Real World Aspects of Derivatives Trading

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- Weselyan University, CT. BS ’86. Physics and German.
- University of Chicago, MBA ’90. Finance and Statistics.
- Spent 15 years on Wall Street in investment banking, quantitative research, sales, product development and trading equity derivative products (PaineWebber, Salomon Brothers, Citigroup and Bank of America).
- Returned home to Seattle in 2002 to start a hedge fund.
- Employ the behavioral finance concept of market sentiment to trade a volatility arbitrage strategy using S&P 500 Index derivatives.

What are Derivatives?

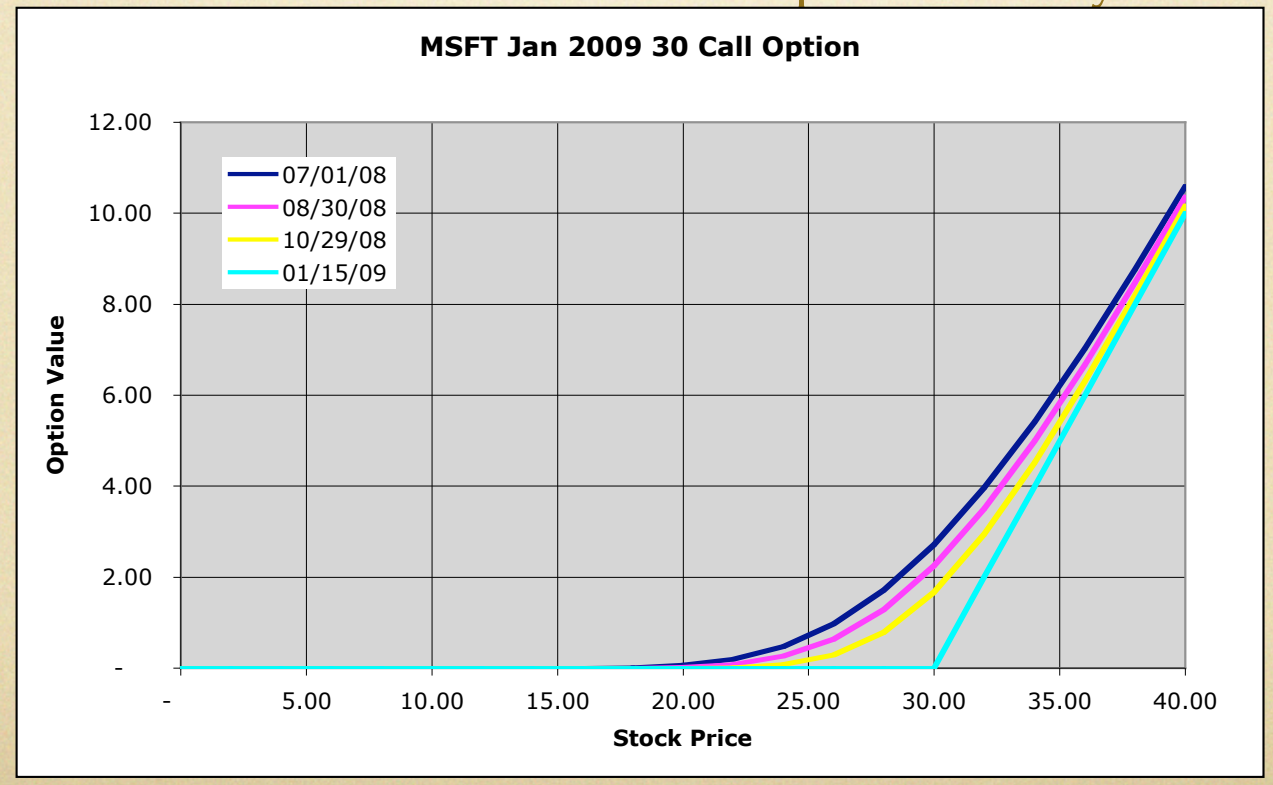
- More general term for futures and options.
- Generally, a standardized (exchanged traded) or OTC (over-the-counter) customized contract that "derives" its value from another asset and/or other variables.
- These contracts carry the right (an option) and/or the obligation (futures) to buy or sell a specific asset at a specific price and time.
- Derivatives are traded on stocks, stock indices, bonds, interest rates, currencies, energy, metals, agricultural goods and even real estate.
- Example: January 2009 $30 call option on Microsoft (MSFT). 8/1/08 price of $0.62 with MSFT at $25.22.

MSFT Example

- Let's say that one wanted to speculate on MSFT rising above $30 over the next six months.
- One could buy the stock or buy a $30 strike call option.

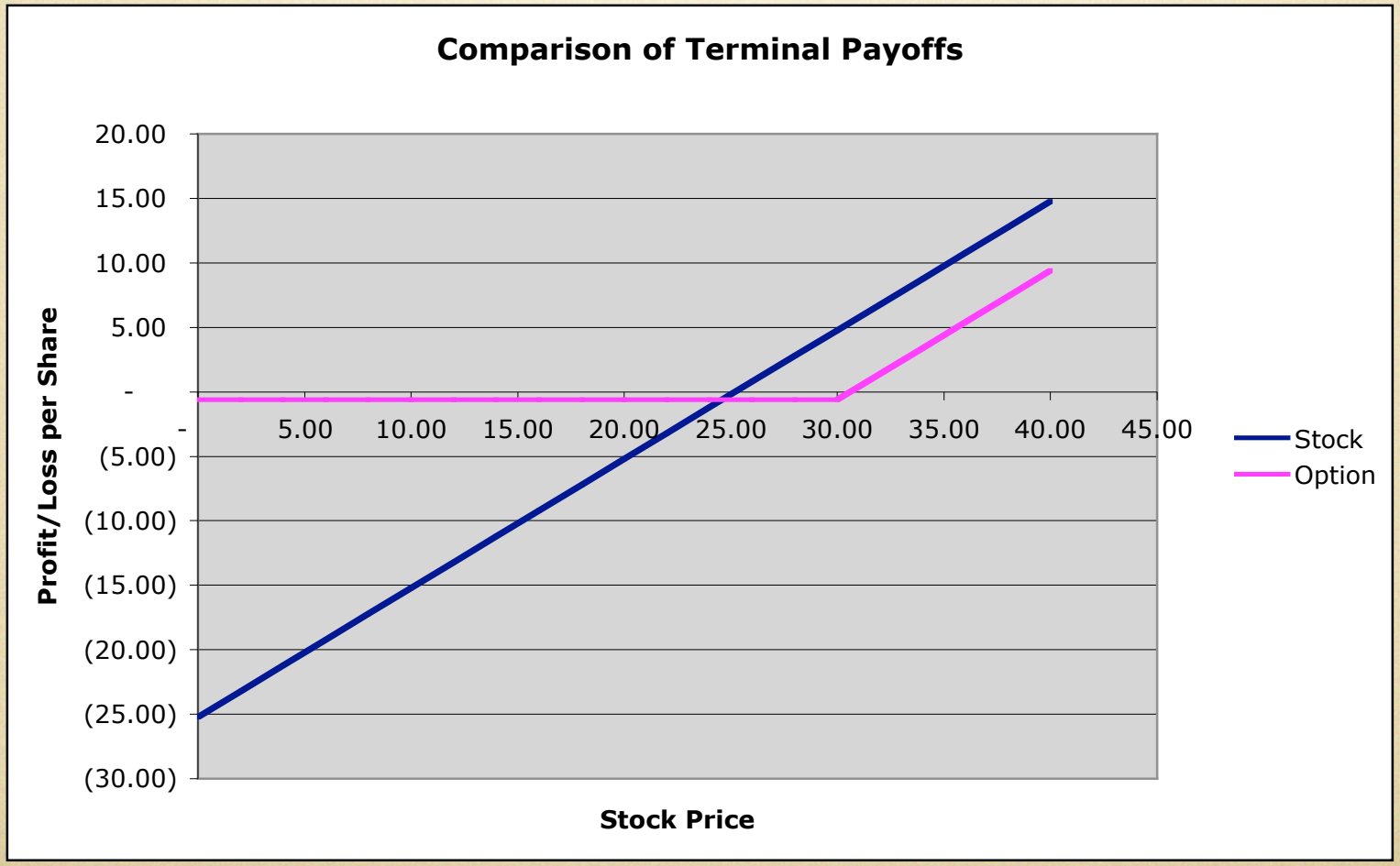
MSFT Example (Cont)

- Call option payoff at expiration: Max (S - K,0).
- Put option payoff at expiration: Max(K - S,0).
- Upfront cost of $0.62 today with the stock at $25.22.
- The theoretical value of the option "decays" over time.



