Lecture 23: Options Markets

Economics 252, Spring 2008

Prof. Robert Shiller, Yale University

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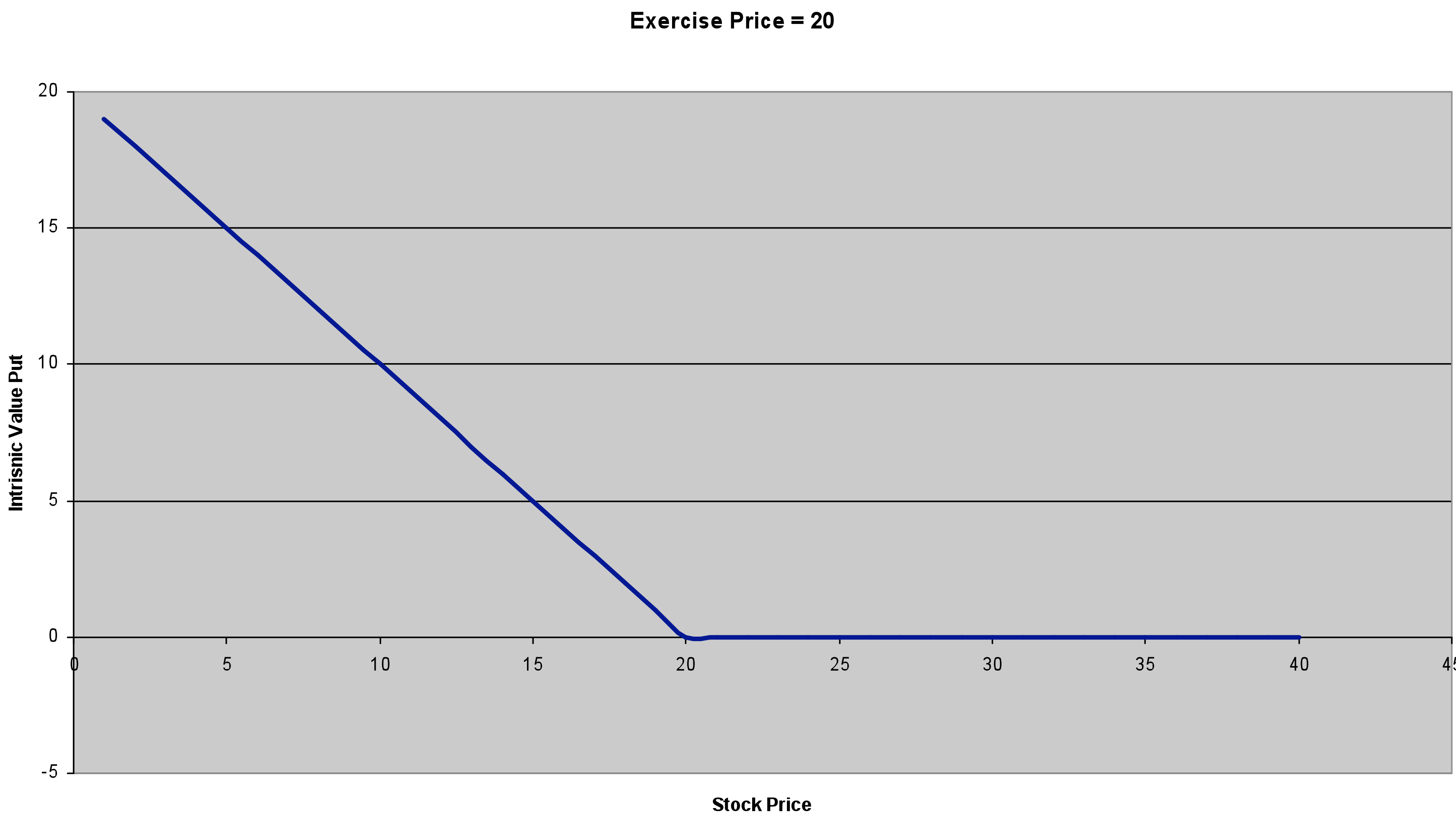

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Put-Call Parity Relation

- Put option price – call option price = present value of strike price + present value of dividends – price of stock
- For European options, this formula must hold (up to small deviations due to transactions costs), otherwise there would be arbitrage profit opportunities

