

Steve Meizinger

FX Options Pricing, what does it Mean?



For the sake of simplicity, the examples that follow do not take into consideration commissions and other transaction fees, tax considerations, or margin requirements, which are factors that may significantly affect the economic consequences of a given strategy. An investor should review transaction costs, margin requirements and tax considerations with a broker and tax advisor before entering into any options strategy.

Options involve risk and are not suitable for everyone. Prior to buying or selling an option, a person must receive a copy of CHARACTERISTICS AND RISKS OF STANDARDIZED OPTIONS. Copies have been provided for you today and may be obtained from your broker, one of the exchanges or The Options Clearing Corporation. A prospectus, which discusses the role of The Options Clearing Corporation, is also available, without charge, upon request at 1-888-OPTIONS or www.888options.com.

Any strategies discussed, including examples using actual securities price data, are strictly for illustrative and educational purposes and are not to be construed as an endorsement, recommendation solicitation to buy or sell securities.

Likelihood of events

- Option pricing is based on the likelihood of an event occurring
- Terms such as most likely, most unlikely, probable, improbable, likely, unlikely and possible describe the likelihood an event occurring, but not from a specific or quantifiable perspective
- Options trader's wanted a more quantifiable solution, the answer: Black-Scholes Options Pricing Model



Where do the prices come from?

- Fisher Black and Myron Scholes developed the most popular pricing model
- Based on the concept that dynamic behavior of asset prices is expected
- Assumption of the model is risk-neutrality
- Many other models are now used, Cox-Ross-Rubenstein is another famous option model along with Garman and Kohlhagen for FX options
- Most are extensions of Black-Scholes



Pricing models, who cares?

- Laws of probability enable practitioners to predict the likelihood of events to occur
- Option pricing models are based on the premise that stock prices are random and cannot be predicted with any accuracy
- Option values are based on bell-shaped, lognormal distribution with a slight upward bias



Efficient or not?

- Efficient Market Hypothesis (EMH) assumes the market fully reflects all available information
- What about periods of excess volatility, pricing "bubbles" and the occasional chaos of the market?



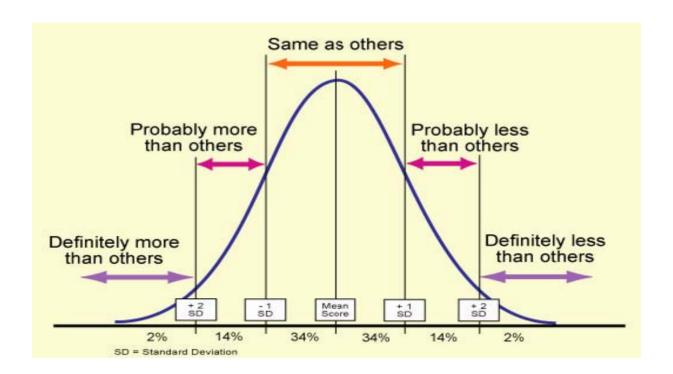
Practical use of normal distributions

- The distribution of heights of American women aged 18 to 24 is approximately normally distributed with mean 65.5 inches and standard deviation 2.5 inches. From the above rule, it follows that
- 68%
 - of these American women have heights between 65.5 2.5 and
 65.5 + 2.5 inches, or between 63 and 68 inches,
- 95%
 - of these American women have heights between 70.5 and 60.5



Statistics play a large role in options

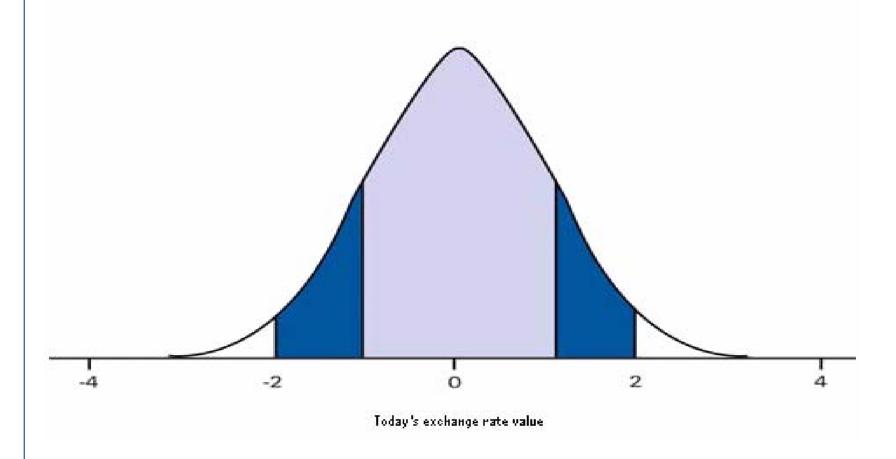
 Practically speaking, one example could be the general male (or female) adult heights