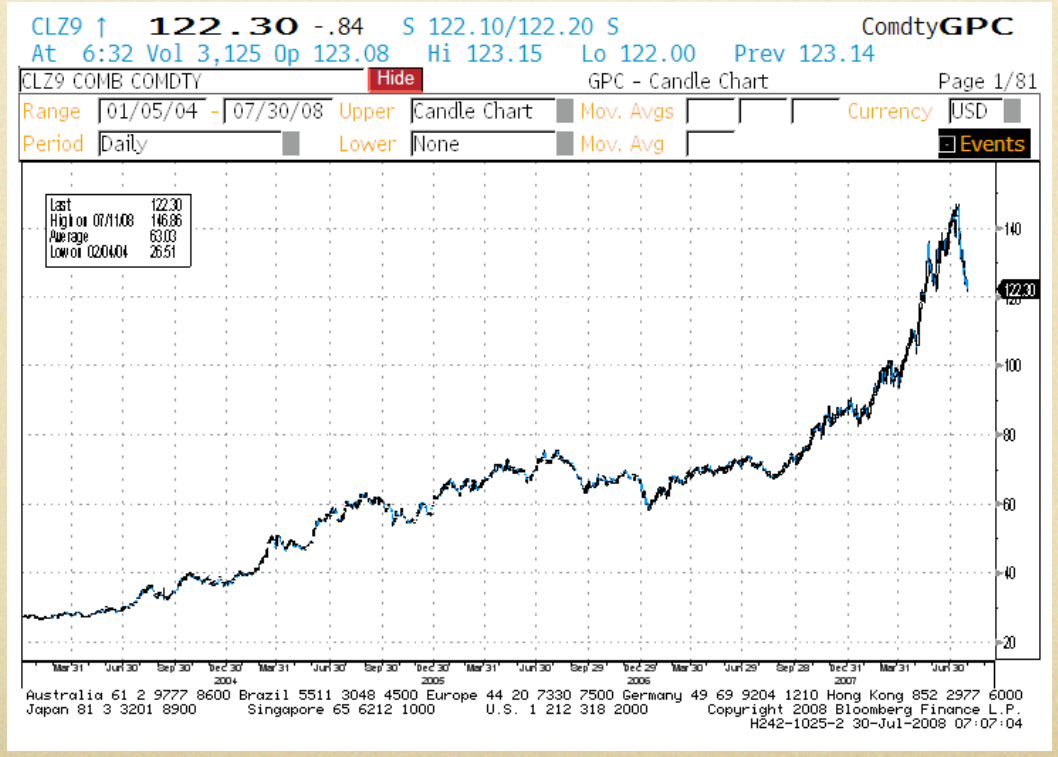
MSFT Example (Cont)

- Derivatives allow one to change the profile of risk and return versus simple "buy-and-hold" investing.



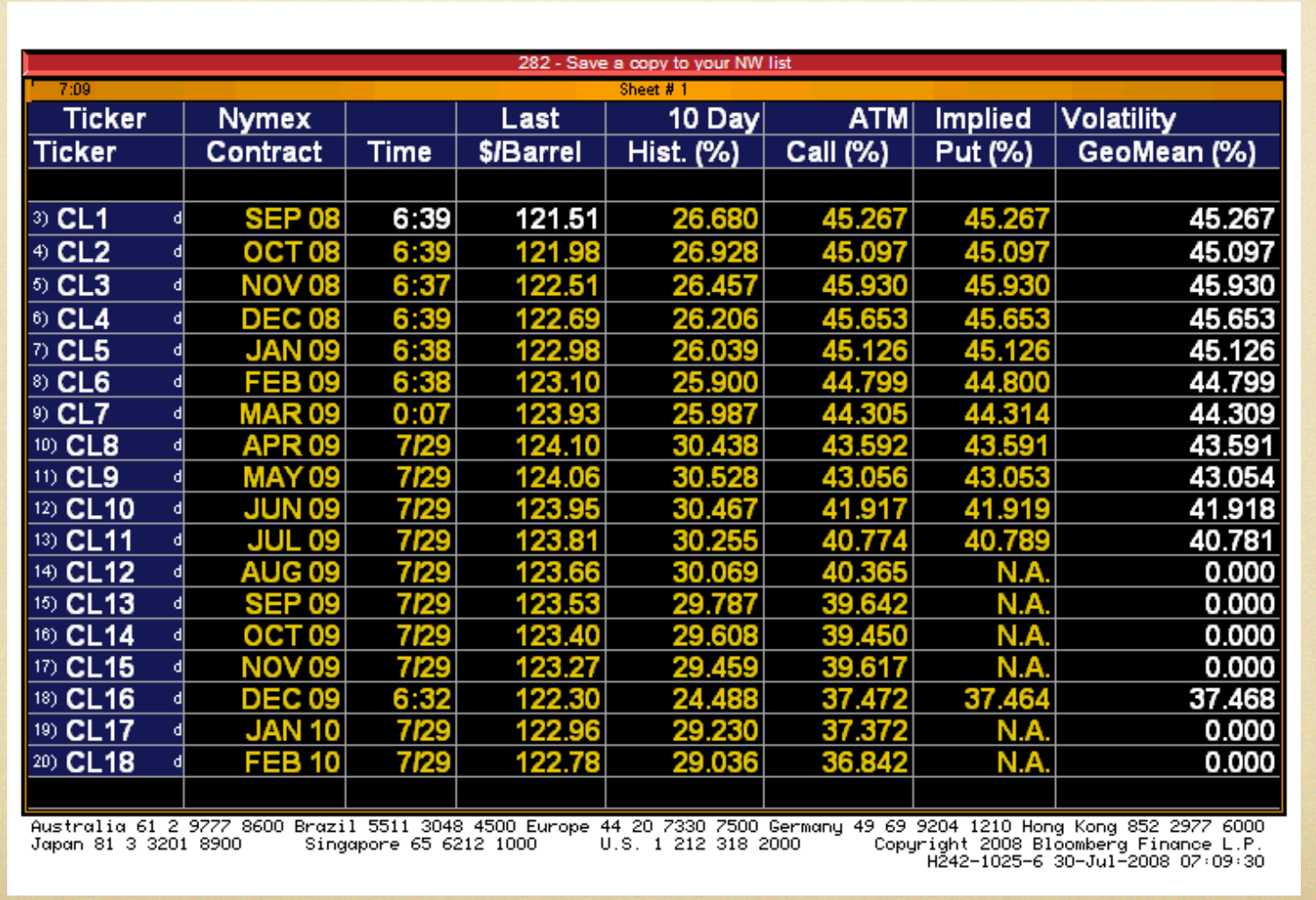
An Example with Oil

- After years of trading in the $20-40 range, crude oil has recently traded as high as $147.90 per barrel.
- This new price action has greatly increased both the actual (or realized) and perceived future volatility (known as "implied volatility" inferred from option prices).



An Example with Oil (Cont)

- Sep 08 futures used to trade around 20% implied volatility and are now at 45% and have traded over 50%!



