VI. The Information Content of Risk-neutral Volatilities and Skewness

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Outline

- implied and realized volatilities
- Bollerslev, Tauchen, and Zhou (2010)
- Xing, Zhang, and Zhao (2010)
- Rehman and Vilkov (2010)
Implied and realized volatility

- As volatility is unobservable in the market, we have to model it with certain assumptions.
- Most well-known and widely used method is ARCH: the variance of the current error term is a function of the variance of the previous error term (Engle, 1982).
- With the availability of options data, option-implied volatilities can be estimated using the BS model as a mapping tool.
- There is a huge literature on the information content of option-implied volatilities, whether they are efficient and unbiased predictor of future realized volatilities.
- The general consensus is that option-implied volatility is an efficient but biased forecast which is consistently higher than realized volatility (risk aversion).
- With the availability of high frequency data, there is evidence that realized volatility from high frequency data is informationally superior to implied volatility.
the variance risk premium is defined as the difference between option-implied variances and realized variances \( \text{VRP}_t \equiv \text{IV}_t - \text{RV}_t \)

- in an equilibrium model with stochastic consumption growth rate and stochastic conditional variance for the consumption growth, the authors show that \( \text{VRP}_t \) is directly related to the stochastic conditional variance of consumption rate hence related to volatility risk

- option-implied variances are based on VIX (CBOT) while realized variances are computed using 5-min high frequency data of SP 500 index

- use variance risk premium as well as more traditional indicators (PE ratio, PD ratio, term spread, default spread, cay, etc) to explain SP 500 index returns

- monthly frequency from 1990.01 to 2007.12
Table 2 summarizes univariate regression results: the VRP is significant over 3-month horizon (0.47) and 6-month horizon (0.30); the t-stat and adjusted $R^2$ decreases rapidly with sample horizon.

Table 3 performs a series of univariate and multivariate regressions with monthly data; when combined with more traditional indicators, the VRP is always significant except when coupled with cay.

Table 4 does the same on quarterly basis: the VRP is always significant with combined with other predictors.

On an annual basis, it is no longer significant as shown in Table 5.

In summary, the variance risk premium has strong predictive power over short- to medium-horizon.
this paper focuses on the information content of volatility smirk at firm level

\[ \text{SMIRK}_{i,t} = \text{VOL}^{\text{OTMP}}_{i,t} - \text{VOL}^{\text{ATMC}}_{i,t} \]

if pessimistic perception exists in the market, investors either buy put options for protection against future stock price drops (hedging) or for a high potential return (speculative)

high buying pressure for puts and steep volatility smirk are associated with bad news about future stock prices

options market and equity market are segmented; informed traders with bad news prefer to trade OTM put options; information is then slowly incorporated into stock prices hence the volatility smirk is able to predict future stock returns

volatility smirk contains information not captured by firm-specific variables such as size, book-to-market ratio, liquidity, and so on
methodology 1: Fama-MacBeth regression

1st stage for each week $t$ perform regression with cross sectional data; after obtaining a time series of slope coefficients ($b_{0t}$, $b_{1t}$, $b_{2t}$) conduct statistical inference on the time series of the coefficients

\[
RET_{i,t} = b_{0t} + b_{1t} SKEW_{i,t-1} + b_{2t} CONTROLS_{i,t-1} + e_{it}
\]

- in the univariate regression the coefficient is -0.0061 (-2.50); when volatility smirk increases from 2.40% (25th percentile) to 8.43% (75th percentile), the decrease in next week’s returns $(8.43\% - 2.40\%) \times (-0.0061) = -5.52$ basis points, or -2.90% per year

- in the multivariate regression, the coefficient is still significant in the presence of 10 firm-specific or option-related control variables, -0.0089 (-3.86)

- when volatility smirk is weighted by trading volume (as opposed to being weighted by moneyness), the results are very similar
Xing, Zhang and Zhao (2010)

methodology 2: sorting stocks into portfolios based on volatility smirk

- each week sort firms into quintile portfolios based on the average smirk of the previous week
- portfolio 1 has the lowest smirk (higher expected returns) and portfolio 5 has the largest smirk (lower expected returns); long portfolio 1 and short portfolio 5 hence returns show economic importance of the variable
- this is common strategy with the advantage that (1) it does not impose any restriction on returns; and (2) reduce noise at firm level
- portfolio 1 has excess returns of 24bp, portfolio 5 has excess returns of 8bp, significant difference of 16bp per week (t-stat -2.19), 9.19% per year
- results are qualitatively similar if options are weighted by trading volume
- shows firms with high volatility smirk underperform firms with low volatility smirk, and steeper volatility smirk forecasts worse news
methodology 3: use both FM regression and portfolio sorting to test how long the predictability can last

