# Notes on Empirical Option Pricing

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# Insights from derivatives markets

- To gain some additional insights to market opportunities it is useful to look at some evidence if supply and demand affects prices in the options markets

# Put-Call Parity Arguments

- Put-call parity $p + S_0 e^{-dT} = c + EX\, e^{-r\,T}$ holds regardless of the assumptions made about the stock price distribution

- It follows that

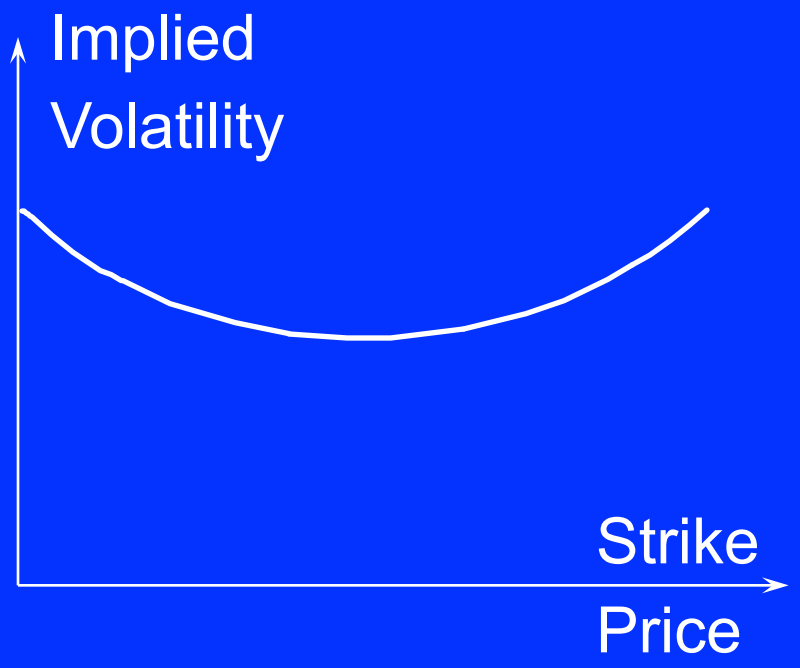
  $p_{mkt} - p_{bs} = c_{mkt} - c_{bs}$

# Implied Volatilities

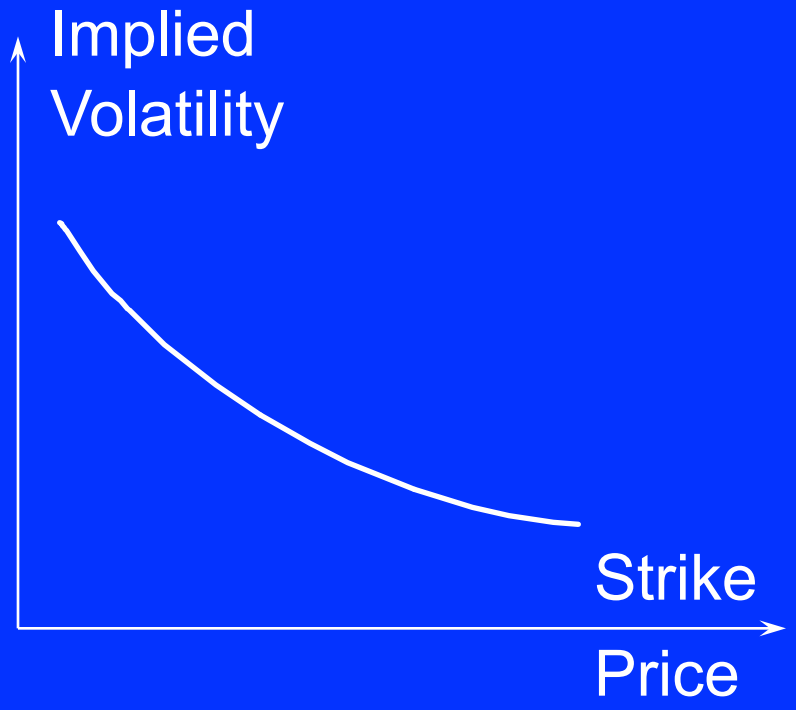
- The implied volatility calculated from a European call option should be the same as that calculated from a European put option when both have the same strike price and maturity
- The same is approximately true of American options

- According to Black & Scholes option pricing theory, implied volatility should be independent of options' exercise price (strike price). Is it?

# The Volatility Smile for Foreign Currency Options – Why could this be?



# The Volatility Smile (Smirk) for Equity Options



# Possible Causes of Volatility Smile (Holes in Black & Scholes)

- Asset price exhibit jumps rather than continuous change
- Volatility for asset price being stochastic

  (One reason for a stochastic volatility in the case of equities is the relationship between volatility and leverage)

  => Other than normal distribution for returns

- Prices are not right due to market participants' limited ability to do arbitrage (no one can borrow sufficiently at risk free rate)?