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7:09 Sheet # 1

Ticker	Nymex		Last	10 Day	ATM	Implied	Volatility
Ticker	Contract	Time	$/Barrel	Hist. (%)	Call (%)	Put (%)	GeoMean (%)
3) CL1 d	SEP 08	6:39	121.51	26.680	45.267	45.267	45.267
4) CL2 d	OCT 08	6:39	121.98	26.928	45.097	45.097	45.097
5) CL3 d	NOV 08	6:37	122.51	26.457	45.930	45.930	45.930
6) CL4 d	DEC 08	6:39	122.69	26.206	45.653	45.653	45.653
7) CL5 d	JAN 09	6:38	122.98	26.039	45.126	45.126	45.126
8) CL6 d	FEB 09	6:38	123.10	25.900	44.799	44.800	44.799
9) CL7 d	MAR 09	0:07	123.93	25.987	44.305	44.314	44.309
10) CL8 d	APR 09	7/29	124.10	30.438	43.592	43.591	43.591
11) CL9 d	MAY 09	7/29	124.06	30.528	43.056	43.053	43.054
12) CL10 d	JUN 09	7/29	123.95	30.467	41.917	41.919	41.918
13) CL11 d	JUL 09	7/29	123.81	30.255	40.774	40.789	40.781
14) CL12 d	AUG 09	7/29	123.66	30.069	40.365	N.A.	0.000
15) CL13 d	SEP 09	7/29	123.53	29.787	39.642	N.A.	0.000
16) CL14 d	OCT 09	7/29	123.40	29.608	39.450	N.A.	0.000
17) CL15 d	NOV 09	7/29	123.27	29.459	39.617	N.A.	0.000
18) CL16 d	DEC 09	6:32	122.30	24.488	37.472	37.464	37.468
19) CL17 d	JAN 10	7/29	122.96	29.230	37.372	N.A.	0.000
20) CL18 d	FEB 10	7/29	122.78	29.036	36.842	N.A.	0.000

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 2008 Bloomberg Finance L.P.
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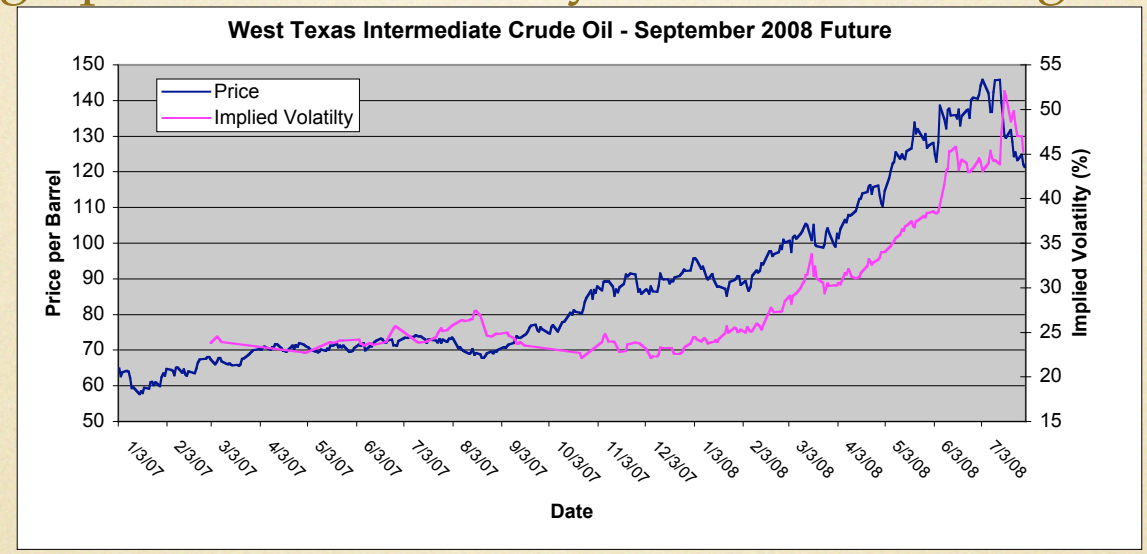
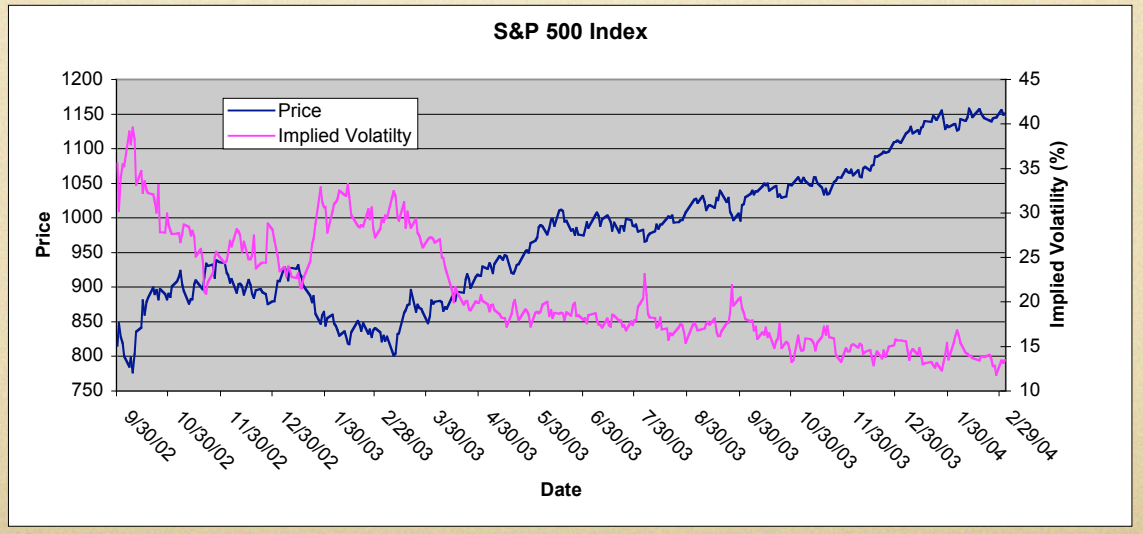
An Example with Oil (Cont)

- High prices in oil are very different from high stock prices.





History of Derivatives

- Derivatives are not new:
  - The Greeks traded in olive forwards 2,000 years ago.
  - The Dutch traded forwards and even options contracts on tulips in the 1600s ("tulipmania").
  - The Japanese founded a futures exchange to trade rice in 1874.
  - The Chicago Board of Trade ("CBOT") was established in 1864 with the first standardized contract to trade agricultural goods.
  - The Chicago Mercantile Exchange ("CME") was founded in 1898.
  - The CBOT and CME recently merged and now trade 1 billion contracts a year with $1,000 trillion in value.

What's new since 1970?

- Interest rates became more volatile giving rise to heavy trading in bond futures.
- University of Chicago Professors Fischer Black and Myron Scholes developed their famous Black-Scholes option pricing model, which gave rise to tremendous growth in equity (stock) and other option trading.
- Wall Street developed a variety of derivatives such as:
  - Exotic options (knock-ins, knock-outs, double barrier, average rate, look-back, rainbow, chooser, binary, range options, etc).
  - Interest rate and other swaps along with swaptions and even volatility swaps.
  - Credit default swaps.
  - Collateralized Debt Obligations (current sub-prime mess).
- Old-fashioned "floor" or pit-trading has given way to fully electronic markets, which allow for faster trading with greater liquidity and even algorithmic trading.

Market Participants

- There are four basic participants in today's derivatives markets:
  - **Commercial hedger**: Seeks to lock in prices for an expected inventory to be delivered or received.
  - **Speculator**: One who is willing to speculate (i.e. bet) on the future price of an asset.
  - **Arbitrageur**: One who seeks to exploit temporary price discrepancies between different products.
  - **Market-Maker**: One who is willing to make both bid and offer prices in a derivative in exchange for extracting a "dealer's spread".
- Participation by these four groups generally ensure that a particular market is efficient and liquid over time.

Gallery of Rogue Traders

- Derivatives often are viewed negatively owing to a number of large trading losses involving derivatives.
  - **Metallgeschaft AG**: Lost $1.3 billion in mis-hedging crude oil exposure in 1993.
  - **Robert Citron/Orange County**: Lost $1.6 billion in betting on the speed of the rise in US short-term interest rates in 1994.
  - **Nick Lesson/Barings Bank**: Lost $1.0 billion trading Nikkei 225 futures in 1995. Barings had to be sold. Lesson did 6.5 years in jail.
  - **Yasuo Hamanaka/Sumitomo Corp**: Lost $2.6 billion trading copper futures in 1996. Hamanaka did 8 years of jail time.
  - **Long Term Capital Management ("LTCM")**: Lost $4.5 billion on a portfolio of bond and equity derivatives with a notional value of $100 trillion in 1998. Wall Street bail-out ensued.
  - **Brian Hunter/Amaranth Advisors**: Lost $6.4 billion trading natural gas contracts in 2006. Investigation pending.
  - **Jerome Kerviel/Societe General**: Lost $7.65 billion secretly trading $80 billion of European stocks futures. Investigation pending.

Black-Scholes (BS) Model

- The value of a call option on an asset S, expiring at time T, with strike price K is:

$$V = SN(d_+) - Ke^{-rT}N(d_-),$$

- where N ($d_\pm$) is the cumulative normal distribution function,

$$d_\pm = \frac{\ln\left(\frac{S}{Ke^{-rT}}\right) \pm \frac{\sigma^2 T}{2}}{\sigma\sqrt{T}},$$

- and r is the risk-free interest rate, continuously-compounded, and σ is the volatility of the asset.
- The Black-Scholes PDE:

$$\frac{\partial V}{\partial t} + rS\frac{\partial V}{\partial S} + \frac{\sigma^2}{2}S^2\frac{\partial^2 V}{\partial S^2} = rV.$$

is a reverse-time parabolic equation that can be solved by reducing it to the heat equation. Explicit solutions may not exist in more general settings - numerical solution methods will be needed.