- if stock market is efficient in incorporating information from the options market, the predictability is short-lived; also if news is a temporary fad and not related to fundamentals, predictability will disappear quickly
- use FM regression with different horizons: returns over week $t+4$, $t+8$, up until $t+24$; i.e. same regression as in methodology 1 but much longer horizons, still control for firm characteristics
- coefficient is significant in the 4th week up to the 20th week
- use portfolio sorting based on previous week’s volatility smirk and hold the portfolio from week $t+1$ to $t+4$, from $t+1$ to $t+8$, up until $t+1$ to $t+28$
- annualized holding period returns from buying portfolio 1 and selling portfolio 5 are of similar magnitude and all significant up until week 28
- stock market is slow in incorporating information on the fundamentals
Xing, Zhang and Zhao (2010)

test the nature of the information contained in options market not captured in the equity market

- volatility smirk is firm-specific so authors relate this information to earnings announcement
- prior literature documents earnings announcement as a major channel for information release
- define earnings surprise, UE, as the difference between announced earnings and the latest consensus earnings forecast, and SUE, as the scaled UE by the stdev of the latest consensus earnings forecast
- firms with high smirk are likely to be firms with low UE/SUE in the next quarter
- tests are performed by sorting firms into portfolios and by FM regressions
- results are statistically significant over all horizons, indicating a close link between the shape of volatility smirk and news about future firm fundamentals
Han (2008) addresses the question of whether sentiment influences option prices through the RN skewness and finds more bullish/bearish sentiment is associated with less/more negative RN skewness.

This paper uses risk-neutral skewness inferred from stock options as sentiment measure for the underlying stocks.

The more negative RN skewness indicates more bearish sentiment towards the stock and the higher probability of a negative price movement.

Hypothesis 1: high-skew stocks outperform low-skew stocks after controlling for systematic risks.
Rehman and Vilkov (2010)

- **hypothesis 2**: RN skewness reflects the sign and degree of stock misvaluation: skewness (investor sentiment) should be the lowest (more negative) for stocks that are most overvalued; on the other hand, undervalued firms tend to have higher skew (more positive sentiment).

- **hypothesis 3**: if arbitrage is more difficult, then sentiment and misvaluation should persist longer for stocks with higher arbitrage risk; misvaluation should correct itself more quickly for stocks that are easier to arbitrage.

- **hypothesis 4**: risk-neutral skewness should co-vary with indicators of how subjective/difficult firm valuation is.
Rehman and Vilkov (2010)

- the study links the literature on option pricing with equity valuation and needs data from both markets
- sample period from January 1996 to June 2007
- infer RN skewness using the model-free methodology of Bakshi, Kapadia and Madan (2003)
to test hypothesis 1: high-skew stocks outperform low-skew stocks

- construct rebalancing portfolios at monthly frequency into deciles, quintiles, quartiles, and terciles according to skew and long portfolios with the highest skew and short portfolios with the lowest skew
- regress returns using the Fama-French 3-factor model or Carhart 4-factor model
- intercept, which captures excess returns, always significant both statistically and economically
- the intercept still significant when MFIV is added to the regression
- also use Fama-MacBeth 2-stage regression model and control for the volatility smirk in Xing, Zhang, and Zhao (2010); find that the RN skewness contains information not captured by the volatility smirk, i.e. coefficient still significant in the presence of volatility smirk
to test hypothesis 2: RN skewness lowest (most negative) for most overvalued firms; i.e. investor sentiment most negative for most overvalued stocks

- use a decomposition methodology in the literature to single out firm-specific pricing errors, i.e. the deviation in a firm’s observed value from the valuation implied by current accounting indicators

- firms are grouped into quintile portfolios and their average valuation error decreases monotonically from lowest-skew portfolios to highest-skew portfolios

- use RN skewness in a multivariate regression to control for firm-specific variables such as size, B/M ratio, the gearing ratio, etc, to explain firm misvaluation and finds that the coefficient for skew quintile is always significantly negative: lowest skew associated with largest misvaluation
to test hypothesis 3: sentiment and misvaluation persist longer for stocks with high arbitrage risk; hence the absolute change in skew should decrease as arbitrage risk increases

- In theory, arbitrageurs buy undervalued stocks and sell a substitute stock simultaneously or sell overvalued stocks and buy a perfect stock stock; in practice, it is difficult to find a perfect substitute and the two return streams do not cancel out; arbitrage risk

- For each stock in the sample, find 3 stocks in the same industry and have the closest size and B/M ratio, i.e. substitute firms

- In a multivariate regression, use excess returns of the substitute firms to explain excess returns of the target firm; the variance of the residuals is the arbitrage risk

- The higher the variance, the poorer the substitutes are in explaining the returns of the target stock hence higher arbitrage risk

- Use arbitrage risk to explain the change and absolute change in RN skewness, coefficients are negative and significant
an essay (either in English or Chinese) to discuss one paper in the reading list
the essay cannot be entirely descriptive; it should be critical at some point
minimum 1 page in Chinese or 2 pages in English with font 12 and single spacing
e-mail pdf document to liux@essex.ac.uk before Friday 10 June with your name and registration number