

Basics of FX Options and FX Option Trading Strategies

FX Derivatives Research

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See the end pages of this presentation for analyst certification and important disclosures.

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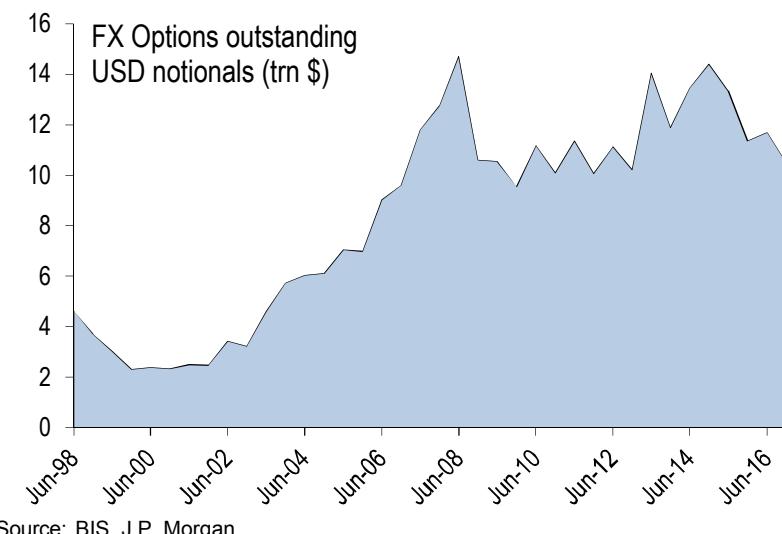
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THE FX OPTIONS MARKET – VOLUMES (source: BIS data, May 2016)

FX Options volume:

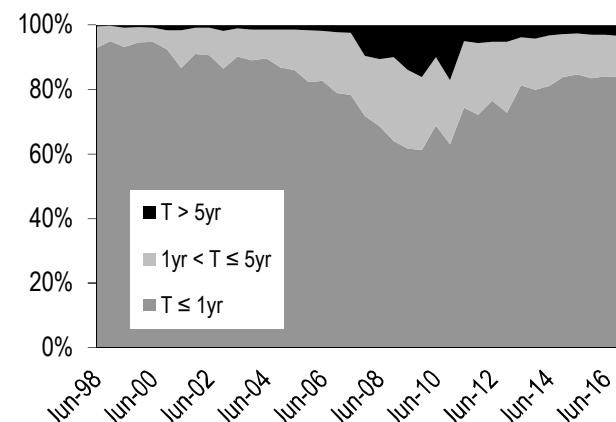
Covers G10 countries + Switzerland

Excluded: Asia, Latam, CEEMEA



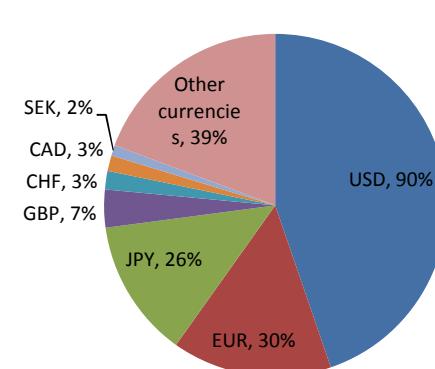
Source: BIS, J.P. Morgan

Maturities:



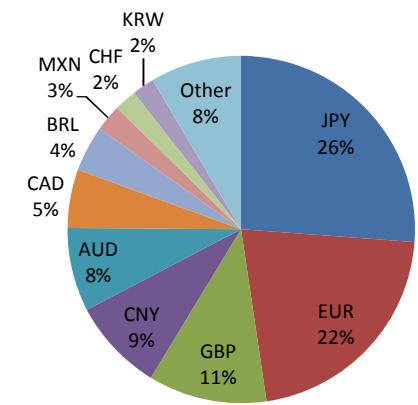
Source: BIS, J.P. Morgan

Outstanding notional by currency



Source: J.P. Morgan

Turnover vs. USD



Market participants:

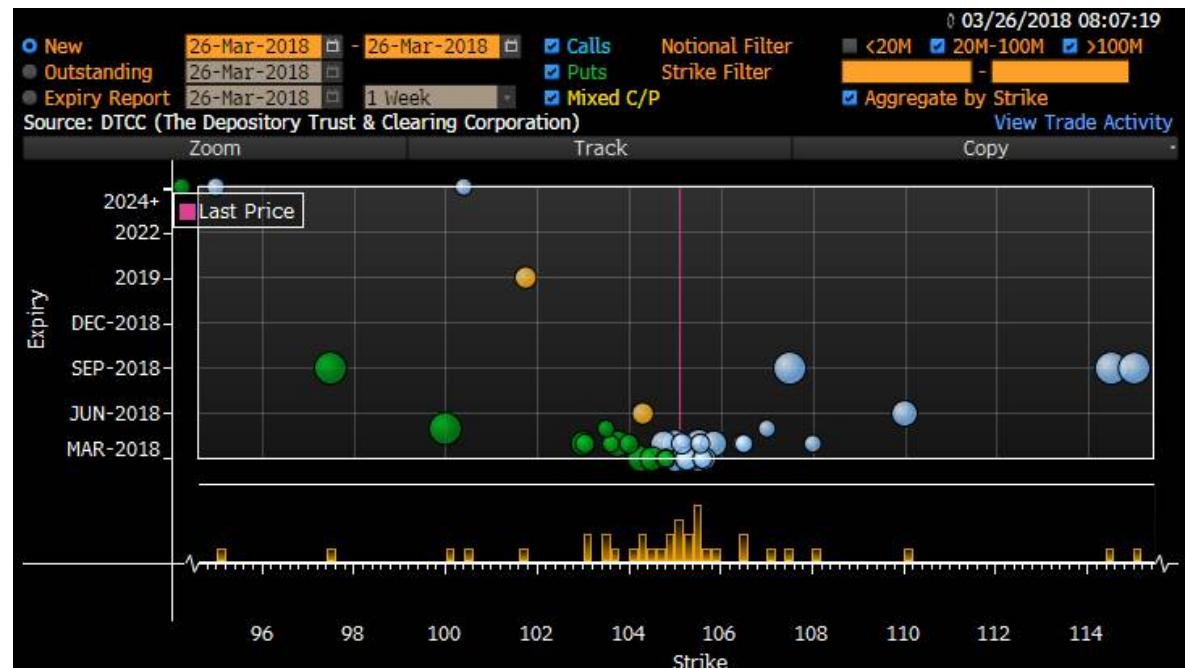
- Market makers
- Institutionals / Hedge funds
- Real Money Managers
- Dealers of structured products
- Corporates
- HNW
- Etc...

Strategies:

- Speculation, alpha P&L generation
- Leveraging macro views
- Hedging
- Monetizing directional views/ranges
- Etc...

OMST (USDJPY Currency) - MARKET POSITIONING (DTCC)

Source: Bloomberg

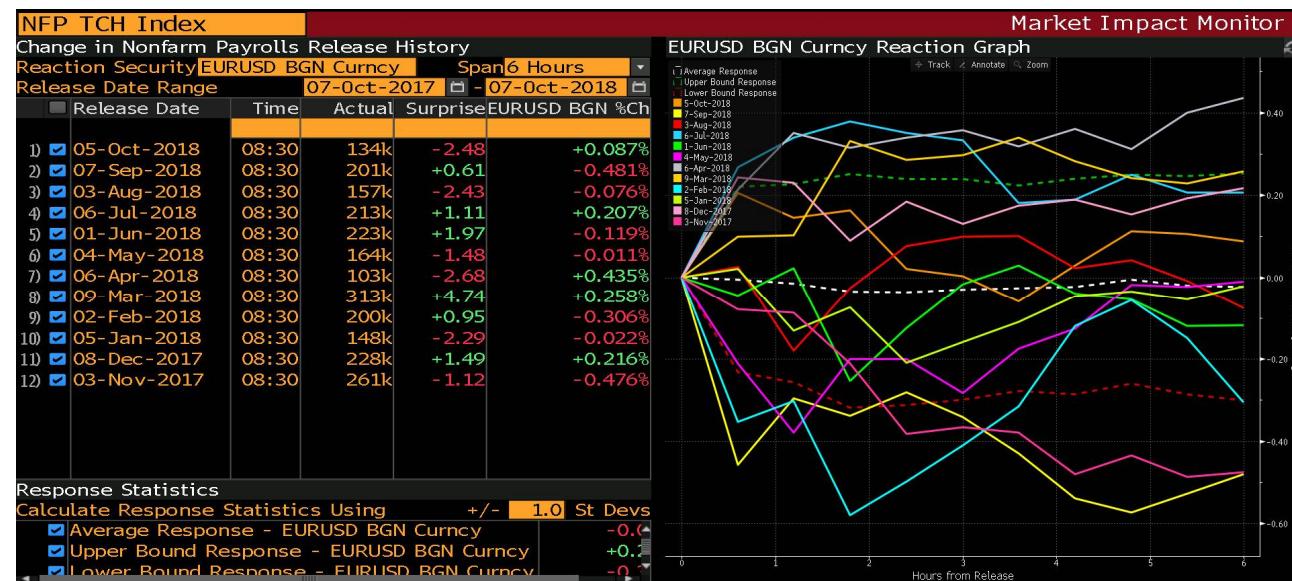


SDRV - DERIVATIVES VOLUMES: (DTCC)

Source: Bloomberg



ECMI



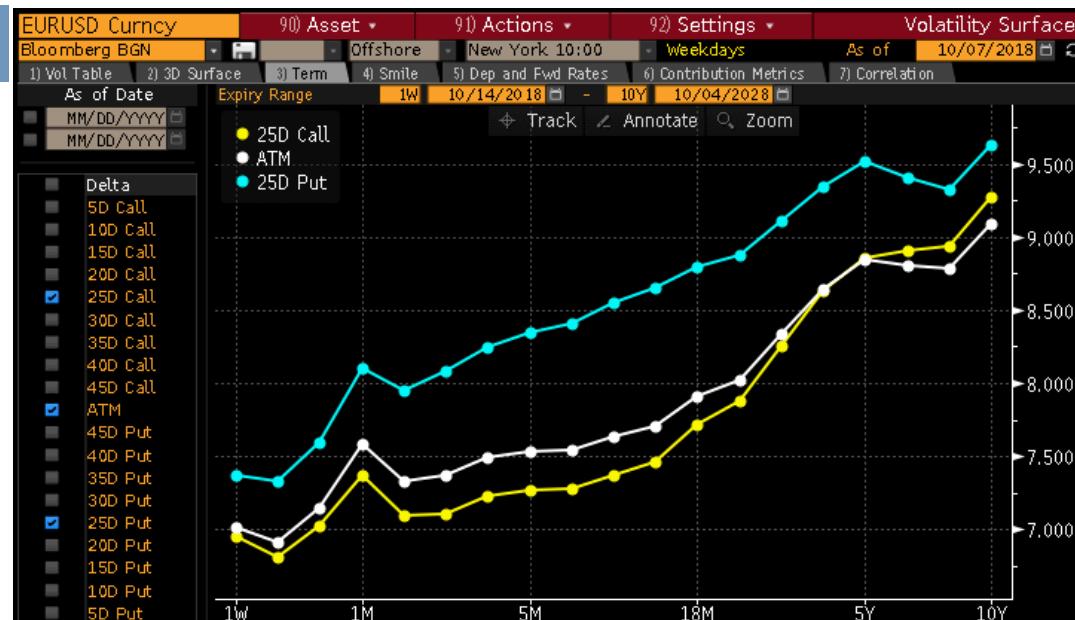
Source: Bloomberg

VOLC



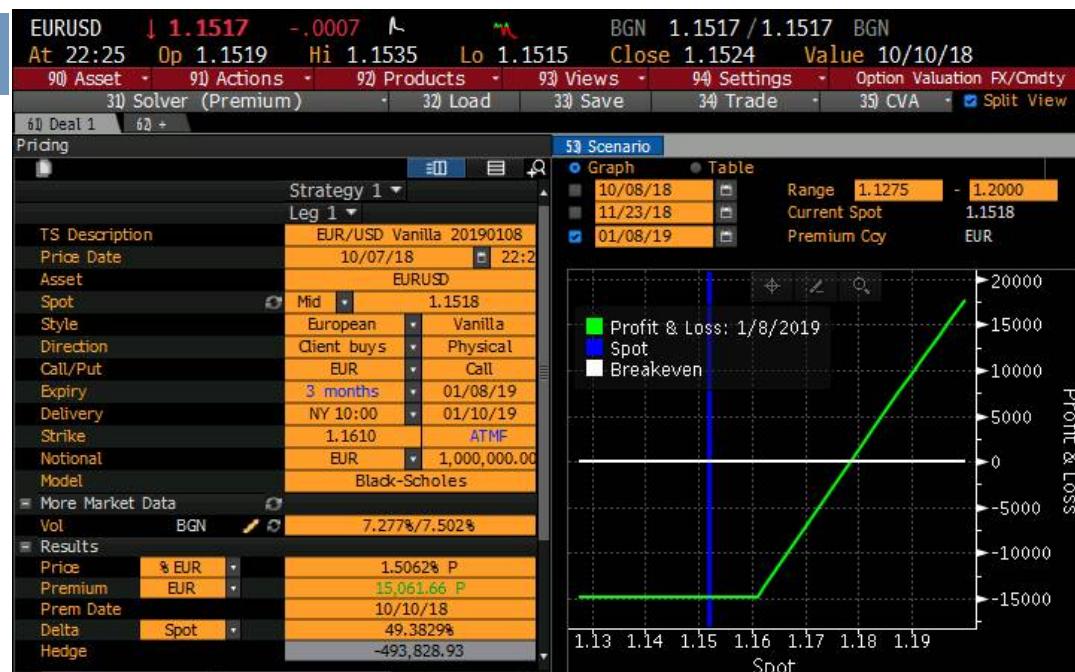
Source: Bloomberg

OVDV



Source: Bloomberg

OVML

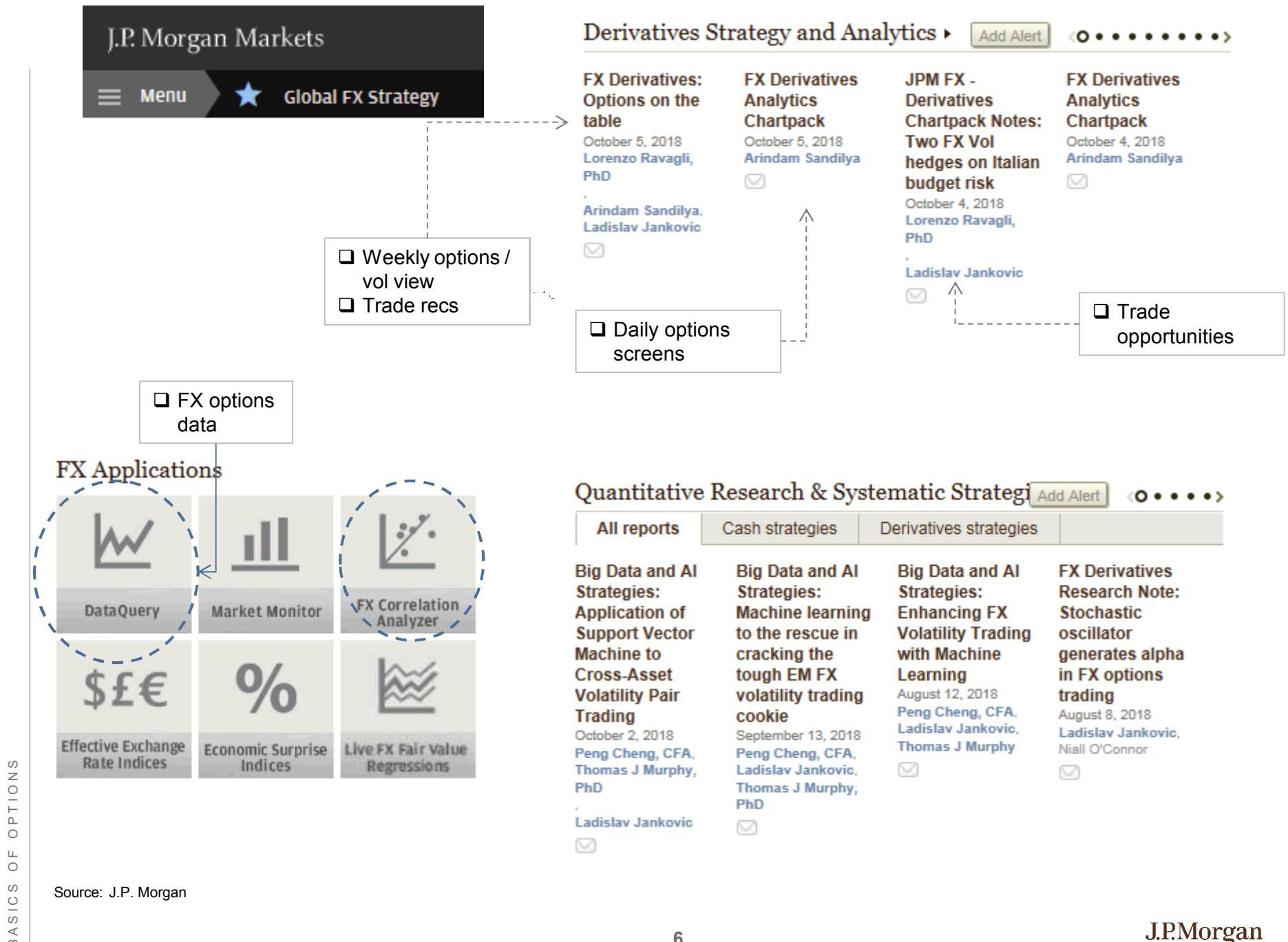


Source: Bloomberg

Options news BBG screens:

- FXvolcol
- FXdrv

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OPTION TERMINOLOGY

Option	The right, but not the obligation, for the holder to buy or sell a certain currency against another, at a certain rate, at/by a certain date in the future.
Call	The right to buy/receive the underlying currency (simultaneously a counter currency put).
Put	The right to sell/deliver the underlying currency (simultaneously a counter currency call).
Strike/Exercise Price	The pre-agreed rate at which currencies are exchanged if the option is exercised.
Exercise	The process by which the right is taken up.
Exercise/Expiry Date	The last date on which the holder of the option may choose to effect the currency transfer at the strike rate. The latest time is usually 10:00 am NY time.
Settlement/Value/ Delivery Date	Options usually settle for spot value. This is most often the second business day after the exercise date, when funds will transfer.
Premium	Option value – usually payable by the option buyer/holder two business days after the transaction date.
European Style	An option which may be exercised only on expiry date with funds to be transferred on the maturity date.
American Style	An option which may be exercised at any time until expiry date with funds to be transferred for spot value from exercise date.
At-the-money forward (spot)	An option whose strike is equal to the current forward outright (spot) price.
In-the-money forward (spot)	An option whose strike is more favorable to the holder than the current forward outright (spot) price.
Out-of-the-money forward (spot)	An option whose strike is less favorable to the holder than the current forward outright (spot) price.

Name	Vanilla Option1
Type	Vanilla Option
Market Date	Mon 14Sep2015
Market State	Mkt2
FX Pair	USD/JPY
Option Type	Call on USD
Expiration Date	Tue 13Sep2016 [365d]
Settlement Date	Thu 15Sep2016
Strike	119.47
Settlement Type	Physical
Settlement Currency	N/A
Expiration Cut	NYC
Quantity Currency	USD
Quantity	100,000,000
Buy/Sell	b - JPM Buys
Spot	120.19/120.21
Forward	119.04/119.08
Forward Point	-1.146/-1.128
Denominated Depo	-0.40
Asset Depo	0.54
Vol for strike	10.259/10.508
ATM Volatility	10.392
Premium Display	% USD
Price(%)	3.8990/4.0134
Price(Pips)	0.00032636/0.00033593
Edge Style	Marked
Edge (%)	0.057
BS+TS TV (%)	3.960
BS+TS TV (Pips)	0.00033142
+ PriceExtra	
BS Delta (%)	46.52
BS Spot Delta (%)	46.52
BS Forward Delta (%)	46.77
Adapted Forward Delta (%)	46.65
Adapted Delta (%)	46.40
Adapted Gamma (%)	4.91
Vega (%)	Sh-F9 to calc
BS Vega (%)	0.40

USER INPUTS

Source: J.P. Morgan

CALL OPTION PAYOFF AT EXPIRATION

Call option payoff = $\text{Max } (S-K, 0)$

where S = price of underlying, K = exercise price

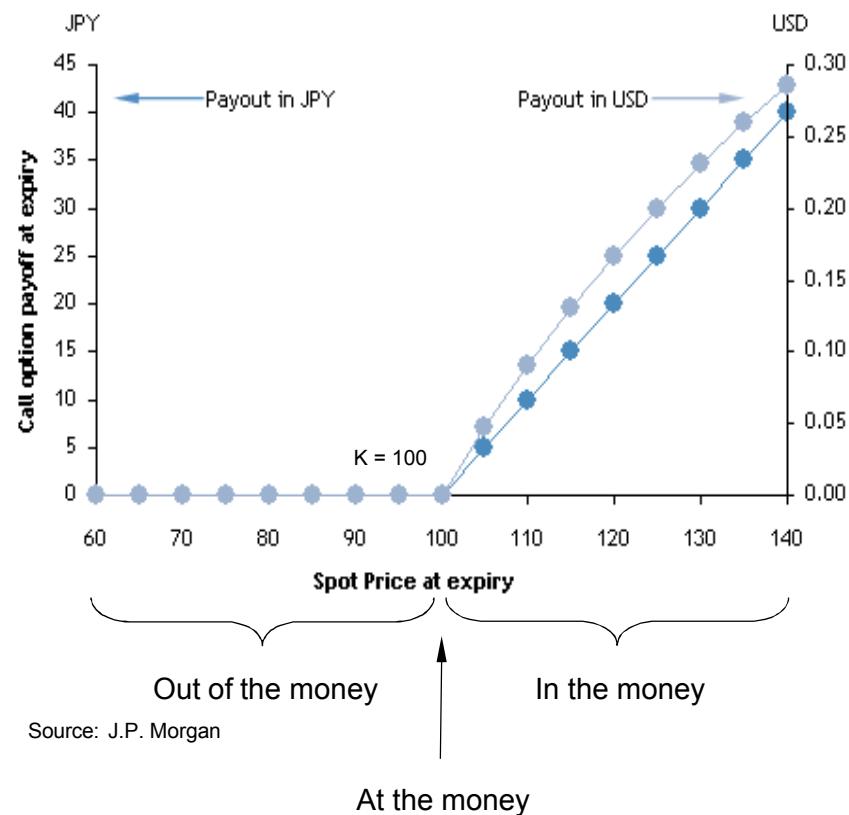
S	$\text{Max } (S-K, 0)$	$\text{Max } (S-K,0)/S$
60	0	0
65	0	0
70	0	0
75	0	0
80	0	0
85	0	0
90	0	0
95	0	0
100	0	0
<hr/>		
105	5	0.0476
110	10	0.0909
115	15	0.1304
120	20	0.1667
125	25	0.2000
130	30	0.2308
135	35	0.2857

Source: J.P. Morgan

Yields payout in numeraire currency pips per unit of asset currency notional e.g. JPY per USD in the case of USD/JPY. To convert JPY payout into USD, divide by the going spot rate at expiry i.e. **USD payout = $\text{max } (S-K,0)/S$**

The linear profile shown below therefore only holds when payout is plotted in numeraire currency pips. The payout profile is **NOT** linear when plotted in terms of the asset currency

An option that delivers a linear payout profile in the asset currency is called a **QUADRATIC** option.



PUT OPTION PAYOFF AT EXPIRATION

Put option payoff = $\text{Max } (K-S, 0)$

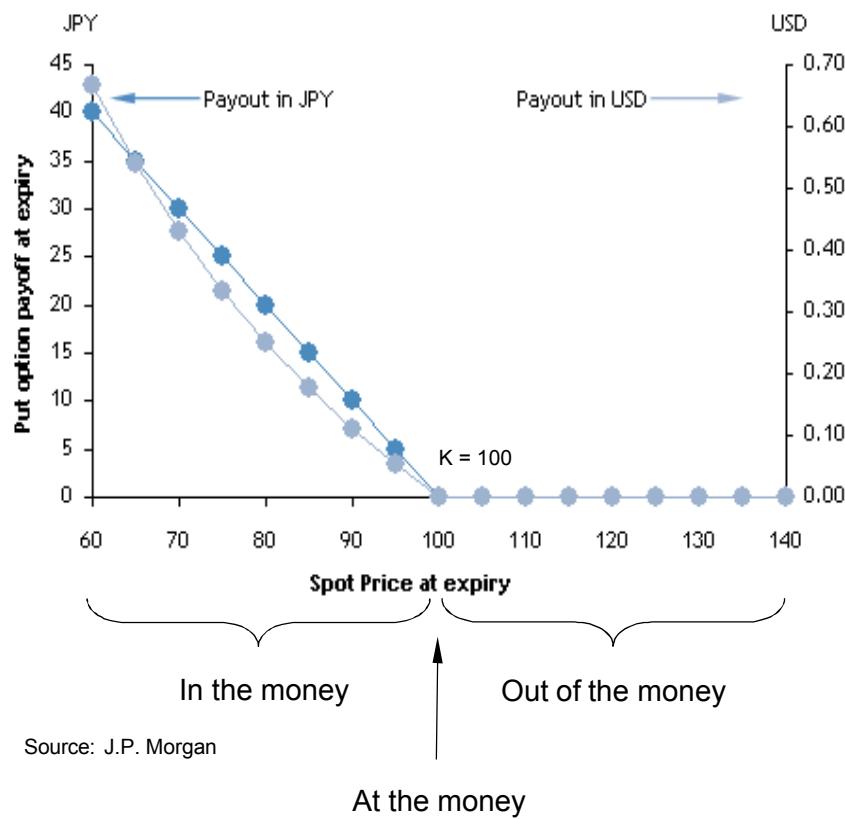
where S = price of underlying, K = exercise price

S	$\text{Max } (K-S, 0)$	$\text{Max } (K-S, 0)/S$
60	40	0.6667
65	35	0.5385
70	30	0.4286
75	25	0.3333
80	20	0.2500
85	15	0.1765
90	10	0.1111
95	5	0.0526
<hr/>		
100	0	0
105	0	0
110	0	0
115	0	0
120	0	0
125	0	0
130	0	0
135	0	0

Yields payout in numeraire currency pips per unit of asset currency notional e.g. JPY per USD in the case of USD/JPY. To convert JPY payout into USD, divide by the going spot rate at expiry i.e. **USD payout = $\text{max } (K-S, 0)/S$**

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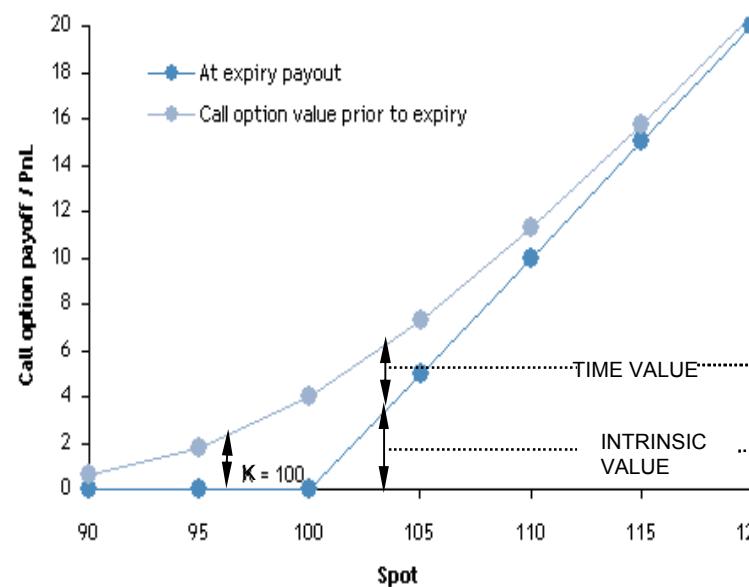
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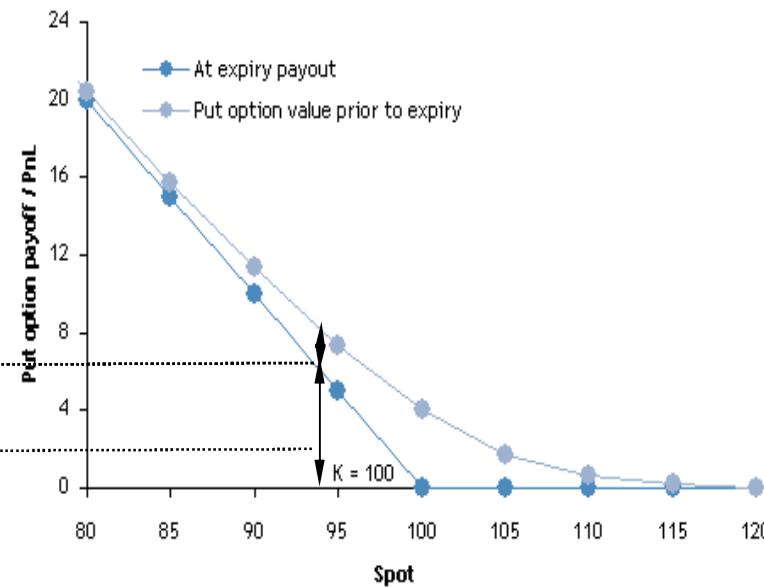
Source: J.P. Morgan

INTRINSIC VALUE AND TIME VALUE

- Prior to expiration, call options trade at prices higher than their “in-the-moneyness”, also referred to as their intrinsic value.
 - Intrinsic value of an in-the-money call = $S - K$
 - Intrinsic value of an in-the-money put = $K - S$
 - Intrinsic value of out of the money options = 0
- The difference between the option value and the intrinsic value is the time value of the option. Time value represents the additional value of an option due to the opportunity for the intrinsic value of the option to increase.
- Option Value = Intrinsic value + Time value**



Source: J.P. Morgan



Source: J.P. Morgan

OPTION PREMIUM QUOTATION

Conventions

Assume that USD/JPY is the currency pair of interest.