# A puzzle: Empirical returns from issuing options

- Driessen & Maenhout (2004)
- Large monthly payoffs from writing Out of The Money Puts (OTM) and At The Money (ATM) straddles:

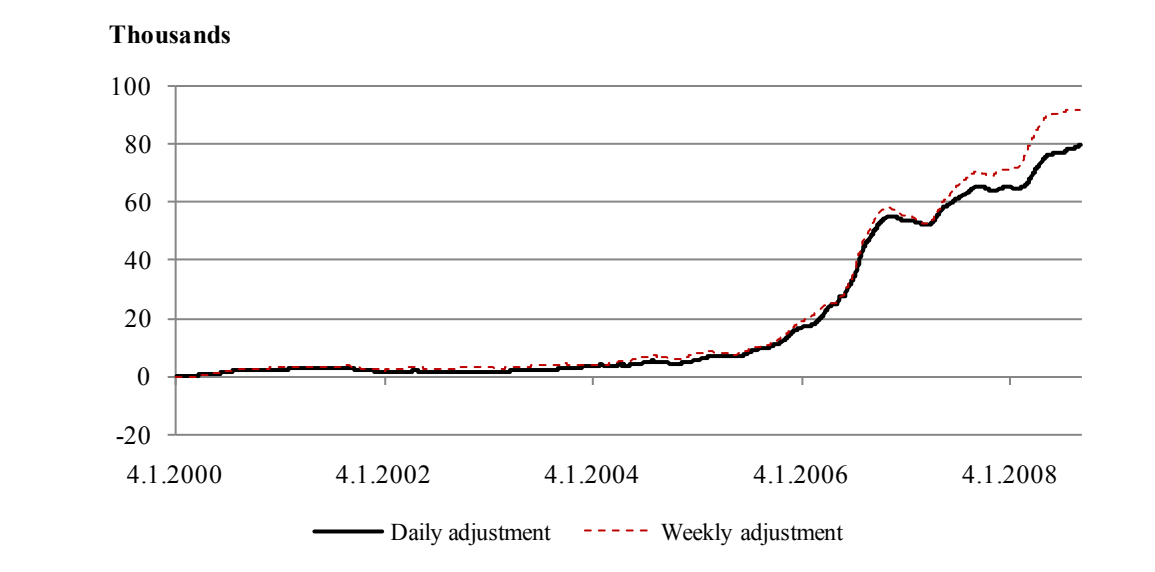
Table 1A: Summary statistics

| Strategy | Mean | Std. dev. | Sharpe | Skewness | Corr. index |
|---|---|---|---|---|---|
| Equity | 0.013 | 0.044 | 0.176 | -0.826 | 1.000 |
| 0.96 OTM put | -0.406 | 1.110 | -0.370 | 5.452 | -0.759 |
| ATM straddle | -0.130 | 0.360 | -0.375 | 2.074 | -0.071 |
| CN OTM put | -0.314 | 1.080 | -0.295 | 2.440 | -0.515 |
| CN ATM straddle | -0.074 | 0.370 | -0.213 | 1.070 | 0.386 |
| 0.92 OTM put | -0.480 | 1.760 | -0.275 | 10.458 | -0.610 |

