



CBOE Risk Management Conference Europe September 2013

The Volatility Surface

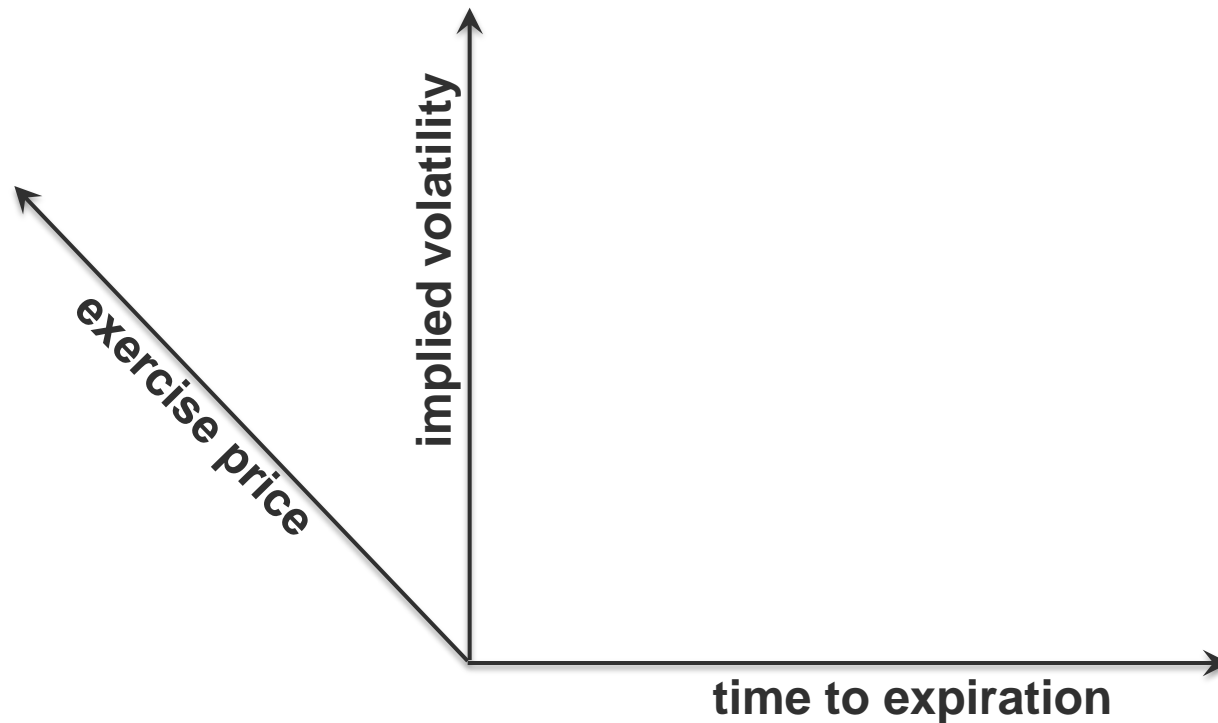
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Traders have long noted that implied volatilities vary across both expiration date (the ***term structure*** of volatility) and exercise price (the volatility ***skew***).

When taken together, the term structure and volatility skew form a ***volatility surface***.



Some important questions:

1. Why does the implied volatility vary across expiration date and exercise price?
2. How can we model the volatility term structure and skew?
3. How do changes in the term structure and skew affect the risk of an option position?
4. Are there trading strategies which focus on changes in the term structure and skew?



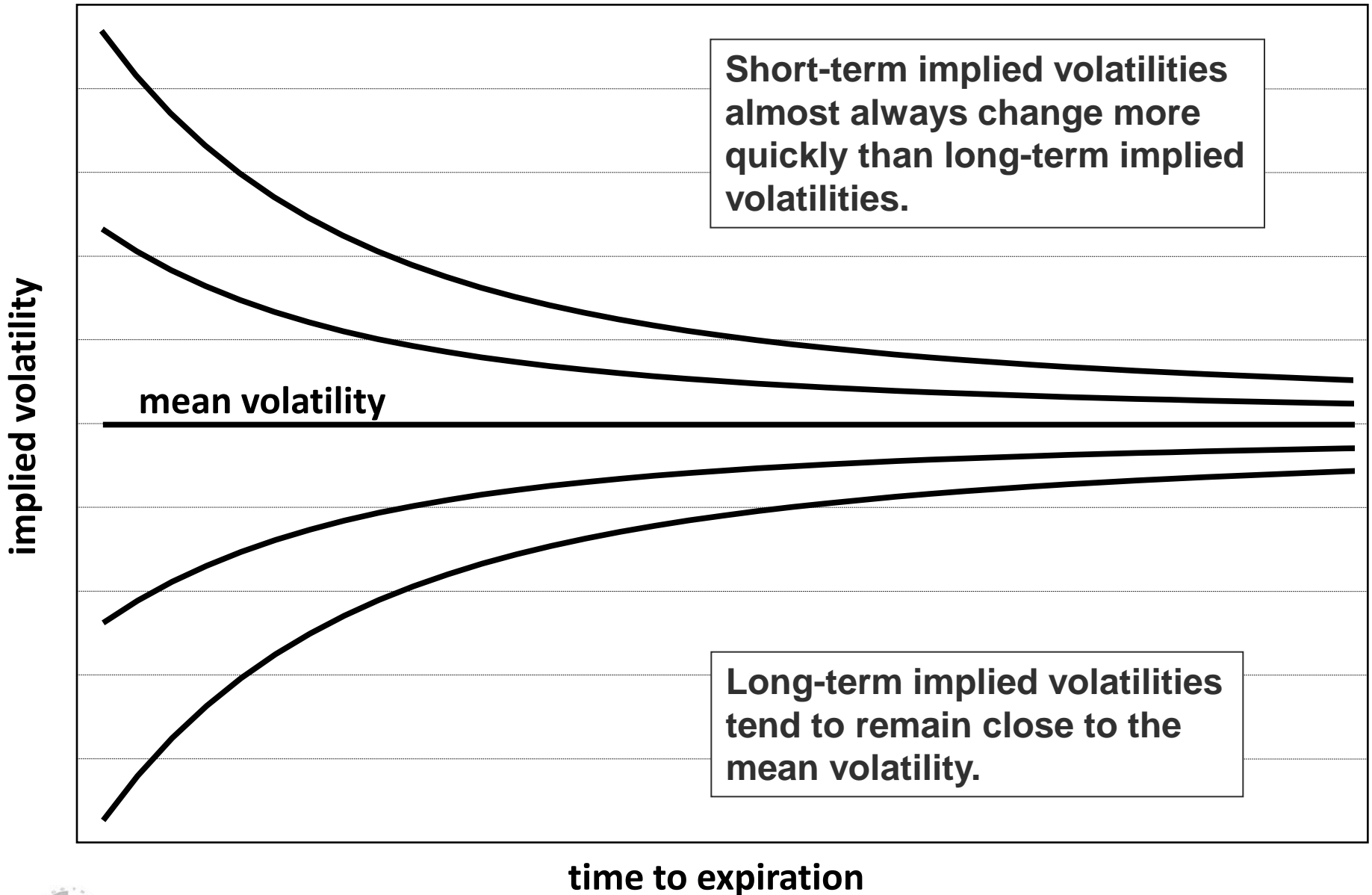
Most underlying contracts have a typical or average volatility to which they tend to revert over long periods of time.

| | current implied <u>volatility</u> | volatility <u>rises</u> | volatility <u>falls</u> |
|-------------------|---|----------------------------|----------------------------|
| March options | 25% | 30% | 20% |
| June options | 25% | 28% | 22% |
| September options | 25% | 26% | 24% |

Volatility tends to be *mean reverting*.