Derivatives have Derivatives

- Beyond valuing the price of a call or put option, the BS model also provides derivatives or sensitivities (also known as "greeks") of the price of the option:

Name	Derivative	Explanation
Delta - Δ	dV/dS	Change in option price given a change in the stock price.
Gamma - γ	d^2V/dS^2	Change in Delta given a change in the stock price.
Vega - υ	$dV/d\sigma$	Change in option price given a change in volatility.
Theta - θ	dV/dT	Change in option price given a change in time (known as time decay).
Rho - ϱ	dV/dr	Change in option price given a change in interest rates.
Psi - ψ	dV/dD	Change in option price given a change in dividends.

- MSFT Example of January 2009 $30 Call Option:

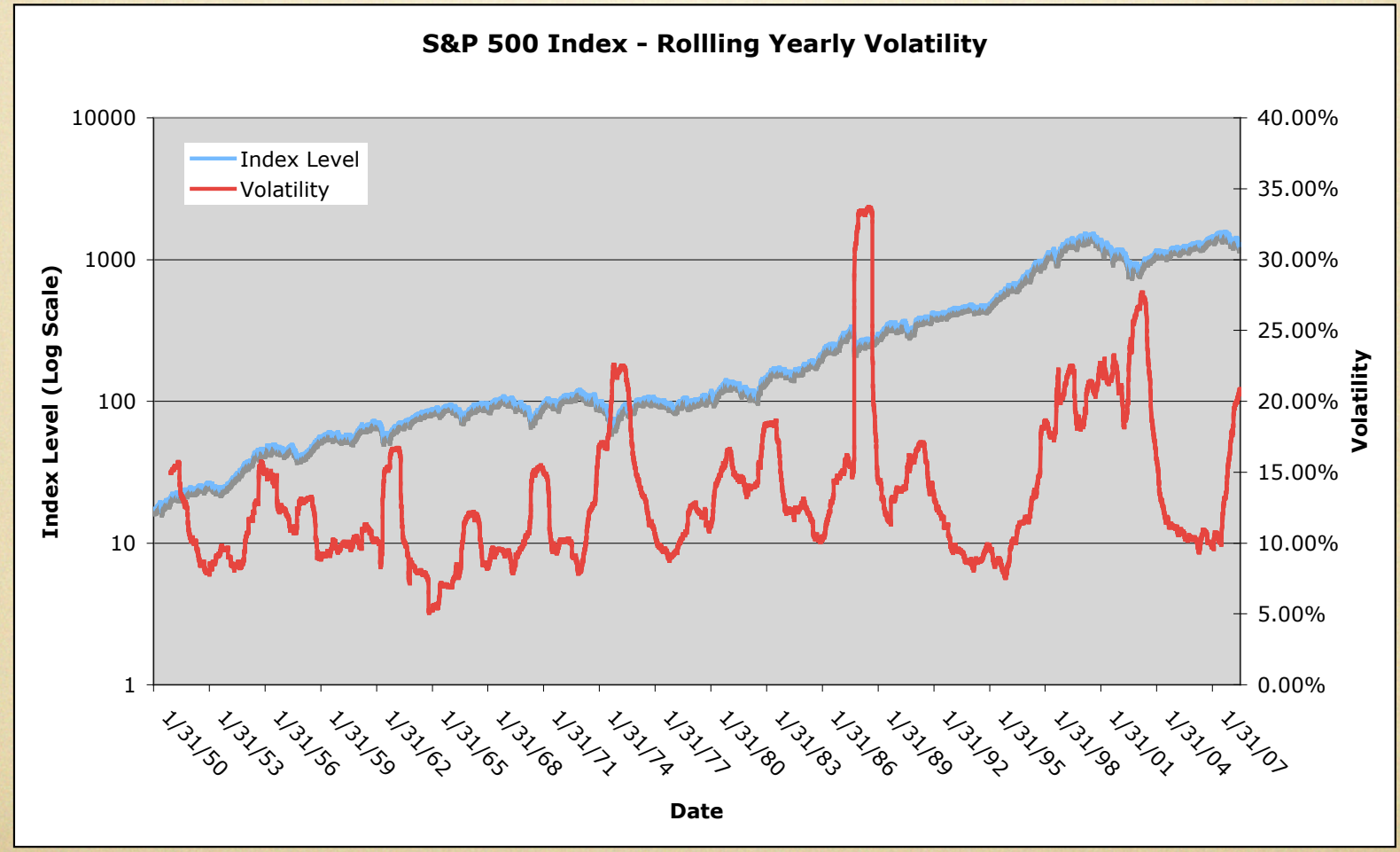
Greek	Value
Price (opt/stock)	0.62/25.22
Delta - Δ	0.23
Gamma - γ	0.0149
Vega - υ	0.051
Theta - θ	0.005
Rho - ϱ	0.001
Implied Volatility	29.769%

What really drives derivatives trading?

- Of the six BS inputs:
  - K and T are deterministic (strike price and time).
  - S, D, R and V can change.
  - D and R have little effect on shorter term options.
  - S is known at all times and Delta risk can be easily managed by buy or selling S (the underlying asset, which is known as “delta-hedging”).
  - V (Volatility) has a very strong effect on the option price and changes in it leave a Market Maker at the greatest relative risk.
- What does the Market Maker do?
  - Buy/sell an equivalent amount of vega in other similar options.
  - Delta hedge to expiration using his estimate of volatility.