- USD is referred to as the base or **asset** currency, JPY is referred to as the terms or **numeraire** currency
- Option premium can be expressed in
 - **Percent of asset currency notional (% USD)**
 - Percent of numeraire currency notional (% JPY)
 - Units of numeraire currency per unit notional of the asset currency (JPY per USD)
 - Units of asset currency per unit notional of the numeraire currency (USD per JPY)

Example

The two-way premium of a **6M 90** strike USD put / JPY call (spot **90.25**) in \$10MM may be expressed as:

1. 4.07 – 4.17% \$
2. 4.08 – 4.19% ¥
3. ¥ 3.6775 – 3.7710 per \$
4. \$ 0.045250 – 0.046333 per ¥

- Buy Option in \$ 10MM : Premium = \$ 417,000
- Buy Option in ¥ 900MM : Premium = ¥ 37,710,000
- Buy Option in \$ 10MM : Premium = ¥ 37,710,000
- Buy Option in ¥ 900MM : Premium = \$ 417,000

Conversion from one convention to another

AC = Asset Currency

NC = Numeraire Currency

- $\%AC = \%NC \times \frac{Strike}{Spot}$
- $\%NC = \%AC \times \frac{Spot}{Strike}$
- $NC \text{ per } AC = \%NC \times Strike$
- $AC \text{ per } NC = \frac{\%AC}{Strike}$

In the earlier example, the USD/JPY option is offered at 4.19% JPY, spot is 90.00 and the strike of the option is 90.25; hence the price of the option in JPY per unit USD notional is

$$\text{JPY per USD} = 4.19\% \times 90 = 3.7710$$

or 377 JPY pips per USD

$$\text{NC pips} \rightarrow \% \text{ AC} \rightarrow \% \text{ NC} \rightarrow \text{AC pips} \rightarrow \text{NC pips}$$

$$\times \frac{1}{S_0} \quad \times \frac{S_0}{K} \quad \times \frac{1}{S_0} \quad \times S_0 K$$

PAYOUT vs. P/L PROFILES

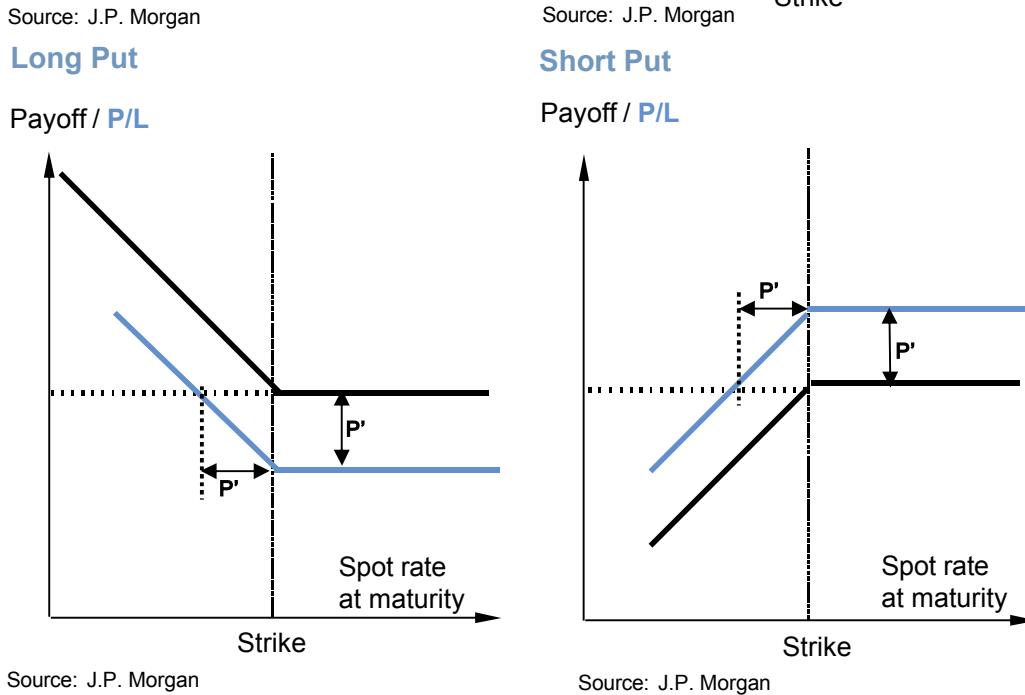
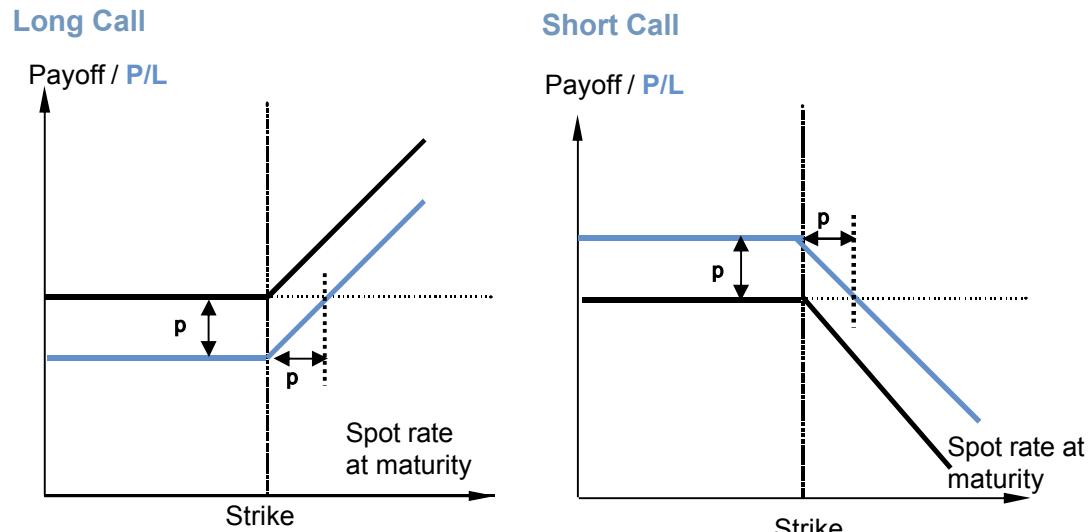
- P/L of an option differs from its payout by the amount of the option premium.
- Because option premium is non-zero, there is a breakeven spot rate only beyond which an option trade makes or loses money at expiry.
- Breakeven spot rates:
 - Call options:** Strike + Premium
 - Put options :** Strike - Premium

Example

Q. What is the breakeven spot rate for a 1.50 strike EUR call/USD put that costs 1.0% EUR? Spot = 1.45

Ans.

- Convert 1.0% EUR to USD per EUR
 - $1\% \text{ USD} = \% \text{ EUR} * \text{Spot} / \text{Strike}$
 $= 1 * 1.45 / 1.50 = 0.97\%$
 - $\text{USD per EUR} = \% \text{ USD} * \text{Strike}$
 $= 0.97\% * 1.50 = 0.0145$
- Breakeven spot rate
 $= \text{Strike} + \text{Premium}$
 $= 1.50 + 0.0145 = 1.5145$



PUT CALL PARITY

Buy a call + sell a put = Synthetic long forward

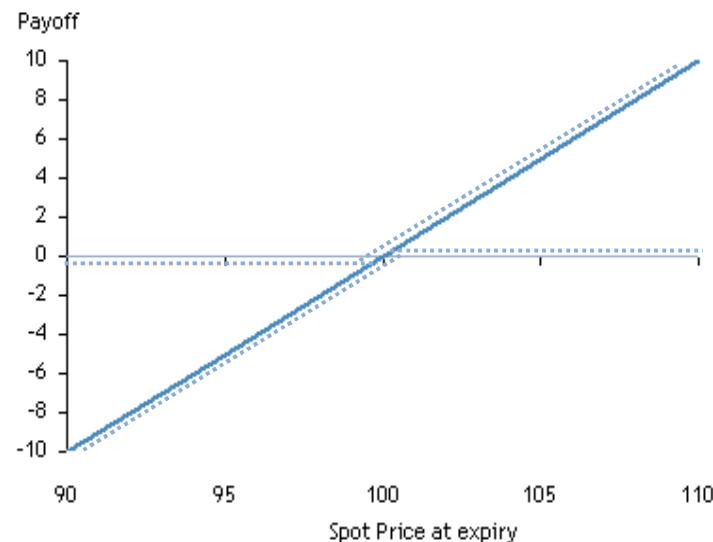
Assume 6M USD/JPY forward is at 100

Consider the following position

- Long a 6M 100 strike USD Call / JPY Put
- Short a 6M 100 strike USD Put / JPY Call

Payout Table

	90	95	100	105	110
A Long USD Call / JPY Put MAX(S-K,0)	0	0	0	5	10
B Short USD Put / JPY Call - MAX(K-S,0)	-10	-5	0	0	0
A+B Long USD Call + Short USD Put	-10	-5	0	5	10
C Long Forward (S - K)	-10	-5	0	5	10

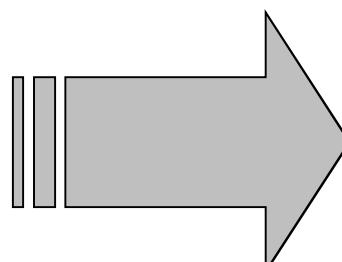


Put-Call Parity Relationship for any strike K

$$C - P = S e^{-r_f T} - K e^{-r_d T}$$

or, given that $F = S e^{(r_d - r_f)T}$

$$C - P = e^{-r_d T} (F - K)$$



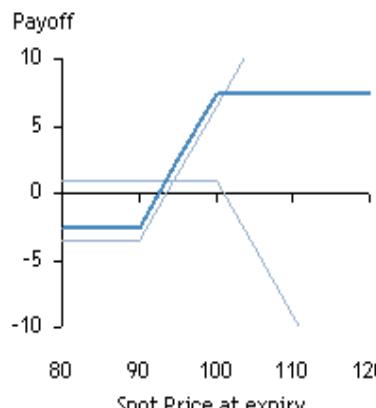
Implications

- One can replicate any of (put, call, forward) using the other two instruments
- ATMF calls and puts have the same price (plug $F = K$ in the second put call parity expression)

BASIC OPTION STRATEGIES

Call Spread

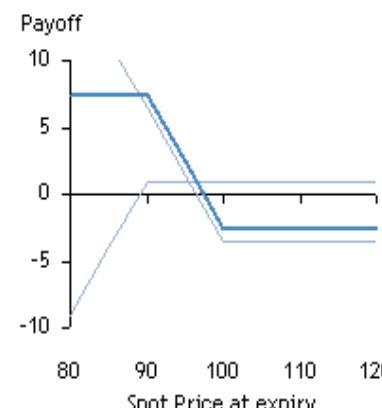
Long 90 Call + Short 100 Call



Source: J.P. Morgan

Put Spread

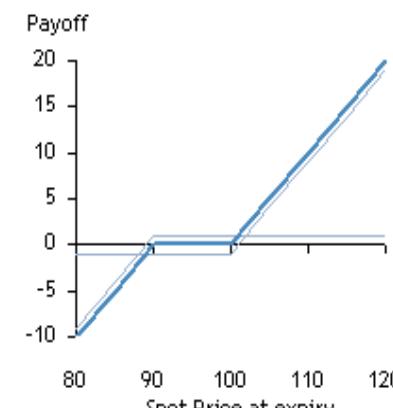
Long 100 Put + Short 90 Put



Source: J.P. Morgan

Risk-Reversal

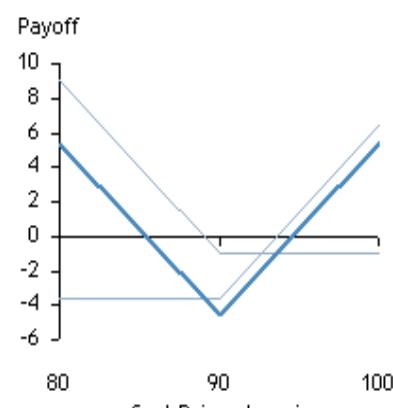
Long 100 Call + Short 90 Put



Source: J.P. Morgan

Straddle

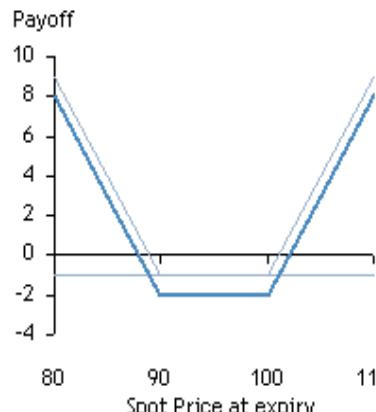
Long 90 Call + Long 90 Put



Source: J.P. Morgan

Strangle

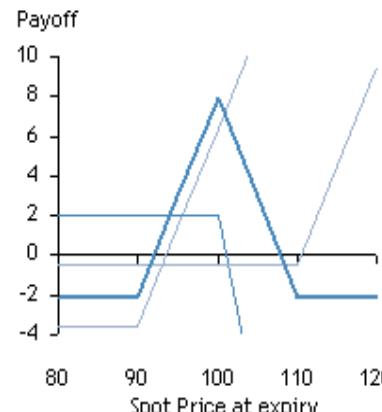
Long 90 Put + Long 100 Call



Source: J.P. Morgan

Butterfly

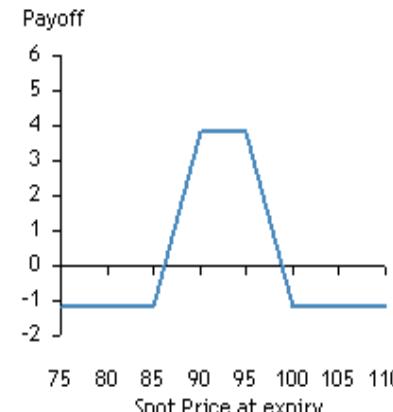
Long 90 Call + 2* Short 100 Call + Long 110 Call



Source: J.P. Morgan

Condor

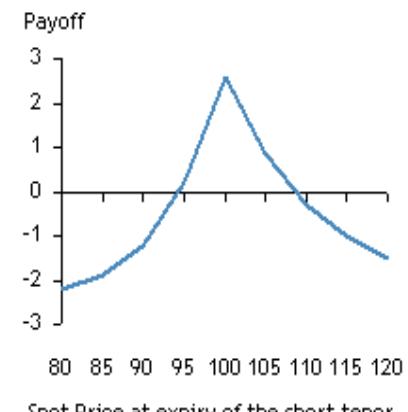
Long 85 Call + Short 90 Call + Short 95 Call + Long 100 Call



Source: J.P. Morgan

Calendar Spread

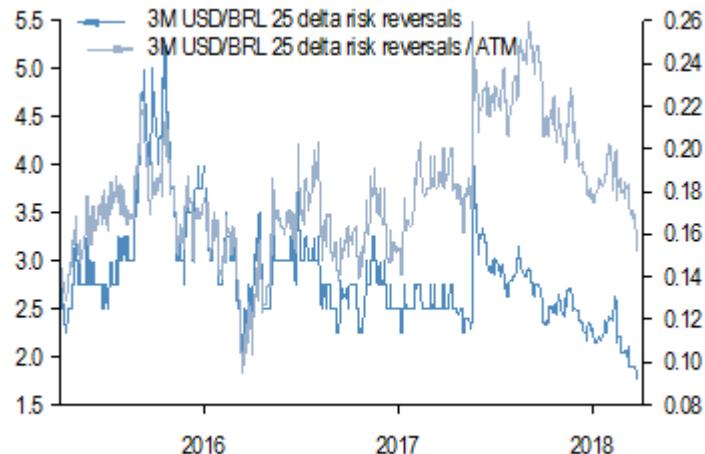
Short 3M 100 Call + Long 1Y 100 Call



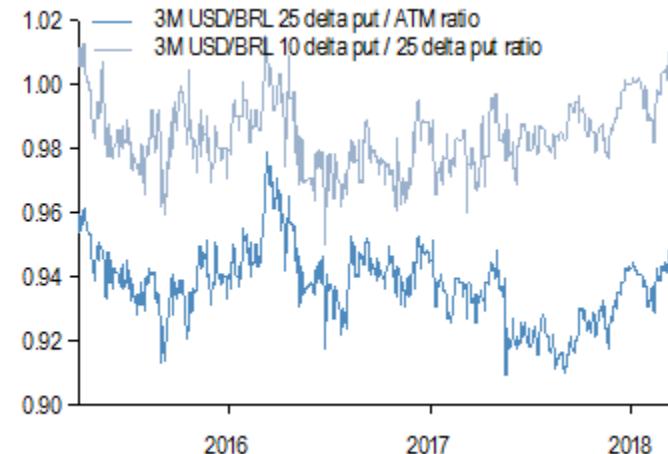
Source: J.P. Morgan

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BASIC OPTION STRATEGIES



Source: J.P. Morgan



Source: J.P. Morgan

Pair	Spot	Ten	OT	Structure					
USD/BRL	3.3129	3M	Put	1X1					
K Near	K Far	P Near (bp)	P Far (bp)	Spread Price (bp)	Max Payout (bp)	Max Payout Cost Ratio	Discount To Outright Vanilla	Net Delta	Net Vega (bp)
3.2941	3.2282	164	88	76	204	2.69	54%	-16	3.2
3.2941	3.1953	164	64	100	309	3.10	39%	-23	5.5
3.2612	3.1623	125	46	79	313	3.97	37%	-20	6.7
3.2282	3.1294	93	32	60	316	5.22	35%	-16	7.0

Source: J.P. Morgan

Agenda

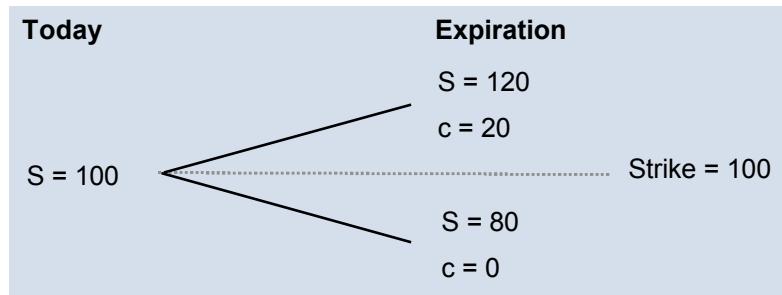
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HOW TO PRICE AN OPTION: ARBITRAGE-FREE PRICING

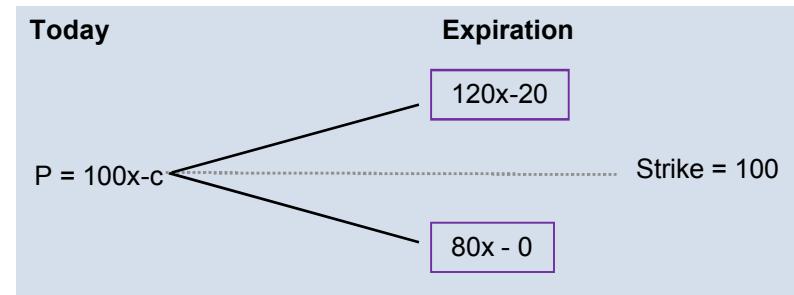
- As a trader, assume you are **short** (i.e. you sell) a **call**. How would you structure a portfolio (one short call + x units of stock) such that you are *perfectly hedged in both up and down scenarios*?

Outcomes for the stock process



Source: J.P. Morgan

Delta-Hedged portfolio: $P = xS - c$



Source: J.P. Morgan

- To be *perfectly hedged*: $120x-20 = 80x$, or $x = 0.50$. i.e. buy 1/2 a share of stock. In both up and down scenarios, portfolio payoff = \$40. **The portfolio is thus riskless**, assured of a \$40 payoff irrespective of the state of the world.
- A riskless portfolio should earn the riskless rate of interest (no-arbitrage condition).** Thus, the PV of the portfolio is the **discounted** value of the portfolio value at expiry, at the risk-free rate (1% in our example):
 - $100x0.5 - c = \$40 / (1+0.01)$
 - Thus, $c = \$10.39$

NO PROBABILITIES WERE NECESSARY – ONLY THE “NO ARBITRAGE” PRINCIPLE IS NEEDED

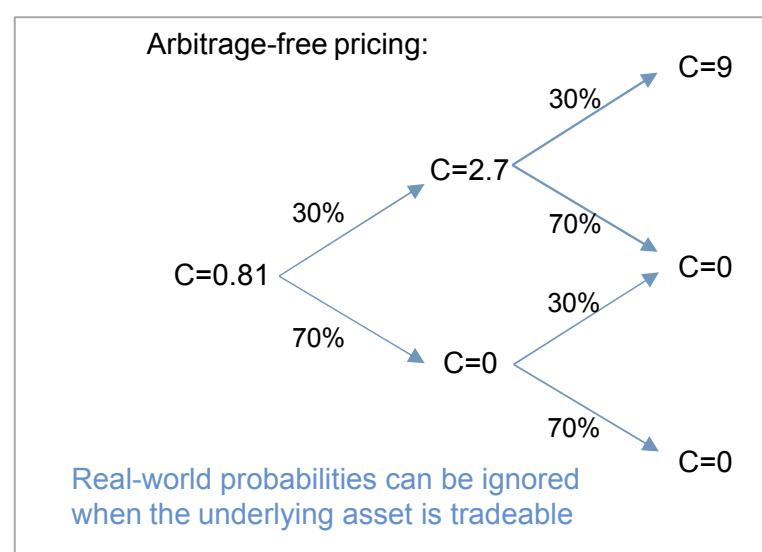
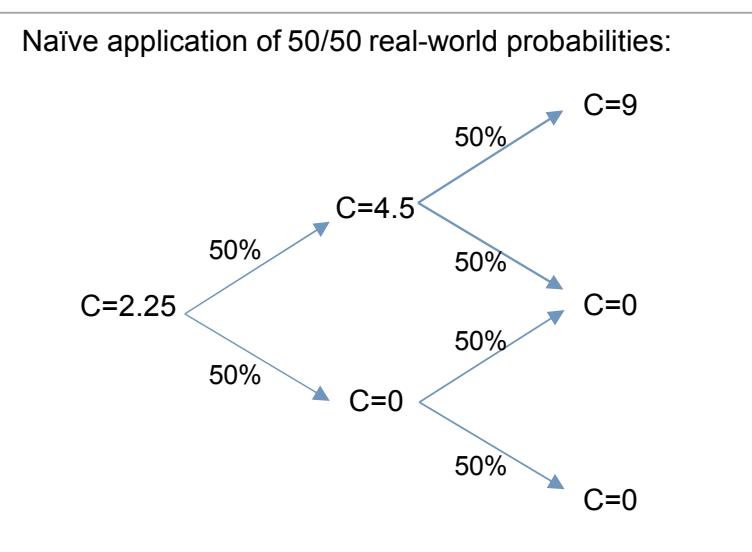
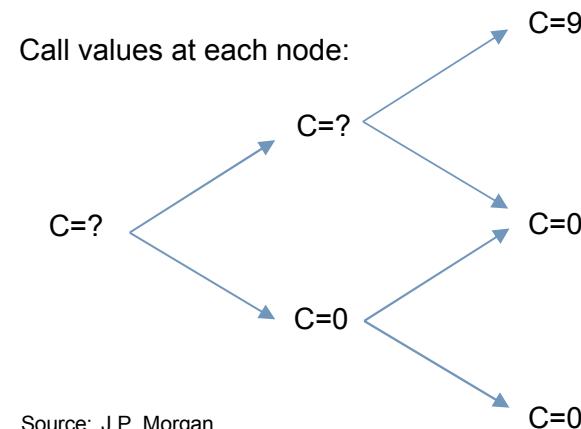
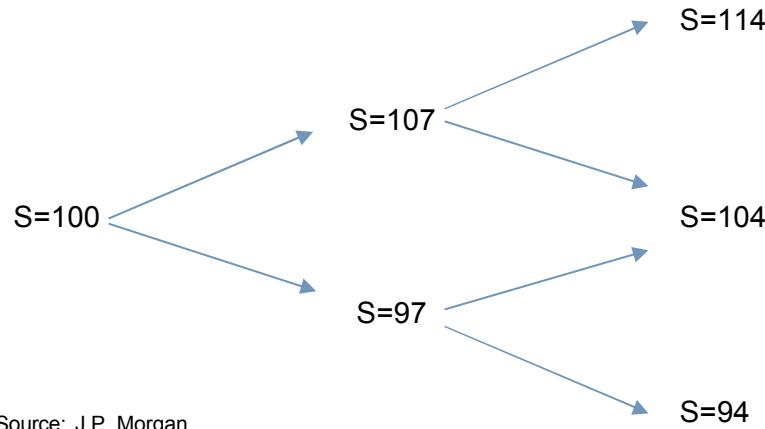
RISK-NEUTRAL PROBABILITIES DERIVED FROM OPTION PRICES

Although no probabilities are required for pricing options, “risk-neutral” probabilities may be estimated

- A “risk-neutral” world is one where investors care only about expected returns, not the risk associated with earning these returns
- **In a risk-neutral world, all assets will earn the risk-free rate**
- Let:
 - p = probability of an up move
 - $q = 1-p$ = probability of a down move
 - r = risk-free interest rate
- $S_0 = \{ S_{\text{up}} p + S_{\text{down}} q \} / (1 + r)$
 - In our example $S_0 = 100$, $S_{\text{up}} = 120$, $S_{\text{down}} = 80$, $r = 1\%$
 - $p = 0.525$; $q = 0.475$
- Since the **call option also earns the riskless rate of return**, its value is the discounted value of the expected payoff:
 - call premium = $(0.525 * \$20 + 0.475 * \$0) / 1.01 = \$10.39$
- Risk-neutral probabilities are a mathematical trick that provides an intuitive way to price options. **Our intuitive valuation of options as the discounted value of expected payoffs is true when using so-called “risk-neutral” probabilities**

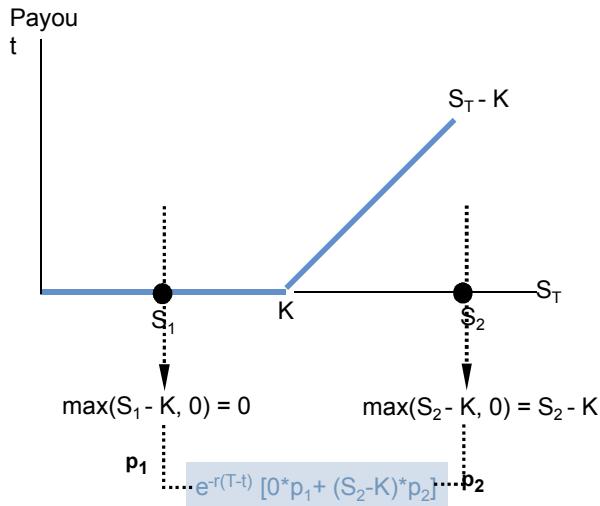
PRICING BY BACKPROPAGATION: STARTING FROM TERMINAL PAYOFFS

Scenario: The Governor sets the price of an asset S at every step, by flipping a fair coin.
 What is the price of a 105 call option expiring in 2 periods, if interest rate is 0?