Term Structure of Volatility



SPX ↓ 1685.02 -4.45 1684.64 / 1685.51

At 9:13 d 0 1690.65 H 1692.99 L 1684.03 Prev 1689.47

95) Actions 96) Templates 97) Hide 98) Table Volatility Comparison

Period Daily Range 10-Jan-2009 - 13-Aug-2013 Ann. Factor 260 CUR LCL Statistics

Security SPX Index Hist Vol 30 100 250 T Model CLV Price Implied Vol



| | | | | | | | | | | | | | | | | | | | | | | |
|--|----|---|------|------|-----------|------|------|------|--------|----|-----|------|------|---------------------------------------|----|----|------|------|-----------|-----|------|------|
| Australia | 61 | 2 | 9777 | 8600 | Brazil | 5511 | 3048 | 4500 | Europe | 44 | 20 | 7330 | 7500 | Germany | 49 | 69 | 9204 | 1210 | Hong Kong | 852 | 2977 | 6000 |
| Japan | 81 | 3 | 3201 | 8900 | Singapore | 65 | 6212 | 1000 | U.S. | 1 | 212 | 318 | 2000 | Copyright 2013 Bloomberg Finance L.P. | | | | | | | | |
| SN 853708 CDT GMT-5:00 G404-190-3 13-Aug-2013 09:28:43 | | | | | | | | | | | | | | | | | | | | | | |



SPX ↓ 1685.81 -3.66 1685.40 / 1686.14

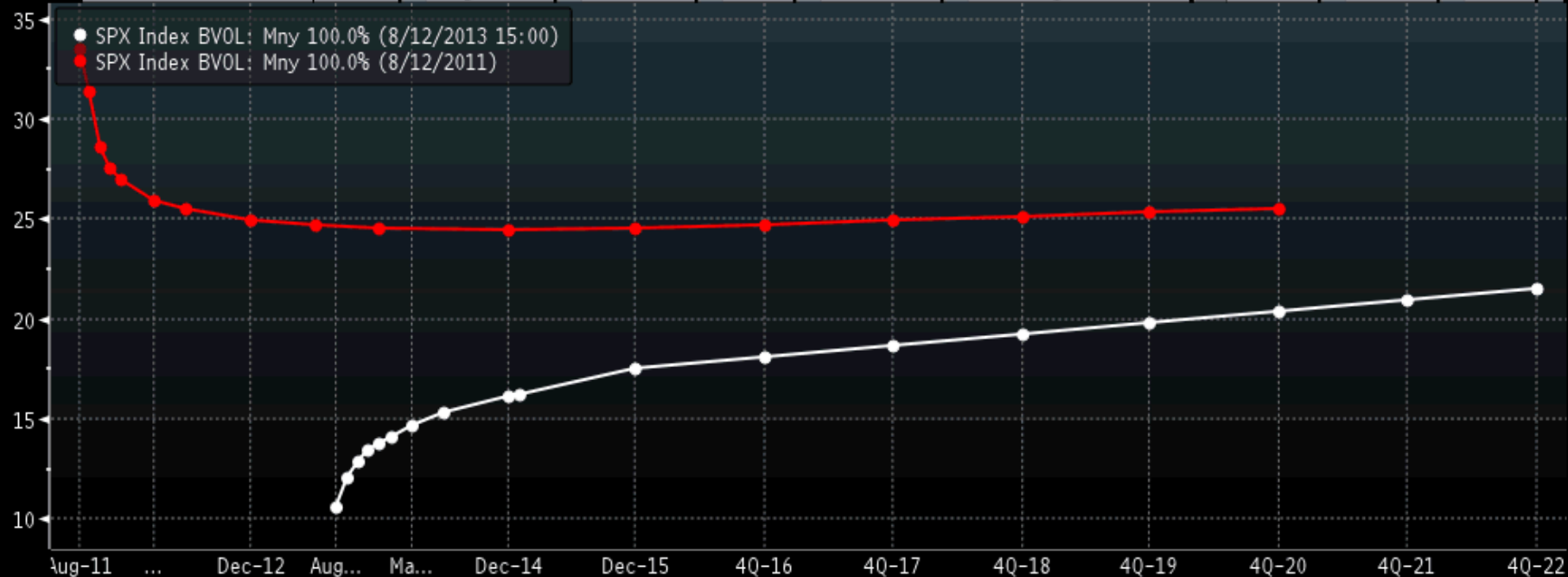
At 9:49 d 0 1690.65 H 1692.99 L 1682.62 Prev 1689.47

SPX Index 90) Asset 91) Actions 92) Settings Volatility Surface

Listed Exp Tenors

1) Vol Table 2) 3D Surface 3) Term 4) Skew 5) Dividends 6) Prices

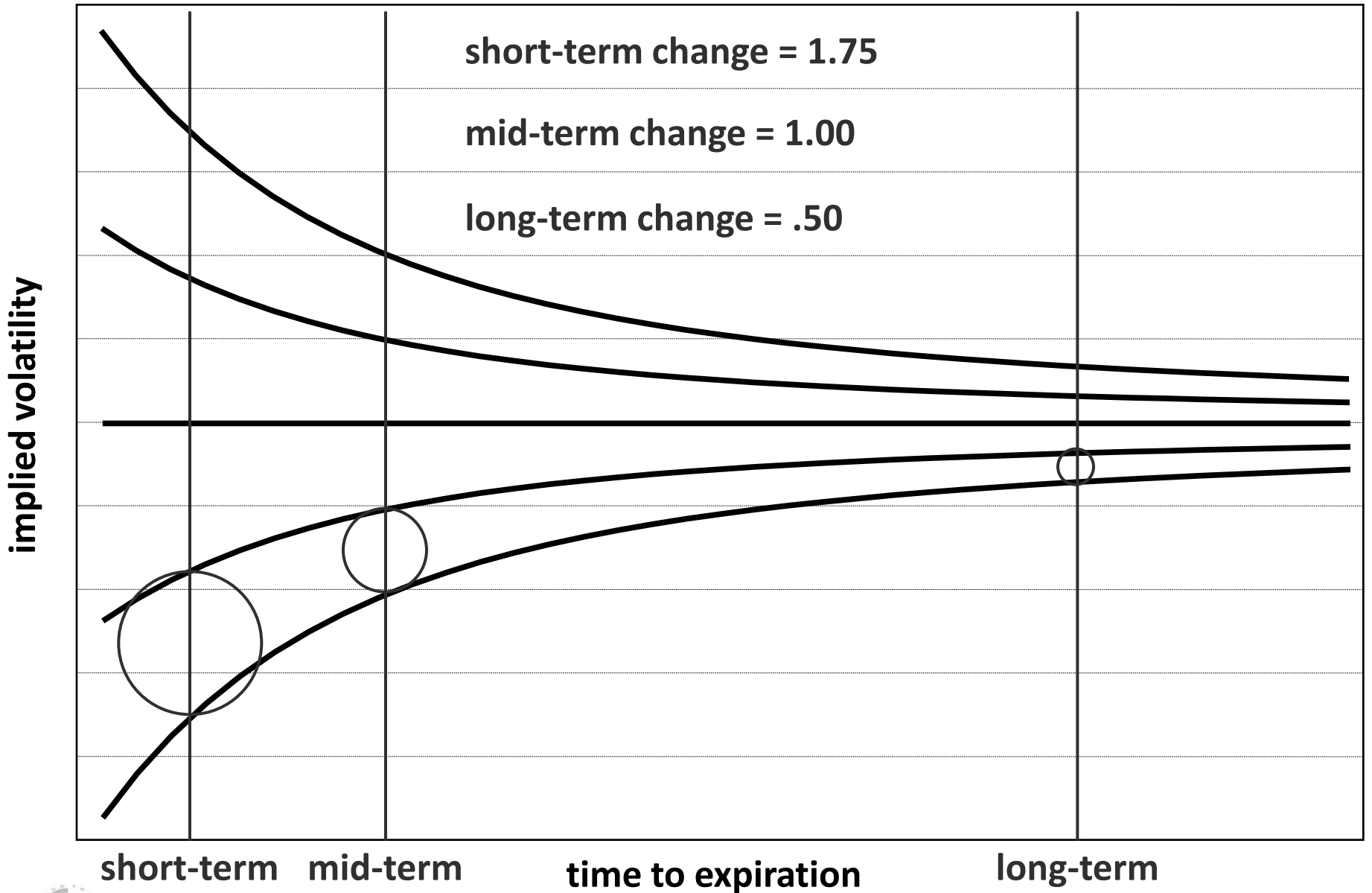
| | Security | Data Series | | | | | Surface as of | | | Comparison | |
|--|-----------|-------------|-----|--------|-----|--------|---------------|-------|------|------------|--|
| 1. <input checked="" type="checkbox"/> | SPX Index | BVOL | Mny | 100.0% | Mid | Custom | 12-Aug-2013 | 15:00 | None | Abs | |
| 2. <input checked="" type="checkbox"/> | SPX Index | BVOL | Mny | 100.0% | Mid | Custom | 12-Aug-2011 | | None | Abs | |
| 3. <input type="checkbox"/> | SPX Index | | Mny | | Mid | Custom | 30-Jul-2013 | | None | Abs | |
| 4. <input type="checkbox"/> | SPX Index | | Mny | | Mid | TD | 13-Aug-2013 | | None | Abs | |



