Implied Volatility

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Implied Volatility

We can use observed option prices to determine what the option market thinks (implies) about the "true" estimate of the stock volatility.

- Implied volatility is foreward looking
- Historical volatility is backward looking

$$OptionPrice = BS(S, r, K, T, \sigma)$$
$$\sigma_{implied} = f(S, r, K, T, OptionPrice)$$

Unfortunately, the functional form of $f(\cdot)$ does not exist.

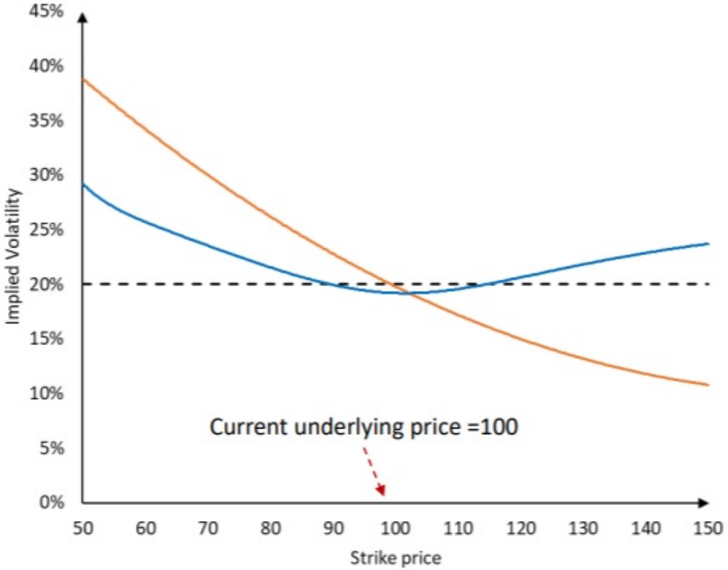
- So we have to use numerical optimization to find $\sigma_{implied}$
- The solver is used in the corresponding Excel file

Implied Volatility and Strike Prices

We can back out implied volatilities from observed option prices using the Black-Scholes option pricing formula.

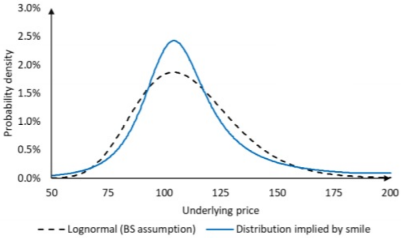
- Theoretically, implied volatility should be constant across strike prices.
- Empirically, we observe differences in implied volatilities.
- This is because asset prices do not follow lognormal distribution.
  - This should be the asset price distribution under Black-Scholes.

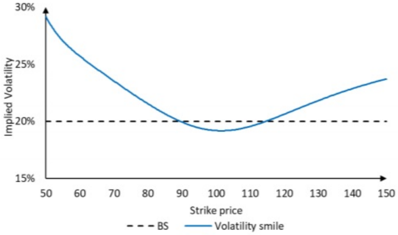
Implied Volatility and Strike Prices



Volatility Smile

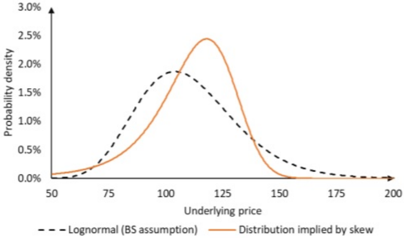
- The volatility smile is typically seen in FX options.
- This is because FX returns have empirically heavier tails, i.e. excess kurtosis.
- The lognormal distribution underestimates probabilities of extreme returns.
- But observed OTM call and put option prices do reflect those extreme returns.
- So implied volatilities will be higher for those options.

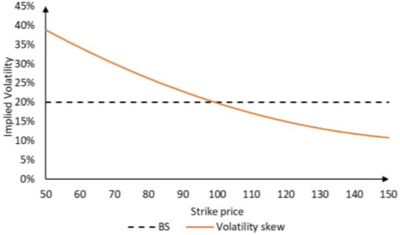




Volatility Skew

- The volatility skew is typically seen in equity options.
- This is because equity returns are empirically negatively skewed.
- The lognormal distribution underestimates probabilities of extreme negative returns.
- But observed OTM call and put option prices do reflect those extreme returns.
- So implied volatilities will be higher (lower) for call (put) options.