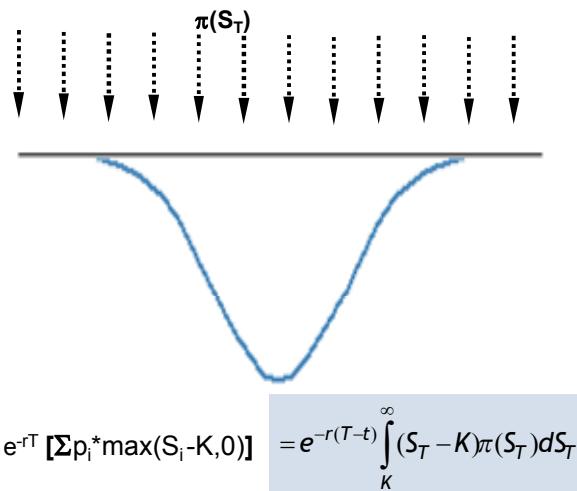
BLACK SCHOLES OPTION PRICING

Risk-neutral option pricing in a two-state world



Source: J.P. Morgan

Risk-neutral option pricing in a continuous world



Source: J.P. Morgan

Notations

- S_0 = Spot rate at inception (expressed in Asset / Numeraire , or Foreign Ccy /Domestic Ccy)
- K = Strike
- T = Time to maturity in years
- r_f = Asset (foreign) ccy interest rate (not in original BS)
- r_d = Numeraire (domestic) ccy interest rate
- σ = Volatility (in %, annualized)

FX Option Pricing Formulas

Price of a Call option

$$c = S_0 \exp(-r_f T) \mathbb{N}(d_1) - K \exp(-r_d T) \mathbb{N}(d_2)$$

Price of a Put option

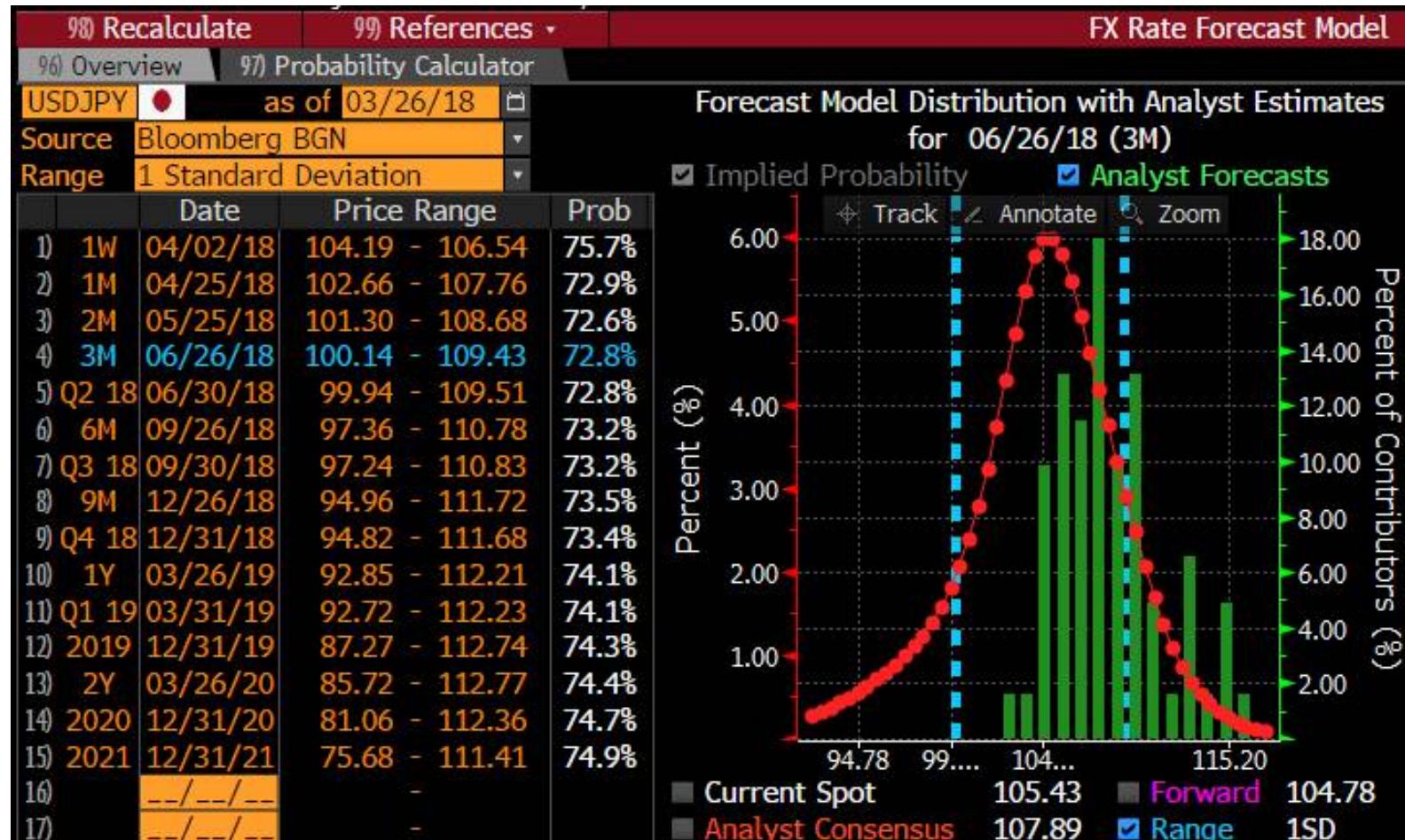
$$p = K \exp(-r_d T) \mathbb{N}(-d_2) - S_0 \exp(-r_f T) \mathbb{N}(-d_1)$$

where

- $d_1 = \frac{\ln(S_0/K) + (r_d - r_f + \sigma^2/2)T}{\sigma\sqrt{T}}$
- $d_2 = d_1 - \sigma\sqrt{T}$
- $\mathbb{N}(z)$ is the normal cdf given by $\frac{1}{\sqrt{2\pi}} \int_{-\infty}^x e^{-\frac{z^2}{2}} dz$

OPTION IMPLIED DISTRIBUTIONS ON BLOOMBERG

FXFM



Source: Bloomberg

FACTORS AFFECTING OPTION VALUE – FIRST LOOK AT “THE GREEKS”

There are six factors that affect the value of an option at inception.
Here are the sensitivities of calls and puts to each of them:

	European		American	
Factor	Call	Put	Call	Put
Underlying Price (DELTA)	+	-	+	-
Strike	-	+	-	+
Volatility (VEGA)	+	+	+	+
Risk-Free Domestic Rate	+	-	+	-
Time to Maturity (THETA)	+	+ / -	+	+
Foreign Interest Rate (equivalent to dividends for equity options)	-	+	-	+

The key driver of option price

Can you think of a situation when increasing the time to maturity lowers the value of a put option?

Source: J.P. Morgan

Agenda

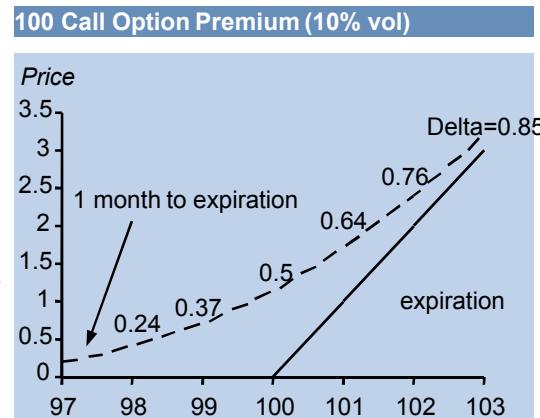
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J.P.Morgan

DELTA

Call Deltas

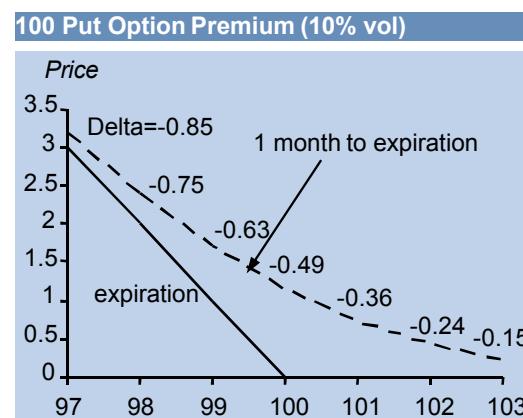
- Increase as the underlying price increases
- Can be interpreted as the probability that the option will finish in the money



Source: J.P. Morgan

Put Deltas

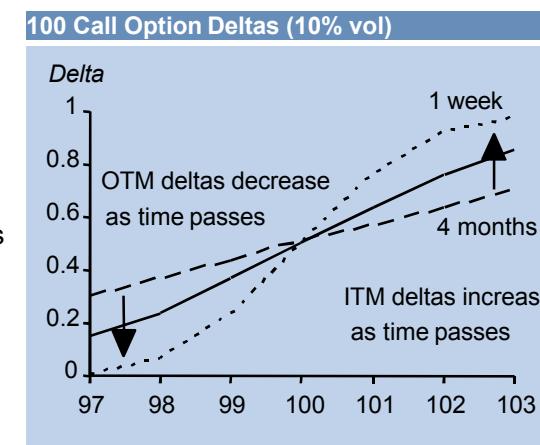
- Increase as the underlying price increases
- Can be interpreted as -1 times the probability that the option will finish in the money



Source: J.P. Morgan

As time passes,

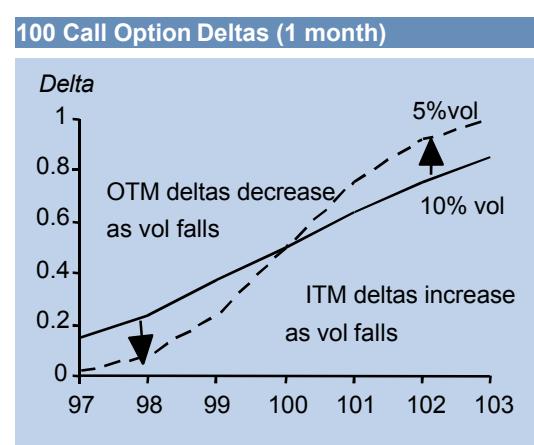
- The delta of ITM options increases
- The delta of OTM options decreases



Source: J.P. Morgan

As volatility falls,

- The delta of ITM options increases
- The delta of OTM options decreases



Source: J.P. Morgan

DELTA S – BLACK-SCHOLES VS REAL (“ADAPTED”)

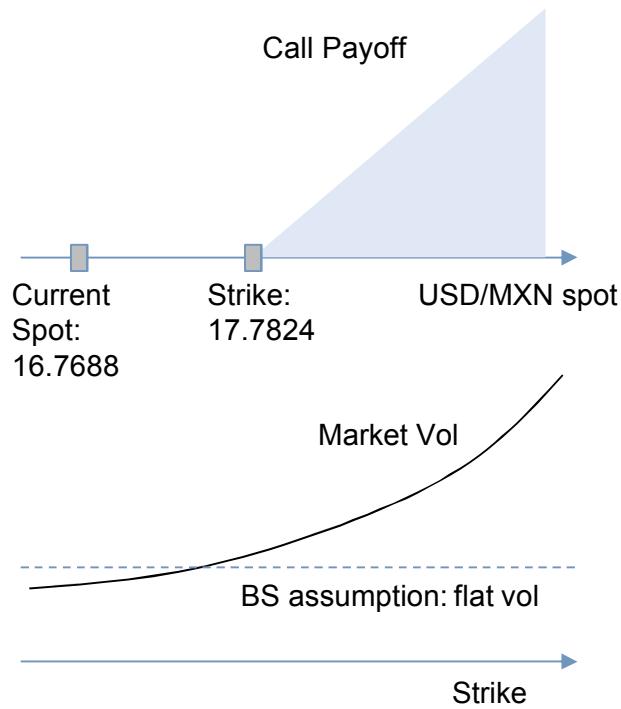
Consider a 3M 25D Call on USD/MXN

Black-Scholes Delta is 25%.

Adapted Delta – the “real delta”, thus the actual FX hedge, taking into account the shape of the vol smile, is lower (19%)

The opposite is true for the Put: real delta is larger than 25% in absolute value.

Why?

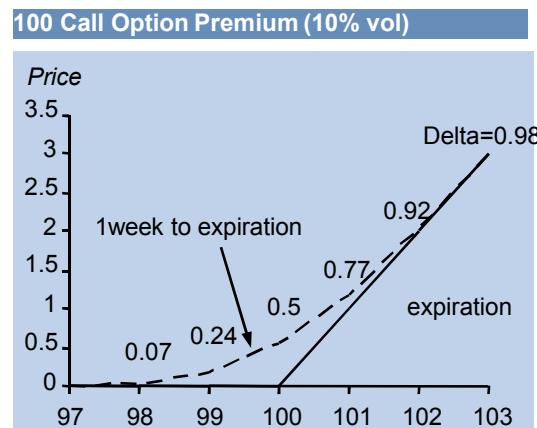


Source: J.P. Morgan

FX Pair	USD/MXN	USD/MXN
Option Type	Call on USD	Put on USD
Expiration Date	Wed 16Dec2015 [92d]	Wed 16Dec2015 [92d]
Settlement Date	Fri 18Dec2015	Fri 18Dec2015
Strike	17.7824	16.1819
Settlement Type	Physical	Physical
Settlement Currency	N/A	N/A
Expiration Cut	MXN	MXN
Quantity Currency	USD	USD
Quantity	100,000,000	100,000,000
Buy/Sell	b - JPM Buys	b - JPM Buys
Spot	16.7688	16.7688
Forward	16.8848	16.8848
Forward Point	0.1160	0.1160
Denominated Depo	3.08	3.08
Asset Depo	0.34	0.34
Vol for strike	15.250	12.598
ATM Volatility	13.475	13.475
Premium Display	% USD	% USD
Price(%)	1.1665	0.9258
Price(Pips)	0.000656	0.000572
Edge Style	Choice	Choice
Edge (%)	0.000	0.000
BS+TS TV (%)	0.885	1.065
BS+TS TV (Pips)	0.000498	0.000658
+ PriceExtra		
BS Delta (%)	25.00	-25.00
BS Spot Delta (%)	24.98	-24.98
BS Forward Delta (%)	25.00	-25.00
Adapted Forward Delta (%)	19.10	-26.70
Adapted Delta (%)	19.09	-26.67
Adapted Gamma (%)	3.17	6.10

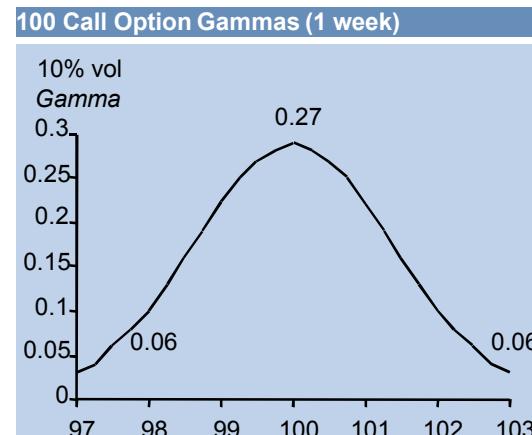
GAMMA

Gamma is the change in delta for one unit move in the underlying.



Source: J.P. Morgan

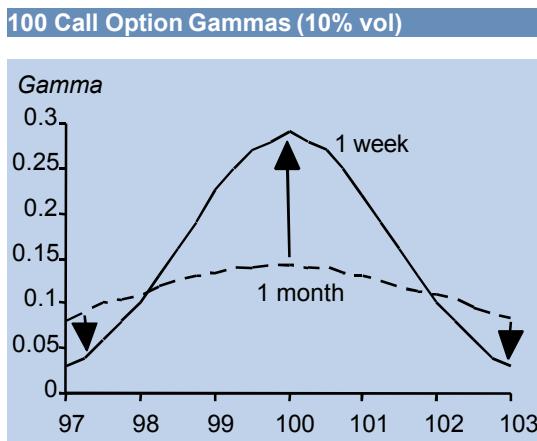
ATM options have the largest gamma.



Source: J.P. Morgan

As time passes,

- The gamma of an ATM option increases
- The gamma of deep ITM and OTM options decreases

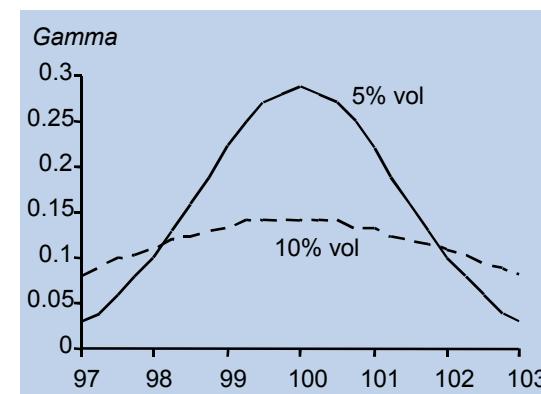


Source: J.P. Morgan

As volatility falls,

- The gamma of an ATM option increases
- The gamma of deep ITM and OTM options decreases

100 Call Option Gammas (1 month)

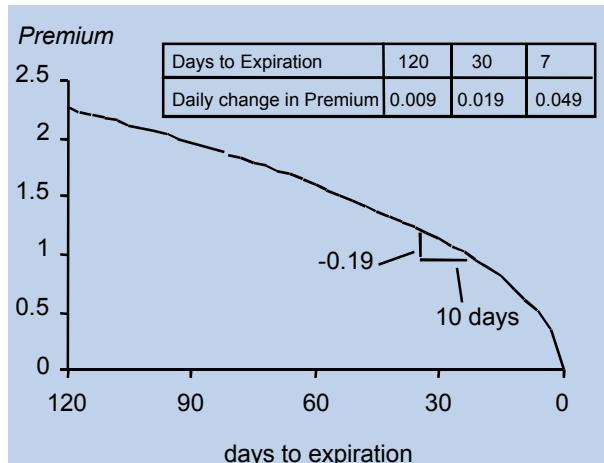


Source: J.P. Morgan

THETA

Theta is the change in the value of an option with one day's passage of time.

ATM Call Option Premium (10% vol)

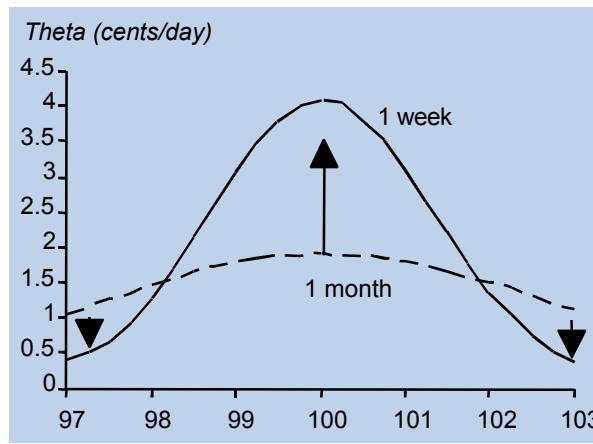


Source: J.P. Morgan

As time passes,

- The theta of an ATM option increases
- The theta of deep ITM and OTM options decreases

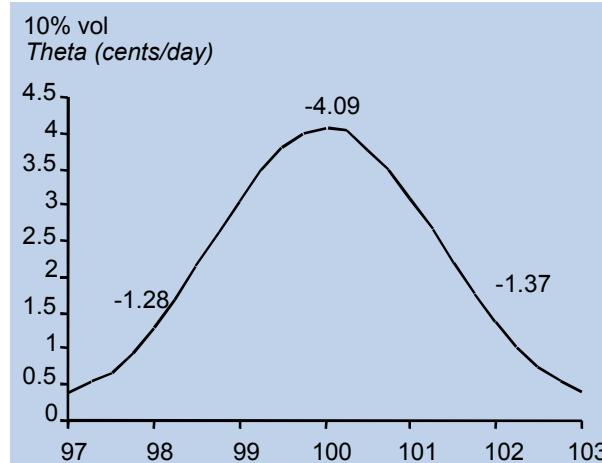
100 Call Option Thetas (10% vol)



Source: J.P. Morgan

ATM options have the largest time value and the largest theta.

100 Call Option Thetas (1 week)

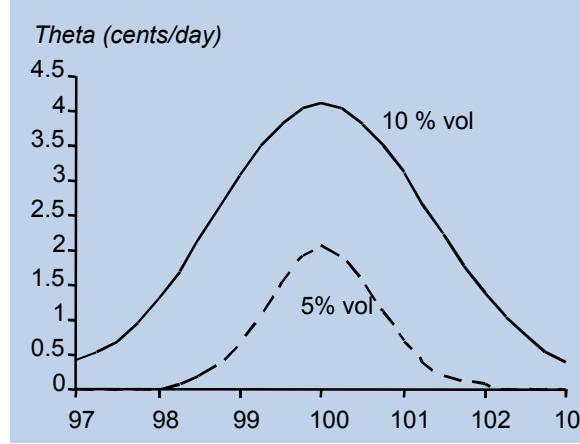


Source: J.P. Morgan

As volatility falls,

- Time value declines
- Theta declines

100 Call Option Thetas (1 week)

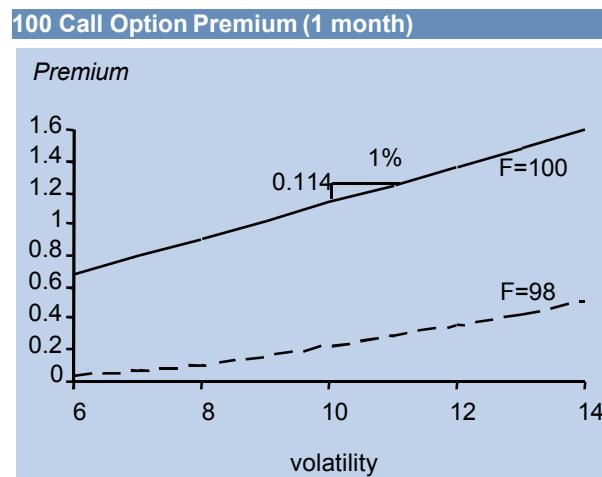


Source: J.P. Morgan

J.P.Morgan

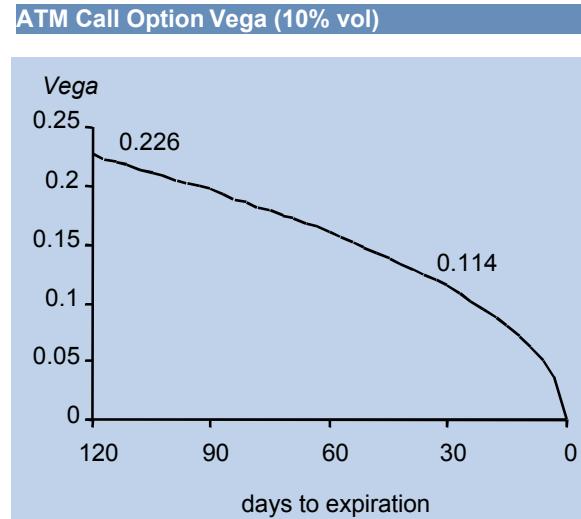
VEGA

Vega is the change in the price of an option for a one percentage point increase in implied volatility.



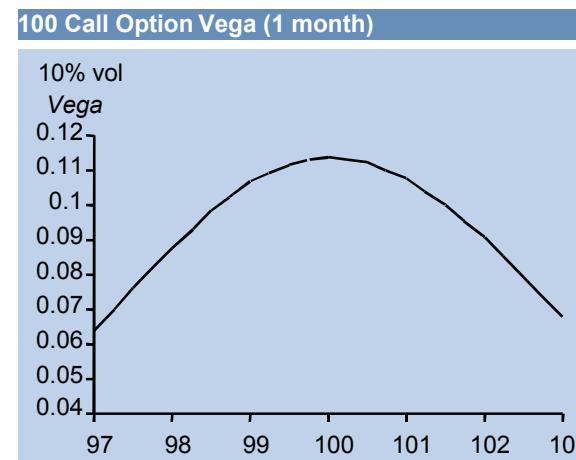
Source: J.P. Morgan

- As time passes,
 - vega decreases



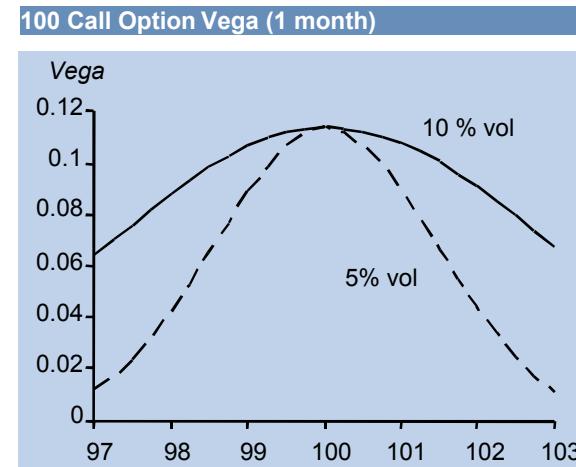
Source: J.P. Morgan

ATM options have the largest vega.



Source: J.P. Morgan

- As volatility falls,
 - Vega decreases for ITM and OTM options
 - Vega is unchanged for ATM options



Source: J.P. Morgan

J.P.Morgan

PUTTING THE GREEKS TOGETHER

- Given the Greeks of an option, it is possible to decompose the one-period change in price of an option into the impact of different variables:

- Delta P/L = Delta * Change in spot
- Gamma P/L = $(1/2) * \text{Gamma} * (\text{Change in spot})^2$
- Theta P/L = Theta * Time Elapsed
- Vega P/L = Vega * Change in Implied Vol

$$\text{Net P/L} = \text{Delta P/L} + \text{Gamma P/L} + \text{Theta P/L} + \text{Vega P/L}$$

Example:

Q. You are long a 6M 99 strike USD/JPY put. Spot is 98. The option Greeks are as follows: delta = 43, gamma = 5, theta = -2bp/day, vega = 28bp. What is the change in price of the option if spot USD/JPY rallied 1% over the next day, assuming that the volatility of the option declined 0.4 percentage points as a result?