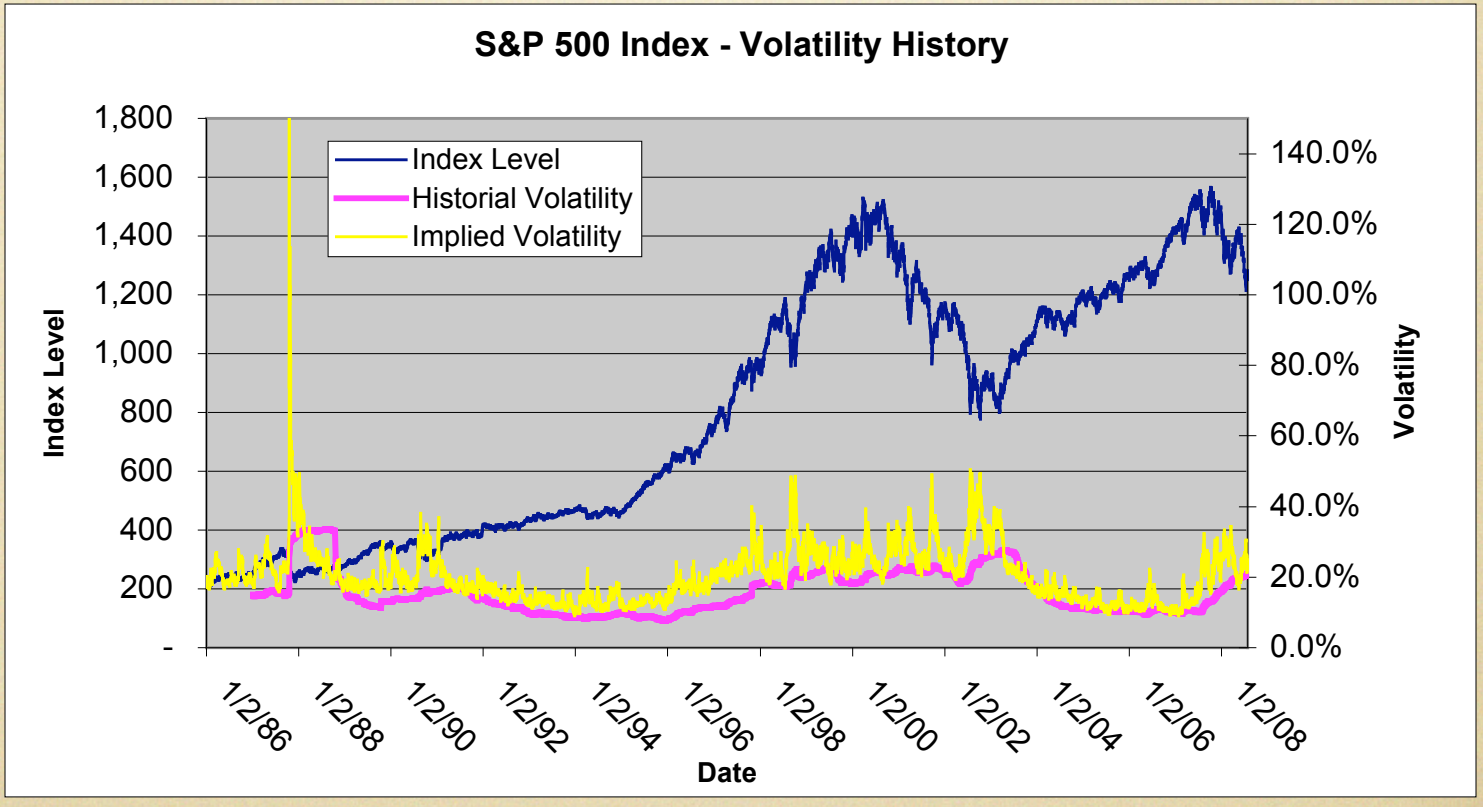
History of S&P 500 Volatilty

- Let's look at the simple standard deviation of daily price changes in the S&P 500 since 1950 on a rolling annual basis.



What does the options market tell us about volatility?

- The Chicago Board Options Exchange ("CBOE") started trading options on the S&P 500 Index in 1983 with the ticker (SPX).



Are we missing something?

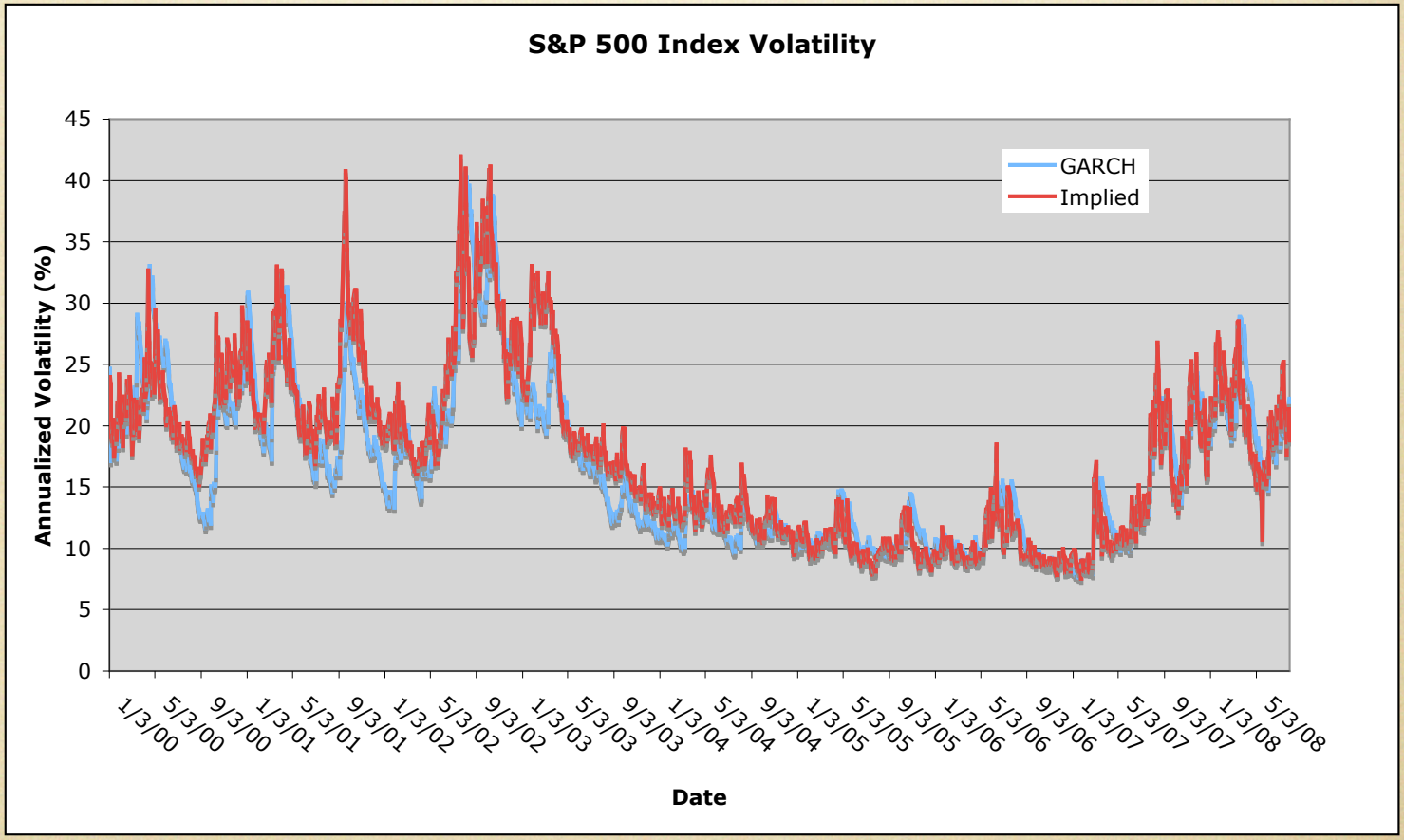
- One can see that implied volatilities are generally higher than historical realized volatilities.
- One aspect of the markets is that traders (at least successful ones) have long memories of what has happened, especially memories of 1987.
- Using a fixed window for calculating a standard deviation ignores distant, past events.
- Most econometric models assume that variance is constant (homoskedastic).
- But, in the real world, traders know that volatility changes over time, i.e. it's heteroskedastic.
- In fact, option traders are arguably most concerned not with the overall level of volatility but with the volatility of volatility ("vol-of-vol").

The GARCH Solution

- In the 1990s Robert Engel, Tim Bollerslev and others developed a family of econometric models which allowed for volatility to change over time.
- GARCH (Generalized Autocorrelated Conditional Heteroskedasticity). (ARCH also).
- $Vol_t = \alpha + \beta Vol_{t-1} + \gamma ret_t^2$,where ret is $(price_t / price_{t-1} - 1)$.
- My model: $\alpha = 0.005$, $\beta = 0.94$ and $\gamma = 0.055$.
- Advantages:
  - All data (price returns) is used in estimating today's volatility.
  - Model is quite sensitive to today's price change.
  - Coefficients tend to be stable over time.
  - Spot volatility estimates tend be quite similar to how Market Makers adjust their volatility estimates over time.

GARCH vs SPX Volatility

- GARCH seems to mimic the Market Makers with a 90% correlation to the implied volatility of the options market.