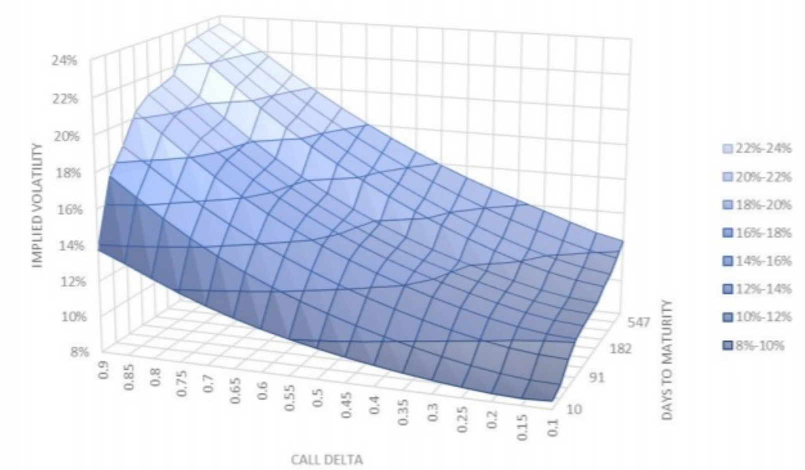


Implied Volatility Surface

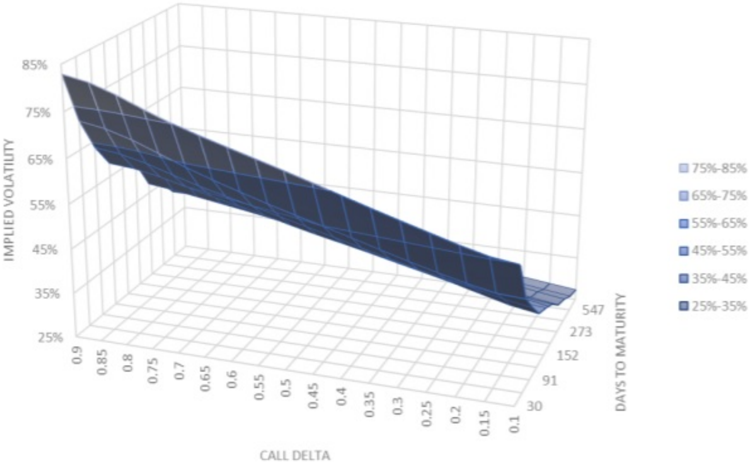
Volatility is not constant, so implied volatilities also differ by maturity.

- This is known as the implied volatility term structure.
- If the market believes volatility will increase in the future, then the implied volatilites of options with a longer maturity will be higher.
- The implied volatility surface plots implied volatility against moneyness and maturity.

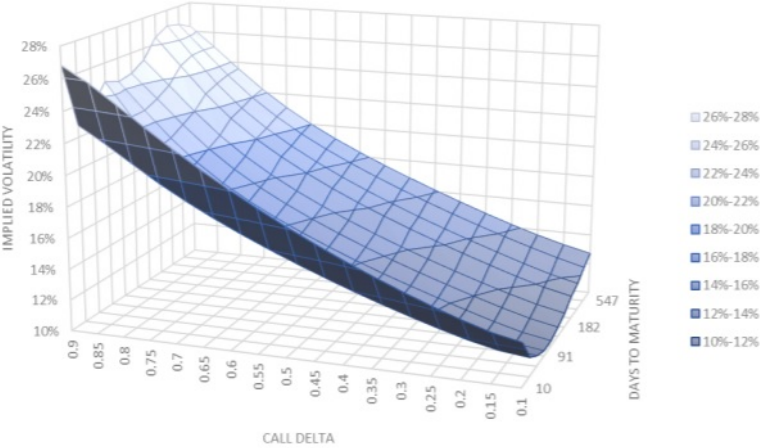
S&P 500 Implied Volatility Surface (Normal Day)



S&P 500 Implied Volatility Surface (2008 Crisis)



S&P 500 Implied Volatility Surface (US Election Day)



Stock Trading Strategies with Option Information

The implied volatility surface is inherently forward looking, so we can exploit it to develop trading strategies.

Baltussen et al. (2012) use the following option measures:

- $SKEW^{OTM} = IV^{OTMP} - IV^{ATMC}$
- $RVIV = RV - IV^{ATM}$

Stock Portoflio Returns (Baltussen et al., 2012)

Table 2. Portfolio Returns of Individual Option Market Variables, January 1996–October 2009

Statistic	Q1	Q2	Q3	Q4	Q5	Q1–Q5
A. $SKEW^{OTM}$						
Excess return (%)	5.46	4.18	2.36	0.34	–1.87	
Sharpe ratio	0.21	0.18	0.10	0.01	–0.08	
Outperformance (%)	3.23**	1.97*	0.18	–1.79*	–3.96**	7.48***
Information ratio	0.58	0.45	0.05	–0.44	–0.67	0.76
CAPM alpha (%)	3.38	2.08	0.23	–1.71	–3.86*	7.49***
4F alpha (%)	2.87*	1.40	–0.01	–2.13	–4.73***	7.96***
B. RVIV						
Excess return (%)	5.02	6.56	5.79	3.69	–2.36	
Sharpe ratio	0.22	0.32	0.27	0.16	–0.08	
Outperformance (%)	1.06	2.54*	1.81	–0.22	–6.04**	7.56*
Information ratio	0.16	0.47	0.38	–0.05	–0.54	0.49
CAPM alpha (%)	2.96	4.47***	3.68***	1.57	–4.13	9.13***
4F alpha (%)	2.02	3.12**	2.52**	0.89	–3.10	7.06**