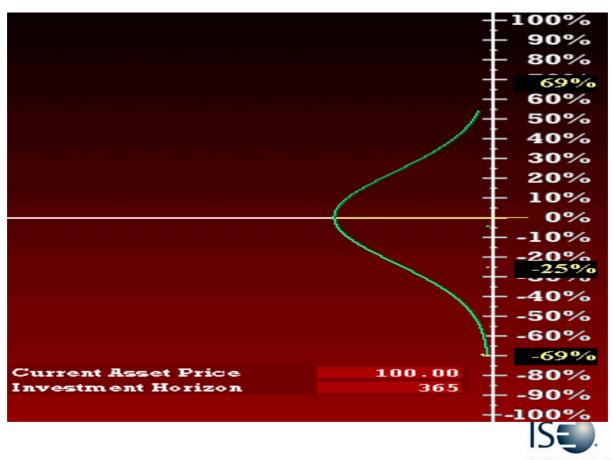
Probabilities matter for FX options

Options theory indicates that prices should stay at the mean, of course there are exceptions



Probability of change

 The theory says the asset is just as likely to move up as down, the volatility forecasts tells us by how much



Features Of ISE FX Options

- Options on exchange rates
- U.S. dollar based
- .50 strike prices
- Premium quoted in U.S. dollars
- European Exercise
- Cash-settled
- Noon Settlement/Option Friday
- Noon Buying Rate FRB of NY
- Available in Conventional Brokerage Account
- Continuous Two-Sided Quotes
- Trading Hours 9:30 4:15



Initial ISE FX Offerings

• USD/EUR (ticker symbol, EUI): 70.65 (0.7065 x 100)

USD/GBP (ticker symbol, BPX): 49.01 (0.4901 x 100)

USD/JPY (ticker symbol, YUK) 115.77
 (115.77 x 1) the rate modifier is 1 for JPY

• USD/CAD (ticker symbol, CDD) 99.85 (0.9985 x 100)



The dollar has dropped recently

	7-31	10-2	Change
CDD	106.61	99.85	6.3%
YUK	118.53	115.77	2.3%
EUI	73.07	70.65	3.3%
BPX	49.34	49.01	0.1%

Pricing Inputs

- » Underlying price
- » Strike price
- » Time until expiration
- » Risk-free rates (also called risk-free interest rate differential)
- » Volatility



Underlying exchange rate value

- Relationship between the strike price and the underlying exchange rate creates the value of the option at expiration
- At expiration all options are worth the intrinsic value or they are worthless
- Option pricing expectations are measured by delta, the rate option moves based on a one unit change in the underlying price
- The greater the likelihood of the option expiring in the money the greater the delta



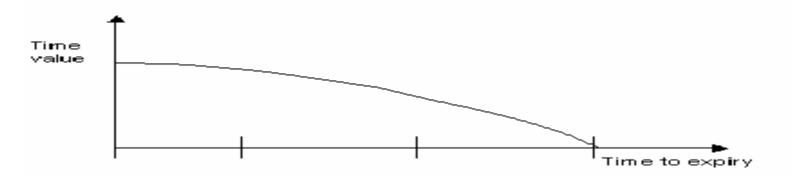
Strike Price

- Each option has a strike price at which the underlying can be bought or sold
- Option strike prices are similar to insurance policies deductibles
- Various strikes prices offer differing risk/reward propositions
- Call strikes can be viewed protecting against US dollar appreciation
- Put strikes can be viewed protecting US dollar weakness



Time

- In most cases the greater amount of time the greater the option's value
- Time decay is not linear, shorter term options decay faster than longer term (theta)



- Generally the greater the time decay the greater the potential for a rapidly changing delta (gamma)
- Gamma manufactures delta creating option price change