# Appendix: Dynamic hedging vs. buying commodity options

## Recent thesis by Riikka Tuominen

### Cumulative Return from Dynamic Hedging of 3-Month Options ($/ton)



# Does supply and demand affect options' prices? (Garleanu, Pedersen, Poteshman, RFS, 2009)

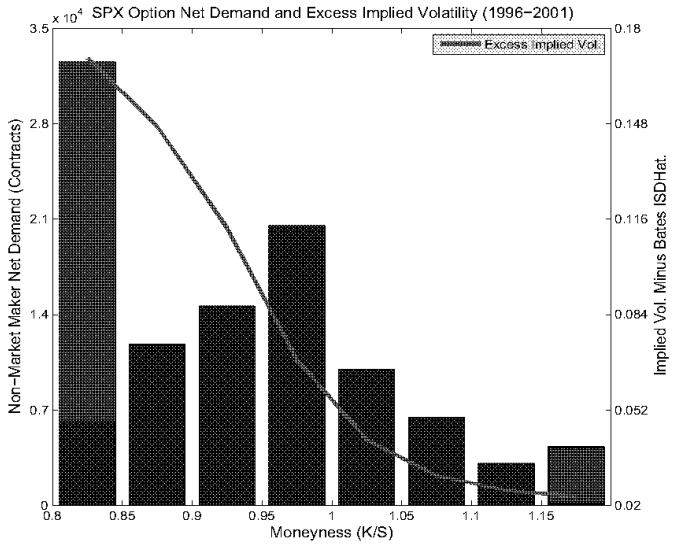
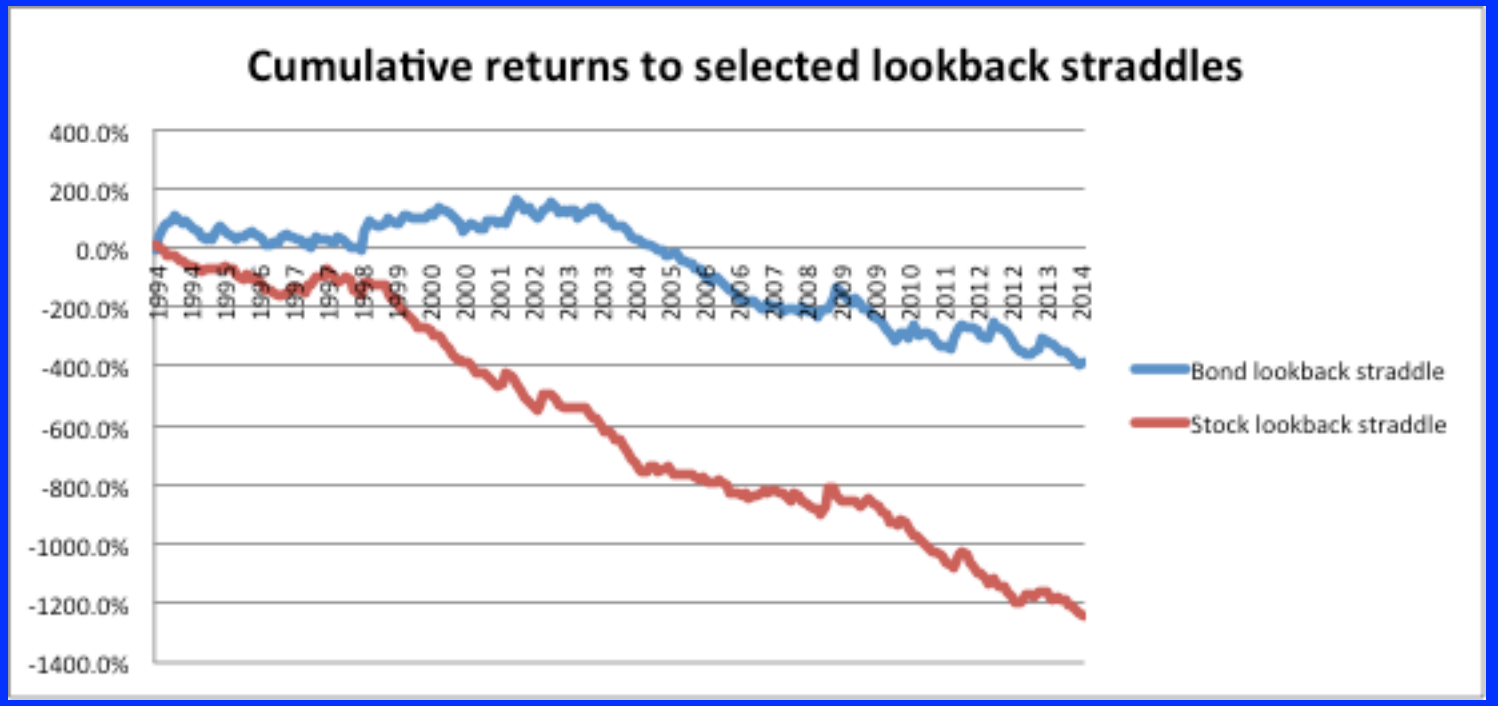



Figure 1: The bars show the average daily net demand for puts and calls from non-market makers for SPX options in the different moneyness categories (left axis). The top part of the leftmost (rightmost) bar shows the net demand for all options with moneyness less than 0.8 (greater than 1.2). The line is the average SPX excess implied volatility, that is, implied volatility minus the volatility from the underlying security filtered using Bates (2005), for each moneyness category (right axis). The data cover 1996-2001.


Cumulative returns to selected lookback straddles
400.0%
200.0%
0.0%
-200.0%
-400.0%
-600.0%
-800.0%
-1000.0%
-1200.0%
-1400.0%
1994
1994
1995
1996
1997
1997
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2000
2001
2002
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2005
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2006
2007
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2009
2009
2010
2011
2012
2012
2013
2014
Bond lookback straddle
Stock lookback straddle

# Volatility Term Structure

- In addition to calculating a volatility smile, traders also calculate a volatility term structure
- This shows the variation of implied volatility with the time to maturity of the option

# Volatility Term Structure

The volatility term structure tends to be downward sloping when volatility is high and upward sloping when it is low

Hedge funds can also take long short positions in volatility

# Example of a Volatility Surface

| | Strike Price | | | | |
|---|---|---|---|---|---|
| | 0.90 | 0.95 | 1.00 | 1.05 | 1.10 |
| 1 month | 14.2 | 13.0 | 12.0 | 13.1 | 14.5 |
| 3 month | 14.0 | 13.0 | 12.0 | 13.1 | 14.2 |
| 6 month | 14.1 | 13.3 | 12.5 | 13.4 | 14.3 |
| 1 year | 14.7 | 14.0 | 13.5 | 14.0 | 14.8 |
| 2 year | 15.0 | 14.4 | 14.0 | 14.5 | 15.1 |
| 5 year | 14.8 | 14.6 | 14.4 | 14.7 | 15.0 |

**To conclude**

**Is it the case that some long/short positions in different types of derivatives should be in the optimal portfolio for investors?**

**Think e.g. commodity producers, before derivatives became popular equity investors carried the commodity price risks (that were imbedded in stock returns). Now when companies hedge those risks (sell the risks in the derivatives markets), is there always a natural buyer to accommodate those risks without some type of a risk premium?**