A. Change in spot = 1% = 100bp

$$\text{Delta P/L} = 0.43 * 100 = 43.0\text{bp}$$

$$\text{Gamma P/L} = (1/2) * (5) * (1)^2 = 2.5\text{bp}$$

$$\text{Theta P/L} = -2\text{bp/day} * 1 \text{ day} = -2.0\text{bp}$$

$$\text{Vega P/L} = 28 * -0.4 = -11.2\text{bp}$$

$$\text{Net P/L} = 32.3\text{bp}$$

OPTION PORTFOLIOS

- A single long call option position has
 - Positive DELTA
 - Positive GAMMA
 - Negative THETA
 - Positive VEGA
- A single long put option position has
 - Negative DELTA
 - Positive GAMMA
 - Negative THETA
 - Positive VEGA
- For a portfolio of options, notional-weighted Greeks are additive. Suppose, a portfolio is long two options, in notionals N_1 and N_2
 - Portfolio Delta = $N_1 * \text{Delta}_1 + N_2 * \text{Delta}_2$
 - Portfolio Gamma = $N_1 * \text{Gamma}_1 + N_2 * \text{Gamma}_2$
 - Portfolio Theta = $N_1 * \text{Theta}_1 + N_2 * \text{Theta}_2$
 - Portfolio Vega = $N_1 * \text{Vega}_1 + N_2 * \text{Vega}_2$
- Can you construct option portfolios that are:
 - Delta-neutral but long gamma?
 - Positive delta but neutral-gamma?
 - Positive gamma but negative vega?

Hint: Greeks vary for different options of the same tenor / different strikes, and for options of the same strike / different tenors

BASICS OF GAMMA TRADING

$$\Delta p = \frac{\partial p}{\partial S} \Delta S + \frac{\partial p}{\partial \sigma} \Delta \sigma + \frac{\partial p}{\partial t} \Delta t + \frac{\partial p}{\partial r_H} \Delta r_H + \frac{\partial p}{\partial r_F} \Delta r_F + \frac{1}{2} \frac{\partial^2 p}{\partial S^2} \Delta S^2 + \dots$$

DELTA VEGA THETA RHO GAMMA

Note that P/L of the delta-hedged option depends ONLY on the **MAGNITUDE** of the spot move dS , not its direction (i.e. the sign). This is what is commonly referred to as volatility trading.

Net P/L from delta hedging an option

- Assuming constant volatility, P/L in one time step Δt is given by

$$\frac{1}{2} \Gamma(\Delta_S)^2 + \Theta(\Delta_t)$$

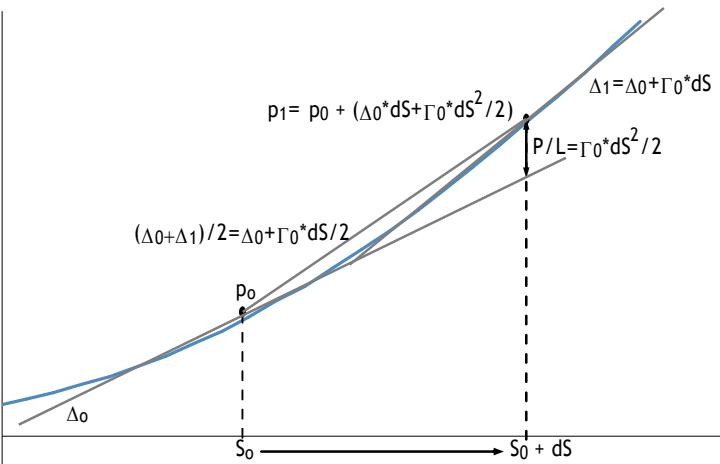
- If interest rate r is assumed to be zero, then algebraic manipulation of the expressions for gamma and theta shown alongside yields the following relationship:

$$\Theta = -\frac{1}{2} \Gamma S^2 \sigma^2$$

- The one step P/L expression above then simplifies to:

$$\frac{1}{2} \Gamma S^2 \left[\left(\frac{\Delta S}{S} \right)^2 - \sigma^2 (\Delta t) \right]$$

Gamma P/L from delta hedging an option



Source: J.P. Morgan

Gamma Trading: From Math to English

→ $\frac{1}{2} \sum_{i=1}^N \left[\left(\frac{\Delta S_i}{S_i} \right)^2 \right]$ **realized variance**

→ σ^2 is called **implied variance**

→ The net P/L of a long delta-hedged option > 0 when **realized variance is greater than implied variance**.

DELTA-HEDGING – A PRACTICAL EXAMPLE

1M Call option delta hedged to maturity

Currency Pair : USD/JPY Strike : 112.66
Option Type : USD call / JPY put Option Notional : \$100,000,000

Day	USD/JPY	Option	Option	Option	Option Vega	Vol for	Option Price	Option P/L	Delta Hedge	Hedge Transaction	Hedge P/L
	Spot	Strike	Delta (%)	Gamma	(bp USD)	strike (%)	(bp USD)	(USD)	Position		(USD)
0	112.74	112.66	50.2	12.2	12	10.6	134	0	50,200,000	Sell 50,200,000 USD	0
1	109.37	112.66	19.6	10.6	9	11.3	38	-960,800	19,620,000	Buy 30,580,000 USD	1,499,550
2	109.15	112.66	18.4	9.6	8	11.6	35	-23,900	18,410,000	Buy 1,210,000 USD	40,398
3	107.84	112.66	11.3	4.9	5	12.1	20	-155,000	11,320,000	Buy 7,090,000 USD	221,180
4	108.35	112.66	12.7	6.1	6	12.1	22	17,200	12,690,000	Sell 1,370,000 USD	-53,968
5	109.38	112.66	16.3	9.4	7	10.8	26	42,900	16,290,000	Sell 3,600,000 USD	-120,775
6	109.23	112.66	14.7	8.5	6	10.8	22	-35,100	14,720,000	Buy 1,570,000 USD	22,712
7	109.22	112.66	13.5	7.9	5	10.5	19	-33,100	13,460,000	Buy 1,260,000 USD	579
8	108.77	112.66	11.0	6.0	5	10.9	15	-38,200	11,000,000	Buy 2,460,000 USD	56,478
9	107.79	112.66	6.9	4.0	3	12.0	9	-62,600	6,850,000	Buy 4,150,000 USD	98,344
10	106.62	112.66	3.1	2.2	2	12.2	4	-54,200	3,080,000	Buy 3,770,000 USD	74,294
11	106.57	112.66	3.4	2.2	2	12.9	4	5,500	3,400,000	Sell 320,000 USD	1,540
12	106.94	112.66	3.7	2.5	2	12.7	4	2,700	3,720,000	Sell 320,000 USD	-11,926
13	106.90	112.66	3.6	2.4	2	13.0	4	-2,100	3,570,000	Buy 150,000 USD	1,548
14	105.69	112.66	1.8	1.4	1	15.0	2	-20,800	1,840,000	Buy 1,730,000 USD	40,529
15	106.72	112.66	2.6	1.9	1	14.2	3	7,000	2,590,000	Sell 750,000 USD	-17,925
16	105.62	112.66	0.8	0.8	0	14.2	1	-20,100	820,000	Buy 1,770,000 USD	26,581
17	106.60	112.66	1.5	1.3	1	13.9	1	5,900	1,460,000	Sell 640,000 USD	-7,584
18	107.14	112.66	1.4	1.3	1	13.2	1	-1,500	1,440,000	Buy 20,000 USD	-7,425
19	106.71	112.66	0.9	0.9	0	15.3	1	-5,100	860,000	Buy 580,000 USD	5,779
20	106.88	112.66	0.5	0.6	0	14.7	0	-3,400	490,000	Buy 370,000 USD	-1,361
21	107.31	112.66	0.5	0.7	0	14.8	0	100	530,000	Sell 40,000 USD	-1,963
22	106.29	112.66	0.0	0.1	0	14.4	0	-3,100	30,000	Buy 5000 USD	5,042
23	106.31	112.66	0.0	0.0	0	12.0	0	-100	0	Buy 30,000 USD	-8
24	106.77	112.66	0.0	0.0	0	16.2	0	0	0	Sell 0000 USD	0

Because we delta-hedge the option to maturity, and the option expires worthless, naked option P/L is exactly equal to initial option price multiplied by option notional

- Realized volatility calculated using spot moves turns out to be 14.5 (more on this on the next slide), which is greater than the implied volatility of 10.6 at entry. No wonder then that buying gamma turns out to be a profitable venture.

(1,337,800) 1,871,618

Naked option P/L = (1,337,800)

Delta-Hedge P/L = 1,871,618

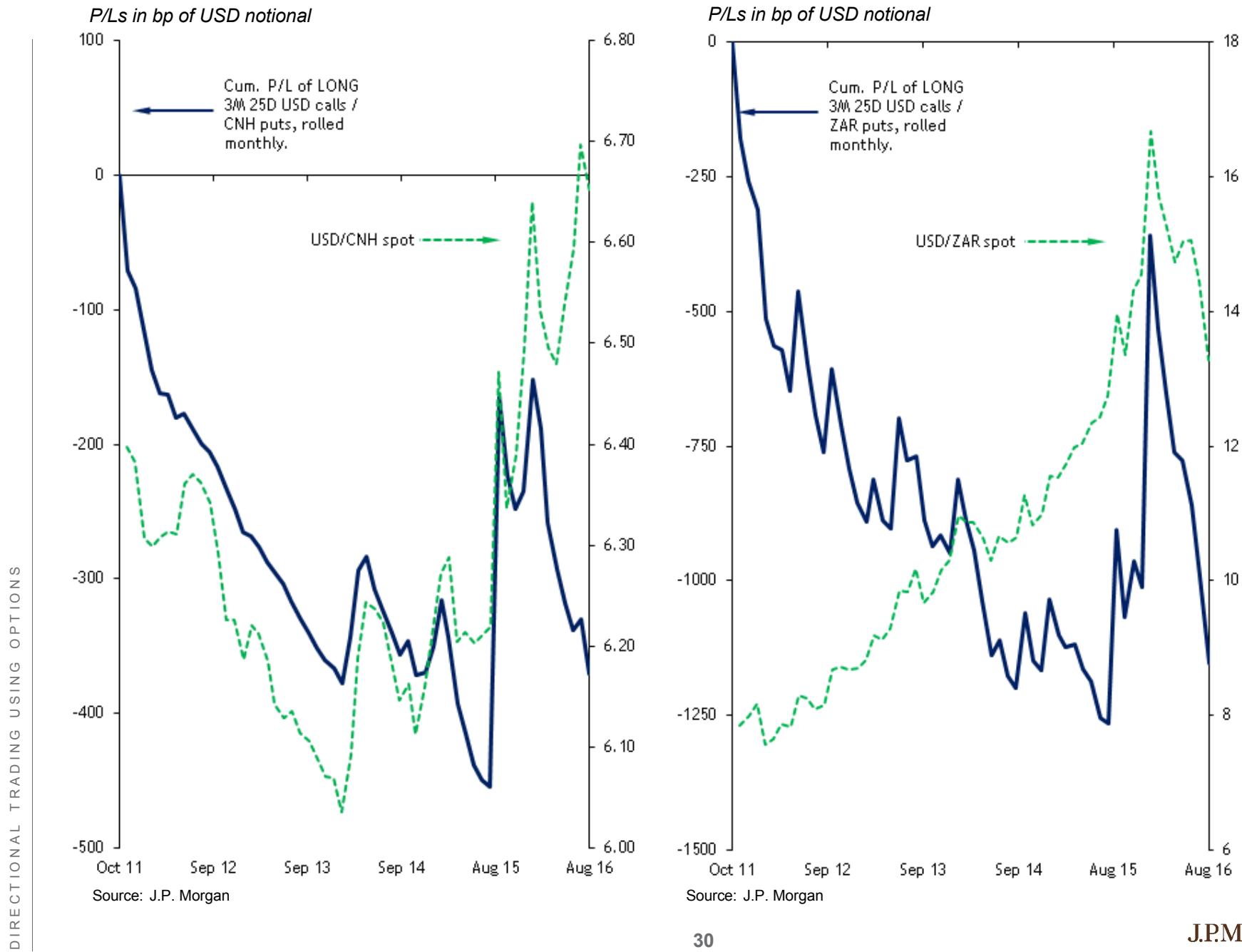
Net Delta-Hedged Option P/L = **533,818**

Agenda

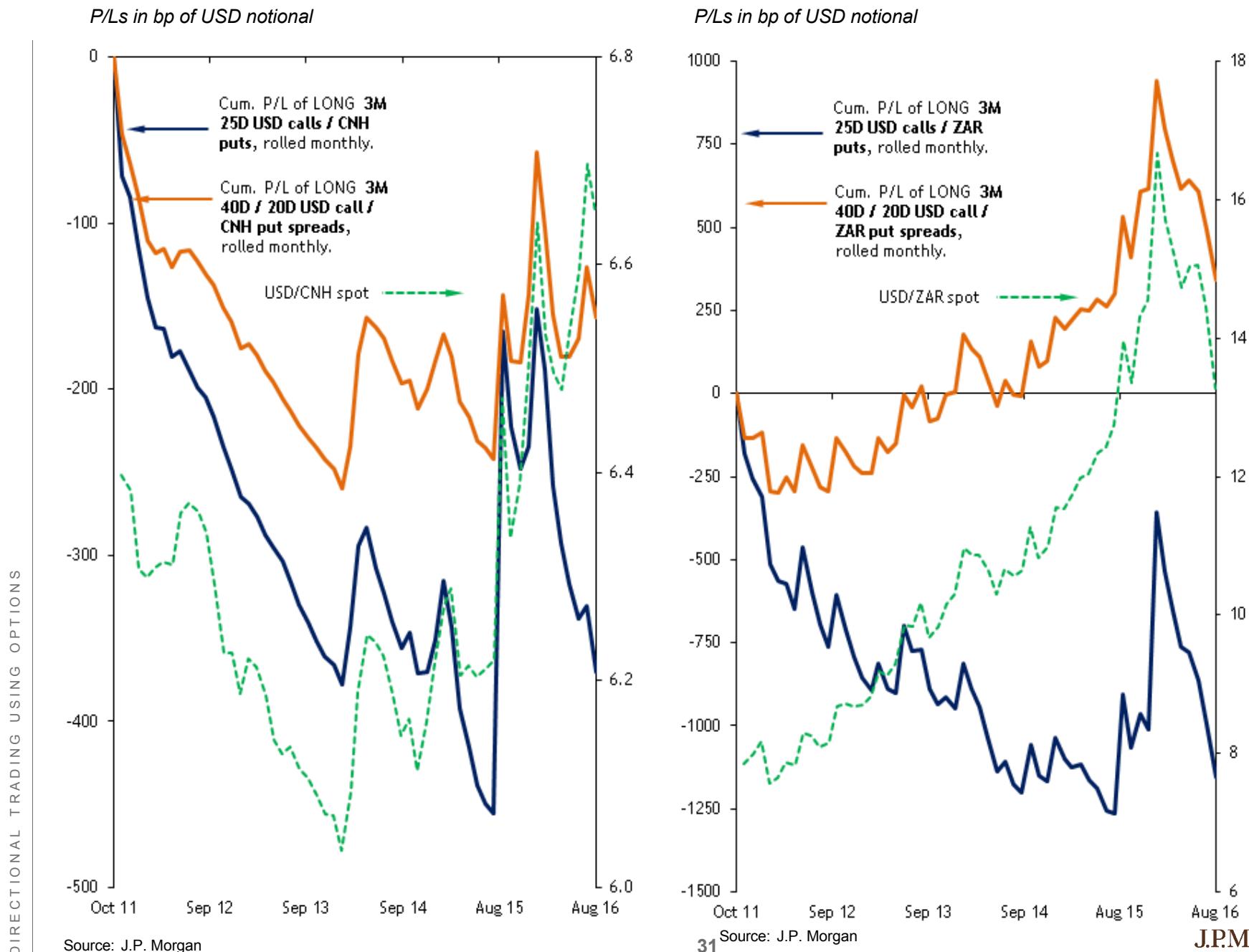
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BUYING OPTIONALITY: ATTRACTIVE IN THEORY, BUT.....

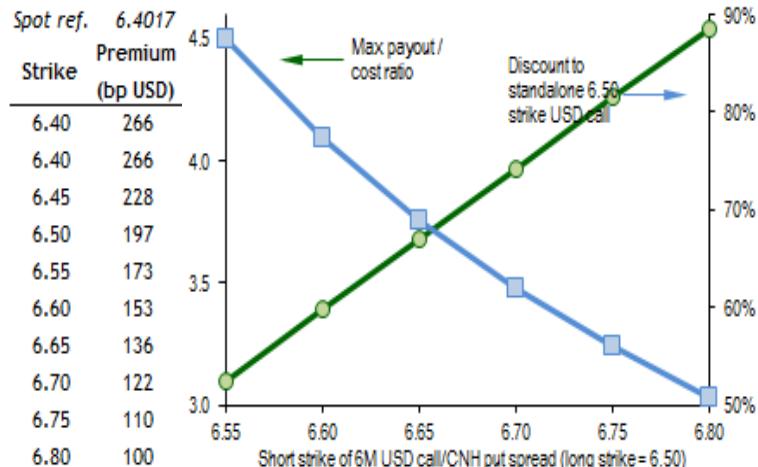


BUYING PREMIUM / DECAY EFFICIENT OPTIONALITY DELIVERS FAR BETTER



UNDERSTANDING CALL/PUT SPREADS

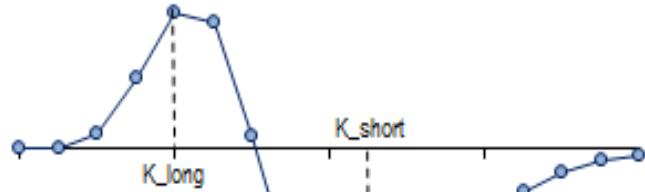
Trade-off 1: Leverage vs. discount to standalone long



Source: J.P. Morgan

Beware the Greek sign flip

Gamma/vega profile of a call spread vs. spot: Long convexity flips to short as spot approaches the short strike



Source: J.P. Morgan

Trade-off 2: Ex-ante optics vs. ex-post returns

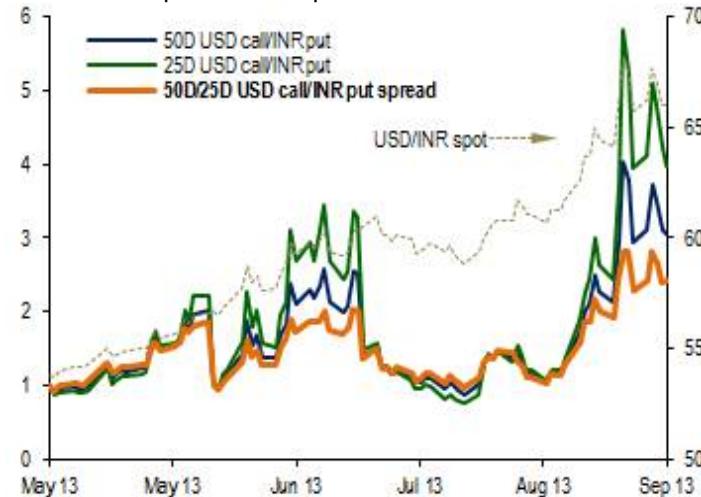
Beware of high leverage! Typically coincides with trend extremes



Source: J.P. Morgan

Careful about spreads in the direction of spot explosion

Return on premium from ATM USD calls/INR puts, OTM USD calls /INR puts and ATM vs. OTM USD call/INR put spreads around the taper tantrum episode. No transaction costs.



Source: J.P. Morgan

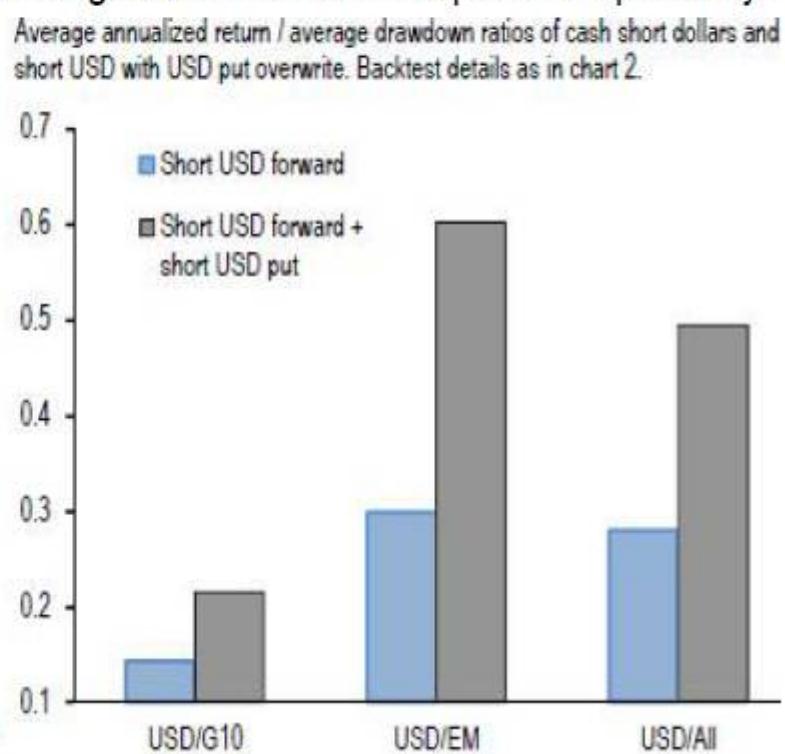
SHORT USD PUT / EM FX CALL OVERLAYS ON LONG EM CASH A USEFUL STRATEGY

Drawdowns (bp USD) of *average annual return equalized* P/L streams of i) equally weighted portfolio of vshort 2M USD forwards vs. a basket of G10 and EM currencies; and (ii) same cash short USD portfolio + short 2M 25D USD puts/CCY calls in equal USD notional. Forwards and options in all cases held for a month and rolled monthly. Assumes no transaction cost on forwards, and constant 0.3 and 0.5 mid-to-bid vol charges on G10 and EM options respectively.

DIRECTIONAL TRADING USING OPTIONS



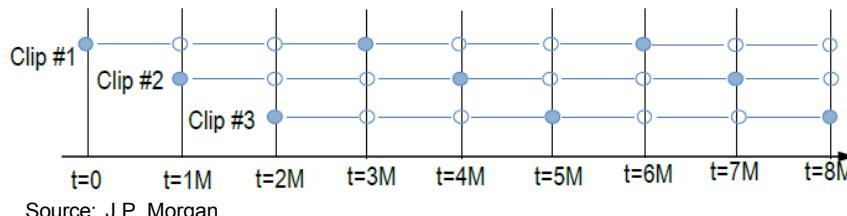
Source: J.P. Morgan



Source: J.P. Morgan

Currency hedging with options

Staggered forward / options hedging strategy

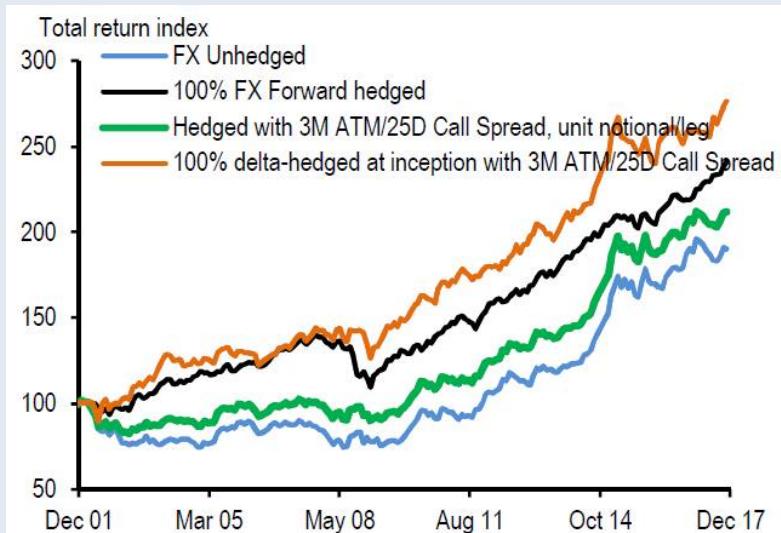


Source: J.P. Morgan

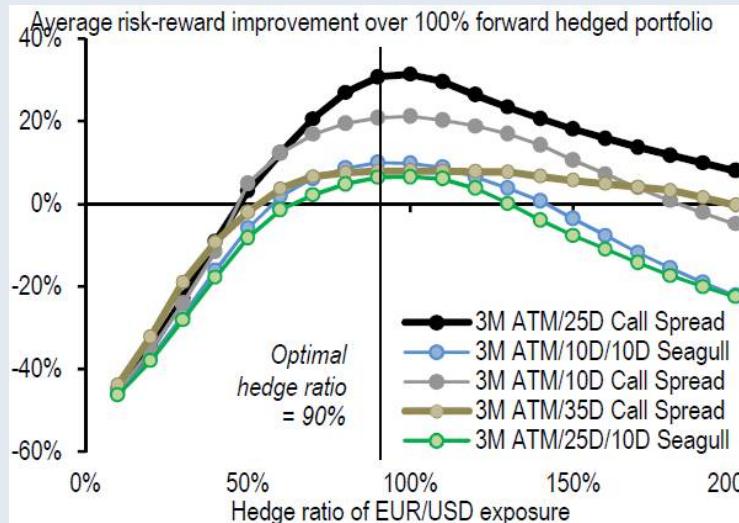
- The best option hedges can increase average portfolio returns by 50bp - 100bp annually over and above forward hedges
- EUR call spreads and seagull structures preferred hedging instruments
 - declines rather than rallies in EUR have been more volatile => lower velocity EUR strength well captured by limited upside structures such as call spreads and seagulls
- Preferred strikes are long ATM vs. short 25D or further OTM
- Preferred maturities are shorter (3M) rather than longer (6M or 1Y)
- In terms of notional sizing, matching option deltas to the underlying currency exposure is far more effective than matching option notinals

<https://www.jpmm.com/research/content/GPS-2622256-0>

Cumulative returns of unhedged, FX forward hedged and FX option (3M ATM/25D call spread for EUR/USD) hedged US securities portfolios



Source: J.P. Morgan



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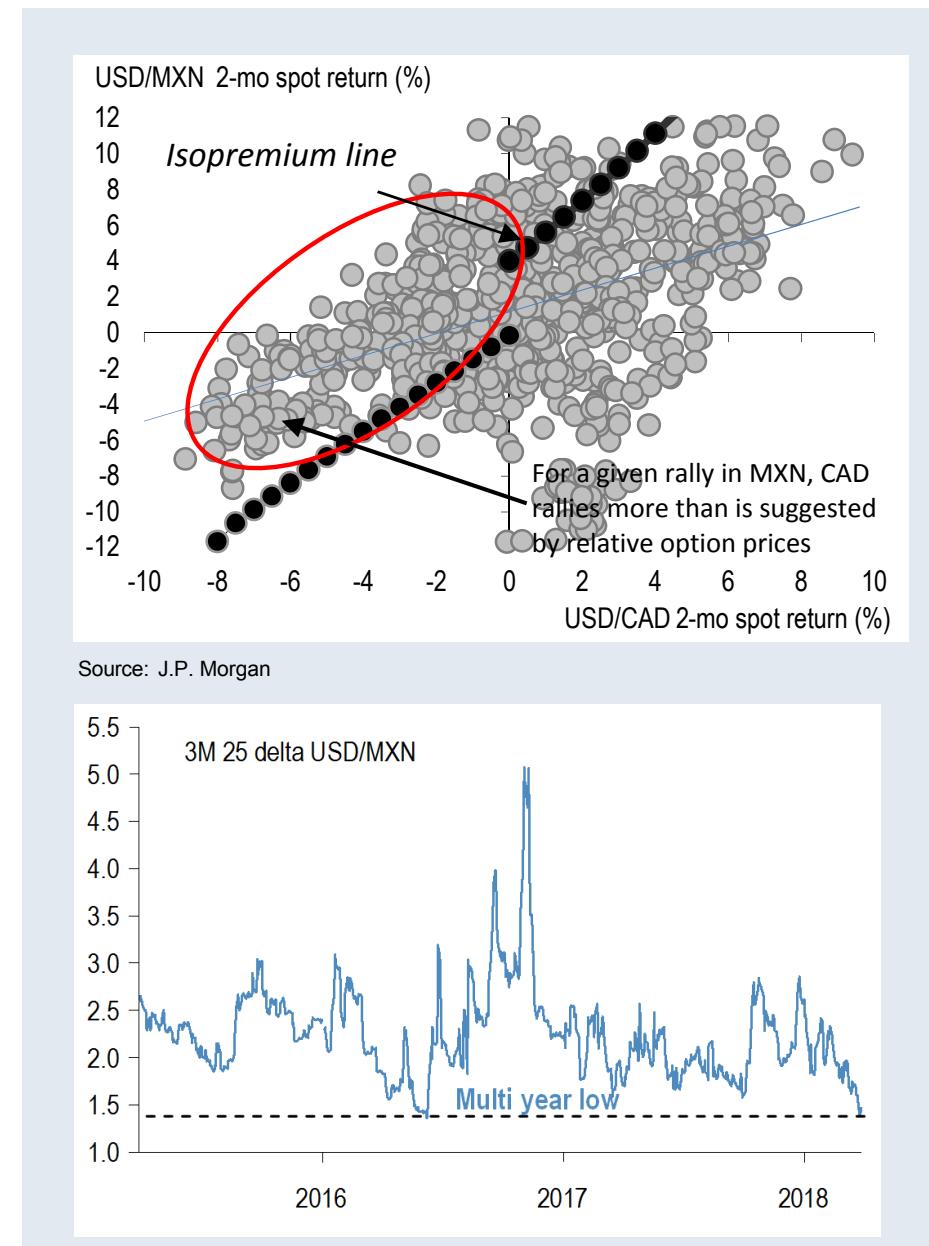
Source: J.P. Morgan