Options have value for 2 reasons

- Cost of carrying underlying position (risk-free interest rates), this
 is also called the interest rate differential
- Potential underlying variance (volatility)
- If both countries had risk-free interest that were 0% and the underlying currency pair had no potential for movement all options would trade at intrinsic value or 0



Risk-free Rates

- Call options can be viewed as a surrogate for underlying stock + put option (S + P) = C
- The cost of carrying an underlying position increases as interest rates increase therefore calls increase accordingly (rho)
- The interest rate differential is very important in FX options pricing



Dividends for stocks are like the contra currencies' risk free interest rate

- Theoretically, exchange rates should decline by the amount of the interest rate differential
- If another currency has much lower risk-free interest rates than the US, the puts will reflect the potential for US dollar devaluation by increasing the put values
- If another currency has much higher risk-free interest rates than the US, the calls will reflect the potential for US dollar revaluation by increasing the call values



Volatility

- How much change is expected?
- Variance as measured by volatility, expected error factor from the mean
- Risk = Standard deviation
- Price movements within one standard deviation movements should occur 68% of the time, within two standard deviations 95%
- Risk/Reward remain in balance, the more growth the market expects for a currency the more risk the currency infers



Greeks and FX options

- The option "Greeks" are applicable for FX options
- The major difference between equity options and FX options is the interest rate differential for the two unique currencies
- The appropriate volatility must be used when pricing FX options



The Greeks

- Delta- The change in the option's value for every one unit change in the currency pair (0.00-1.00)
- Gamma- The change in the option's delta for every one change in the underlying (gamma "manufactures delta") (i.e. .07). For example, the currency pair moves up 1 unit and call delta was .52, new call delta will be .59
- Theta- The change in the option's value for every one day decrease in the time remaining until expiration. The dollar amount of time decay expressed in decimals. If an option closes at \$3.5 with -.20 theta and the pair opens the next day unchanged, the new theoretical value is \$3.3



The Greeks

 Vega- The change in the option's value for a one percentage point increase in implied volatility. Expressed in decimals. For example if an option had a vega of .25 and a theoretical value is \$2.5, if the volatility were increase by 1% the option would have a new theoretical value of \$2.75



Interest rate differential

- Standard definition for Rho- The change in the option's value for a one percentage point increase in risk-free interest rates. Expressed in decimals, calls and puts have differing values. For example a Rho of .06 indicates the option's theoretical value will increase by .06 given a 1% increase in interest rates Long calls and short puts have positive rho
- The interest rate differential is very important when trading FX options. The appropriate risk-free rates must used when calculating options values



Official Central Bank Rates

• UK 5.75%

• US 4.75%

• Canada 4.50%

• Euro 4.00%

• Japan 0.50%

Interbank rates (Thompson Financial)

Country	1 month	3 month	6 month	1 year
U.S.	5.09	5.20	5.10	5.05
Canada	4.85	4.90	5.08	4.90
Japan	0.72	0.97	1.07	1.14
Euro	4.35	4.76	4.73	4.73
Sterling	6.02	6.20	6.18	6.06



Contra rate minus U.S rate

	10-2	7-31
YUK	4.37%	4.57%
EUI	0.74%	1.09%
CDD	0.24%	0.70%
BPX	1.00%	0.68%



Volatility

- The volatility associated with an asset is stated in annual percentage, it is a one standard deviation up or down estimation of future price
- Very concise and powerful way of conveying the amount of uncertainty in underlying forecasts
- The option's sensitivity to volatility is measured by vega, the amount the option will increase by a 1 unit change in volatility



Types of Volatility

- Historical
- Implied
- Forecasted or future
- Your option strategies are based on your forecast



Historical Volatility

- Calculate the past history of the mean price of the currency pair over a certain period of time (10 day, 30, 60, or 252)
- Calculate the standard deviations for the periods
- Standard deviation is the mathematical term for risk, or the variance from the average
- The distribution curve graphically describes how much the currency pair fluctuated in the past



Implied Volatility

- Reverse engineering of the Black-Scholes or Garman-Kohlhagen option pricing model or similar models
- Instead of solving for an option's value, use market price and solve for implied volatility
- The assumption is that market participants are more knowledgeable than past data
- Many experts believe implied volatility is the best predictor for future volatility