Aug-11 ... Dec-12 Aug... Ma... Dec-14 Dec-15 40-16 40-17 40-18 40-19 40-20 40-21 40-22
 Australia 61 2 9777 8600 Brazil 5511 3048 4500 Europe 44 20 7330 7500 Germany 49 69 9204 1210 Hong Kong 852 2977 6000
 Japan 81 3 3201 8900 Singapore 65 6212 1000 U.S. 1 212 318 2000
 SN 853708 CDT GMT-5:00 6404-190-1 13-Aug-2013 10:04:48



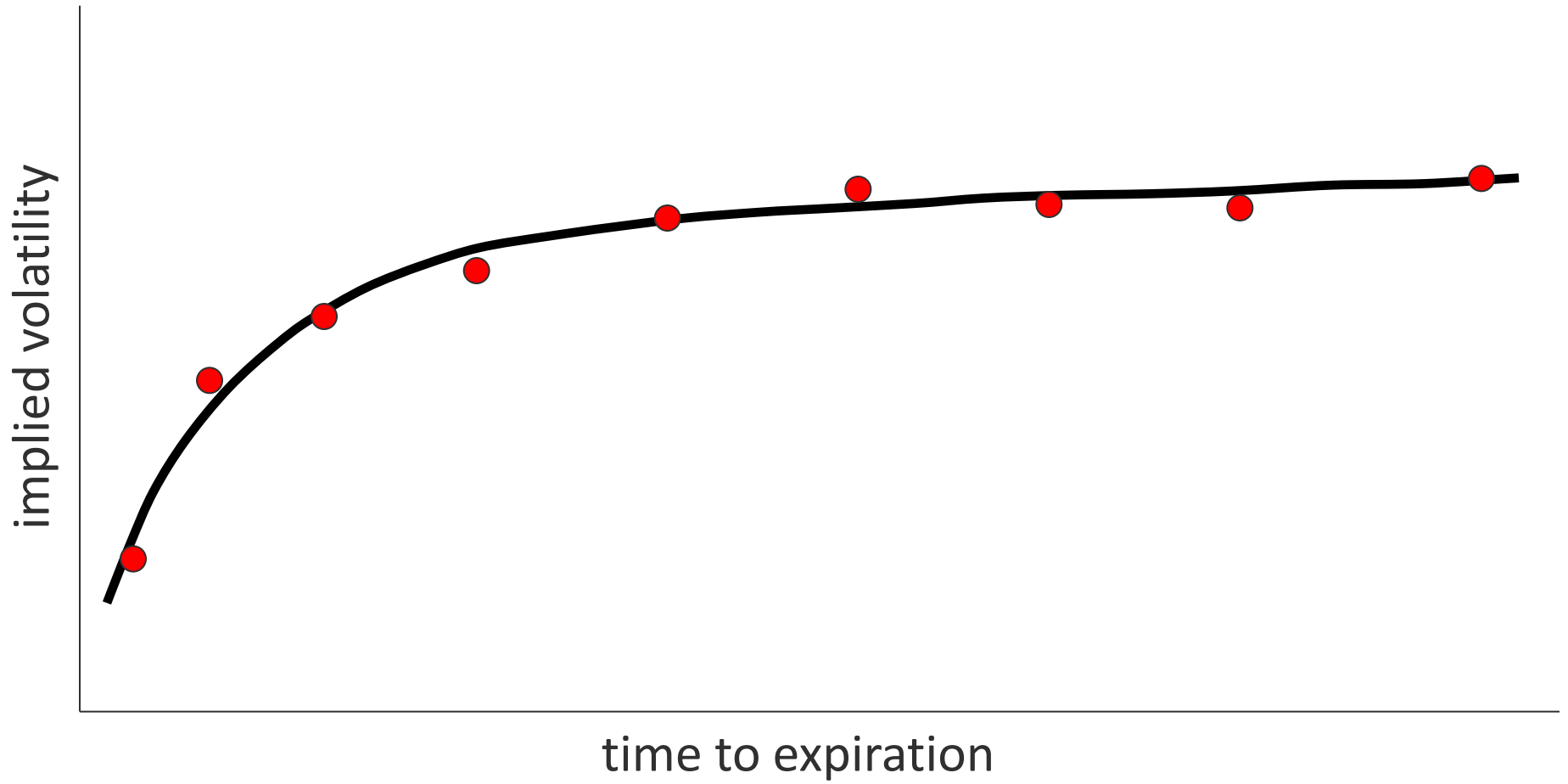
Term Structure of Volatility



| | <u>vega</u> | <u>adjustment</u> | adjusted <u>vega</u> |
|-----------|-------------|-------------------|-------------------------|
| March | -4.20 | 1.75 | -7.35 |
| June | +2.80 | 1.00 | +2.80 |
| September | +1.40 | .50 | +.70 |
| | <hr/> | <i>total</i> | <hr/> |
| total | 0 | <i>adjusted</i> | -3.85 |
| | | <i>vega</i> | |