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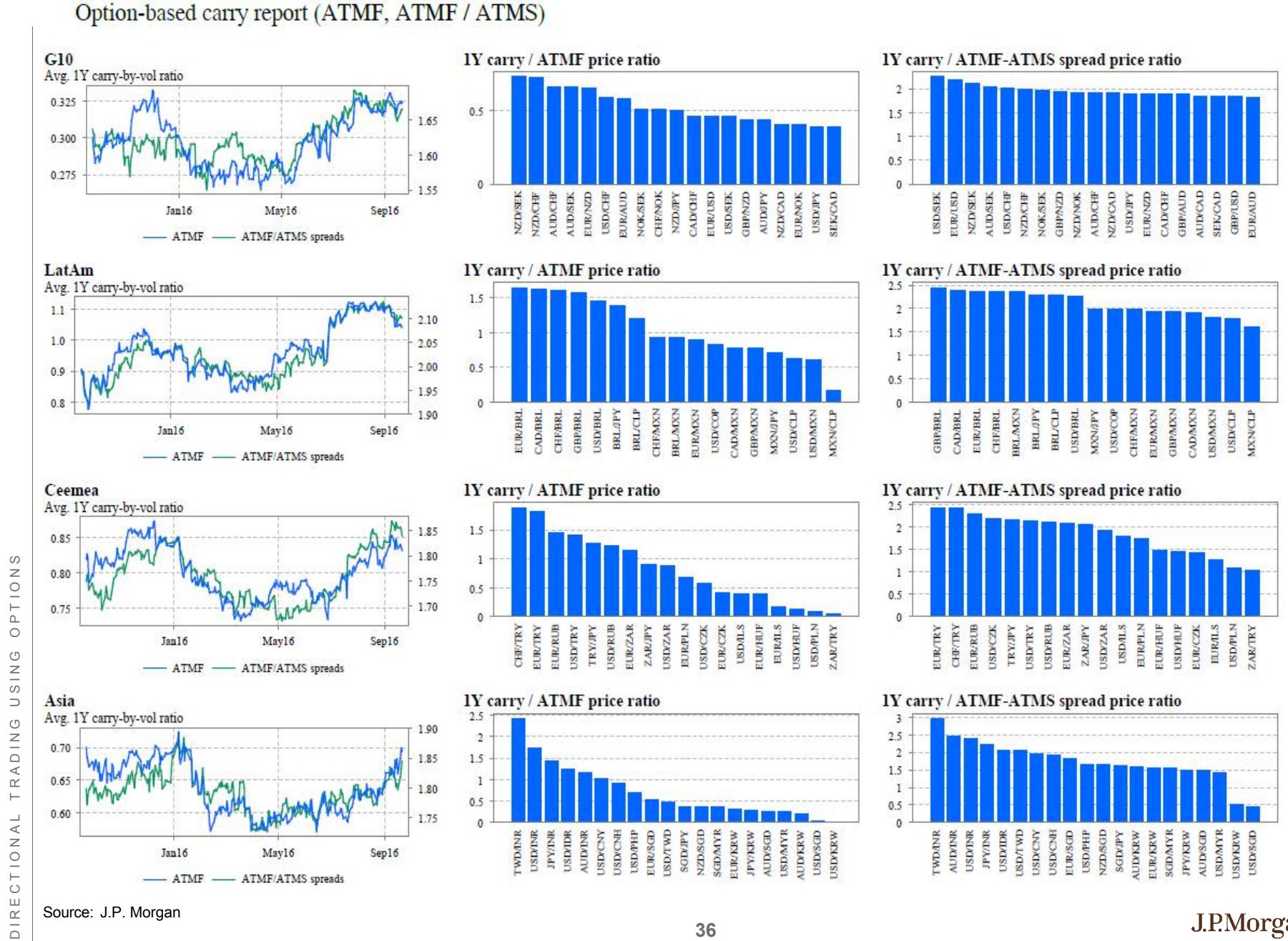
Directional RV expression - Conditionals

- Relative value expression of buying ccy1/ccy2 cross
- Low (or zero) upfront premium commitment and little or no exposure to an anti-risk outcome
- The construct banks on relative mispricing of the two vol surfaces.
- *isopremium line* = a string of zero-option cost strikes (i.e. a pair of spot moves that are equally probable based on option market pricing)
- The scatter of past returns then illustrates how well option market prices their joint historical occurrence
- A highly asymmetric or lopsided set-up of the return scatter vis-à-vis the isopremium line indicates a potential mispricing in relative option prices.

=> Buy 10wk USD/CAD puts 1.29 strike (spot 1.2886) vs. sell 10wk USD/MXN puts 18.18 strike (spot 18.1870), in equal notional (not delta-hedged), premium-neutral



ATMF vs. ATMS OPTION SPREADS FOR SYSTEMATIC CARRY TRADING



Source: J.P. Morgan

BASIC OPTION STRATEGIES CASE : CALL/ PUT SPREADS FOR TRADING CARRY

- **Carry = P/L that can potentially accrue if market conditions were to remain unchanged over the trade horizon.**
- In FX, carry trading = **buying high yielding currencies and selling low yielding currencies**, via forward transactions.
- Stands to pocket the difference between the two rates
- Example; USD/BRL:

Via fwds

- Spot (S) = 3.88 | $r_{BRL,3M} = 13.15\%$ | $r_{USD,3M} = 0.35\%$
- Forward (F) = $3.88 * [1 + 13.15\% * (3/12)] / [1 + 0.35\% * (3/12)]$
= 4.0055

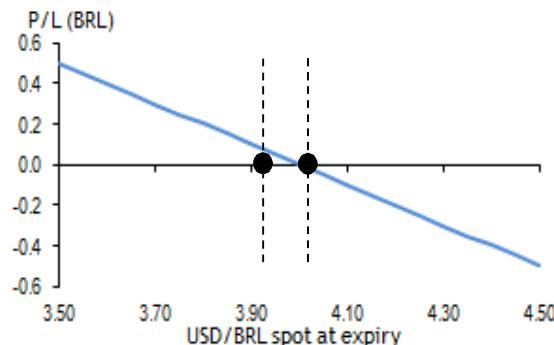
The carry trade: sell 3M USD/BRL NDFs at 4.0055

Via options

- **buy 3M ATMF (i.e. strike = forward = 4.0055) USD puts/BRL calls and sell 3M ATMS (i.e. strike = spot =) USD puts/BRL calls**
- in the event of an adverse spot move, the downside from the put spread is floored at the option premium

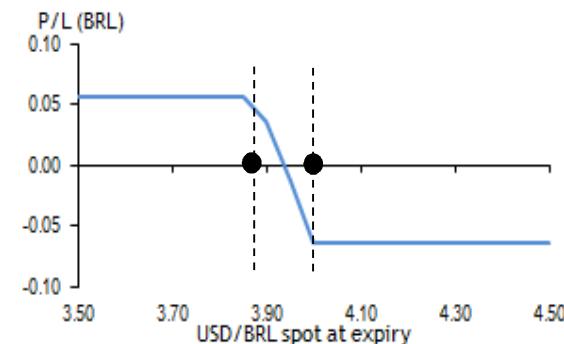
Trading carry using USD/BRL forwards vs. options

Short USD/BRL NDF at 4.0055



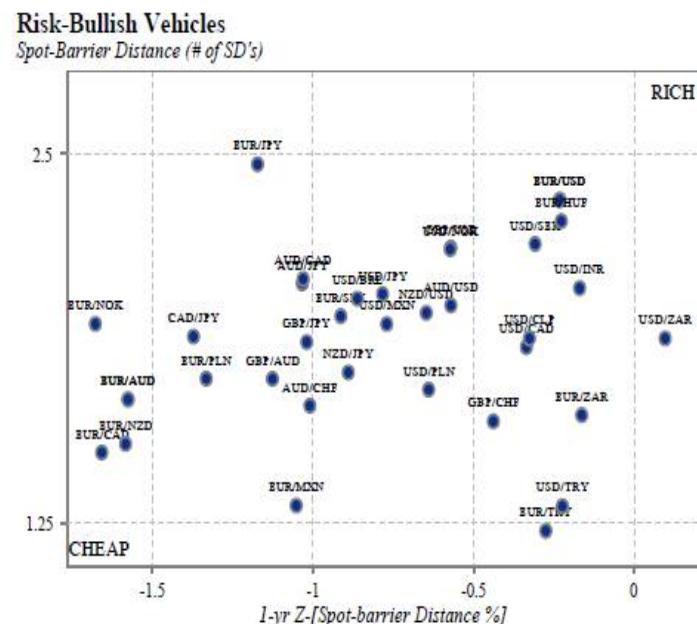
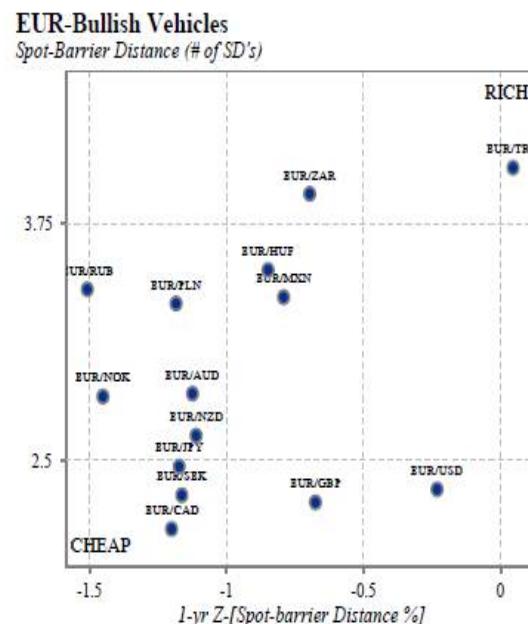
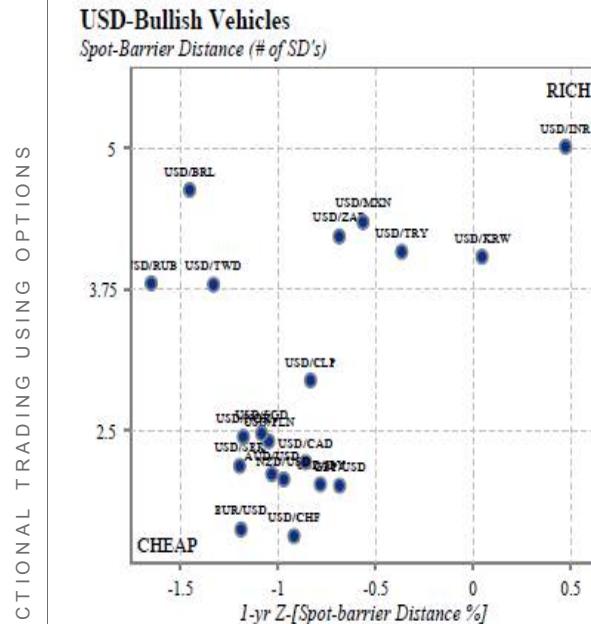
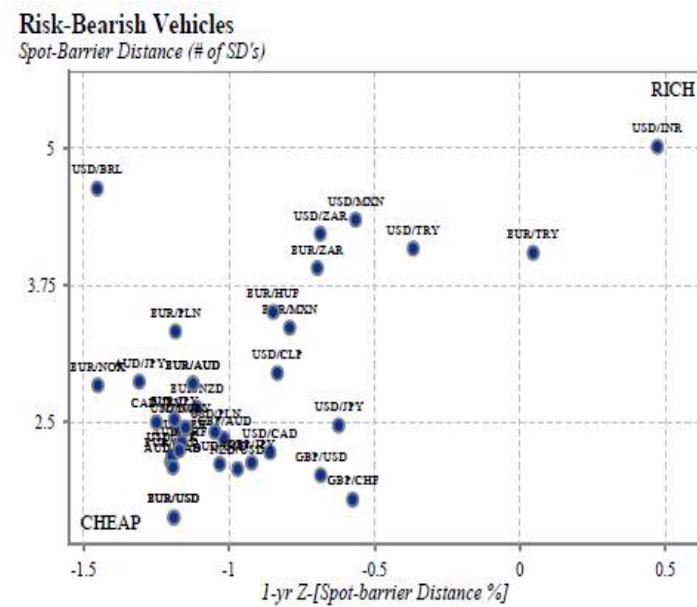
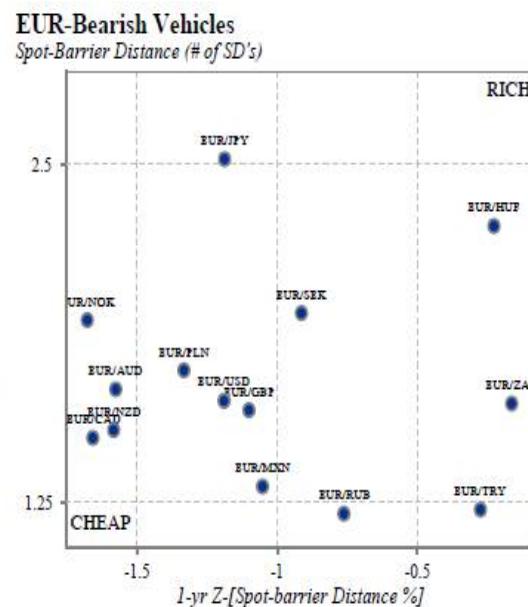
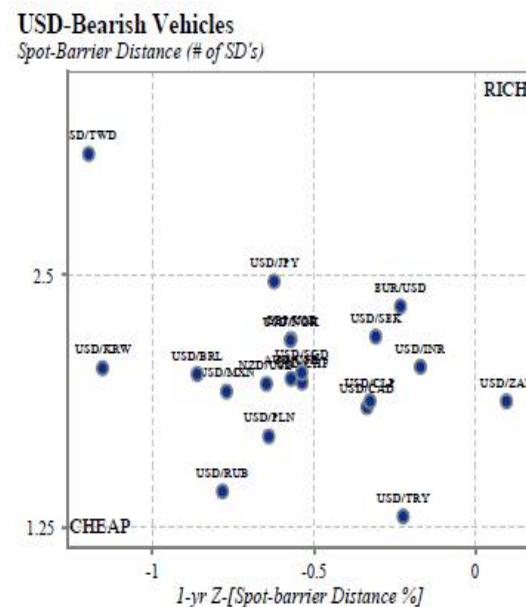
Source: J.P. Morgan

Short USD/BRL 4.0055 vs. 3.88 (ATMF / ATMS) put spread



Source: J.P. Morgan

ASSORTING DIRECTIONAL (ONE TOUCH) TRADES BY FX THEMES

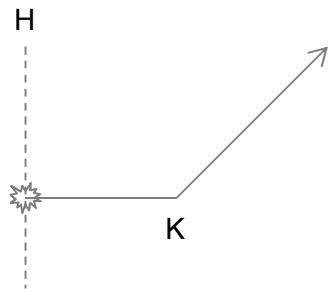


Source: J.P. Morgan

Basic types of Barrier options

Calls

Down-and-in or down-and out call

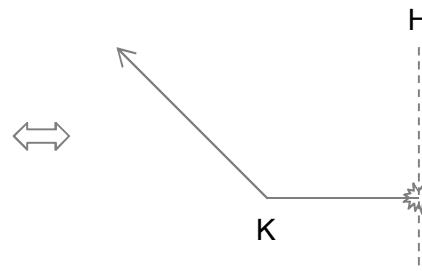


- Initially Spot > H
- KI call: spot must touch barrier H for OTM vanilla call to come to existence
- KO call: if spot touches barrier H OTM vanilla call knocked out (worthless)

Source: J.P. Morgan

Puts

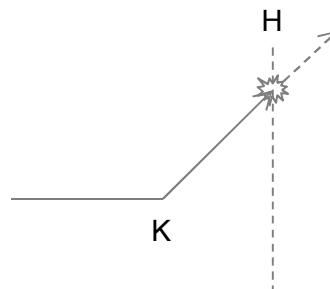
Up-and-in or up-and out put



- Initially Spot < H
- KI put: spot must touch barrier H for OTM vanilla put to come to existence
- KO put: if spot touches barrier H OTM vanilla put knocked out (worthless)

Source: J.P. Morgan

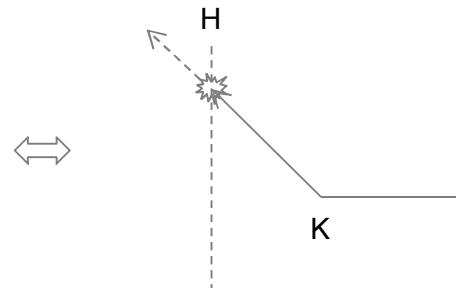
Up-and-in or up-and out call



- Initially Spot < H
- RKI call: spot must touch barrier H for ITM vanilla call to come to existence
- RKO call: if spot touches barrier H ITM vanilla call knocked out (worthless)

Source: J.P. Morgan

Down-and-in or down-and out put



- Initially Spot > H
- RKI put: spot must touch barrier H for ITM vanilla put to come to existence
- RKO put: if spot touches barrier H ITM vanilla put knocked out (worthless)

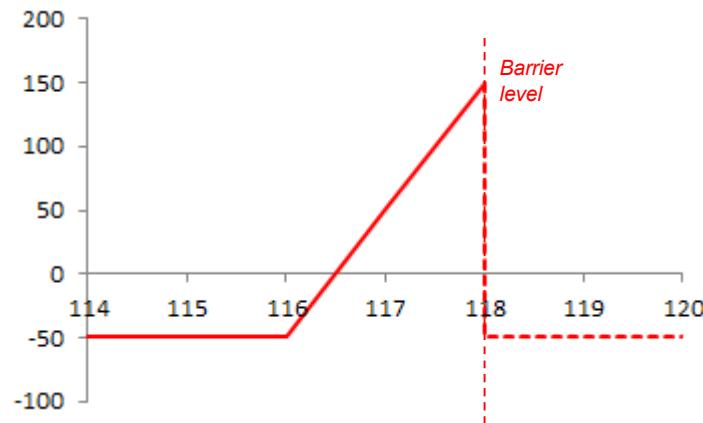
Source: J.P. Morgan

* H designates the barrier level

** K designates the options strike

Reverse knock-outs and knock-ins

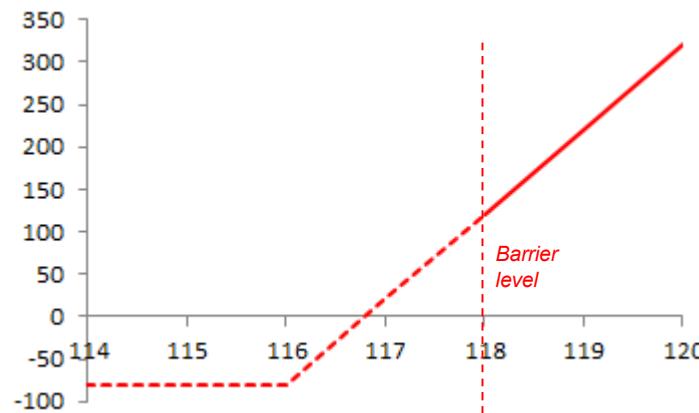
Reverse Knock-out Call/Put



Source: J.P. Morgan

- **in-the-money** when triggered => substantially lower premia than vanilla options.
- expresses a view on contained spot moves
- Used when:
 - spot positions crowded => spot grinds;
 - in anticipation of central bank intervention to slow / smooth spot moves;
 - when out-of-the-money strikes are expensive so that selling them provides substantial premium savings vis-à-vis the vanilla; and
 - as overlays on core cash positions for increasing leverage

Reverse Knock-in Call/Put:



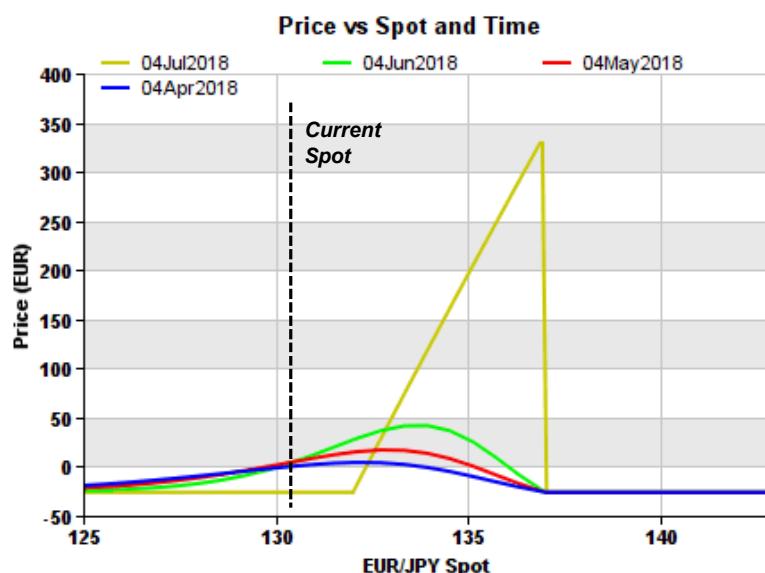
Source: J.P. Morgan

- **sold** to fund purchased options elsewhere
 - provides a margin of safety vs. selling vanilla outright
- A seller of a 116 strike USD/JPY call with 118 RKO is **not** short the 116 strike call till 118 trades, hence has 2 big figures of extra protection.
- RKO + RKO = Vanilla option identity holds

Reverse knock-out example

3M 132 strike EUR call / JPY put that knocks out at 137

- Substantial cheapening of vanilla premium by setting a KO barrier
 - 26.07bp for RKO vs. 109.7bp for vanilla
- Variation of price vs. spot:
 - Early on, spot declines => reduce option premium similar to vanilla
 - RKO option price increases initially as spot drifts higher as the **vanilla call feature dominates**
 - Further on, **KO starts to dominate**
 - RKOs can be considered to be:
 - a combination of long a **vanilla** option and short **one touch**



Source: J.P. Morgan

Single Barrier With Rebate	
Type	Single Barrier With Rebate
Market Date	Wed 04Apr2018
Market State	Mkt2
FX Pair	EUR/JPY
Option Type	Call on EUR
Expiration Date	Wed 04Jul2018 [91d]
Settlement Date	Fri 06Jul2018
Strike	132.00
Settlement Type	Physical
Settlement Currency	N/A
Expiration Cut	NYC
Barrier	137.0000
Barrier Direction	Up
In or Out	Out
Rebate (% of Notional)	0.00
RebateCcy	EUR
Pay Time	Expiry
Quantity Currency	EUR
Quantity	10,000
Buy/Sell	b - JPM Buys
Spot	130.3262
Forward	130.3889
Forward Point	0.0627
Denominated Depo	-0.21
Asset Depo	-0.40
Vol for strike	8.186
ATM Volatility	8.346
Pricing Model	Stoch Garf IR
Premium Display	% EUR
Price(%)	0.2607
Vanilla(%)	1.097
BS Vanilla(%)	1.128
OneTouch(%)	21.60
BS OneTouch(%)	24.01
Premium Rebate(%)	0.3325

Source: J.P. Morgan

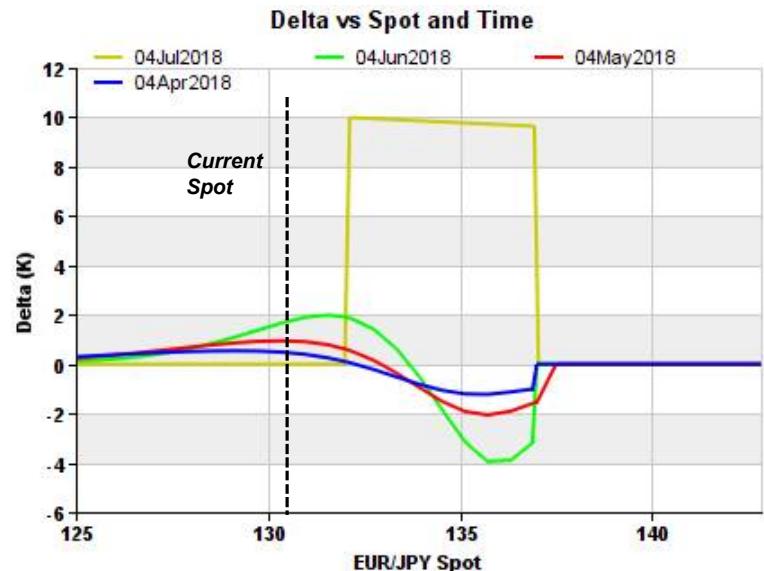
Greeks of reverse knock-outs

■ Variation of Delta vs. spot and time

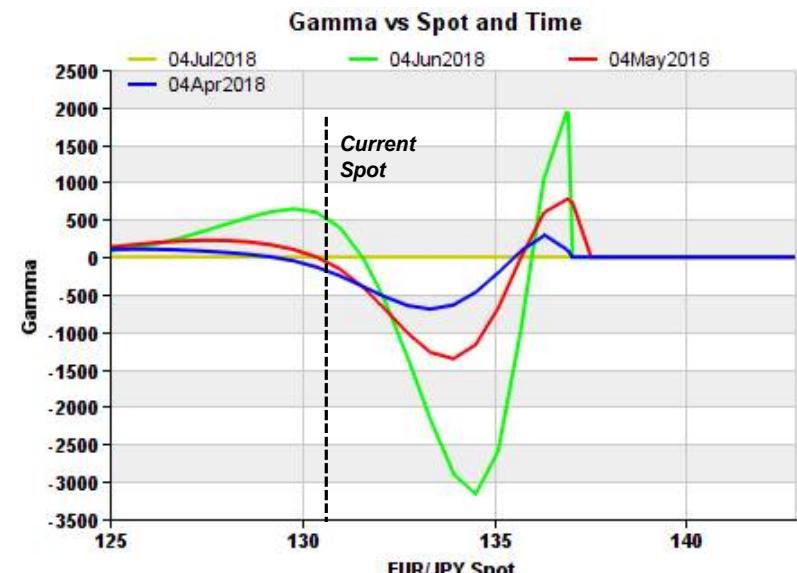
- Delta is initially positive (i.e. long EUR/JPY) ~ vanilla
- As KO begins to dominate the positive effect of higher spot on the vanilla EUR call => ***delta flips to negative***
- As barrier gets triggered => substantially negative ΔPrice , so $\Delta\text{Price} / \Delta\text{Spot} \ll 0$
- Delta is zero if the RKO barrier triggers
- Passage of time reduces the probability of barrier breach => positive for price and delta