YUK (Ivolatility.com)

Price	Change (%)	52 wk High	52 wk Low	Stock volume	Avg. options volume 🛂	Avg. options open interest
115.76	+0.96 (+0.84%)	121.08 07/23/2007	113.46 09/07/2007	0	3,630	87,440

	Current	1 WK AGO	1 MO AGO	52 wk Hi/Date	52 wk Low/Date							
	HISTORICAL VOLATILITY 🛭											
10 days	11.21%	10.10%	13.32%	17.84% - 29-Aug	9.62% - 21-Sep							
20 days	11.02%	12.81%	14.06%	14.52% - 13-Sep	10.31% - 27-Sep							
30 days	11.65%	13.06%	0.00%	13.31% - 20-Sep	11.41% - 28-Sep							
		IMP	LIED VOLATILIT	Y 🛂								
IV Index call 🛭	8.82%	9.59%	13.52%	17.63% - 16-Aug	7.70% - 25-Jul							
IV Index put 🛭	8.90%	9.84%	13.30%	17.04% - 16-Aug	7.61% - 25-Jul							
IV Index mean 🛭	8.86%	9.71%	13.41%	17.33% - 16-Aug	7.65% - 25-Jul							
	HISTORICAL 30-DAYS CORRELATION AGAINST US Dollar Index₫											
30 days	N/A	N/A	N/A	N/A - N/A	N/A - N/A							

Price Chart
120 116
Volatility Chart
16% 12% 8%
Aug Sep Oct

Implied Vola (%)	Call Delta 🛭	Change (%)	Call Bid/Ask Mean ☑	Expiry 2	Strike 🛭	Days	Put Bid/Ask Mean 🛂	Change (%)	Put Delta 🛂	Implied Vola (%) 🛭
9.18%	57.54%	0.35 (41.18)	1.200	Oct07	115.0	19	0.800	-0.50 (-38.46)	-42.48%	9.60%
9.31%	49.37%	0.30 (46.15)	0.950	Oct07	115.5	19	1.050	-0.50 (-32.26)	-50.30%	9.72%
9.05%	41.07%	0.25 (55.56)	0.700	Oct07	116.0	19	1.300	-0.60 (-31.58)	-58.23%	9.47%
8.86%	32.88%	0.20 (66.67)	0.500	Oct07	116.5	19	1.600	-0.65 (-28.89)	-66.03%	9.32%
8.94%	50.95%	0.40 (36.36)	1.500	Nov07	115.0	47	1.400	-0.50 (-26.32)	-48.38%	8.69%
8.55%	45,35%	0.30 (33.33)	1.200	Nov07	115.5	47	1.650	-0.55 (-25.00)	-53.94%	8.61%
8.60%	39.93%	0.30 (42.86)	1.000	Nov07	116.0	47	1.900	-0.60 (-24.00)	-59.72%	8.35%
8.48%	34.46%	0.25 (45.45)	0.800	Nov07	116.5	47	2.200	-0.65 (-22.81)	-65.34%	8.22%



CDD (Ivolatility.com)

Price	Change (%)	52 wk High	52 wk Low	Stock volume 🛭	Avg. options volume 🛭	Avg. options open interest 🛭
99.21	♦ -0.07 (-0.07%)	107.83 08/15/2007	99.21 10/01/2007	0	510	37,810

	Current 1 WK AGO 1 MO AGO 52 wk Hi/Date 52 wk Low/Date											
HISTORICAL VOLATILITY 2												
10 days	9.41%	8.65%	8.06%	13.76% - 21-Aug	6.23% - 17-Sep							
20 days	7.79%	8.72%	10.84%	12.41% - 20-Aug	7.25% - 17-Sep							
30 days	8.01%	10.27%	0.00%	11.09% - 04-Sep	8.01% - 01-0ct							
		IMF	LIED VOLATILIT	Y 🛂								
IV Index call 🛂	8.94%	9.70%	10.37%	11.47% - 16-Aug	7.29% - 25-Jul							
IV Index put 🛭	9.05%	9.77%	10.42%	10.95% - 04-Sep	6.91% - 24-Jul							
IV Index mean 🛭	9.00%	9.74%	10.40%	11.18% - 17-Aug	7.31% - 25-Jul							
HISTORICAL 30-DAYS CORRELATION AGAINST US Dollar Index█												
30 days N/A N/A N/A N/A - N/A N/A - N/A												

