portfolios, the mean portfolio monthly return is computed as the equal-weighted (and value-weighted) average of returns of all stocks in the portfolio. Carhart (1997) four factor model is used to obtain risk-adjusted returns (alphas). The idiosyncratic component of smile slope is the residual of the regression of smile slope on the smile slope of S&P 500 index option (SPX). Panel A (C) present results based on the put slope constructed using OTM puts with a delta of −0.20. Panel B (D) present results based on the call slope constructed using OTM calls with a delta of 0.20. The sample period is from January 1996 to December 2008. T-statistics (Newey–West adjusted) are in parentheses under estimates. *, ** and *** represent statistical significance at 10%, 5% and 1% respectively.

Panel A: Portfolios sorted on put slope with delta = −0.20

Low dispersion	Q1	Q2	Q3	Q4	Q5	Q5 − Q1
Low dispersion						
1-month return	0.73%***	0.54%**	0.55%***	0.57%***	0.76%***	0.03%
	(3.29)	(2.56)	(2.68)	(3.30)	(4.07)	(0.10)
3-month return	1.88%***	1.65%***	1.43%***	1.63%***	1.91%***	0.03%
	(3.48)	(3.15)	(3.02)	(4.09)	(4.00)	(0.00)
6-month return	3.32%***	3.54%***	3.17%***	3.21***	3.15%***	−0.17%
	(3.80)	(3.86)	(4.27)	(4.67)	(3.96)***	(−0.20)
12-month return	6.89%***	6.38%***	6.22%***	7.11%***	5.62%***	−1.27%
	(3.55)	(3.44)	(4.23)	(4.43)	(3.45)	(−0.62)
High dispersion						
1-month return	0.89%***	0.29%*	0.16%	0.14%	0.22%	−0.67%***
	(3.97)	(2.11)	(1.09)	(0.80)	(1.35)	(−3.01)
3-month return	1.91%***	0.81%**	0.82%**	0.71%	0.62%	−1.29%***
	(4.45)	(2.45)	(2.25)	(1.56)	(1.49)	(−3.12)
6-month return	3.46%***	1.49%***	1.09%**	1.03%	0.93%	−2.53%***
	(5.35)	(3.35)	(2.19)	(1.60)	(1.29)	(−3.95)
12-month return	6.36%***	2.76%***	1.88%**	1.46%	1.42%	−4.94%***
	(3.87)	(2.88)	(2.18)	(1.35)	(1.26)	(−3.62)

Panel B: Portfolios sorted on call slope with delta = 0.2

	Q1	Q2	Q3	Q4	Q5	Q5 − Q1
Low dispersion						
1-month return	0.21%	0.42%**	0.60%**	0.80%***	1.11%***	0.90%***
	(1.05)	(2.60)	(3.73)	(4.23)	(3.97)	(3.35)
3-month return	0.34%	1.13%**	1.98%***	2.36%****	2.70%***	2.36%**
	(0.77)	(3.02)	(3.90)	(4.76)	(4.40)	(4.48)
6-month return	0.34%	2.57%***	3.72%***	4.73%***	5.07%***	4.73%***
	(0.62)	(4.03)	(4.28)	(5.10)	(5.14)	(5.81)
12-month return	−0.45%	6.06%***	7.29%***	9.52%***	9.79%***	10.24%***
	(0.39)	(3.92)	(4.26)	(4.42)	(5.09)	(5.77)
High dispersion						
1-month return	−0.35%	0.12%	0.20%***	0.37%***	0.65%**	1.00%***
	(−1.31)	(0.57)	(0.93)	(1.41)	(2.54)	(3.17)
3-month return	−1.02%*	0.17%	1.03%**	1.34%**	2.14%***	3.16%***
	(−1.93)	(−0.36)	(−2.21)	(−2.30)	(−3.15)	(5.14)
6-month return	−2.10%***	0.24%	1.91%***	2.99%***	3.69%***	5.79%***
	(−2.88)	(−0.36)	(−2.62)	(−3.33)	(−4.07)	(6.34)
12-month return	−3.61%***	0.65%	2.82%*	5.02%***	5.76%***	9.37%***
	(−2.11)	(0.46)	(1.70)	(−2.95)	(3.64)	(5.66)