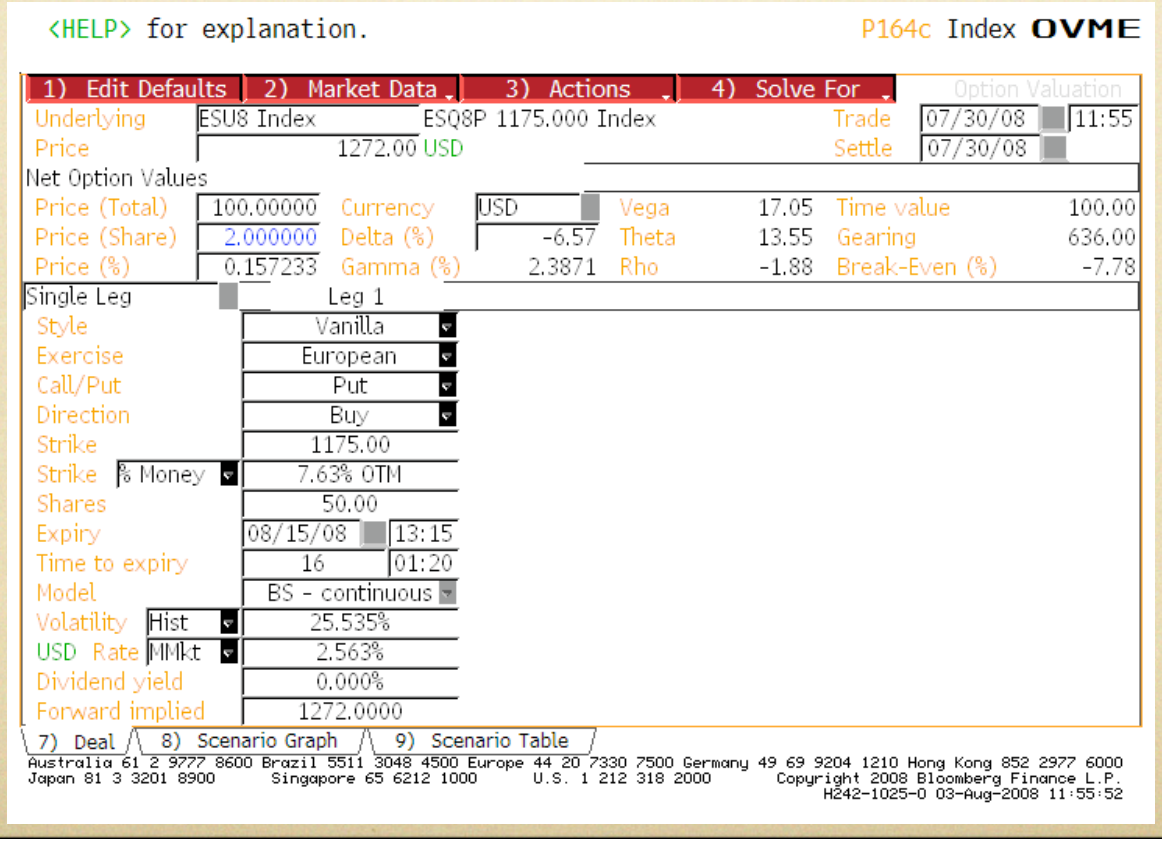
Practical Examples

- How does all of this work?
- Online option pricer: http://www.intrepid.com/robertl/option-pricer1/option-pricer.cgiNBOPMForm.php
- Let's price a European exercise style, one year, at-the-money (S=K=100) European call option assuming r= 2%, d=0% and volatility = 30%.
- Let's use the derivatives to estimate:
  - The price of the option if the S moves to 101.
  - A two-year version of the same option.
  - What's the vega (sensitivity to volatility) of the option?
  - What happens if volatility moves to 40%?
  - What if it is a put option (i.e. the right to sell the stock at 100)?

S&P 500 Index Put Option

- Example: July 1175 August 2008 S&P 500 Index put option (European exercise style).

- Pricing Data: Px=$2.0, T=16 days, S= 1272.0, K=1175, V= 25.535% and r=d=2.563%.



S&P 500 Index Put Option (Cont)

- What do different market participants do, when they trade this option?
  - Hedger : Buy it for $2.00 to protect his portfolio.
  - Speculator: Sells it for $2.00 and hopes it expires worthless.
  - Arbitrageur: Thinks that it $0.10 to expensive, sells it, delta hedges and buys some 1150 puts at $1.0 in case something really bad happens.
  - Market marker: Sells it, delta hedges it and manages the exposure of his overall portfolio of options. Maybe another client sells the same option to him later in the day at $1.90 and he unwinds his futures hedge.

Merrill Lynch Example

- Merrill Lynch (MER) was due to announce second financial quarter (Apr-Jun) earnings last Tuesday.
- Owing to the Wall Street sub-prime crisis, MER had already incurred $40 billion of asset write-downs, i.e. presumed losses.
- MER still had $30 billion of unhedged CDOs on its balance sheet and traders were expecting something really bad to happen.
- Instead, MER announced that it had sold the $30 billion portfolio at $0.22 per $1.00 of nominal value versus MER's estimate of its value of $0.50 a month ago.
- What happened to its exchange traded options?

Merrill Lynch Example (Cont)

Merrill Options Trading `Stood Out' Prior to Loss (Update1) 2008-07-29 20:32:07.820 (New York)

July 29 (Bloomberg) -- Traders who bought Merrill Lynch & Co. options yesterday betting the biggest U.S. brokerage would extend its worst slide in 21 years may have been tipped off, options analysts say. Merrill options rose to the highest in almost two weeks yesterday and traders increased bearish bets hours before thefirm said that it would take $5.7 billion in writedowns. The stock rose 7.9 percent today, its first advance in five days.

``I got a lot of calls from people saying, `Why so much volume in the puts?' I had no idea,'' said Steve Sosnick, a market maker at Greenwich, Connecticut-based Interactive Brokers Group Inc., which handles one-seventh of all equity options traded worldwide. ``When I see the news come out after the close, it makes me suspicious that somehow this got out.''

Jessica Oppenheim, a Merrill spokeswoman, and John Heine, a spokesman for the Securities and Exchange Commission, declined to comment. Merrill added $1.92 to $26.25 in New York after investors bet Chief Executive Officer John Thain eliminated the company's subprime mortgage risk.

Implied volatility, the key gauge of options prices, jumped to 109.2 yesterday as Merrill shares lost 12 percent. Two days earlier, implied volatility rose to 87.11 and the shares dropped 14 percent. Merrill's stock fell 29 percent from July 22 through yesterday, the worst four-day slide since October 1987.

The most-traded Merrill options yesterday were contracts that give the right to sell at $25 by Aug. 15, followed by August $22.50 puts. Merrill closed at $24.41. The contracts made up almost a quarter of all Merrill options traded yesterday. The $22.50 puts lost 69 percent today, while the $25 contracts lost 58 percent, reversing earlier gains of 41 percent and 25 percent, respectively.

Michael McCarty, an options strategist at Meridian Equity Partners Inc. in New York who writes a daily report to clients on unusual and unexplained trading, cited Merrill's August $25 puts in his note yesterday.

``This stood out,'' he said. ``The implied volatility jumped quite a bit for a single day and considering the context of where the market was and where the stock was trading, it was an outsized move.''

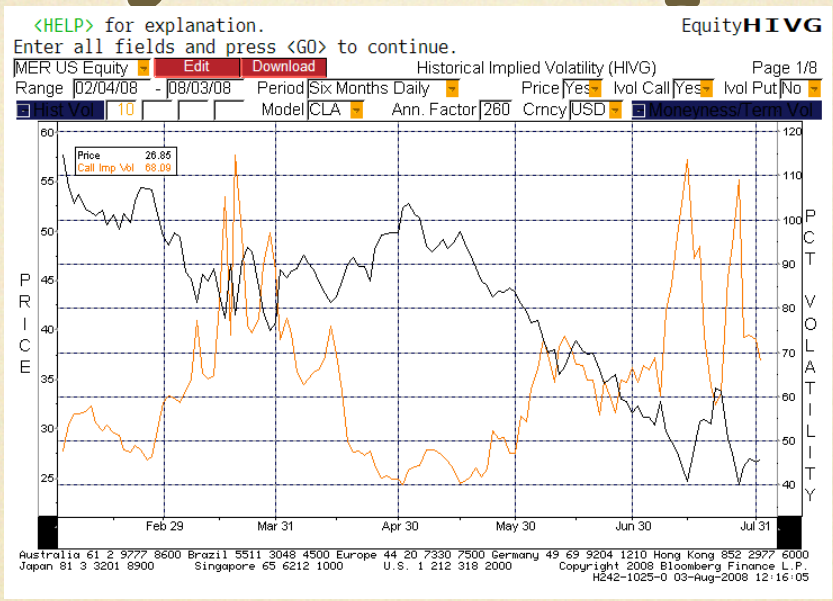
Merrill said after yesterday's close of U.S. exchanges that it sold $8.55 billion of stock and will book $5.7 billion of writedowns in the third quarter. The brokerage also said it will liquidate $30.6 billion of bonds at a fifth of their face value to shore up credit ratings imperiled by mortgage losses. Trading of puts on Merrill was almost twice the call volume yesterday, when the August $25 puts added 56 percent to $3.20 and the August $22.50 puts rose 58 percent to $2.09.