pen t 🛂	Price Chart
310	104
	Volatility Chart
	10%
	Aug Sep Oct

Implied Vola (%) 🛭	Call Delta 🛂	Change (%)	Call Bid/Ask Mean ☑	Expiry 2	Strike 🛭	Days	Put Bid/Ask Mean 🖸	Change (%)	Put Delta 🛭	Implied Vola (%) 🛭
8.98%	62.17%	-0.25 (-17.86)	1.150	Oct07	98.5	19	0.550	0.07 (15.79)	-37.76%	9.15%
9.35%	52.47%	-0.20 (-18.18)	0.900	Oct07	99.0	19	0.800	0.12 (18.52)	-47.29%	9.53%
9.18%	42.97%	-0.15 (-18.75)	0.650	Oct07	99.5	19	1.050	0.15 (16.67)	-56.60%	9.37%
9.03%	33.61%	-0.15 (-25.00)	0.450	Oct07	100.0	19	1.350	0.15 (12.50)	-65.73%	9.25%
8.76%	57.82%	-0.20 (-11.43)	1.550	Nov07	98.5	47	1.000	0.12 (14.29)	-41.73%	9.07%
8.89%	51.49%	-0.20 (-13.33)	1.300	Nov07	99.0	47	1.200	0.10 (9.09)	-47.83%	8.85%
8.78%	45.18%	-0.15 (-12.50)	1.050	Nov07	99.5	47	1.450	0.10 (7.41)	-54.16%	8.77%
8.82%	39.04%	-0.15 (-15.00)	0.850	Nov07	100.0	47	1.750	0.15 (9.38)	-60.28%	8.82%



Implied volatilities as of June 29

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Implied Volatility Rates

The implied volatility rates are averages of mid-level rates for bid and ask "at-money-quotations" on selected currencies at 11:00 a.m. on the last business day of the month.

Implied Volatility Rates for Foreign Currency Options* June 29, 2007



	1 W K	1MO	2MO	3 M O	6 M O	1YR	2YR	3YR
EUR	4.8	4.7	5.0	5.1	5.5	5.9	6.0	6.1
JPY	6.9	6.6	6.7	6.8	6.9	7.0	7.0	7.0
CHF	5.6	5.6	5.7	5.8	6.2	6.6	6.6	6.5
GBP	4.9	4.8	5.0	5.1	5.5	5.8	6.0	6.0
CAD	9.2	7.8	7.3	7.1	6.8	6.7	6.7	6.8
AUD	7.9	7.5	7.5	7.4	7.4	7.4	7.3	7.3
GBPEUR	3.8	3.7	3.8	3.9	4.0	4.1	4.2	4.3
EURJPY	7.5	7.4	7.4	7.4	7.4	7.4	5.0	7.5

* This release provides survey ranges of implied volatility mid rates for the money options as of 11:00 a.m. The quotes are for contracts of at least \$10 million with a prime counterparty.



Federal Reserve Bank of NY implied volatilities Sept 28



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EDUCATION

Implied Volatility Rates

The implied volatility rates are averages of mid-level rates for bid and ask "at-money-quotations" on selected currencies at 11:00 a.m. on the last business day of the month.