Panel C: Value-weight portfolios sorted on put slope with delta = −0.20

	Q1	Q2	Q3	Q4	Q5	Q5 − Q1
Low dispersion						
1-month return	0.23%	0.10%	0.54%***	0.39%**	0.28%	0.05%
	(1.16)	(0.51)	(2.77)	(2.42)	(1.22)	(0.14)
3-month Return	0.50%	1.25%**	1.66%***	1.25%***	0.32%	−0.18%
	(0.94)	(2.46)	(3.88)	(3.23)	(0.63)	(−0.28)
6-month return	1.49%**	2.21%**	3.70%***	2.97***	0.55%	−0.94%
	(2.17)	(2.50)	(4.38)	(4.31)	(0.76)	(−0.97)
12-month return	1.80%	4.34%***	7.10%***	7.59%***	4.24%***	2.44%
	(1.51)	(2.83)	(4.67)	(4.41)	(3.05)	(−1.52)
High dispersion						
1-month return	0.39%*	0.14%*	0.01%	−0.13%	−0.35%	−0.74%
	(1.77)	(0.57)	(0.05)	(−0.41)	(−1.07)	(−1.24)
3-month return	0.33%	0.38%	0.53%	−0.08%	−1.20%	−1.53%**
	(0.51)	(0.66)	(0.86)	(−0.12)	(−1.62)	(−2.04)
6-month return	2.28%***	1.96%**	1.67%**	−0.35%	−2.26%*	−4.54%***
	(2.61)	(2.20)	(1.99)	(−0.45)	(−1.80)	(−4.38)
12-month return	3.16%*	1.95%***	1.42%**	−0.36%	−3.60%**	−6.76%***
	(1.64)	(1.26)	(0.98)	(−0.29)	(−2.49)	(−3.76)

Table 7. (*continued*)

Panel D: Value-weight portfolios sorted on call slope with delta = 0.2						
	Q1	Q2	Q3	Q4	Q5	Q5 − Q1
Low dispersion						
1-month return	−0.07%	0.31%	0.71% ***	0.23%	0.37% *	0.44% *
	(−0.28)	(1.39)	(3.40)	(0.85)	(1.69)	(1.61)
3-month return	−0.41%	0.80% *	1.22% ***	1.65% ****	1.20% **	1.61% **
	(−0.85)	(1.87)	(3.43)	(3.07)	(2.27)	(2.44)
6-month return	−0.82%	2.47% ***	3.01% ***	2.86% ***	2.65% ***	3.47% ***
	(−1.13)	(3.17)	(4.03)	(3.04)	(3.29)	(3.44)
12-month return	−0.94%	1.20% ***	6.36% ***	6.39% ***	6.08% ***	7.02% ***
	(−0.49)	(3.88)	(4.29)	(3.66)	(4.14)	(3.60)
High dispersion						
1-month return	−0.85% ***	−0.15%	−0.09%	−0.19%	0.06%	0.91% **
	(−2.79)	(0.44)	(0.38)	(0.59)	(0.19)	(2.17)
3-month return	−1.93% ***	−0.89%	−0.30%	0.73%	1.23% **	3.16% ***
	(−3.65)	(−1.24)	(−0.50)	(−1.20)	(1.92)	(4.55)
6-month return	−2.49% ***	−1.04%	0.16%	1.48% *	3.34% ***	5.83% ***
	(−2.72)	(−1.10)	(0.19)	(1.79)	(3.39)	(5.41)
12-month return	−3.92% *	−1.30%	0.01%	1.80%	3.82% **	7.74% ***
	(−1.83)	(−1.20)	(0.01)	(1.29)	(2.14)	(4.26)