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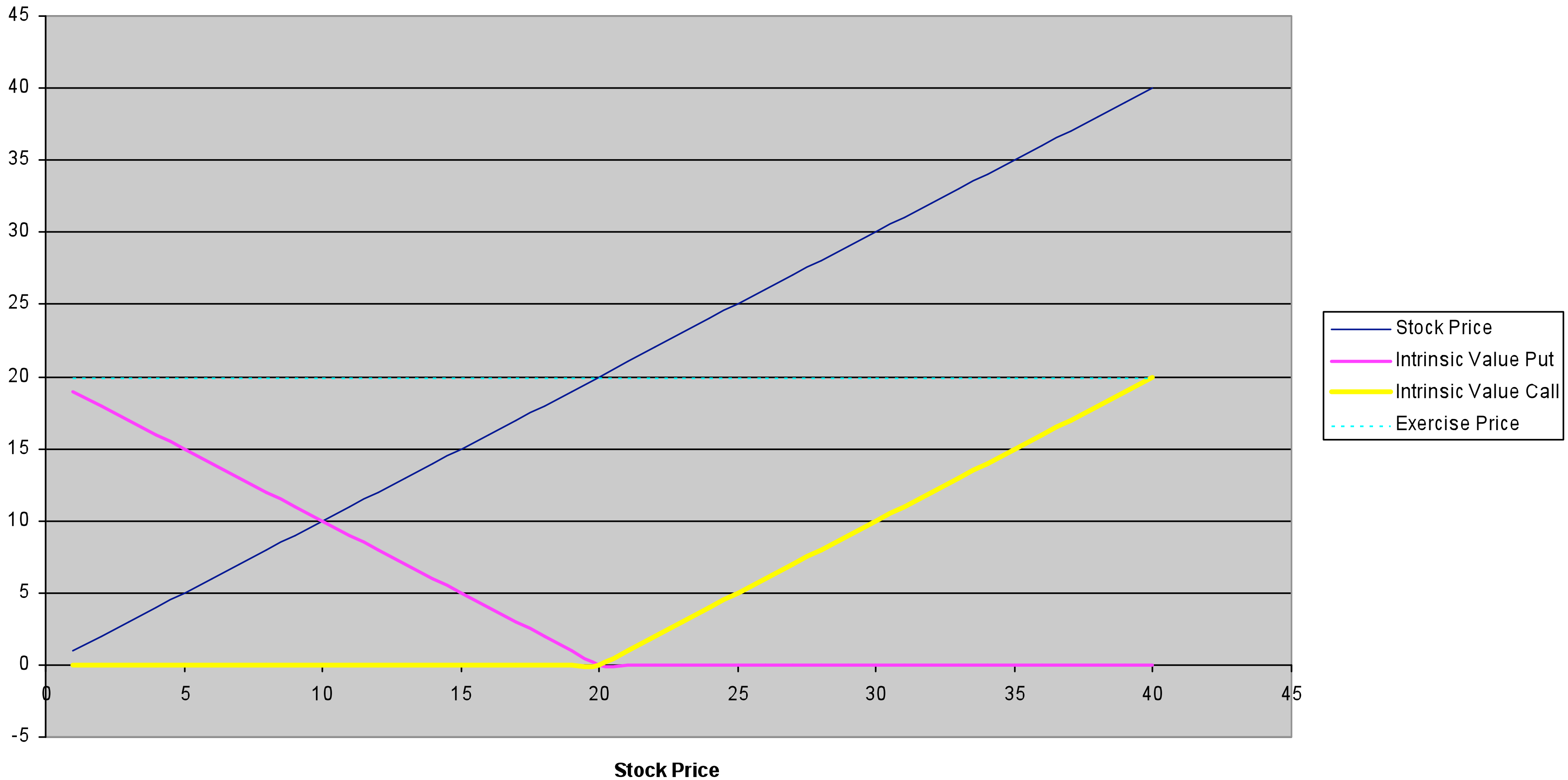
Put Call Parity Relation Derivation