REGIONAL OUTREACH

Implied Volatility Rates for Foreign Currency Options* September 28, 2007

Printer version

ABOUT THE FED

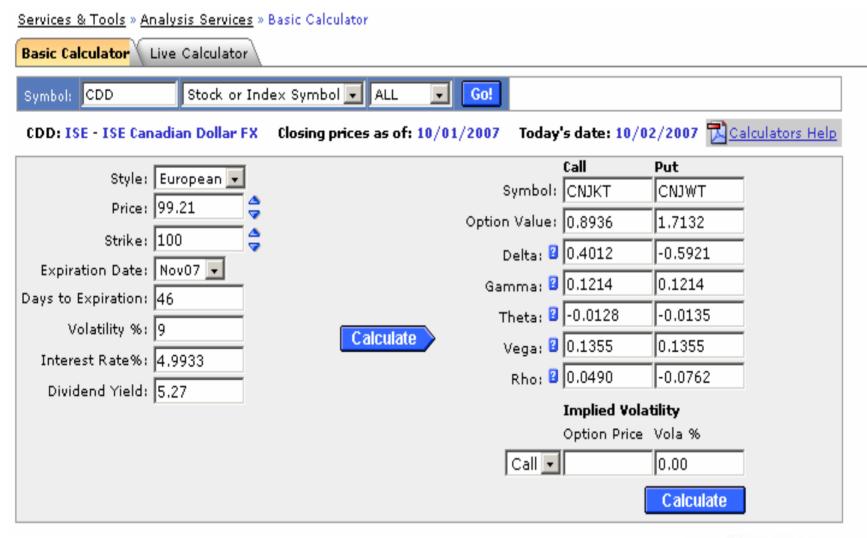
	1WK	1MO	2MO	3 M O	6 M O	1YR	2YR	3YR
EUR	8.0	6.7	6.6	6.6	6.5	6.6	6.6	6.6
JPY	10.9	9.2	9.0	8.7	8.3	8.1	7.9	7.9
CHF	8.7	7.2	7.1	7.0	6.9	6.9	6.9	6.8
GBP	8.2	7.2	7.2	7.1	7.1	7.1	7,1	7.1
CAD	9.4	8.7	8.6	8.4	8.3	8.2	8.2	8.3
AUD	12.6	11,6	11,1	10.6	9.9	9.6	9.5	9.3
GBPEUR	6.6	5.9	5.9	5.8	5.6	5.5	5.3	5.3
EURJPY	10.2	9.7	9.5	9.3	8.9	8.7	6.6	8.6

^{*} This release provides survey ranges of implied volatility mid rates for the money options as of 11:00 a.m. The quotes are for contracts of at least \$10 million with a prime counterparty.



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CDD using an option calculator



CDD November 100 calls and puts reference 99.17

	Call	Put
100	0.80-0.90	1.70-1.80
101	0.50-0.60	2.40-2.50



Vital FX pricing inputs

- All FX options pricing inputs are important but the most important are:
 - Volatility
 - Cost of money (interest rate differential)

Cost of money

- Since ISE FX options are dollar relative an investor must use the proper interest rate and dividend yield
 - The "dividend yield" is the US risk-free
 - The "interest rate" is the contra currency risk-free interest rate

Forward pricing

- An interest rate is nothing more than a mathematical relationship that maps a present value to a future value or vice versa
- This interest rate differential for foreign currency pairs may create a different forward price relative to the "spot" or cash price



Forward pricing

- In forward pricing the difference between the risk-free interest rates will create the forward price
- If the US interest rate is higher than the contracurrency the puts will reflect this relationship by increasing in value relative to the calls
- The current best example of this is YUK, US dollar/Japanese yen, the difference in short-term interest rates is currently approximately 4.25%

Cost of carry for equity options compared to forward pricing

- Essentially, the cost of carrying for an equity instrument is equivalent to forward pricing for foreign exchange instruments
- In equity option pricing the cost of carrying a position is in relation to the dividends paid by the underlying security. For large dividend paying stocks (MO is a good example), the nearterm puts will reflect the dividend amount by increasing the value of the puts relative to the calls



Forward price example

- July 119 YUK strike price, 87 days until expiration, US short term (prior to the cut in rates) interest rate is 5.25% and Japan short term interest rate is 0.60%
- 119 (strike price) multiplied with the interest rate differential .04625 (4.625%) multiplied by 87/365 is \$1.31
- If the spot price was 118.73 the forward price for YUK would be approximately 117.42



Option pricing needs the interest rate differential

Spot YUK 118.73 Forward YUK 117.41 (118.73-1.32) 119 Calls 119 Puts 0.95-1.00 2.55-2.60

According to options theory and forward pricing the 119 puts should be 1.59 greater than the calls (in this case they are 1.60 greater)



YUK quotes as of May 16, 2007, spot price is 120.68 (120 strike)

Expiry months	120 calls	120 puts
May	.7580	.1015
June	1.00 - 1.05	.8085
July	1.10 - 1.20	1.70- 1.80
September	1.20 - 1.30	2.45- 2.55
December	1.40 - 1.50	3.90- 4.00



Forecasting Volatility

- Each option trade includes embedded forecasts, not only for the FX pair, the time period, but also for volatility
- Differing strike prices are affected differently by changes in perceived volatility (Vega)
- The longer the time period the greater the impact of volatility (Vega)



U.S dollar/ Canadian dollar (CDD)



INTERNATIONAL SECURITIES EXCHANGE.