■ Variation of Gamma vs. spot and time

- Short gamma exposure => absence of spot movement is the most friendly outcome early on
- Gamma becomes increasingly more negative as spot drifts higher
- Gamma flips to peak positive just ahead of the RKO barrier, since small positive ΔSpot leads to a substantially positive Δdelta => $\Delta\text{Delta} / \Delta\text{Spot} \gg 0$
- With time small spot moves have large influence on the likelihood of barrier survival => short gamma-ness increases



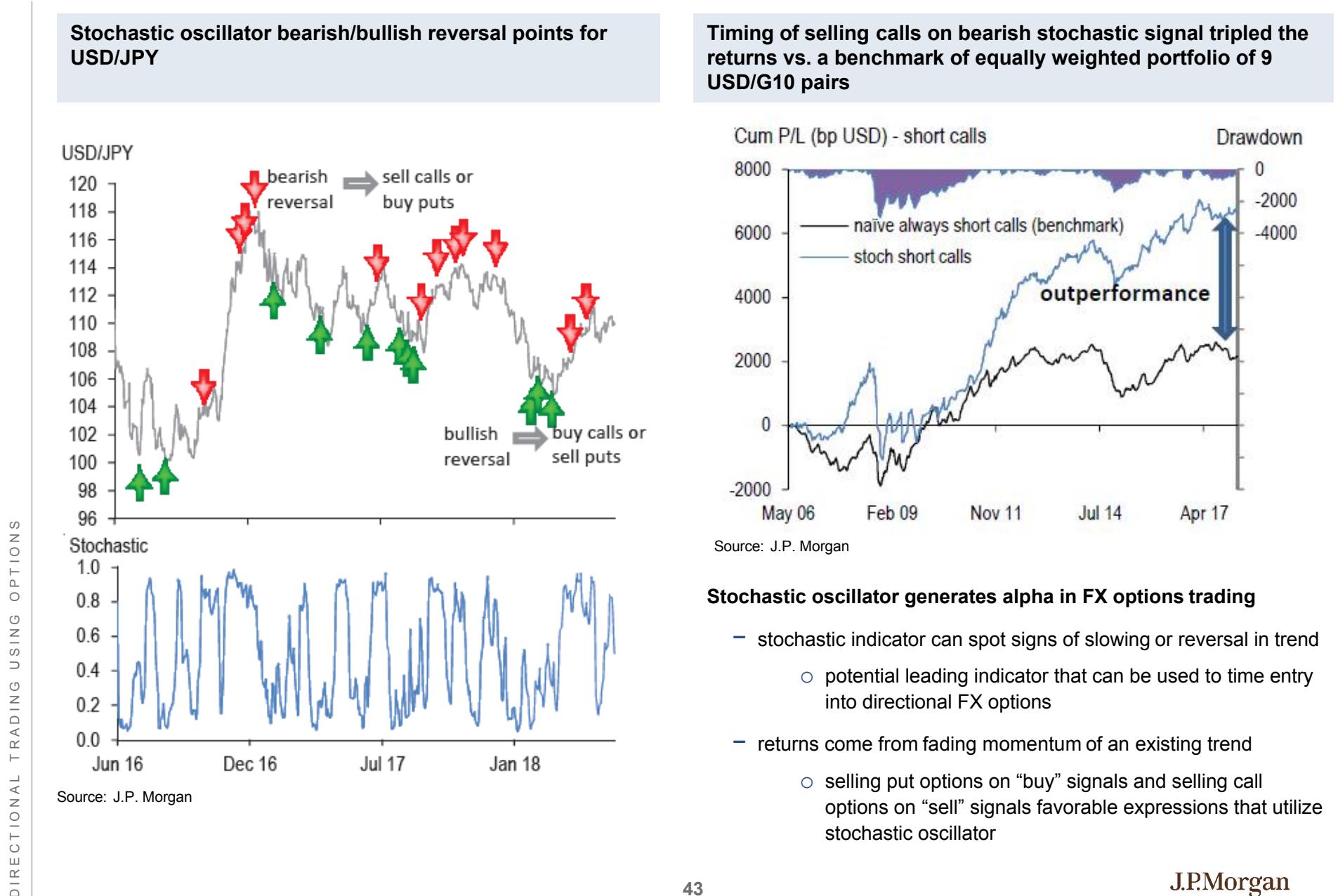
Source: J.P. Morgan



Source: J.P. Morgan

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Technical signals (stochastic oscillator) for directional options trading



GENERAL CONSIDERATIONS FOR DIRECTIONAL OPTION STRUCTURES

- **Is vol broadly rich or cheap?** Historical analysis on implied vol, implied vs. realized vol comparisons
- **For EM currencies in particular, is vol rich/cheap commensurate with the amount of carry?** Do not mind buying higher-than-average vol if interest rate carry is high and subsidizes a good portion of option theta
- **Is the trade in the direction of, or against the skew?** Options in the direction of the skew i.e. in the direction where vols are expensive e.g. USD calls/EM puts are ***nominally*** expensive to buy standalone but also provide the best *ex-post* returns. USD call/EM put spreads reduce nominal upfront premium vis-à-vis outright USD calls, but at the expense of performance if the directional view does indeed materialize. Think more deeply about the view.
- **Are risk-reversals rich or cheap?** Irrespective of the direction of the trade, this is an important input. If riskies are cheap, buy outright options in the direction of the skew; if expensive, spreads can be considered. Be biased to not buy outright options against the skew since vol will decline if spot moves in that direction; buy spreads unless skew is abnormally rich.
- The **trade-off between certain time decay versus uncertain payoff** demands close attention to rich/cheap analysis to avoid over-paying for options.

Agenda

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Basics of options	1
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Trading volatility as an asset class	55
Option markets as a source of intelligence for spot markets	66

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Implied Volatility

- forecast of how variable the underlying price is expected to be over the remaining life of the option.
- calculated from an option premium as the level of volatility that gives a theoretical option price equal to its market price

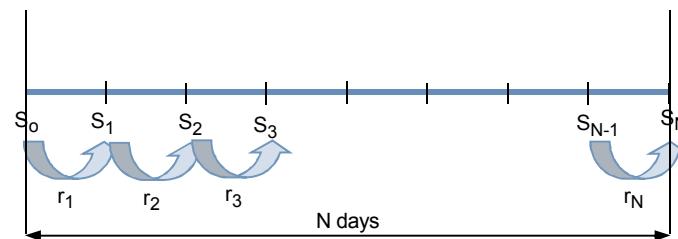
$$c = S_0 \exp(-r_f T) \mathbb{N}(d_1) - K \exp(-r_d T) \mathbb{N}(d_2)$$

$$d_1 = \frac{\ln(S_0/K) + (r_d - r_f + \sigma^2/2)T}{\sigma\sqrt{T}}$$

$$d_2 = d_1 - \sigma\sqrt{T}$$

Realized Volatility = calculated

Non-meanadjusted or RMS volatility = $\sqrt{\frac{1}{N} * \sum_{i=1}^N \left[\ln\left(\frac{S_i}{S_{i-1}}\right) \right]^2} * \sqrt{252}$



Source: J.P. Morgan

Annualization of volatility

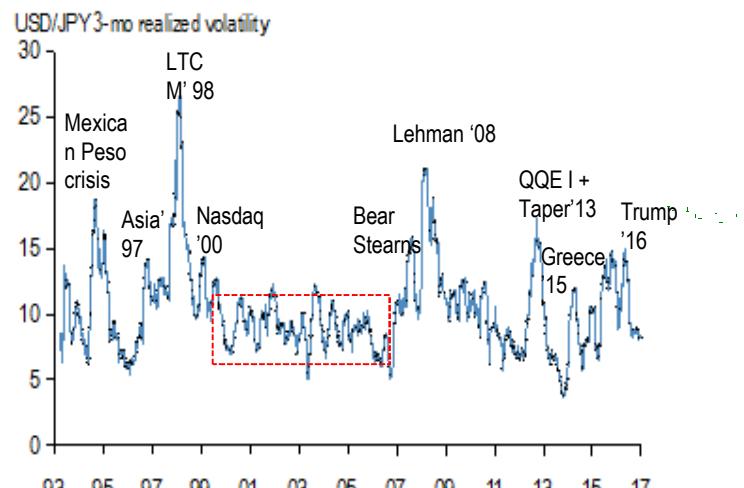
- The volatility of any sample of daily returns can be annualized by multiplying by $\sqrt{252}$
- The volatility of any sample of weekly returns can be annualized by multiplying by $\sqrt{52}$

Additivity of variance

$$\sigma_N^2 = \frac{M * \sigma_M^2 + (N - M) * \sigma_{N-M}^2}{N}$$

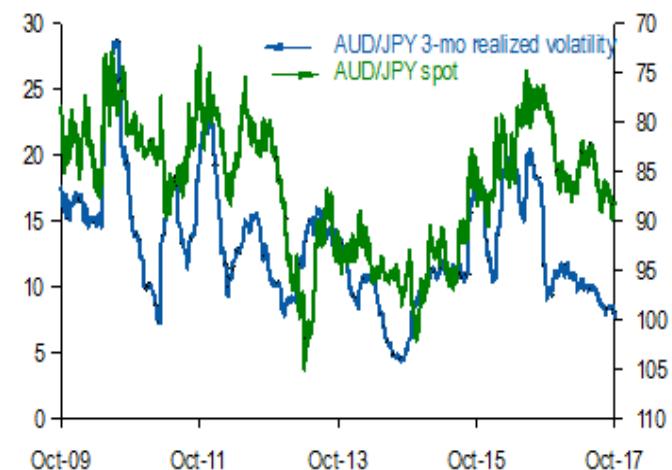
HISTORICAL VOLATILITY IN FX

Realized FX volatility tends to cluster into high and low regimes like every other asset class....



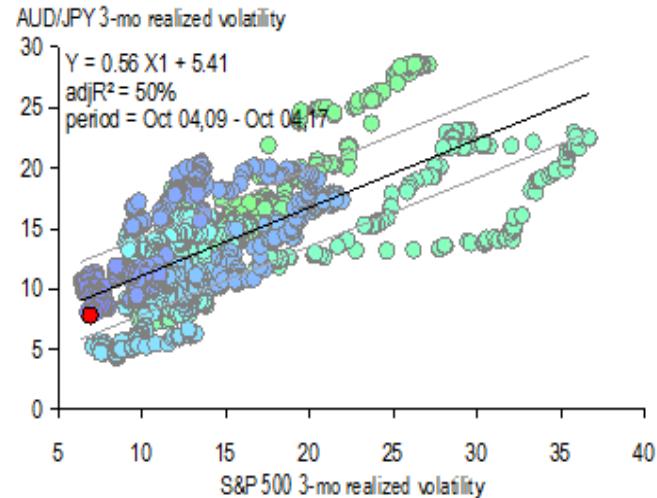
Source: J.P. Morgan

Realized vol in some currency pairs like AUD/JPY are strongly correlated to spot moves



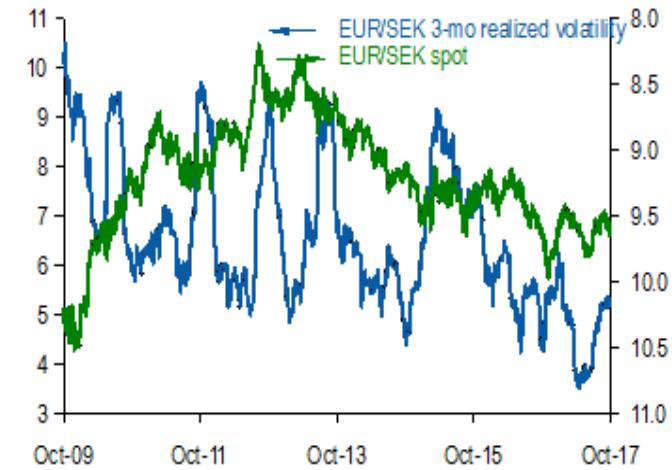
Source: J.P. Morgan

...and is reasonably well correlated with equity volatility, especially in the high-beta / carry pairs



Source: J.P. Morgan

...and not so much in some others like EUR/SEK



Source: J.P. Morgan

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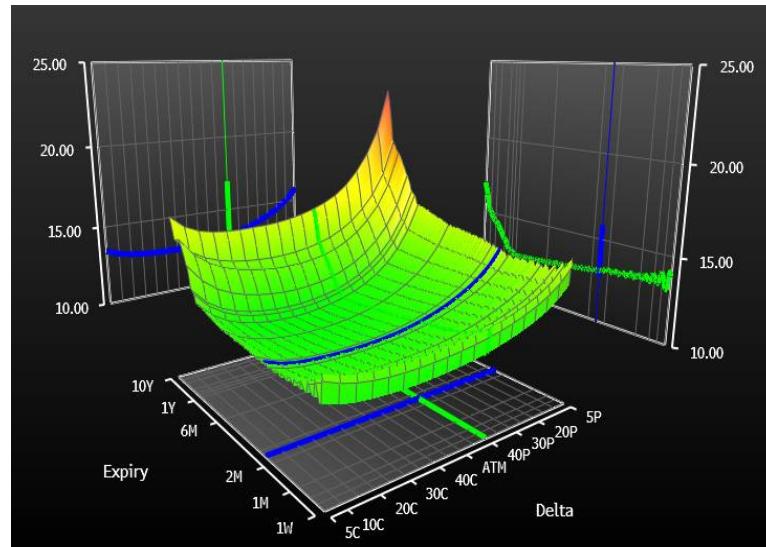
IMPLIED VOLATILITY SURFACE

- Once the Black-Scholes assumption of constant volatility is relaxed, different values of volatilities can be quoted for different combinations of tenors and strikes.
- The market convention for implied vols is to quote five values for each tenor: **ATM vols**, and special measures of out-of-the-money vols : **Risk-Reversals and Butterflies for the 10D and 25D strikes**.
- Interpolation is needed to retrieve the vols for all deltas/strikes.



Quotation in Deltas is specific to FX and precious metals

USD/JPY vol surface (source: Bloomberg)



Source: Bloomberg

- Risk-reversal (RR) = Call vol – Put vol
- Butterfly (BF) = (Call vol + Put vol)/2 - ATM

- To retrieve vols for the individual calls and puts:

- Call vol = ATM + BF + (RR/2)
- Put vol = ATM + BF - (RR/2)

ATMs, RR_s, BF_s ⇔ Absolute vol levels

	ATM	25D RR	25D BF	10D RR	10D BF		10D Put	25D Put	ATM	25D Call	10D Call	
1M	13.2	-0.9	0.3	-1.7	0.9		1M	14.9	14.0	13.2	13.1	13.3
2M	13.1	-1.0	0.4	-1.9	1.0		2M	15.1	14.0	13.1	13.0	13.2
3M	12.9	-1.1	0.4	-2.1	1.3		3M	15.2	13.9	12.9	12.8	13.2
6M	12.5	-1.2	0.5	-2.3	1.6		6M	15.4	13.6	12.5	12.4	13.0
1Y	12.4	-1.3	0.6	-2.6	2.1		1Y	15.9	13.7	12.4	12.4	13.3
18M	12.6	-1.4	0.6	-2.7	2.2		18M	16.3	14.0	12.6	12.6	13.6
2Y	12.8	-1.5	0.6	-2.8	2.2		2Y	16.5	14.2	12.8	12.7	13.7
3Y	13.5	-1.5	0.6	-2.7	2.4		3Y	17.3	14.9	13.5	13.5	14.6
5Y	14.6	-1.6	0.6	-3.0	2.4		5Y	18.6	16.1	14.6	14.6	15.6

Source: J.P. Morgan

IMPLIED VOLATILITY SURFACE QUOTING CONVENTIONS

Definitions of At-the-Money (ATM)

- At-the-money-spot (ATMS): $K = S$ (100% strike in equities)
- At-the-money-forward (ATMF): $K = F$ (common in EM FX)
- Delta-neutral (D/N):** K such that call delta = - put delta i.e. net delta of a straddle (long call + long put) is zero. Eliminates need for the market-maker to delta-hedge

Variants of delta

- Spot delta:** textbook delta = $\delta P/\delta S$ = spot sensitivity
- Forward delta:** $\delta P/\delta F$ = forward sensitivity, used to capture interest rate risk implicit in forward points. Typically for NDF currencies and long-dated options
- Black Scholes delta:** output from textbook B/S model
- Smile delta:** B/S delta adjusted to account for variation of vol with strike
- Premium adjusted delta:** Takes care of the correction induced by payment of the premium in foreign currency, which is the amount by which the delta-hedge in foreign currency has to be reduced.

$$\Delta_{\text{PREMIUM ADJUSTED}} = \Delta_{\text{PREMIUM UNADJUSTED}} - (p/S),$$

p = premium in domestic ccy per unit of foreign ccy

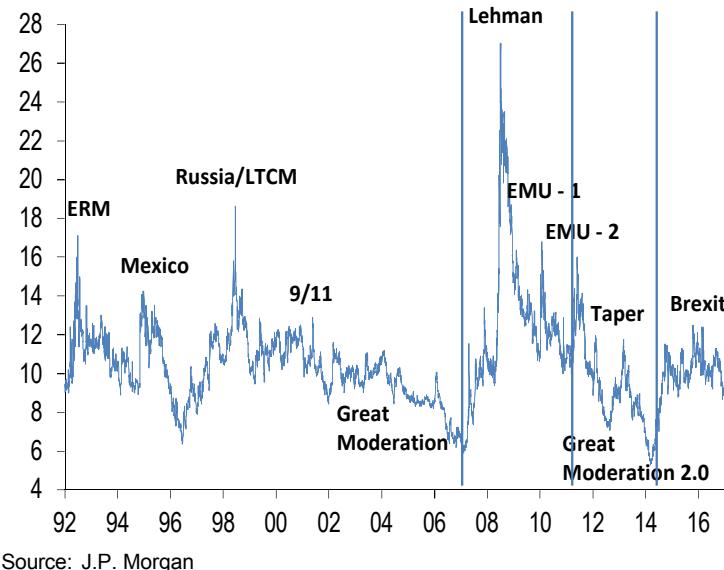
Market conventions of ATM and delta

Pair	Premium-adjusted delta?	Spot Delta ≤ 1Y?	ATM	Pair	Premium-adjusted delta?	Spot Delta ≤ 1Y?	ATM
EUR/USD	No	Yes	DNS	USD/BRL	Yes	No	ATMF
AUD/USD	No	Yes	DNS	USD/CLP	Yes	No	ATMF
GBP/USD	No	Yes	DNS	USD/ILS	Yes	No	DNS
NZD/USD	No	Yes	DNS	USD/MXN	Yes	No	ATMF
USD/CAD	Yes	Yes	DNS	USD/TRY	Yes	No	DNS
USD/CHF	Yes	Yes	DNS	USD/ZAR	Yes	No	DNS
USD/JPY	Yes	Yes	DNS	EUR/BRL	Yes	No	ATMF
USD/NOK	Yes	Yes	DNS	EUR/CLP	Yes	No	ATMF
USD/SEK	Yes	Yes	DNS	EUR/ILS	Yes	No	DNS
EUR/AUD	Yes	Yes	DNS	EUR/MXN	Yes	No	ATMF
EUR/CAD	Yes	Yes	DNS	EUR/TRY	Yes	No	DNS
EUR/CHF	Yes	Yes	DNS	EUR/ZAR	Yes	No	DNS
EUR/GBP	Yes	Yes	DNS	BRL/JPY	Yes	No	ATMF
EUR/JPY	Yes	Yes	DNS	MXN/JPY	Yes	No	ATMF
EUR/NOK	Yes	Yes	DNS	TRY/JPY	Yes	No	DNS
EUR/NZD	Yes	Yes	DNS	ZAR/JPY	Yes	No	DNS
EUR/SEK	Yes	Yes	DNS	BRL/CLP	Yes	No	ATMF
CAD/JPY	Yes	Yes	DNS	BRL/MXN	Yes	No	ATMF
CHF/JPY	Yes	Yes	DNS	CAD/BRL	Yes	No	ATMF
AUD/JPY	Yes	Yes	DNS	CAD/MXN	Yes	No	ATMF
GBP/JPY	Yes	Yes	DNS	CHF/MXN	Yes	No	ATMF
NZD/JPY	Yes	Yes	DNS	ZAR/TRY	Yes	No	DNS
AUD/NZD	Yes	Yes	DNS				
AUD/CAD	Yes	Yes	DNS				
AUD/CHF	Yes	Yes	DNS				
GBP/AUD	Yes	Yes	DNS				
GBP/CAD	Yes	Yes	DNS				
GBP/CHF	Yes	Yes	DNS				

Source: J.P. Morgan

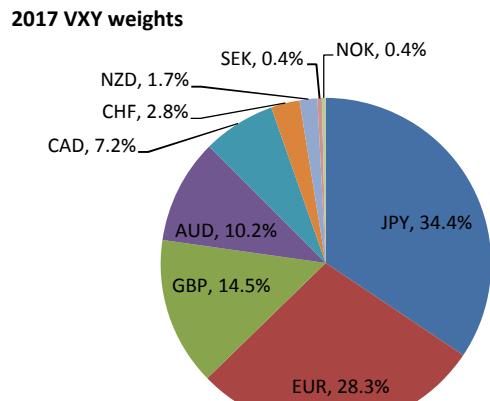
VXY: JPM FX IMPLIED VOLATILITY INDICES

- Industry benchmark for tracking aggregate volatility in currencies analogous to the CBOE Volatility Index® (VIX®) used in Equity markets.
- VXY is an index of **3M ATM vols** across USD-pairs, with weights based on the BIS Triennial Central Bank Survey of turnover in FX markets.
- Bloomberg tickers: JPMVXYG7, JPMVXYEM, JPMVXYGL



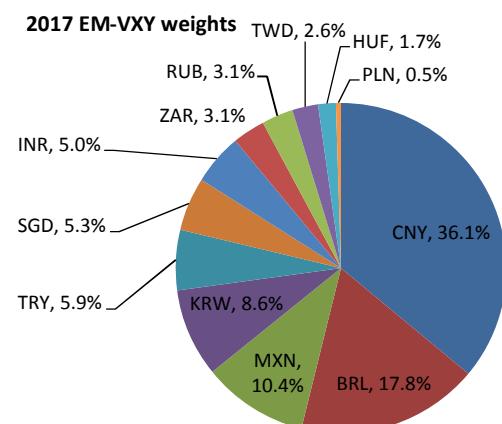
Source: J.P. Morgan

Composition of VXY G7



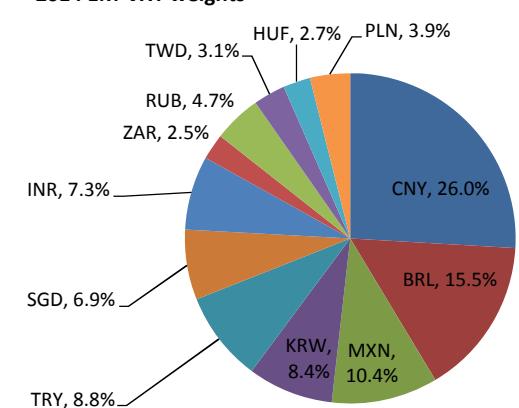
Source: J.P. Morgan

Composition of VXY EM



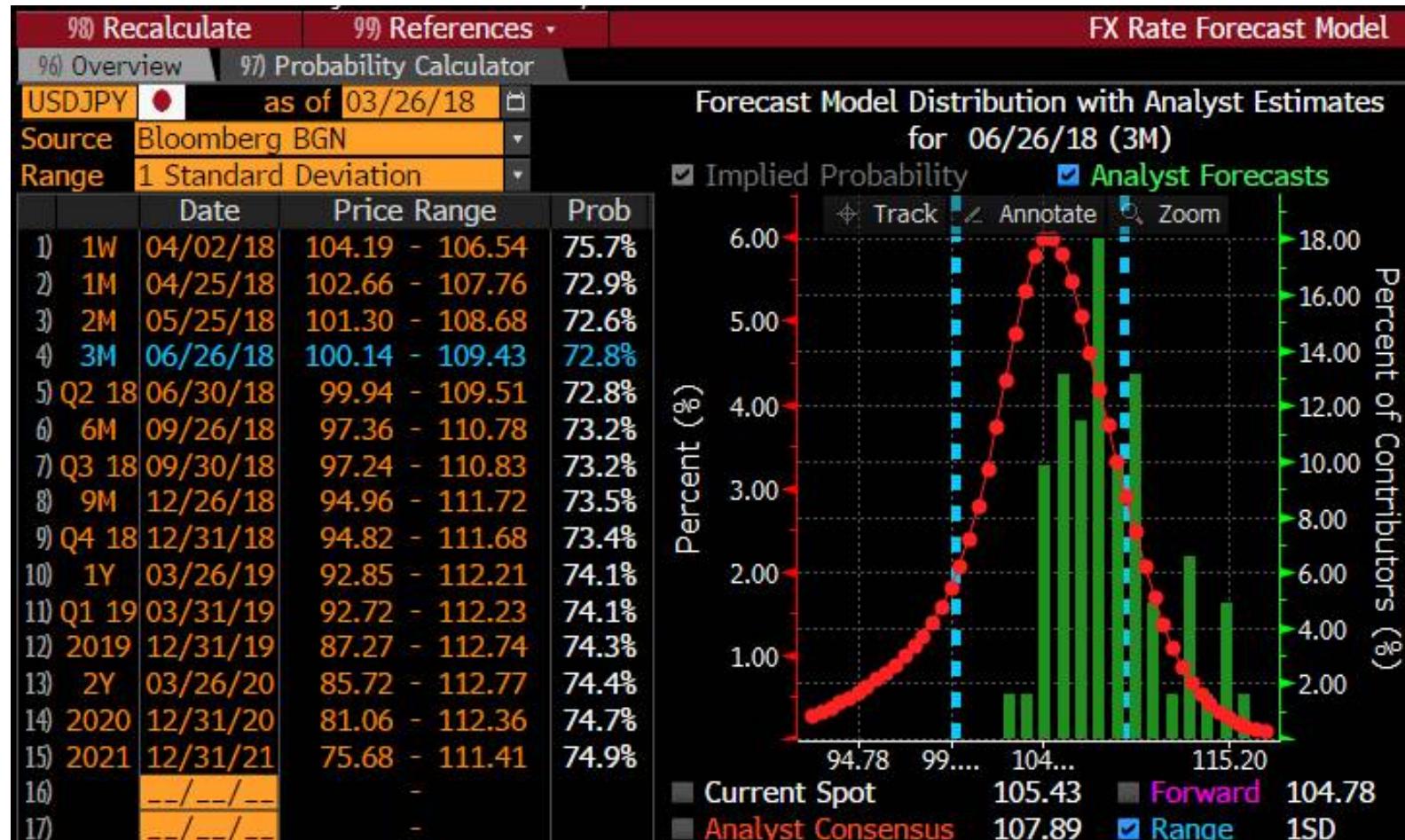
Source: J.P. Morgan

2014 EM-VXY weights



J.P.Morgan

OPTION IMPLIED DISTRIBUTIONS ON BLOOMBERG

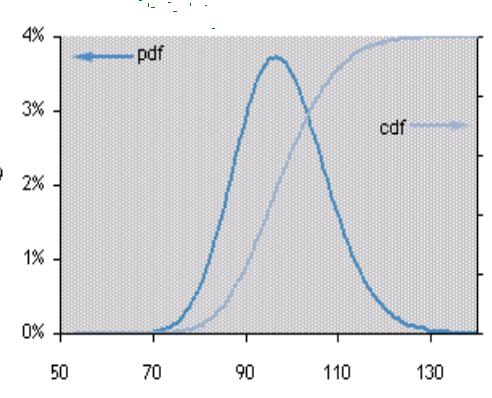
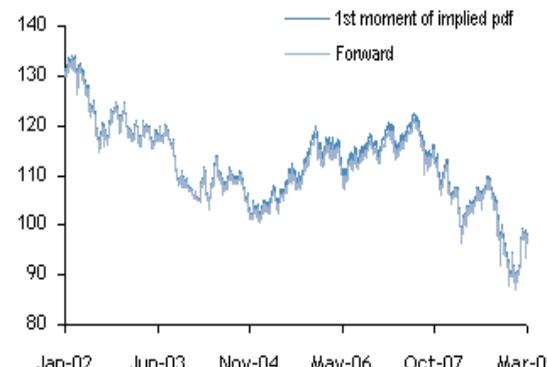