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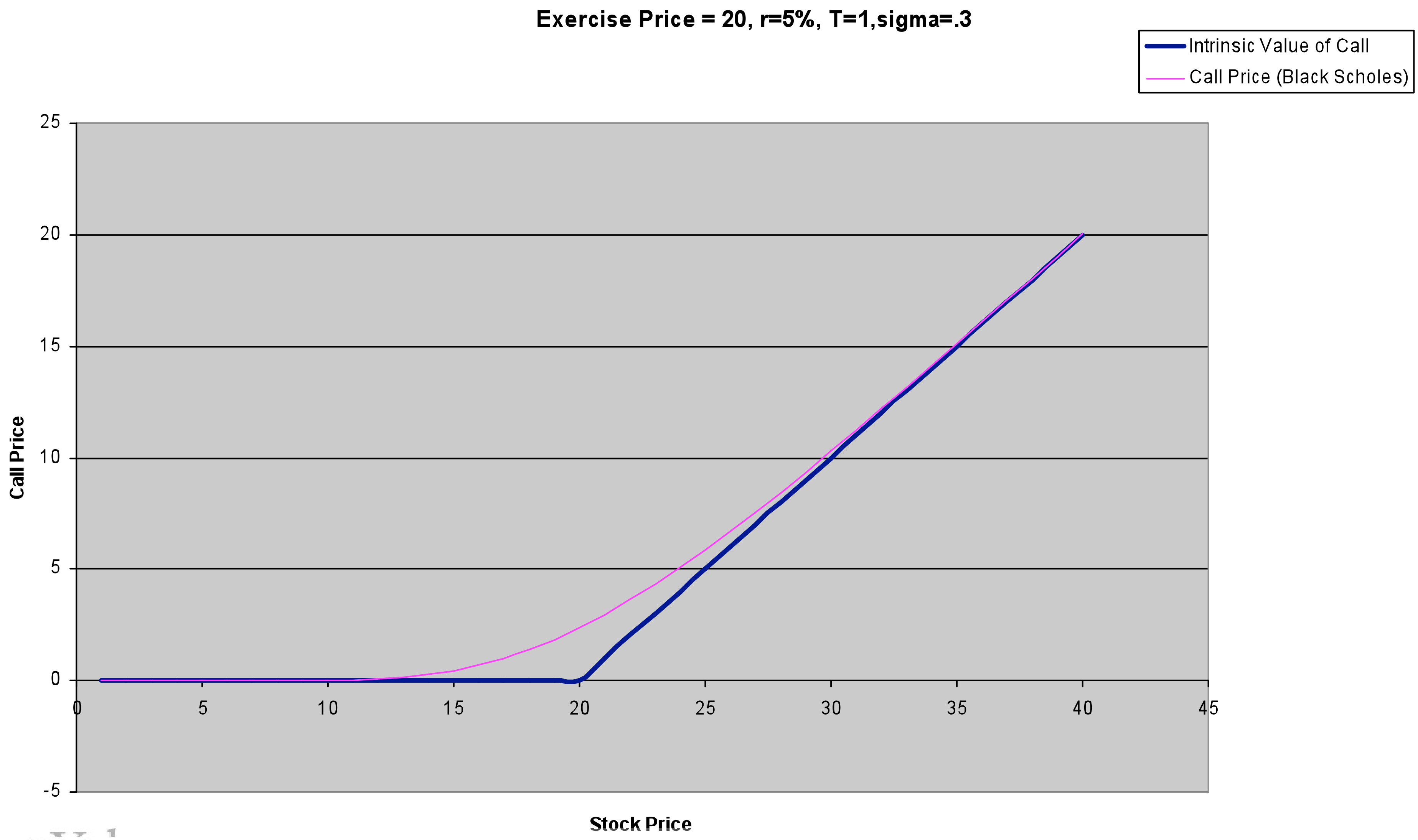

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Binomial Option Pricing

- S = current stock price
- u = 1+fraction of change in stock price if price goes up
- d = 1+fraction of change in stock price if price goes down
- r = risk-free interest rate

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Binomial Option Pricing, Cont.