Table 8. Fama–MacBeth regression of stock returns on idiosyncratic component of smile and control variables. This table presents results of Fama–MacBeth regression for stock returns on the idiosyncratic component of smile slope and control variables. The Newey–West t-statistics are reported under the estimates. PUT (CALL) IDIO SLOPE is the idiosyncratic component of smile slope of puts (calls). OPEN INTEREST is the daily total open interest of all OTM puts (calls) averaged over a month in Panel A (B). PUT VOLUME is the daily total trading volume of all OTM puts (calls) averaged over a month in Panel A (B). LOGSIZE is the nature logarithm of the market capitalization as of the last day of previous month. B/M is the book-to-market ratio computed as book common equity value divided by the market capitalization of the last day of previous month. LAGRET is the previous month return. PVOL is the volatility premium, the difference between the implied volatility of ATM options (averaged using both puts and calls) and the stock return volatility each month computed using daily stock returns. TURNOVER is the monthly trading volume over number of outstanding shares. DISPERSION is the dispersion in financial analysts' earnings forecasts, measured as the standard deviation of forecasts for quarterly earnings scaled by the absolute value of the mean earnings forecast. *, ** and *** represent statistical significance at 10%, 5% and 1% respectively.

	1-month	3-month	6-month	12-month
Intercept	0.0197	0.0571	0.162 **	0.513 ***
	(0.77)	(1.26)	(2.36)	(4.27)
PUT IDIO SLOPE	−0.063 ***	−0.126 ***	−0.246 ***	−0.434 ***
	(−4.94)	(−5.57)	(−6.20)	−(−6.45)
CALL IDIO SLOPE	0.115 ***	0.321 ***	0.638 ***	1.157 ***
	(6.87)	(10.90)	(12.30)	(12.71)
PUT OPEN INTEREST	0.0001	0.0001	0.0002	0.0007 **
	(1.01)	(1.54)	(1.37)	(3.01)
PUT OPTION VOLUME	0.001	0.0029	0.009 *	0.009
	(0.71)	(1.10)	(1.91)	(0.91)
CALL OPEN INTEREST	0.0001	0.0001	0.0001	0.00066 **
	(1.09)	(0.86)	(1.06)	(2.44)
CALL OPTION VOLUME	−0.0014	−0.0026	−0.005	−0.0088
	(−1.21)	(−1.46)	(−1.58)	(−1.16)
LOGSIZE	−0.001	−0.002	−0.006 *	−0.0195 ***
	(−0.63)	(−0.94)	(−1.90)	−(−3.71)
B/M	0.0008	−0.0009	−0.011 *	−0.0228 **
	(0.48)	(−0.30)	(−1.92)	(−2.20)
LAGRET	−0.0044	0.0092	0.058 ***	0.079 **
	0.45	(0.63)	(2.61)	(1.99)
PVOL	0.01629 *	0.0237	0.035 *	0.098 ***
	(1.91)	(1.79)	(1.70)	(2.63)
TURNOVER	0.9728	2.879 *	5.942 **	12.584 ***
	(1.21)	(1.88)	(2.46)	(2.79)
DISPERSION	−0.0038 ***	−0.0056 **	−0.001	0.005
	(−2.84)	(−2.53)	(−0.32)	(0.80)
Adjusted R-square	7.08%	6.97%	7.19%	7.84%

dominates the systematic component, and explains the overall positive risk-adjusted returns.

Belief differences appear to play a role in the relationship between the smile slope and future stock returns, and the put and call slopes predict future stock returns in opposite ways. Our results highlight two considerations when studying linkages between the option and stock markets. First, call slopes and put slopes impact future stock returns differently, and many measures of smile slope or implied volatility that take the average or difference of the call and put slopes are essentially throwing away useful information. Second, the idiosyncratic and systematic components of slope also contain distinct information, with the idiosyncratic component playing the dominant role in the relationship between the smile slope and future stock returns.

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