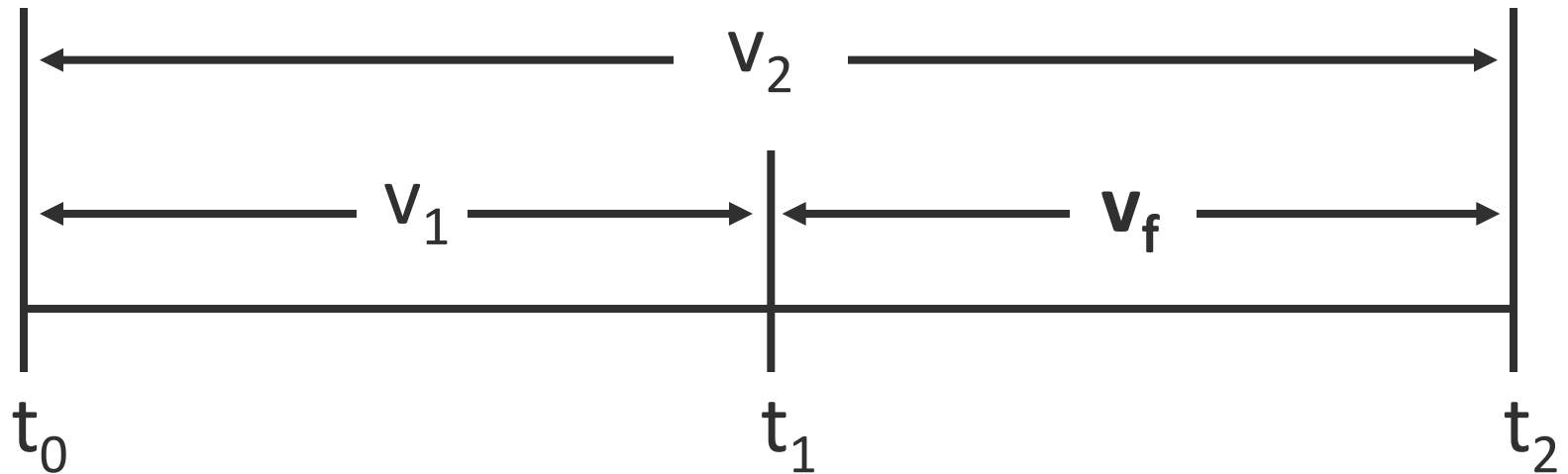


What strategies might make sense?



v_1 = short term implied volatility

v_2 = long term implied volatility

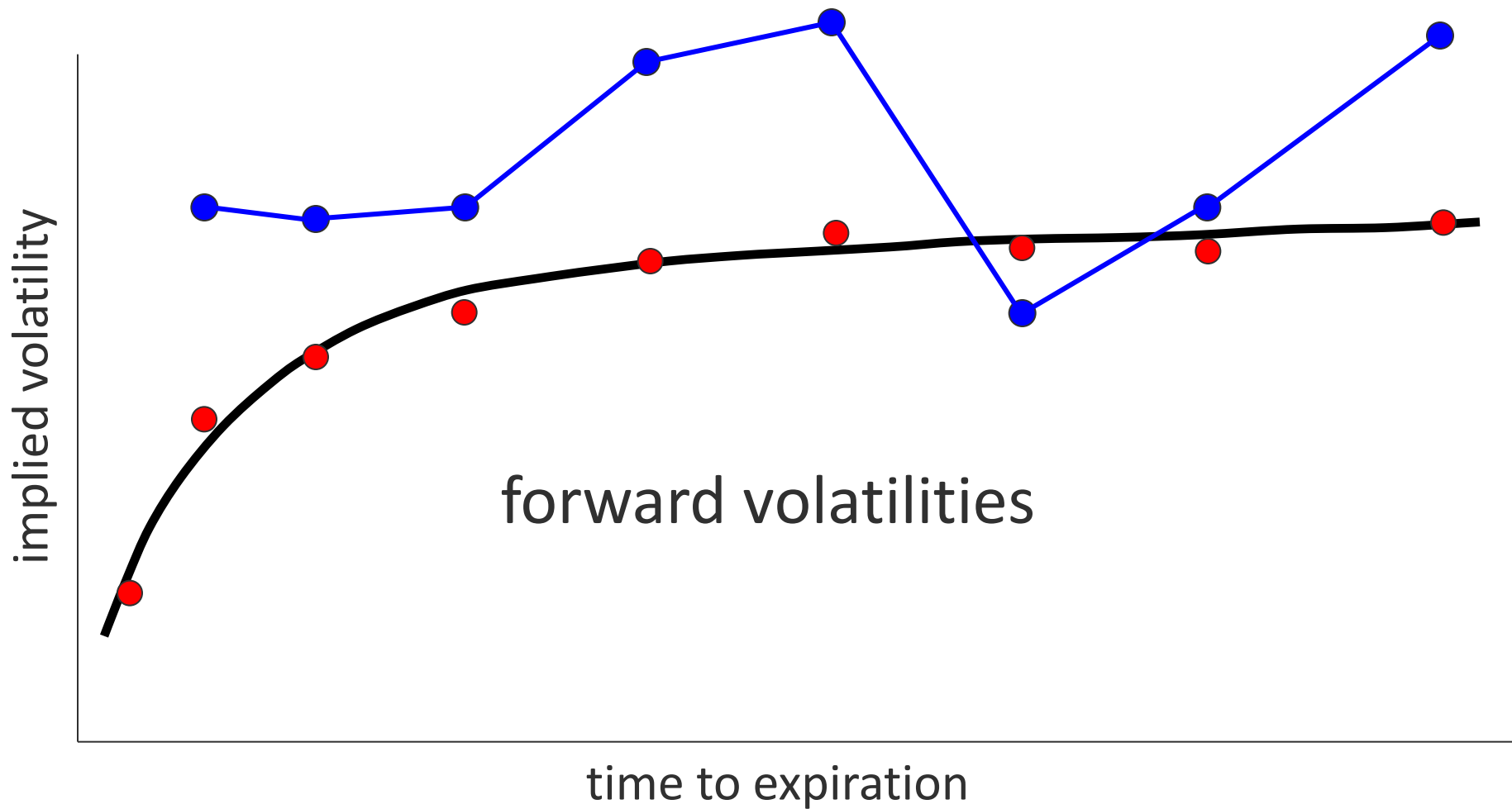


forward volatility =

$$\sqrt{[(v_2^2 * t_2) - (v_1^2 * t_1)] / (t_2 - t_1)}$$



What strategies might make sense?



Long stock

Stock price = 100

Typical hedging strategies:

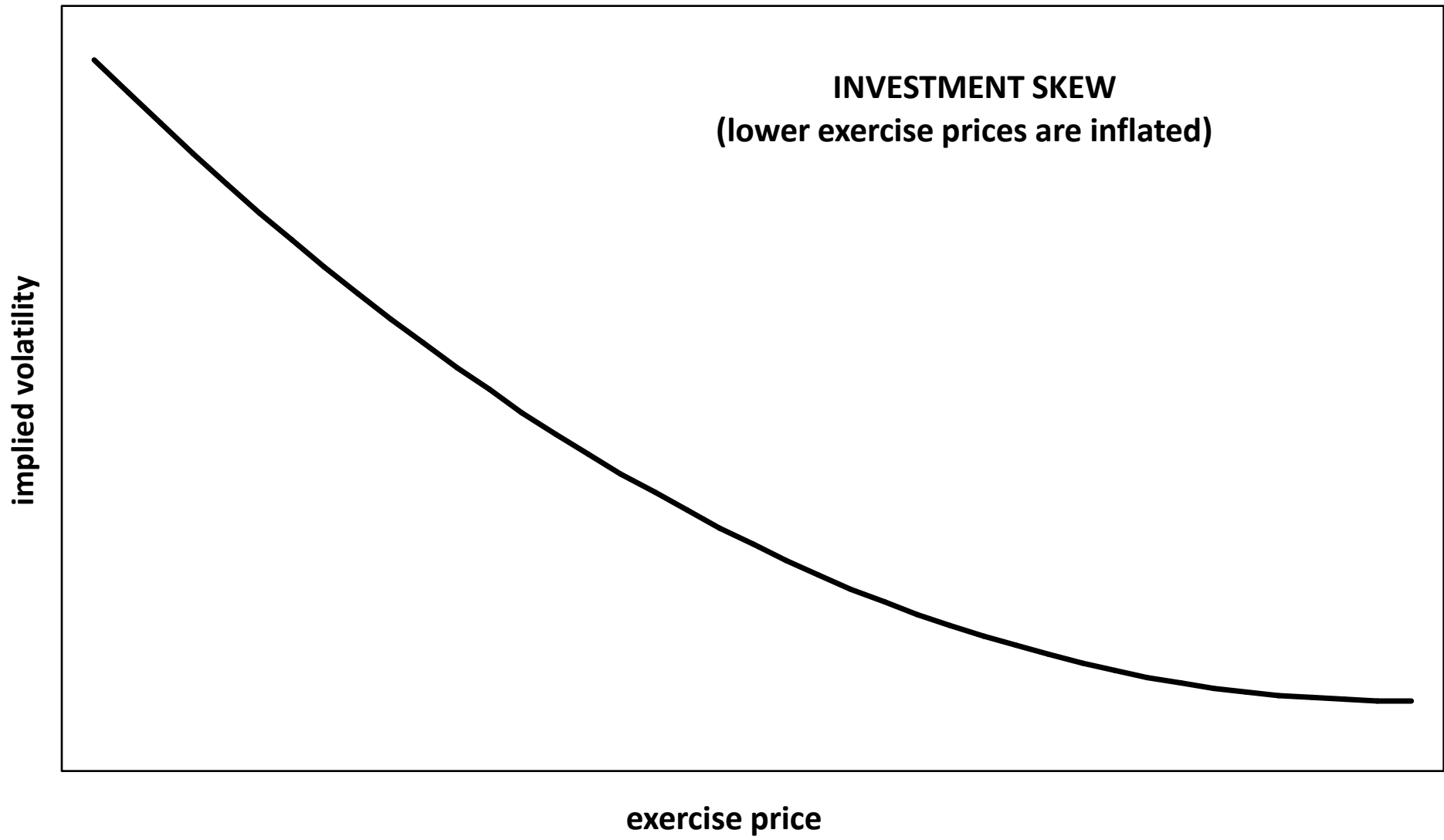
buy protective puts

which exercise price 95 / 105 ?

sell covered calls

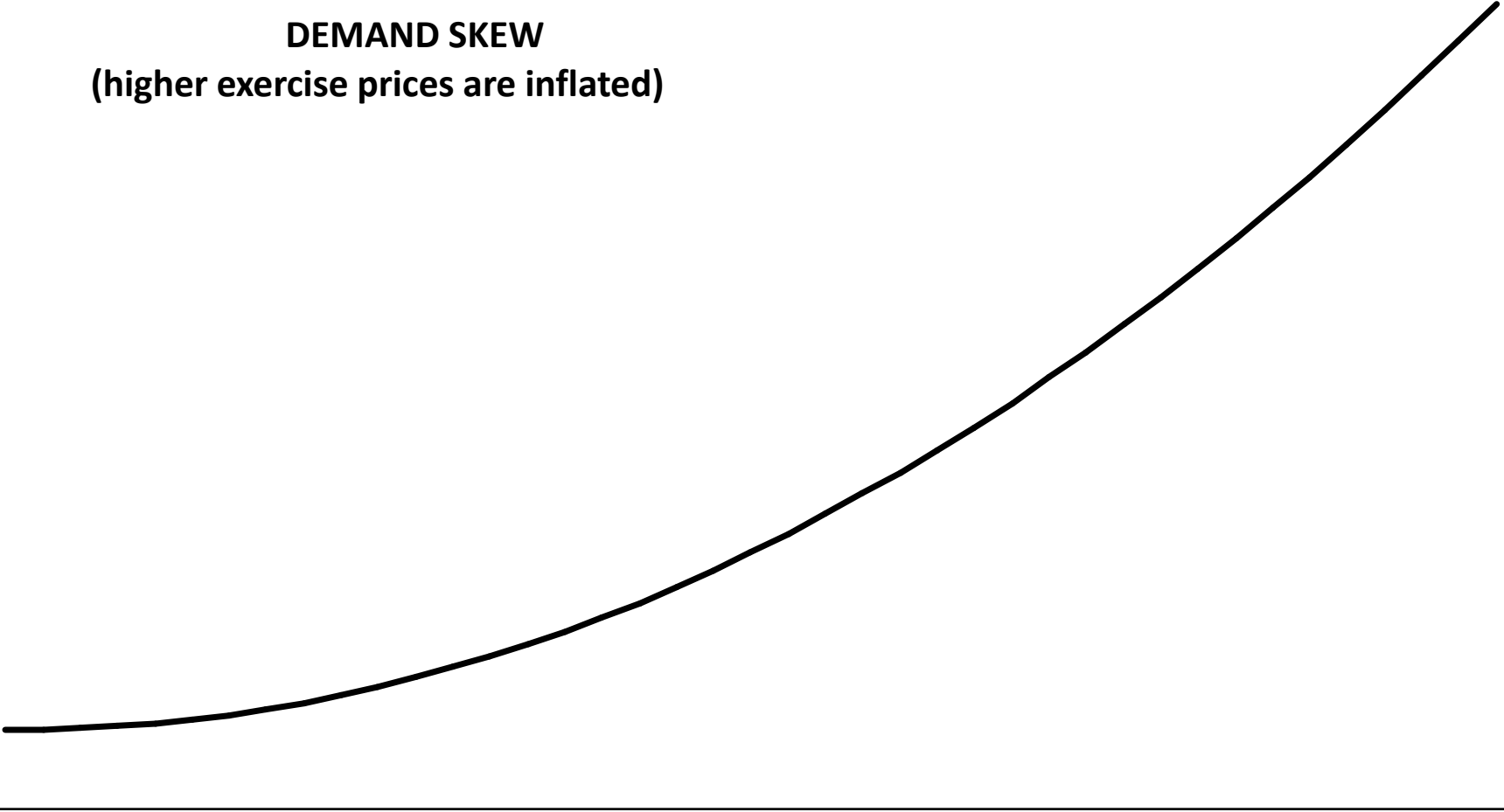
which exercise price 95 / 105 ?