Source: Bloomberg

MOMENTS OF OPTION IMPLIED DISTRIBUTIONS

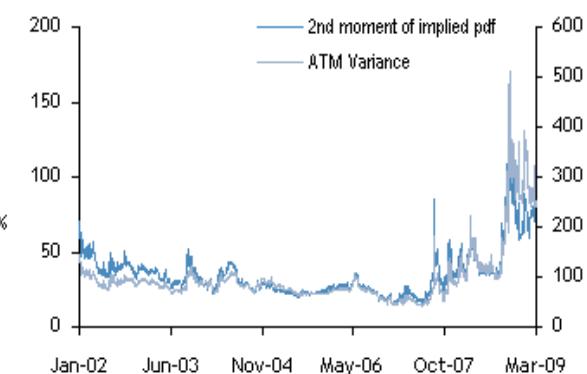
The first moment of the implied distribution is the forward

There is no incremental information that is to be gleaned from the option market as regards M_1

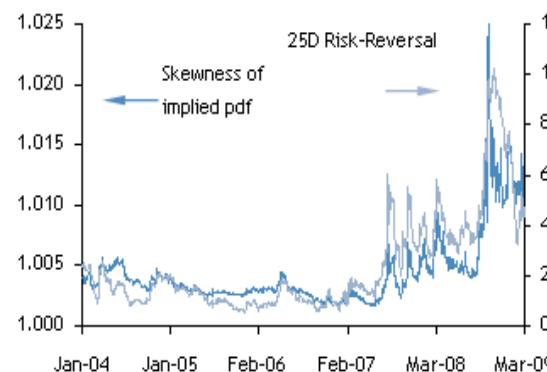


The second moment of the implied distribution is a function* of the ATM variance

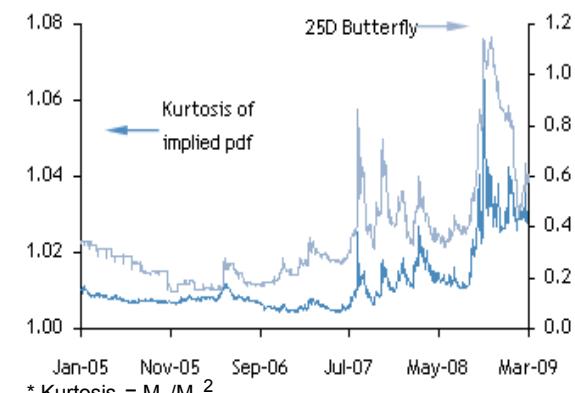
For M_2 therefore, just the ATM vol is enough of a proxy, the rest of the vol surface is immaterial



The skewness* of the implied distribution is highly correlated to risk-reversals (call vol – put vol)

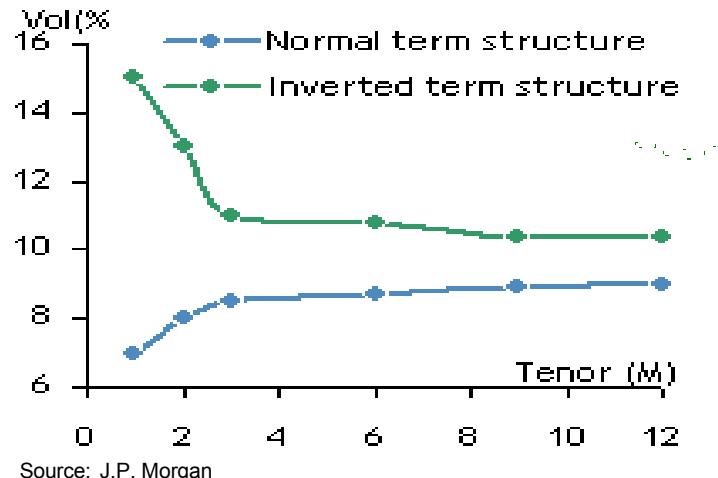


The kurtosis* of the implied distribution is highly correlated to butterflies



DECOMPOSING THE VOL SURFACE: TERM STRUCTURE (VOL CURVE)

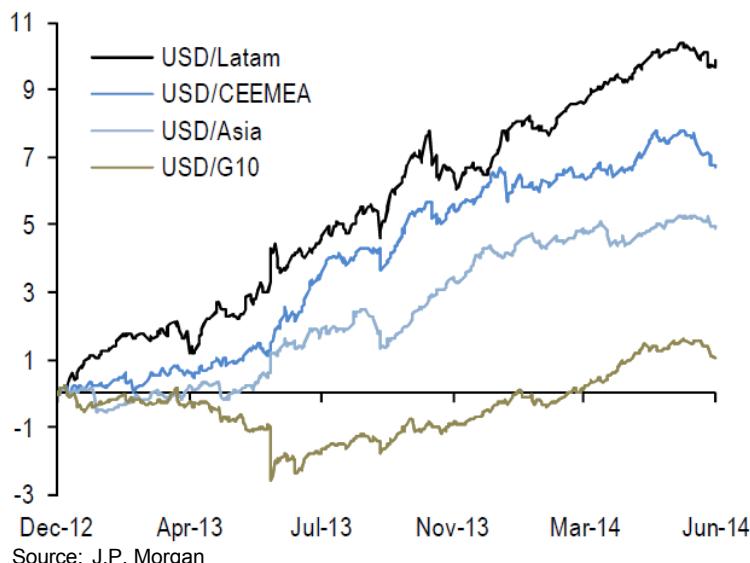
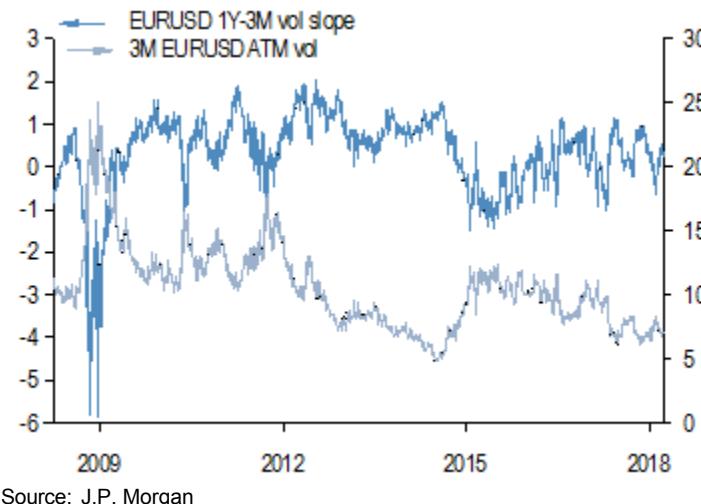
- View on gamma is essential to formulating a curve view.



Vol curve steepeners have been a sturdy source of alpha in EM FX, less so in G10

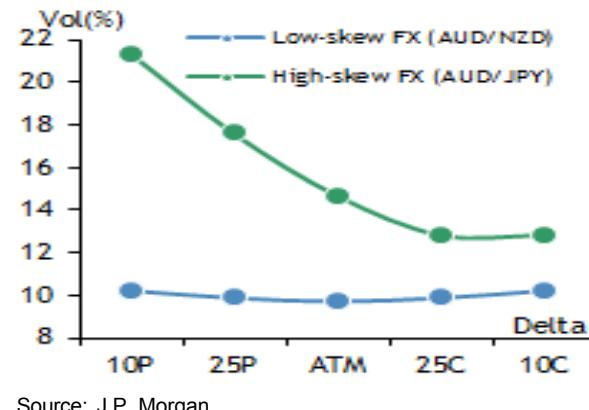
- Cumulative returns (in vol pts.) from vega-neutral **short 3M vs. long 1Y straddle** spreads
- Options delta-hedged daily using smile forward deltas and option maturity-matched forwards/NDFs, and rolled into fresh strikes every 3-months

- Vol curves mean-reverting, more than the vols**
- Vol curve trades: buying/selling **vega-neutral** amounts



DECOMPOSING THE VOL SURFACE: RISK REVERSAL (VOL SKEW)

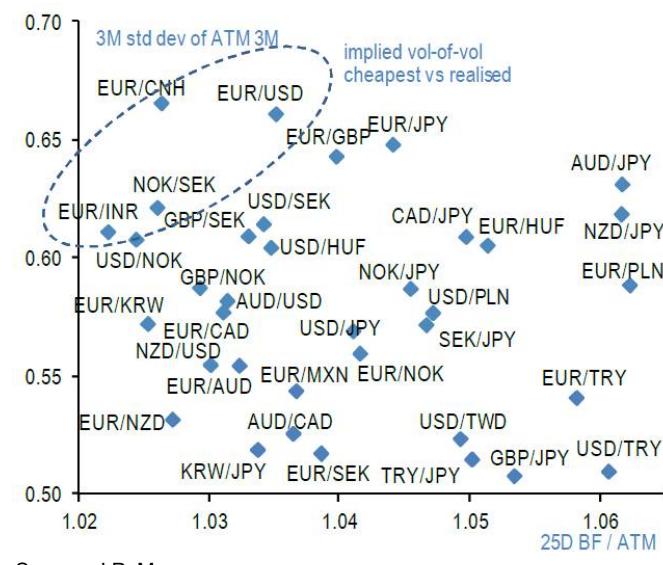
- Risk-reversals reflect the option market's expectation of a change in ATM implied vols for a given move in spot
- Well correlated to the **correlation between spot and vol moves**
- Often valued by comparing them to ATM vol (RR / ATM ratio)
- The highest carry attract the most flows => susceptible to the sharpest unwinds
 - skews bid higher for carry currency puts



Source: J.P. Morgan

DECOMPOSING THE VOL SURFACE: BUTTERFLY (VOL FLY)

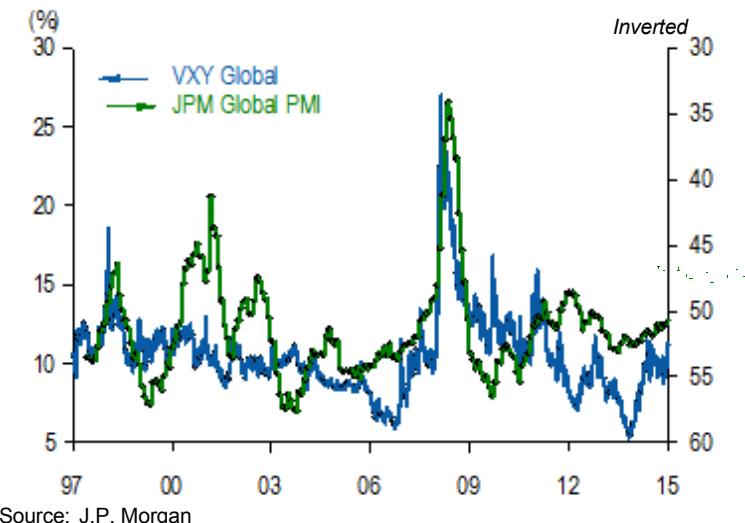
- Convexity of the vol surface
- Quoted as the *mean* of the volatilities of fixed delta call and put strikes (10-delta and 25-delta are standard) minus ATM vol
- flies (a non-directional measure of the variation of vol with strike)
 - well-correlated with volatility (or stdev) of ATM vol => captures **vol-of-vol**



Source: J.P. Morgan

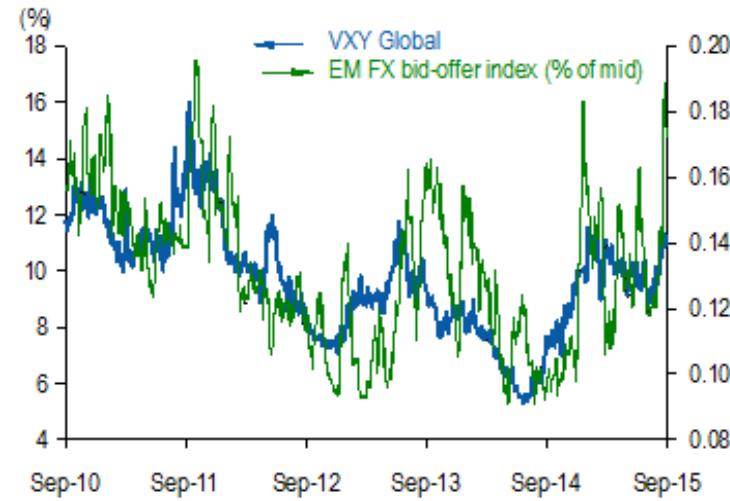
SOME GENERAL VOLATILITY CONCEPTS

Volatility responds to macro developments



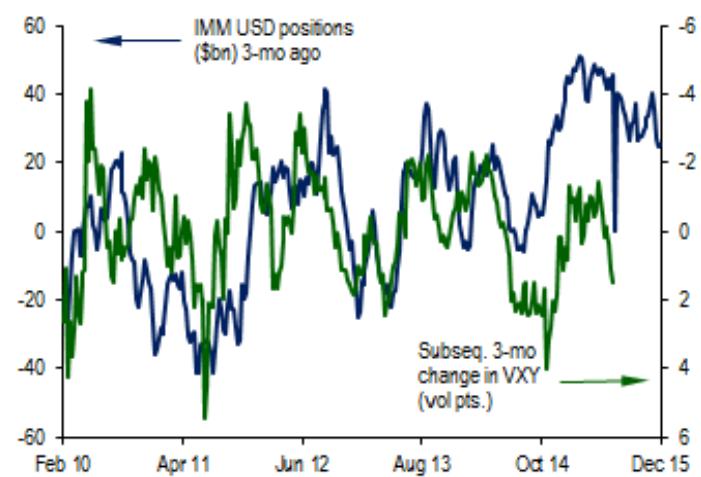
Source: J.P. Morgan

Market micro-structure matters too



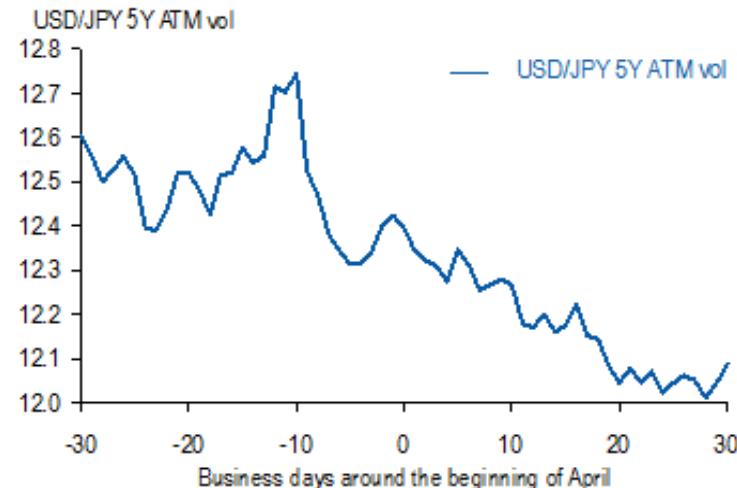
Source: J.P. Morgan

Cash pre-positioning is key to future vol movements



Source: J.P. Morgan

Demand and supply of options heavily influences option prices, especially in longer tenors



Source: J.P. Morgan

Agenda

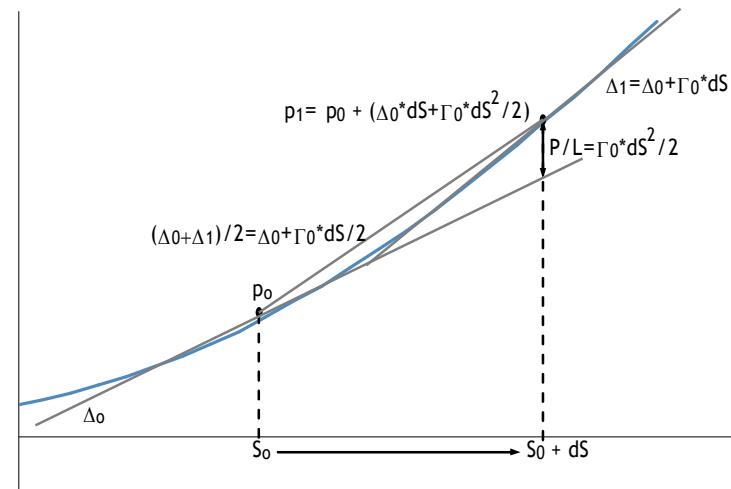
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VOLATILITY AS AN ASSET CLASS

- What if you have a view on volatility, but no view on spot?
- Volatility Trading is profiting from a discrepancy between implied volatility and realized volatility or in changes in implied volatility
- In Vanilla Options the two primary ways to profit from volatility trading:
 - Gamma Trading
 - Vega Trading
- In Exotic Options, there are various structures that can be used to express a volatility view. The most basic:
 - Forward Volatility Agreements
 - Volatility Swaps
 - Variance Swaps

Gamma P/L from delta hedging an option

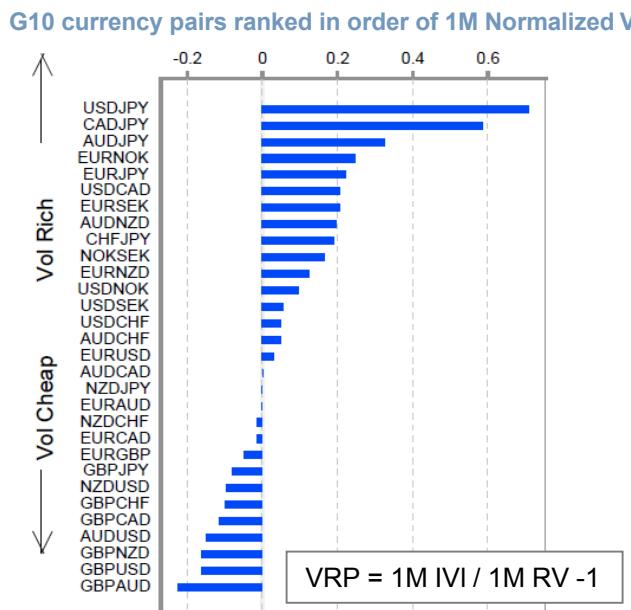


Source: J.P. Morgan

TRACKING VOLATILITY VALUATIONS

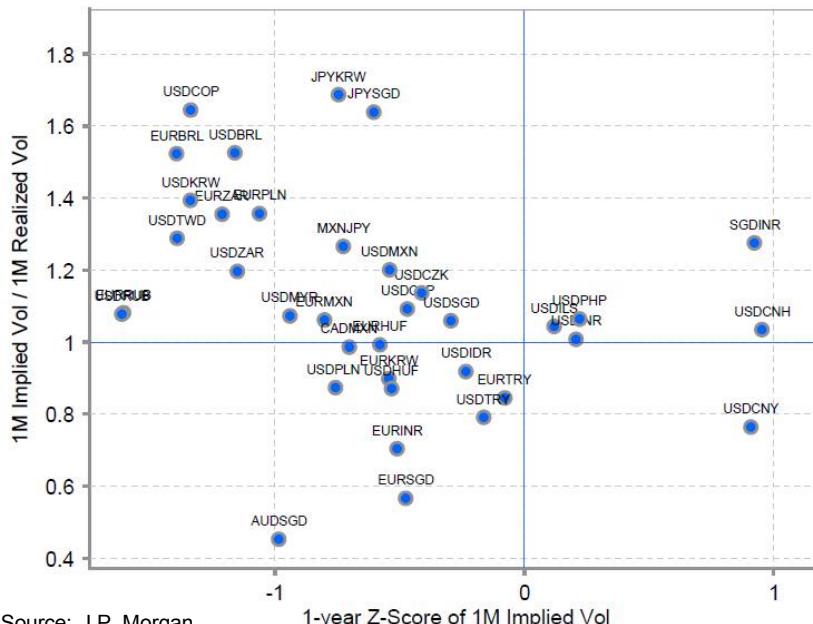
- Implied / realized volatility ratios are a commonly accepted and widely used approach to tracking richness/cheapness of front-end vols
- Plotting implied/realized ratios along with implied vol z-scores on the same chart provides a better perspective on the trade-off between the richness / cheapness of implied vols relative to history and to realized vols
- The theme at the front-end of G10 vols seems to be that gamma in JPY is elevated amid upcoming elections and GBP x-vols performing as weekly dose of Brexit uncertainty keeps spot jittery.
- EM: depressed implied vols but even softer realized vols => notable option premium in such as BRL

TRADING VOLATILITY AS AN ASSET CLASS

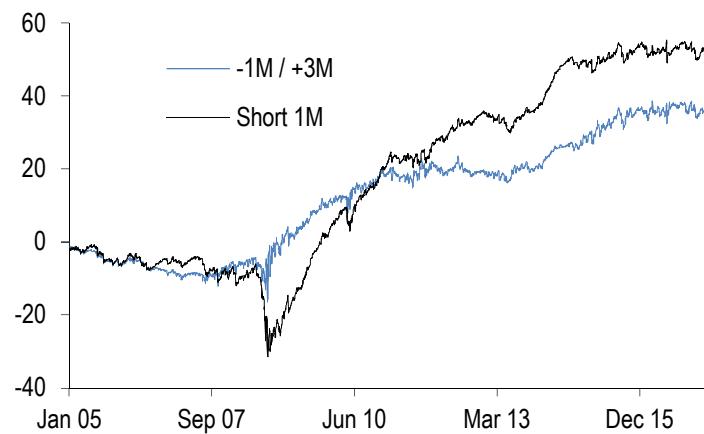


Source: J.P. Morgan

EM gamma (1M vol) metrics



Cum P/L (vol pts) for Short 1M (VXY-GL weights)

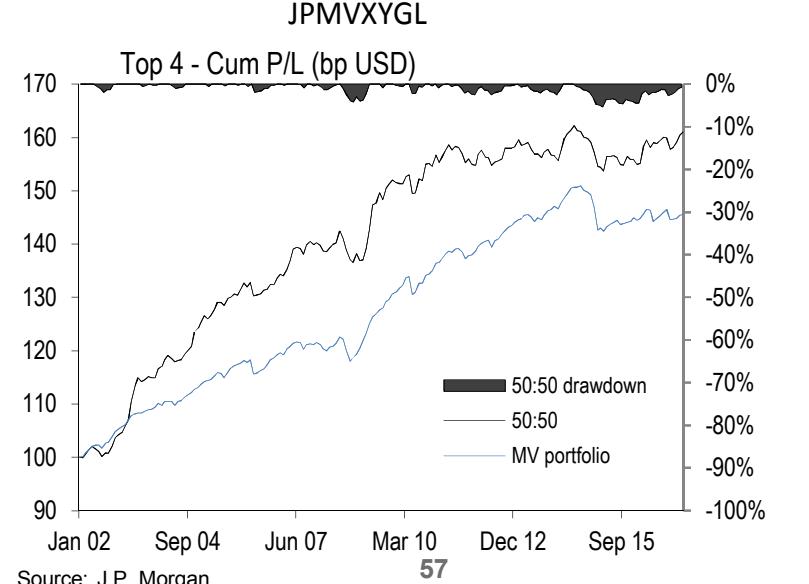


Short vol shows undesirable left tail – carry a worthy complement

**Short straddles: good returns but downside risk
ATMF options best compromise**

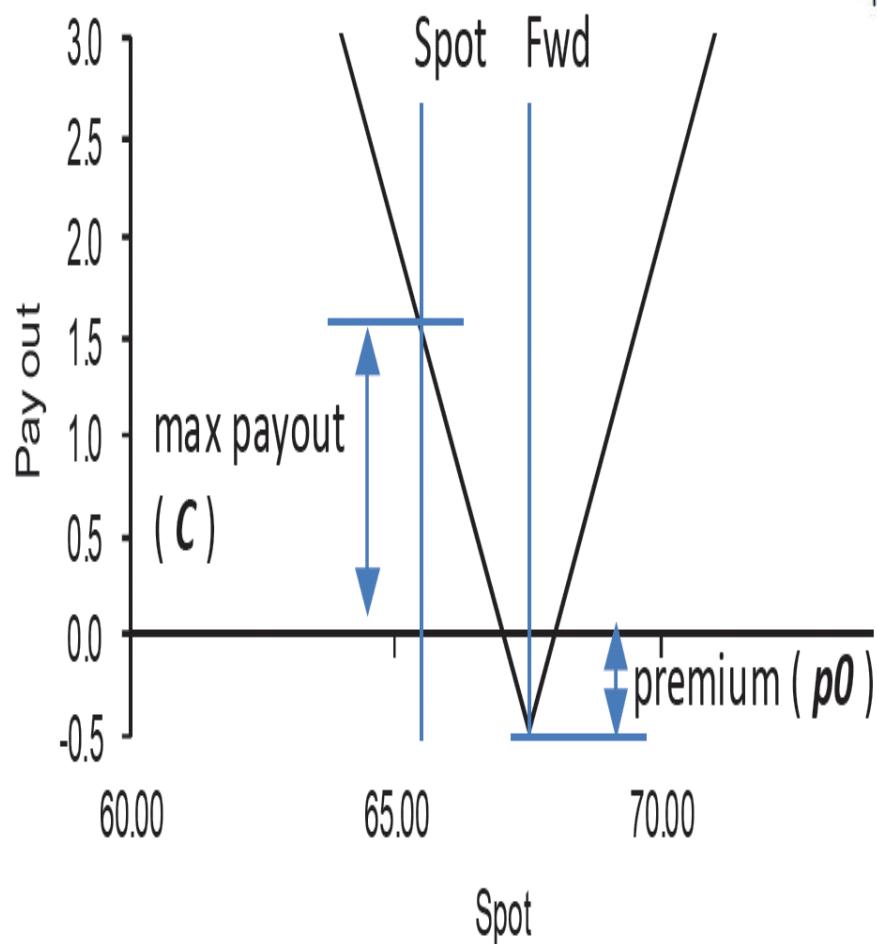
	Short straddle ATMF carry				ATMF/ATMS carry		Short straddle ATMF carry				ATMF/ATMS carry				
	EW		Top 4		EW		Top 4		EW		Top 4				
	ret	stdev	SR	skew	kurtosis	ret	stdev	SR	skew	kurtosis	ret	stdev			
50-100	1.4% 3.2%	0.9% 1.3%	1.62 2.34	-0.89 -0.80	1.33 1.63	1.9% 6.4%	2.4% 4.5%	0.78 1.41	0.97 1.72	0.5% 1.62	2.5% 1.75	-1.7% -1.7%	0.8% 2.6%	-0.2% 1.1%	
0-50	2.6% 3.5%	1.0% 1.9%	2.63 1.82	-2.77 -3.71	11.66 16.98	-0.6% -0.28	1.7% 0.43	0.1% 0.15	1.0% 0.77	1.6% -0.26	1.0% 0.39	1.1% 0.24	3.6% 1.55	0.0% -0.04	0.5% 0.58

Source: J.P. Morgan



CARRY / VOL IS AN INPUT INTO NON-DIRECTIONAL / VOL TRADES, ESPECIALLY IN EM

Chart 1. Stylized payout profile of a vanilla ATMF straddle in a high-yielding USD/EM currency pair



TRADING VOLATILITY AS AN ASSET CLASS

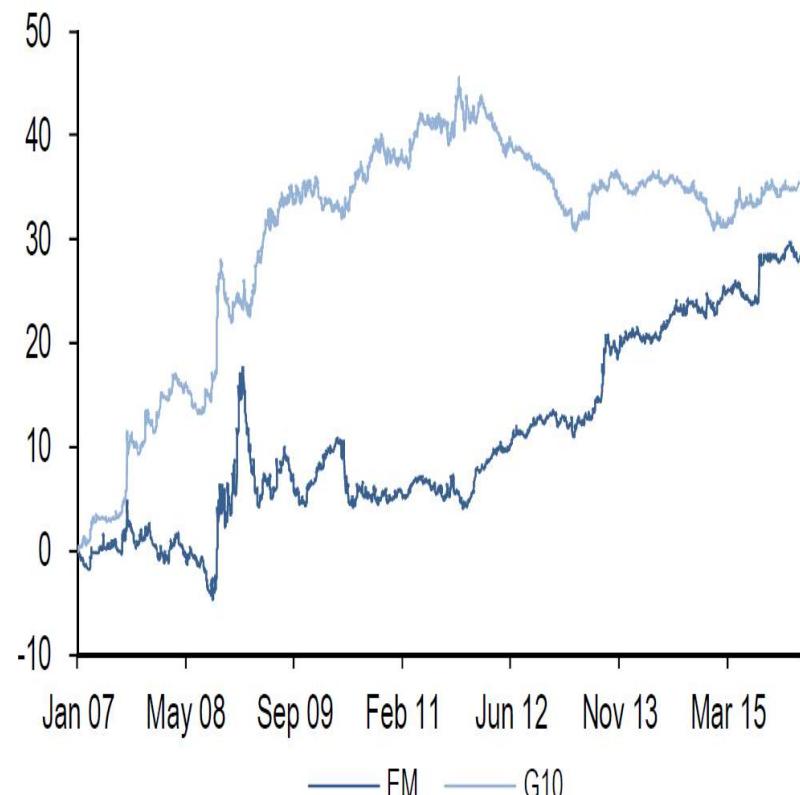
Source: J.P. Morgan

Source: [Extracting vol alpha using carry-to-risk signals](#)

Chart 4. Cumulative P/Ls from buying top N carry/risk 6M tenor straddles and selling N lowest carry/risk straddles.