- C = current price of call option
- C_u = value of call next period if price is up
- C_d = value of call next period if price is down
- E = strike price of option
- H = hedge ratio, number of shares purchased per call sold

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Hedging by writing calls

- Investor writes one call and buys H shares of underlying stock
- If price goes up, will be worth $uHS\text{-}C_u$
- If price goes down, worth $dHS\text{-}C_d$
- For what H are these two the same?

$$H = \frac{C_u - C_d}{(u-d)S}$$

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Binomial Option Pricing Formula

- One invested $HS\text{-}C$ to achieve riskless return, hence the return must equal $(1+r)(HS\text{-}C)$
- $(1+r)(HS\text{-}C)=uHS\text{-}C_u=dHS\text{-}C_d$
- Subst for H, then solve for C

$$C=\left(\frac{1+r-d}{u-d}\right)\left(\frac{C_u}{1+r}\right)+\left(\frac{u-1-r}{u-d}\right)\left(\frac{C_d}{1+r}\right)$$

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Black-Scholes Option Pricing

Call T the time to exercise, σ^2 the variance of one-period price change (as fraction) and N(x) the standard cumulative normal distribution function (sigmoid curve, integral of normal bell-shaped curve) =normdist(x,0,1,1) Excel (x, mean,standard_dev, 0 for density, 1 for cum.)

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Black-Scholes Formula

$$C = S\mathrm{N}(d_1) - E\mathrm{N}(d_2)$$

where

$$d_1 = \frac{\ln(\frac{S}{E}) + rT + \sigma^2 T / 2}{\sigma \sqrt{T}}$$

$$d_2 = \frac{\ln(\frac{S}{E}) + rT - \sigma^2 T / 2}{\sigma \sqrt{T}}$$

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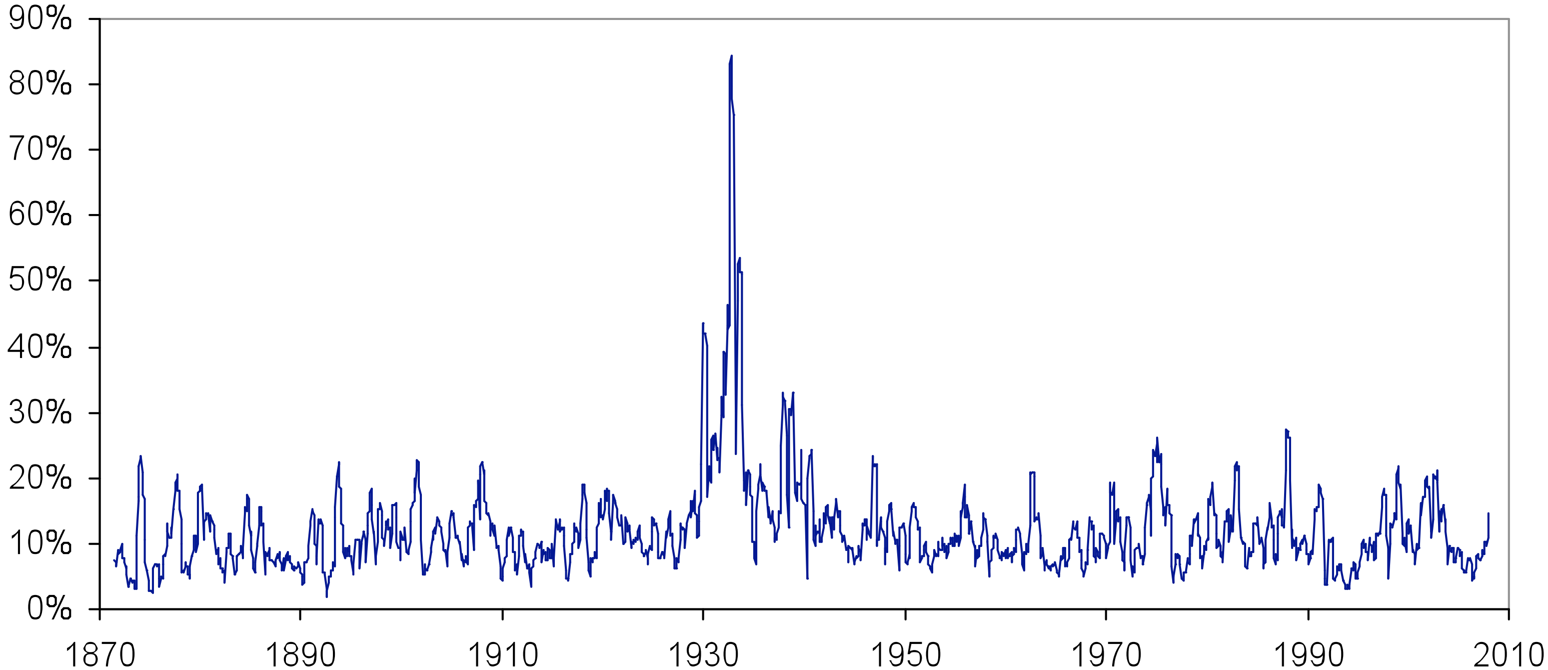
Actual S&P500 Volatility Monthly July1871- April 2008