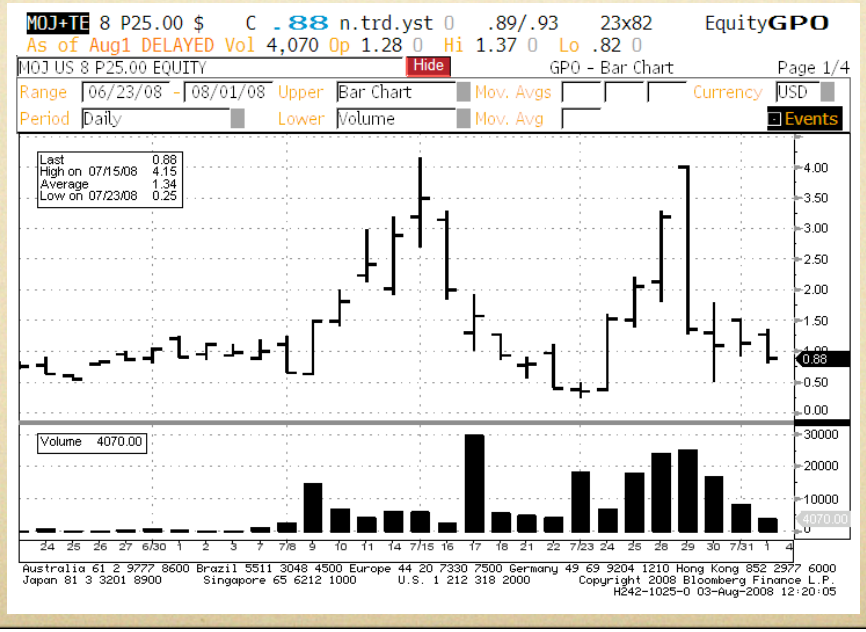
``It hints that possibly there was a leak,'' said Frederic Ruffy, the senior options strategist at WhatsTrading.com, a New York-based provider of options market analysis. ``There was a lot of defensive, bearish trading in the options leading up to the announcement yesterday, suggesting that some investors were preparing for bad news.''

Pat Neal, head of equity derivatives strategy at Jefferies Group Inc. in New York, said the options trading and volatility increase were to be expected after the shares declined.

``The stock got clobbered the last couple days, so clearly people were expecting something to occur,'' Neal said. ``Implied volatility was up, but it's not unexpected given the change in spot price.''

Merrill Lynch Example (Cont)

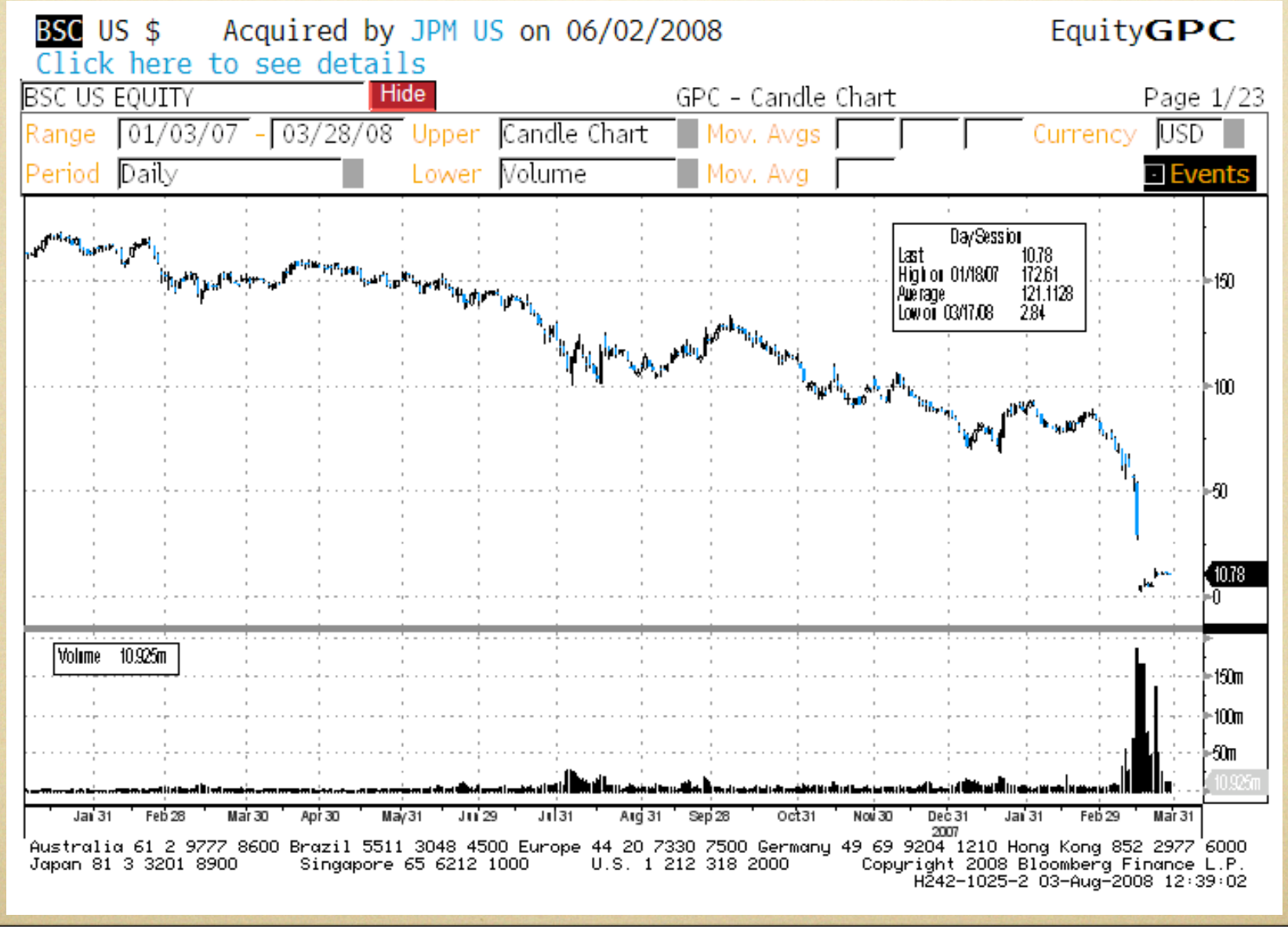




Bear Stearns Example

- As the sub-prime mortgage mess began to unfold last summer, a brokerage firm formely known as Bear Stearns, was in the very midst of it.
- Bear Stearns had a hedge fund, which lost roughly 100% of its $2+ billion of value within a few weeks.
- Bear Stearns owned a lot of mortgage bonds, which were declining in value.
- Bear Stearns borrowed a lot of money on an overnight basis from other Wall Street brokerage houses and banks, which left it in a vulnerable position.
- Wall Street traders thought that Bear Stearns was going to go bankrupt and it almost did.

Bear Stearns Example (Cont)