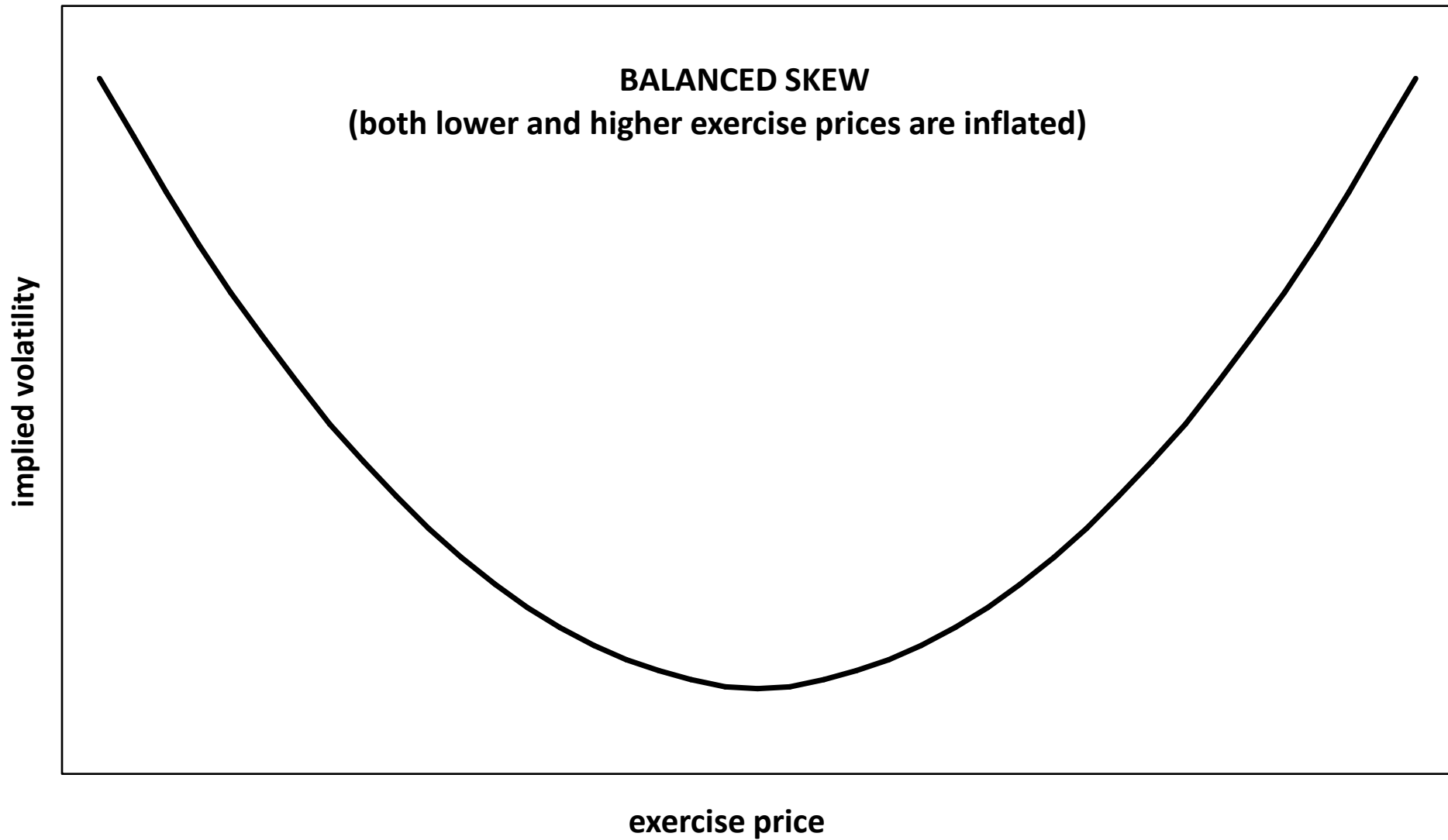
DEMAND SKEW
(higher exercise prices are inflated)

implied volatility



exercise price





Some assumptions on which traditional theoretical pricing models are built:

Price changes are normally distributed
(prices at expiration are lognormally distributed)

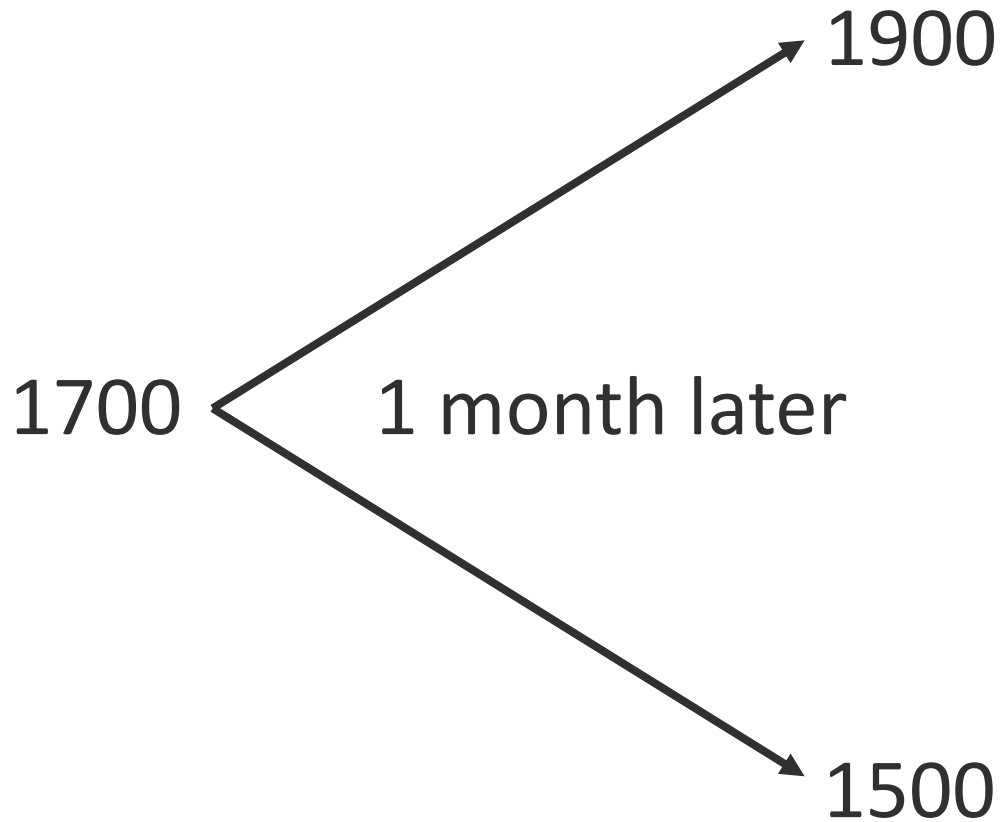
Volatility is constant over the life of the option

Trading is continuous, with no gaps in the price of the underlying contract

Volatility is independent of the direction in which the underlying contract moves



Stock index = 1700.00



Will the index be more volatile at 1500 or 1900?



You buy an at-the-money straddle in a stock index.

What is your approximate delta position?