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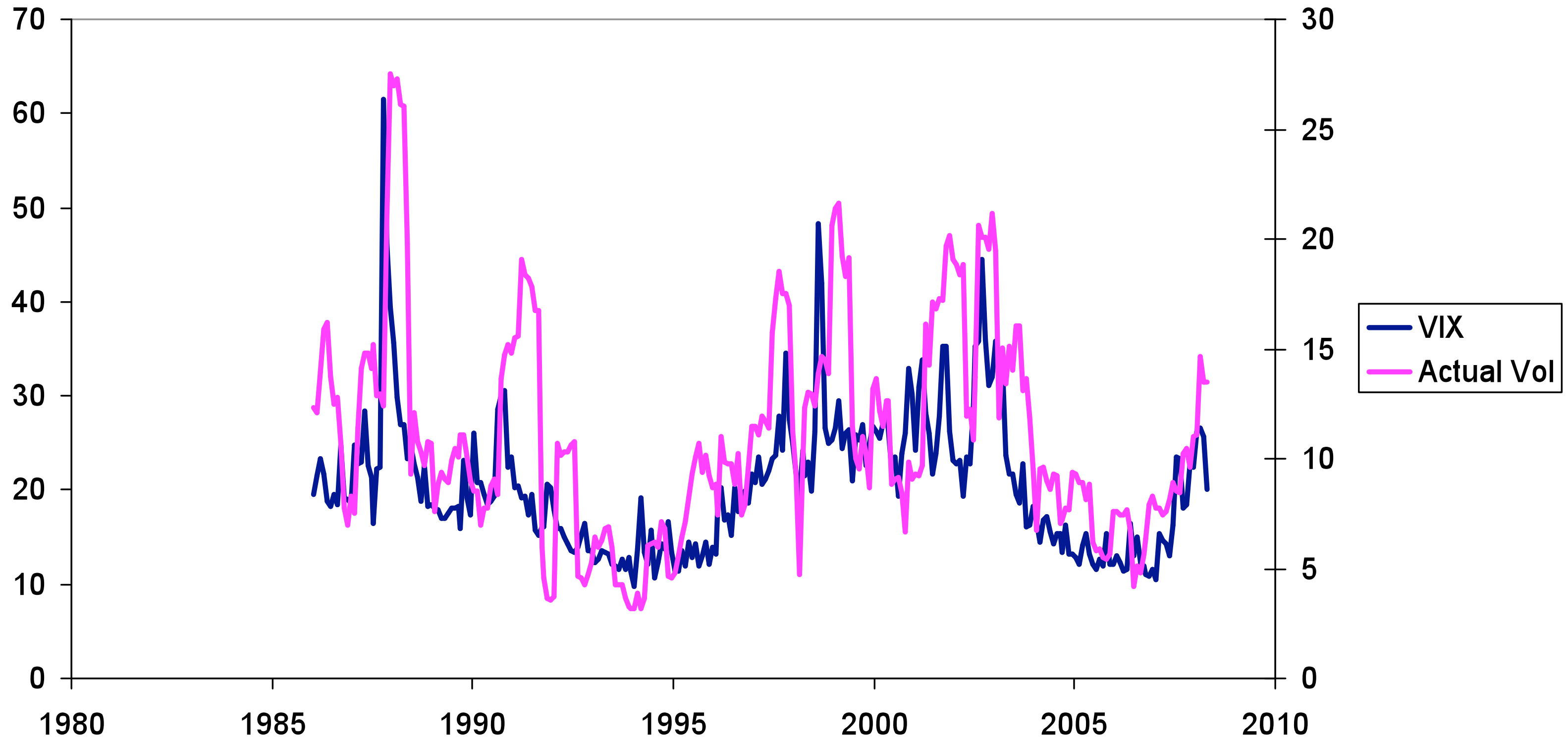
Implied and Actual Volatility Monthly Jan 1986-April 2008



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