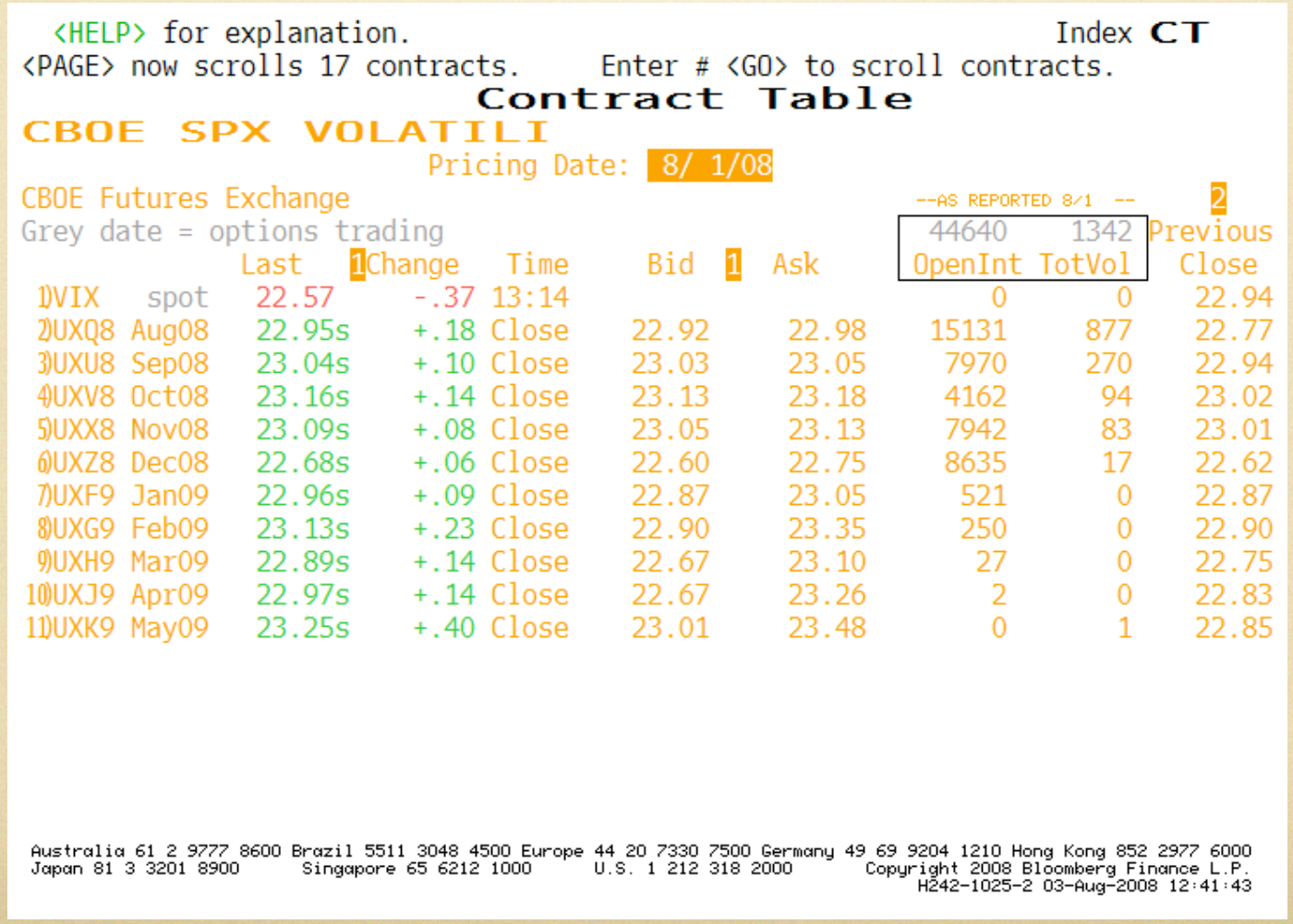


Volatility Products: The VIX

- Several years ago the CBOE developed the VIX (Volatlity IndeX), which is a measure of the implied volatility of constant maturity one-month options on the S&P 500 Index.
- The VIX is widely followed by the financial press and is often referred to as the "fear gauge".
- Recently, the CBOE listed futures contracts on the VIX, then option contracts and now there are even listed binary and range options on VIX.
- Trading volumes have been especially large in VIX options, as traditional portfolio managers use VIX call options to protect their portfolios in the event of a large market decline and corresponding spike in volatility.

VIX Futures

- Here's what the market in VIX Volatility Futures looked like on Friday.



<HELP> for explanation. Index CT

<PAGE> now scrolls 17 contracts. Enter # <GO> to scroll contracts.

Contract Table

CBOE SPX VOLATILI

Pricing Date: 8/ 1/08

CBOE Futures Exchange

Grey date = options trading

		Last	1Change	Time	Bid 1	Ask	--AS REPORTED 8/1 -- 2 OpenInt	TotVol	Previous Close
1)VIX	spot	22.57	-.37	13:14			44640	1342	22.94
2)UXQ8	Aug08	22.95s	+.18	Close	22.92	22.98	15131	877	22.77
3)UXU8	Sep08	23.04s	+.10	Close	23.03	23.05	7970	270	22.94
4)UXV8	Oct08	23.16s	+.14	Close	23.13	23.18	4162	94	23.02
5)UXX8	Nov08	23.09s	+.08	Close	23.05	23.13	7942	83	23.01
6)UXZ8	Dec08	22.68s	+.06	Close	22.60	22.75	8635	17	22.62
7)UXF9	Jan09	22.96s	+.09	Close	22.87	23.05	521	0	22.87
8)UXG9	Feb09	23.13s	+.23	Close	22.90	23.35	250	0	22.90
9)UXH9	Mar09	22.89s	+.14	Close	22.67	23.10	27	0	22.75
10)UXJ9	Apr09	22.97s	+.14	Close	22.67	23.26	2	0	22.83
11)UXK9	May09	23.25s	+.40	Close	23.01	23.48	0	1	22.85

Options on VIX Futures

- There are even options on VIX Futures.

VIX 22.57Y as of close 8/ 1 Index OMON

VIX Index | Templates | Edit | Expiry | Reverse Axes | Option Monitor ...

CBOE SPX VOLATILITY INDX 22.57 0.00 Hi -- Lo -- Vol

Center 22.50 Number of Strikes 18 or % from Center Exchange Composite

51) Calls						52) Puts					
	Ticker	Strike	Bid	Ask	Volm	OInt	Ticker	Strike	Bid	Ask	Volm	OInt
VIX 20 AUG 2008 (Contract Size 100)							VIX 20 AUG 2008 (Contract Size 100)					
1)	VIX+HB	10.0	12.80	13.10		3817	21) VIX+TB	10.0		.10		25
2)	VIX+HC	15.0	7.80	8.10	62	1419	22) VIX+TC	15.0		.05		5386
3)	VIX+HR	17.0	5.80	6.10		650	23) VIX+TR	17.0		.10		3373
4)	VIX+HS	18.0	4.80	5.10	44	2693	24) VIX+TS	18.0	.05	.10	31	13158
5)	VIX+HT	19.0	3.90	4.30	21	4216	25) VIX+TT	19.0	.15	.20	432	21396
6)	VIX+HD	20.0	3.30	3.40	1300	6164	26) VIX+TD	20.0	.30	.35	4864	25915
7)	VIX+HX	22.5	1.75	1.80	3593	29650	27) VIX+TX	22.5	1.35	1.40	846	51413
8)	VIX+HE	25.0	.95	1.00	4164	76183	28) VIX+TE	25.0	2.90	3.10	319	14773
9)	VIX+HY	27.5	.55	.60	2293	78525	29) VIX+TY	27.5	4.90	5.20	51	2007
10)	VIX+HF	30.0	.30	.40	2763	79007	30) VIX+TF	30.0	7.20	7.50	80	874
11)	VIX+HZ	32.5	.15	.25	3296	35178	31) VIX+TZ	32.5	9.50	9.90	22	116
12)	VIX+HI	35.0	.05	.10	1442	70075	32) VIX+TI	35.0	12.00	12.30	20	213
13)	VIX+HU	37.5		.10	112	3584	33) VIX+TU	37.5	14.40	14.70		187
14)	VIX+HH	40.0		.05		4387	34) VIX+TH	40.0	16.90	17.20	10	216
15)	VIX+HV	42.5		.05		1595	35) VIX+TV	42.5	19.30	19.70		225
16)	VIX+HG	45.0		.05		3076	36) VIX+TG	45.0	21.80	22.20		241
17)	VIX+HJ	50.0		.05		2073	37) VIX+TJ	50.0	26.80	27.20		151
VIX 17 SEP 2008 (Contract Size 100)							VIX 17 SEP 2008 (Contract Size 100)					
18)	VIX+IB	10.0	12.90	13.30		1653	38) VIX+UB	10.0		.10		
19)	VIX+IC	15.0	7.90	8.30	3	2193	39) VIX+UC	15.0		.10		301
20)	VIX+IR	17.0	6.00	6.40		196	40) VIX+UR	17.0	.10	.15		2922

New VIXes

- The success of the S&P 500 Index volatility contract products has given rise to other volatility products:
  - Nasdaq 100 Index (Technology) - VXN
  - Russell 2000 (Small Cap) - RVX
  - German DAX Index - VDAX
  - A new Oil Vix is being planned.
- In fact, some academics argue that volatility has become its own "asset class", though in reality its only the second moment of the return distribution of the underlying asset. (Goldman Sachs paper).

Walkaway

- Use the same calculus and statistics learned as a physics undergraduate to model and trade derivatives using Brownian motion and the heat transfer equation.
- Have truly and continue to enjoy applying the analytical tools learned in school and on Wall Street.
- The application of hard-core scientific methods to the financial markets is relatively new, as Ph.D.'s first started appearing on Wall Street in the 1980s.
- However, in spite of the power of theory, the market is the final arbiter of economic reality, "The market can stay irrational longer than you can stay solvent." (John Maynard Keynes).

Additional Resources

- "Futures, Options and Other Derivatives". John Hull. http://www.rotman.utoronto.ca/~hull/ofod/
- "Dynamic Asset Pricing Theory". Darrel Duffie. http://www.stanford.edu/~duffie/.
- "My life as a quant". Emmanuel Derman, 2008. (Overlapped with him in Summer of 1989 at Salomon Brothers and we later used his implied tree theory to price barrier options.).
- Computational Finance at the UW. Prof. Doug Martin.
- Useful tools: Excel, C, C++, Perl, Python, R, Sage, Splus, etc.
- http://en.wikipedia.org/wiki/Greeks_(finance)
- Please email me anytime with questions at nwaltner@kulshancapital.com.