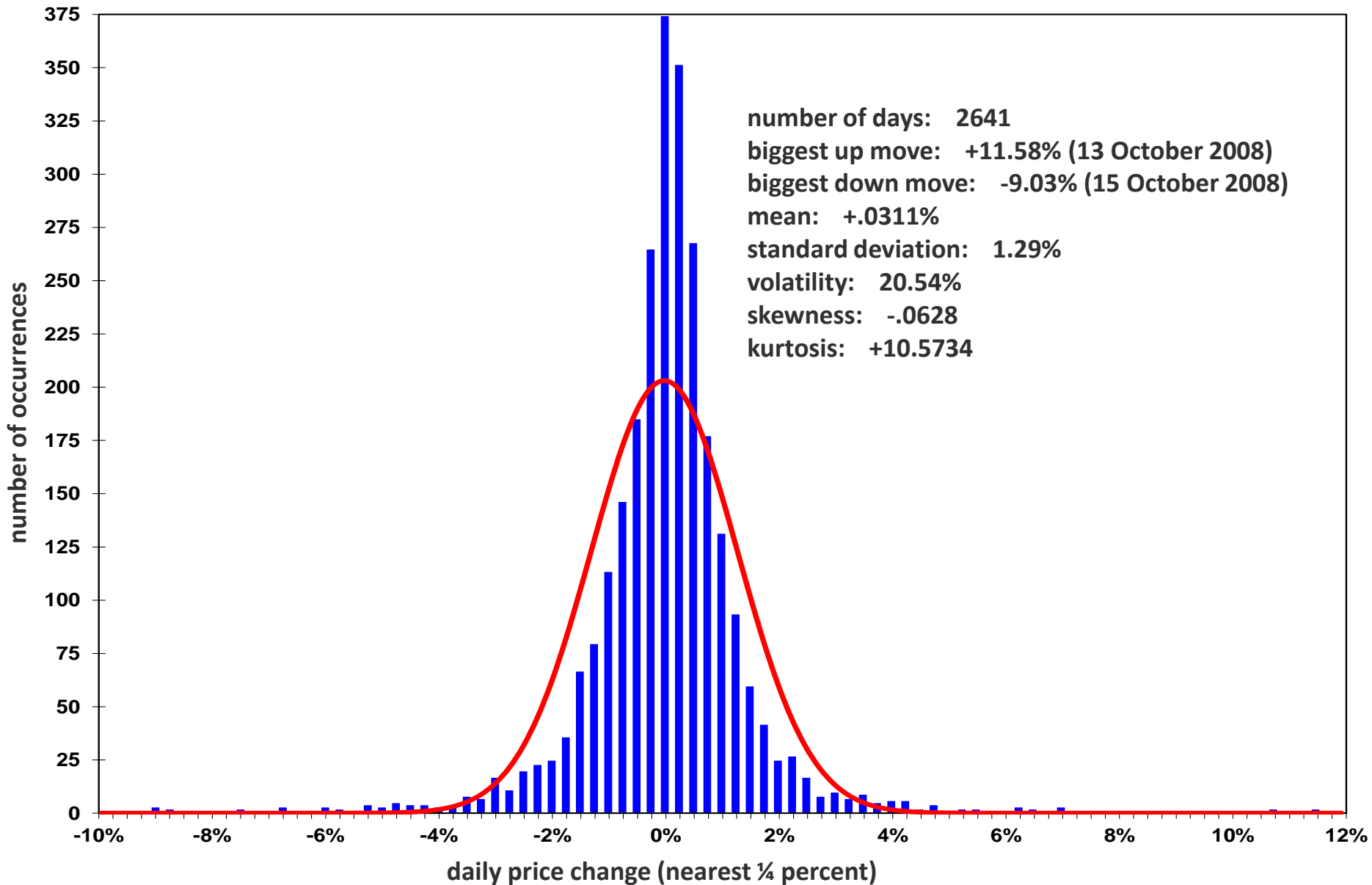
What does *delta neutral* mean?

Do you have a preference whether the market rises or falls?

Would it make any difference if the underlying is a commodity?



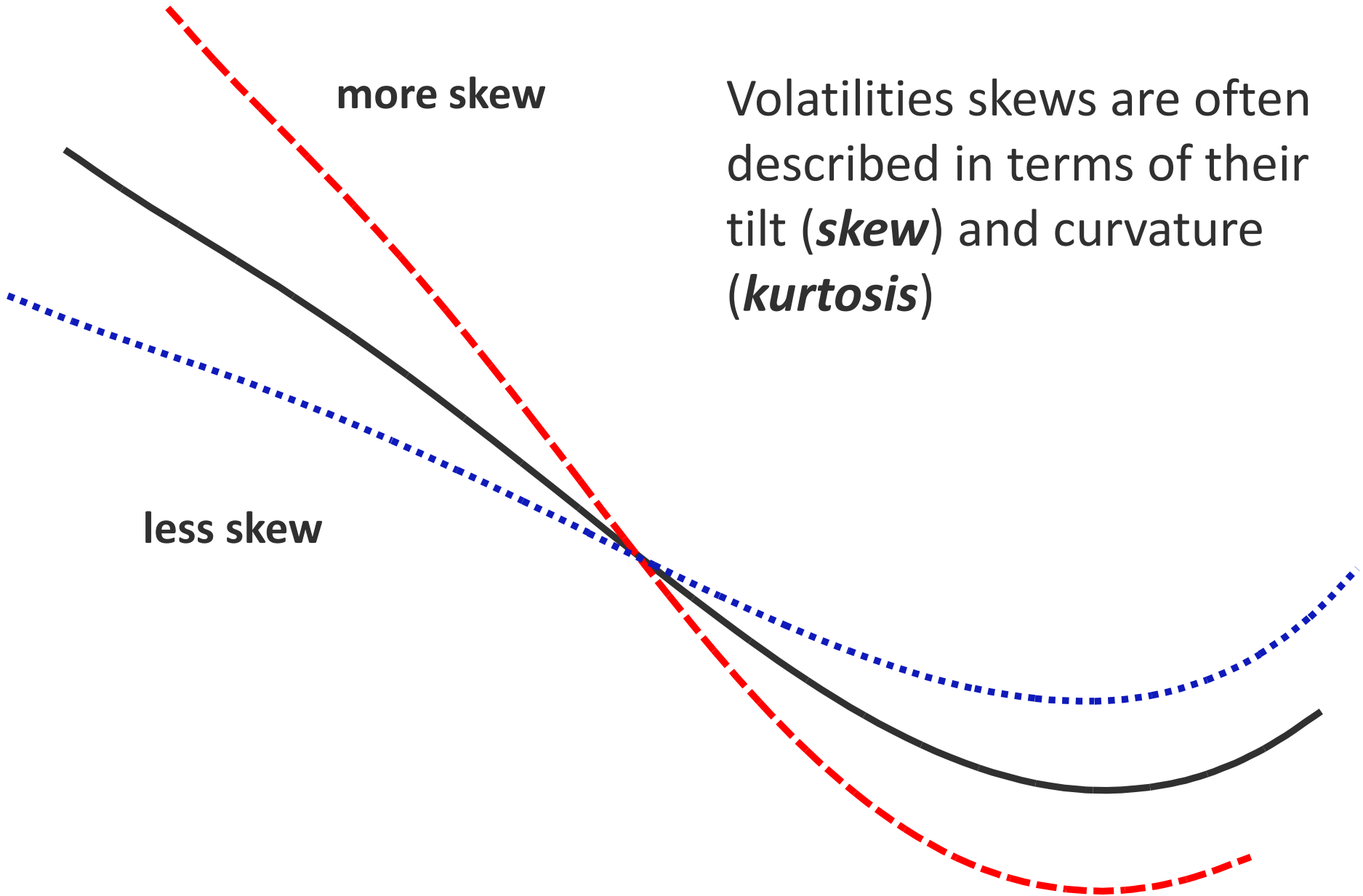
S&P 500 Daily Price Changes: January 2003 through June 2013



Volatilities skews are often described in terms of their tilt (*skew*) and curvature (*kurtosis*)