U.S. dollar/ yen (YUK)



Volatilities may revert back to their past average price, the mean

- Volatility is normally changing
- What time frame do you use to calculate historical volatilities?
- Question is when will it revert?



Volatilities for FX options

- Implied FX volatilities are considerably lower than equity option implied volatilities
- Implied FX volatilities are currently less than broad US equity index implied volatilities



Another implied volatility source (ivolatility.com)

	1 month implied volatility	
YUK	8.9%	
CDD	9.0%	
EUI	7.4%	
BPX	7.9%	



Volatilities are dynamic

- Each and every trading day implied volatilities change, be careful...
- FX volatilities are low but remember there isn't any guarantee that they will stay low, or for that fact when and if they will change

Differing prices?

- Market professionals use slightly different pricing models, creating opportunities to trade
- When prices are too high (relative to your expectations) this simply means that there are more buyers than sellers.
- When prices are too low (relative to your expectations) this simply means there are more sellers than buyers
- Pricing differences are based on the aggregation of all market participants future expectations for volatility

Your Forecast: Volatility is "high", and future volatility will be lower than today's

- Buy call vertical or put vertical spread depending on your market forecast to mitigate volatility risk
- Sell out of the money call spread and out of the money put spread (iron condor) with balanced risk
- Sell straddles or strangles albeit with substantially more downside risk
- Buy butterfly spread, buy in the money spread and sell at the money spread (buy 100c, sell 105c, sell 105c buy 110c), assuming the FX pair will close out the strike prices sold



Your Forecast: Volatility is "low", and future volatility will be higher than today's

- Purchase calls or puts
- Buy ratio spread (also called a backspread), buy two out of the money options, sell one at the money
- Buy straddles or strangles hoping to realize increased stock volatility (breakouts) or increased implied volatility
- Buy out-of-the-money call or put spreads assuming the FX pair will move to the strike price selected by expiration



Changing parameters

Increase input	CALL PRICE	PUT PRICE
Strike Price	•	^
Stock Price	^	Ψ
Time Until Expiration	^	^
Risk-free rates US	•	^
Risk-free rates contra	^	\
Volatility	^	^



Assumptions for FX option models

- Stock prices are efficient creating a lognormal distribution
- Interest rates are constant for the two currencies (they actually deviate slightly throughout the term normally)
- Volatility is constant (not always true, especially during stressful market periods)
- Currencies can be borrowed to facilitate hedging (normally true for institutional FX trading firms)
- Markets do not gap (Markets do gap creating difficulty for delta neutral hedging)



Who cares about all this?

- Without variances in interest rates and volatility, options would have no value
- Gaining a better understanding of options pricing allows investors to understand the risk reward tradeoffs
- Pricing is based on the theory that markets are random and efficient
- The Black Scholes model, or similar models, helps give investors guidance on option pricing, it does not guarantee a certain options price



Summary

- The Black-Scholes option pricing model, or similar models, calculates theoretical prices based on currency pair price, strike price, time left until expiration, interest rate differential between the two currencies, and volatility
- Volatility and the interest rate differentials between the currency pairs are the most important option pricing parameters for investors to consider when trading ISE FX Options



Summary

 A better understanding of the pricing model inputs can help investors incorporate your own market expectations with your own risk/return tradeoffs

Commonly asked questions regarding ISE FX Options

- Can I get price charts? Yes, Bigcharts.com has all of the ISE traded pairs available as well as the option chains
- Do the "greeks" work for FX options pricing? Yes, if an investor inputs the correct interest rate and dividend yield (US risk-free rate) option calculators will work, and of course the volatility
- How much do these options cost? Same as equity options, \$1.50 options costs \$150
- How does the term "pips" relate to ISE FX Options. Roughly speaking 100 pips equals 1 ISE point
- What does dollar relative mean? The base currency is the US dollar, if the US dollar increases relative to the foreign currency the value of the pair increases, if the dollar decreases the value of the pair decreases



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