more skew

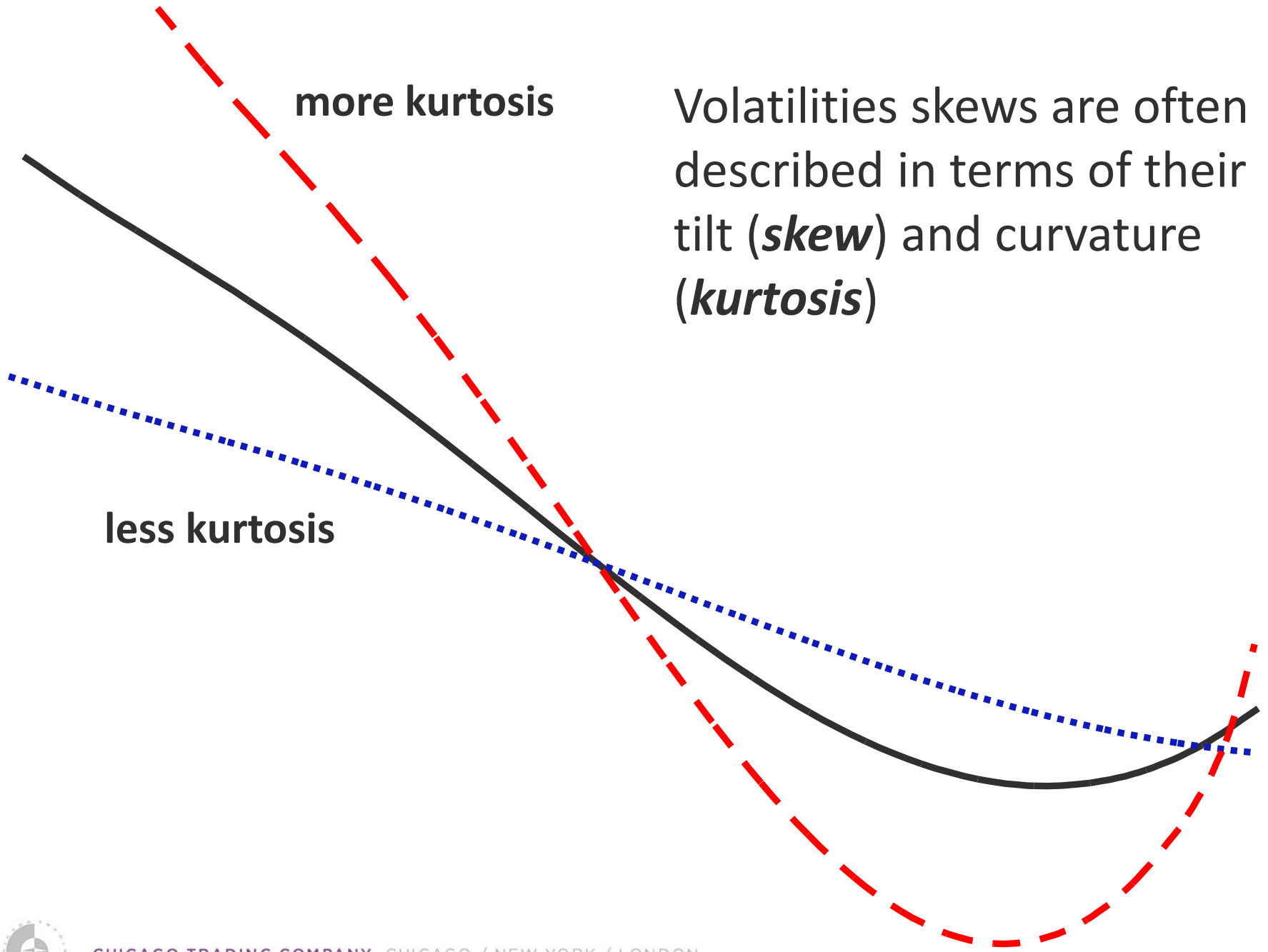
less skew



Volatilities skews are often described in terms of their tilt (*skew*) and curvature (*kurtosis*)

more kurtosis

less kurtosis



Skew Strategy (Risk Reversal)

buy (sell) puts at a lower exercise price

sell (buy) calls at a higher exercise price

buy (sell) underlying contracts so that the entire position is delta neutral.

A common measure of volatility skewing is the difference between the implied volatility of the -25 delta put and implied volatility of the 25 delta call (the 25 delta risk reversal).



Kurtosis Strategy

buy (sell) out-of-the-money strangles

take an opposing at-the-money straddle position so that the entire position is gamma and / or vega neutral.

Kurtosis options are often those with deltas in the range of 4 to 6 (-4 to -6 for puts).



SPX ↓ 1689.47 -1.95 1686.80 / 1692.42

At 15:36 d O 1688.37 H 1691.49 L 1683.35 Prev 1691.42

SPX Index 90) Asset 91) Actions 92) Settings Volatility Surface

S&P 500 INDEX 1689.52 USD Bloomberg Mid As of < 12-Aug-2013 > 15:00

1) Vol Table 2) 3D Surface 3) Term 4) Skew 5) Dividends 6) Prices

Moneyness 10) Edit Listed Exp Tenors Fwd Dates Strikes

| Exp | ImpFwd | 80.0% | 90.0% | 95.0% | 97.5% | 100.0% | 102.5% | 105.0% | 110.0% | 120.0% | 150.0% |
|--------|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| | | 1351.6 | 1520.6 | 1605.0 | 1647.3 | 1689.5 | 1731.8 | 1774.0 | 1858.5 | 2027.4 | 2534.3 |
| Aug-13 | 1688.31 | 49.20 | 36.57 | 24.03 | 17.02 | 10.65 | 11.34 | 15.91 | 24.16 | 33.22 | 41.88 |
| Sep-13 | 1686.31 | 25.90 | 19.44 | 15.97 | 14.01 | 12.04 | 10.29 | 9.64 | 10.90 | 12.96 | 17.73 |
| 3Q-13 | 1685.72 | 24.98 | 19.07 | 15.88 | 14.13 | 12.37 | 10.71 | 9.76 | 10.10 | 12.28 | 17.11 |
| Oct-13 | 1684.65 | 24.14 | 18.84 | 15.97 | 14.44 | 12.92 | 11.47 | 10.41 | 9.93 | 11.43 | 16.19 |
| Nov-13 | 1682.08 | 23.70 | 18.53 | 16.03 | 14.72 | 13.43 | 12.20 | 11.20 | 10.47 | 12.10 | 17.40 |
| Dec-13 | 1680.07 | 22.98 | 18.40 | 16.15 | 14.95 | 13.80 | 12.75 | 11.84 | 10.92 | 11.83 | 14.94 |
| 4Q-13 | 1679.53 | 22.67 | 18.29 | 16.13 | 15.02 | 13.93 | 12.90 | 12.00 | 11.10 | 11.84 | 15.06 |
| Jan-14 | 1678.69 | 22.61 | 18.38 | 16.29 | 15.20 | 14.11 | 13.08 | 12.22 | 11.34 | 11.84 | 15.00 |
| Mar-14 | 1673.21 | 22.13 | 18.41 | 16.55 | 15.60 | 14.66 | 13.78 | 13.02 | 11.98 | 11.65 | 13.56 |
| 1Q-14 | 1672.46 | 21.92 | 18.36 | 16.56 | 15.65 | 14.75 | 13.91 | 13.17 | 12.13 | 11.70 | 13.70 |
| Jun-14 | 1666.36 | 21.83 | 18.57 | 16.94 | 16.13 | 15.34 | 14.58 | 13.89 | 12.81 | 12.02 | 13.48 |
| 2Q-14 | 1665.63 | 21.81 | 18.60 | 16.99 | 16.19 | 15.41 | 14.67 | 13.98 | 12.91 | 12.09 | 13.50 |
| Dec-14 | 1653.41 | 21.37 | 18.68 | 17.37 | 16.75 | 16.14 | 15.57 | 15.03 | 14.13 | 13.13 | 13.41 |

97) Option Pricing (OVME) 98) Legend Zoom - 100%

99) Quick Pricer

Strike 1689.5 Call Vol 13.60% Price 41.642 Dividend yield 2.122%
 Expiry 10-Nov-2013 Buy Spot 1689.520 Delta 48.41% Impl forward 1681.814

Australia 61 2 9777 8600 Brazil 5511 3048 4500 Europe 44 20 7330 7500 Germany 49 69 9204 1210 Hong Kong 852 2977 6000
 Japan 81 3 3201 8900 Singapore 65 6212 1000 U.S. 1 212 318 2000
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