$N = 3$; 6M tenor options and no TC.

Cumulative P/L (vol pts)



Source: J.P. Morgan

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DOUBLE NO-TOUCHES / RANGE BINARIES AS SHORT VOL PLAYS

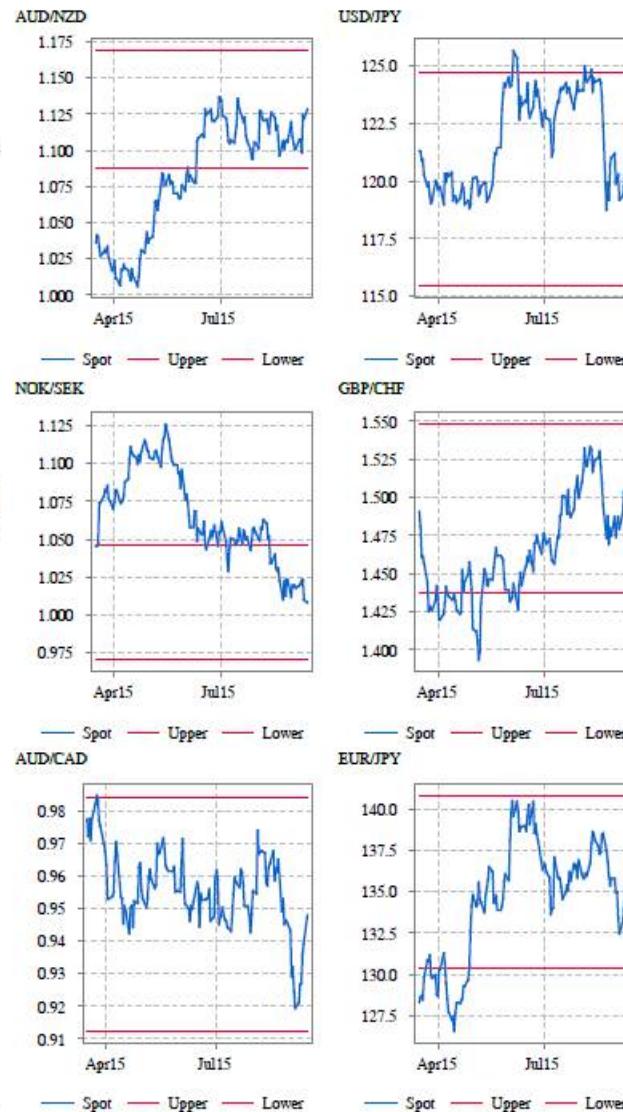
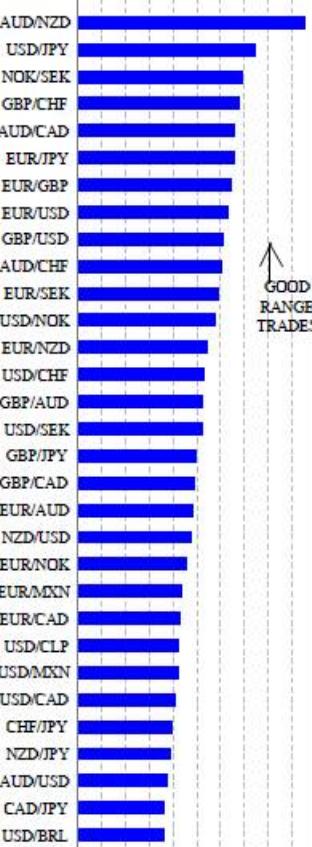
3M Range Binary Report

Ccy Pair	Spot	Tenor	Lower Barrier	Upper Barrier	3M Spot Low	3M Spot High	Binary Range / Trading Range
AUD/NZD	1.1283	3M	1.0877	1.1686	1.0941	1.1365	1.91
USD/JPY	120.07	3M	115.4202	124.7098	118.7400	124.9950	1.49
NOK/SEK	1.0081	3M	0.9702	1.0460	1.0081	1.0628	1.39
GBP/CHF	1.4932	3M	1.4370	1.5479	1.4516	1.5331	1.36
AUD/CAD	0.9479	3M	0.9124	0.9840	0.9195	0.9739	1.32
EUR/JPY	135.59	3M	130.3818	140.7970	132.4801	140.4220	1.31
EUR/GBP	0.7338	3M	0.7071	0.7606	0.6942	0.7356	1.29
EUR/USD	1.1293	3M	1.0839	1.1747	1.0854	1.1576	1.26
GBP/USD	1.5390	3M	1.4956	1.5823	1.5171	1.5884	1.22
AUD/CHF	0.6936	3M	0.6587	0.7277	0.6722	0.7291	1.21
EUR/SEK	9.3468	3M	9.0948	9.5988	9.2140	9.6415	1.18
USD/NOK	8.2101	3M	7.8261	8.5940	7.7168	8.3854	1.15
EUR/NZD	1.7824	3M	1.6881	1.8766	1.6202	1.7936	1.09
USD/CHF	0.9703	3M	0.9336	1.0060	0.9177	0.9862	1.06
GBP/AUD	2.1527	3M	2.0613	2.2447	2.0291	2.2037	1.05
USD/SEK	8.2767	3M	7.9270	8.6263	8.1136	8.7860	1.04
GBP/JPY	184.77	3M	177.5042	192.0439	180.8156	195.4500	0.99
GBP/CAD	2.0405	3M	1.9695	2.1134	1.9367	2.0845	0.97
EUR/AUD	1.5797	3M	1.5002	1.6595	1.4459	1.6109	0.97
NZD/USD	0.6336	3M	0.6015	0.6657	0.6256	0.6935	0.94
EUR/NOK	9.2716	3M	8.9204	9.6228	8.7356	9.5096	0.91
EUR/MXN	18.98	3M	17.8152	20.0593	17.2205	19.8056	0.87
EUR/CHF	1.0957	3M	1.0671	1.1233	1.0362	1.1013	0.86
EUR/CAD	1.4973	3M	1.4349	1.5612	1.3792	1.5270	0.85
USD/CLP	687.65	3M	656.2909	719.7091	630.0350	705.1300	0.84
USD/MXN	16.81	3M	15.9831	17.5545	15.2465	17.1099	0.84
USD/CAD	1.3259	3M	1.2810	1.3720	1.2196	1.3306	0.82
CHF/JPY	123.75	3M	119.0256	128.5822	122.2160	134.2650	0.79
NZD/JPY	76.07	3M	71.8941	80.2523	74.6563	85.4485	0.77
AUD/USD	0.7149	3M	0.6814	0.7482	0.6927	0.7826	0.74
CAD/JPY	90.55	3M	86.4206	94.6040	89.5918	100.8363	0.73
USD/BRL	3.8666	3M	3.5279	4.1321	3.0576	3.8890	0.73
AUD/JPY	85.83	3M	81.4590	90.1859	82.6667	96.2419	0.64

3M range binaries ranked by Barrier Range/Trading Range

Barrier Range/Trading Range

0 0.2 0.4 0.6 0.8 1 1.2 1.4 1.6 1.8 2



Note:

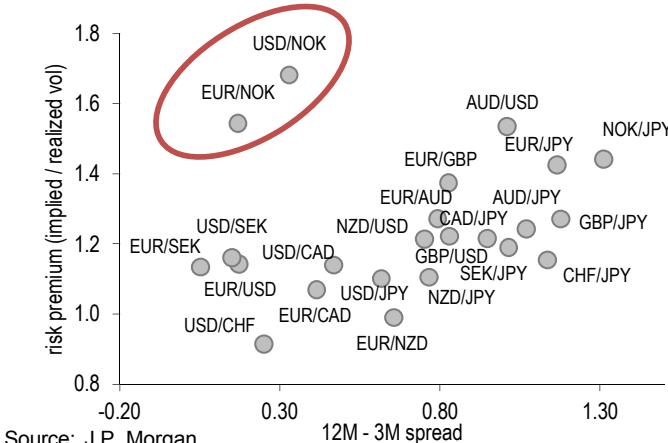
- All range binaries are selected such that their barriers are equidistant from spot on either side, and cost 20% TV (w/o bid-offer) i.e. a 5:1 payout ratio. Range binaries with high barrier range/trading range ratio have barriers that subsume a large fraction of the recent historical trading range of spot, and should therefore count as better range binary candidates than the rest.
- Note that the range barriers are agnostic i.e. they assume no view on spot, nor do they take into account any historical trend in spot till today. A dealable range binary trade may therefore need a tweak of the barriers higher or lower depending on the investor's view on spot.

Curve trades | Gamma spreads

NOK -3M/+9M calendar

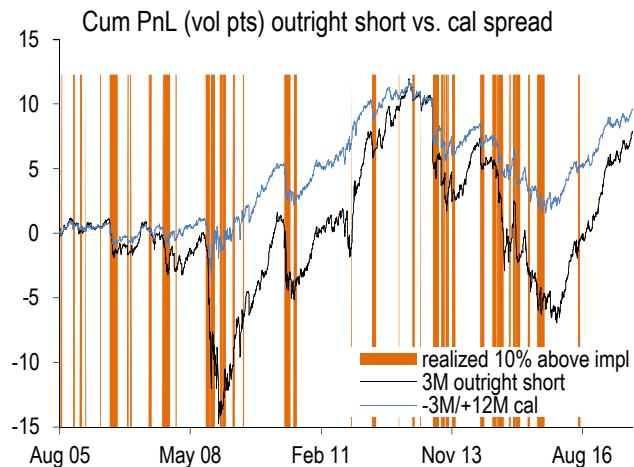
NOK screens favorably within G10 for short gamma plays given the richness of NOK front vols vis-à-vis realized vols

Left upper corner (high risk premium and flat or inverted vol curves) currencies are best placed for short front vs. long back cal spread trades.



Source: J.P. Morgan

EUR/NOK calendars show appealingly strong recent upside trend.
Cumulative P/L (vol pts) (LHS) EUR/NOK short 3M / Long 12M delta-hedged calendar spread vs. outright 3M short vol



Source: J.P. Morgan

NZD/USD – AUD/USD gamma spread

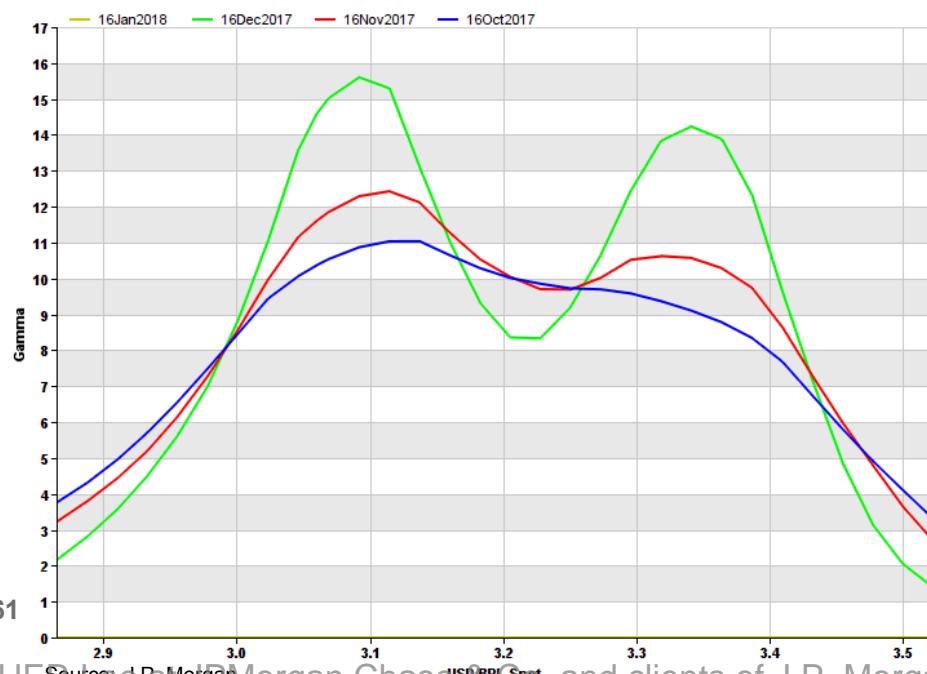
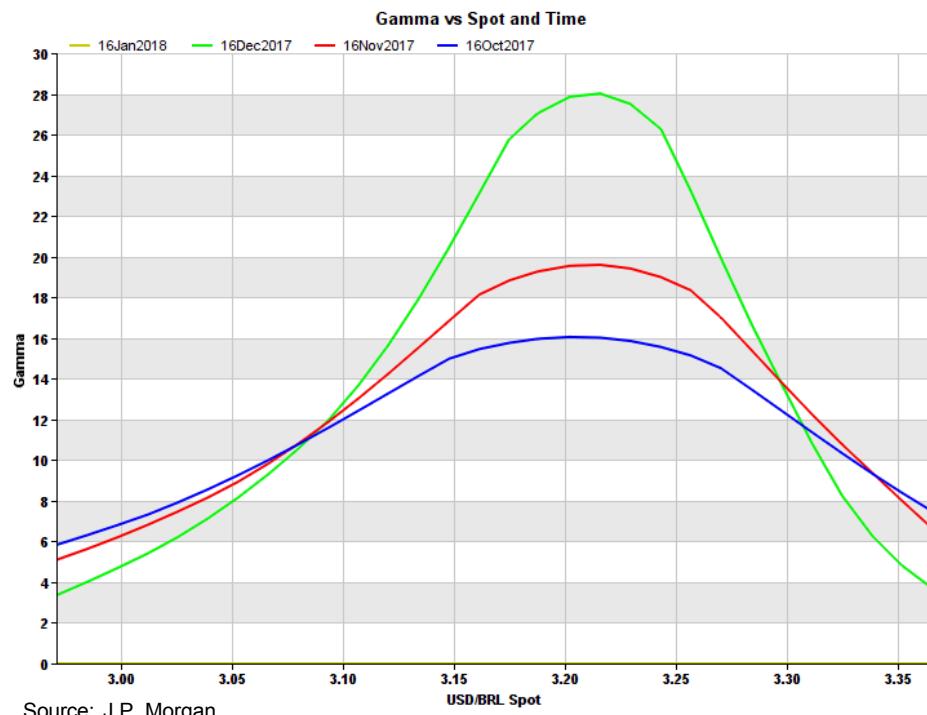


GAMMA PROFILES

- 3M USD/BRL ATMF straddle vs. 3M 25 delta USD/BRL strangle (strikes ~ +/-4%)
- NDF @ 3.1863

Name	3M Strangle	3M Straddle
Type	Strangle	Straddle
Market Date	Mon 16Oct2017	Mon 16Oct2017
Market State	Mkt2	Mkt2
FX Pair	USD/BRL Offshore	USD/BRL Offshore
Expiration Date	Tue 16Jan2018 [92d]	Tue 16Jan2018 [92d]
Settlement Date	Thu 18Jan2018	Thu 18Jan2018
Strike		3.1863
Settlement Type	Cash	Cash
Settlement Currency	USD	USD
Expiration Cut	BRL	BRL
Option Type	Strangle	Straddle
Strangle Type	Broker	
Broker Delta	25.00	
Broker Vol	11.556/12.408	
Call Leg Strike	3.3186	
Put Leg Strike	3.0600	
Quantity Currency	USD	USD
Quantity	100	100
Buy/Sell	b - JPM Buys	b - JPM Buys
Position	Per Leg	Per Leg
Spot	3.1501	3.1501
Forward	3.1863	3.1863
Forward Point	0.03624/0.03624	0.03624/0.03624
Denominated Depo	5.87	5.87
Asset Depo	1.35	1.35
Vol for strike		11.334/12.013
ATM Volatility	11.674	11.674
Call Leg Volatility	12.716/13.521	
Put Leg Volatility	10.286/11.204	

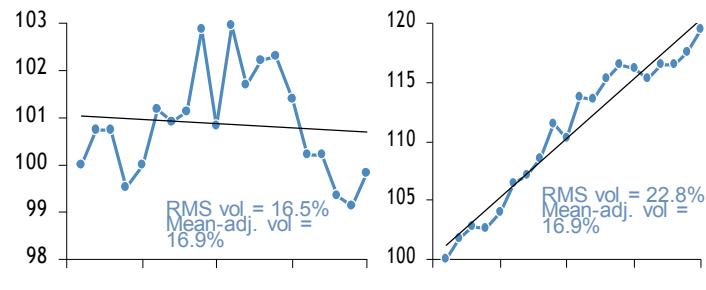
Source: J.P. Morgan



VOLATILITY SWAPS

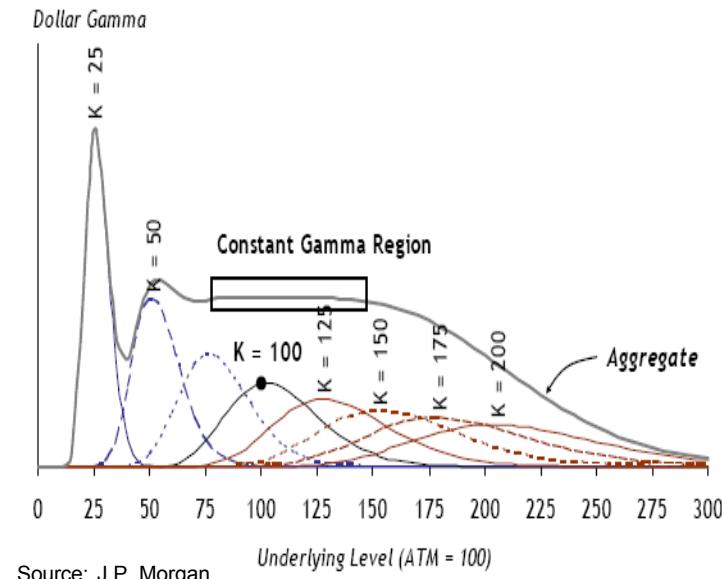
- In a trending environment straddles lose gamma and can no longer effectively monetize the difference between implied and realized volatility
- => own a series of strikes = ~ constant gamma profile
- Better: own (or sell) a volatility swap
- The payout of a volatility swap is simply: $(\text{Realized Vol} - \text{Vol Swap Strike}) \times \text{vega amount}$
- The notional quantity is expressed in vega amounts
 - e.g. Sell \$500,000 of 3M vega at 10.0%
- The volatility is typically determined by a set number of fixings
 - E.g. Spot rate sampled every business day at exactly 11:00 AM NYT from inception to expiry
- The **advantages** of a volatility swap versus a delta-hedged option:
 - **No need to delta hedge**
 - A constant gamma and vega profile across strikes
 - Ability to cleanly monetize the difference between implied and realized vol

In a trendless market (left-hand chart below), we can monetize realized volatility via a delta-hedged straddle, but in a trending environment, we lose our gamma along the way.



Source: J.P. Morgan

Owning a series of strikes in weights inversely proportional to the square of the strike gives an approximately constant gamma profile. Owning a volatility swap gives a payout with an exactly constant gamma profile.



Source: J.P. Morgan

FORWARD VOLATILITY AGREEMENTS (FVAs)

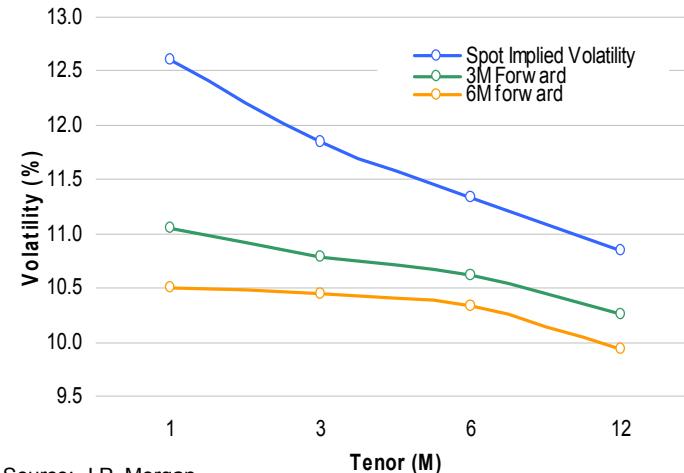
- Forward Volatility Agreement (FVA) is the right to buy or sell a fixed tenor option at a fixed point in the future.

$$\sigma_{n,m}^2 * n_{daycount} = \sigma_{n+m}^2 * (n_{daycount} + m_{daycount}) - (\sigma_m^2 * m_{daycount})$$

where n and m are either months or years, i.e. $\sigma_{1,2}$ is 1m, 2m forward

- Often considered to be a systematic buy when Spot Vol Curves are inverted, or downward sloping and systematic sells when Spot Vol Curves are steep, or upward sloping. Neither proposition is correct.
- Current Realized Vol, Structural concerns and the Macro regime's effect on the overall level of Volatility all need to be assessed when determining whether Forward Vol should be bought or sold.
- Provides exposure to forward implied volatility but without having to actively manage the Delta and Gamma.
- If the structure was created synthetically using Vanilla Options it would be in gamma neutral weights at inception, hence less 3m and more 6m, giving the net position the Vega exposure.

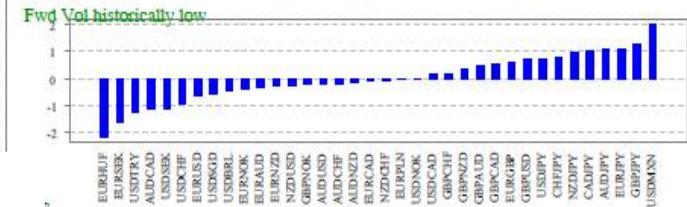
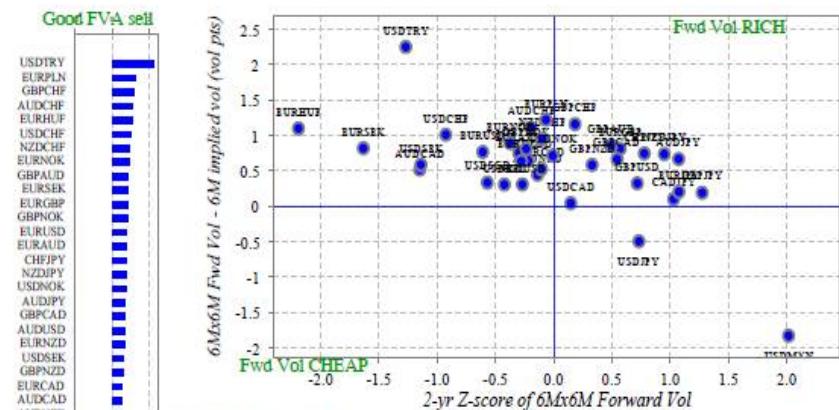
Forward volatility vs. Spot/ Implied Volatility Curves



Source: J.P. Morgan

Forward Volatility Ranking

6Mx6M Forward Vols

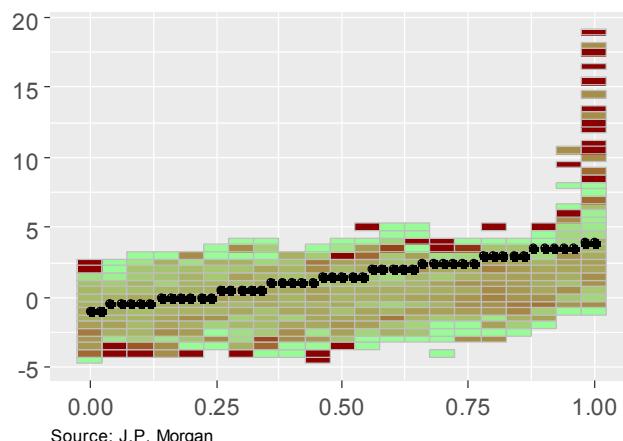


Source: J.P. Morgan

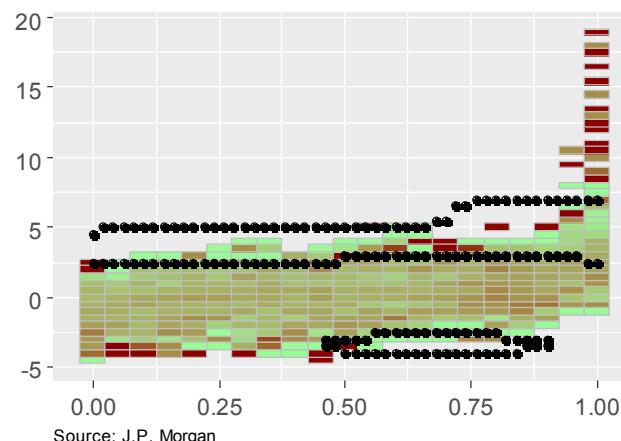
Systematic FX vol trading – a machine learning approach

G10 FX vols

Logistic regression (predicted hit ratio of 70%)

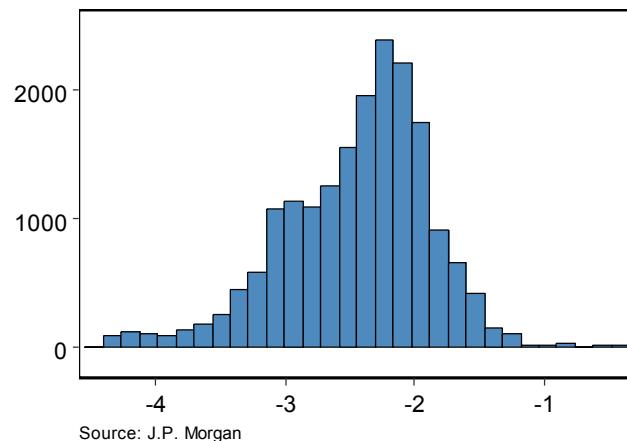


SVM boundary of 70% overlaid on actual data

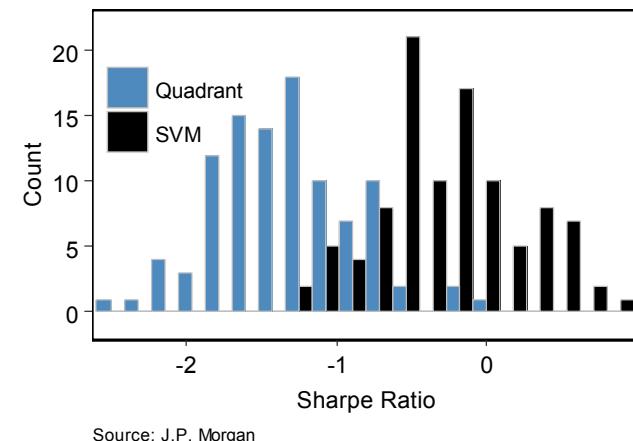


EM FX vols

Log of 1 Month Implied Volatility



Long 1M volatility

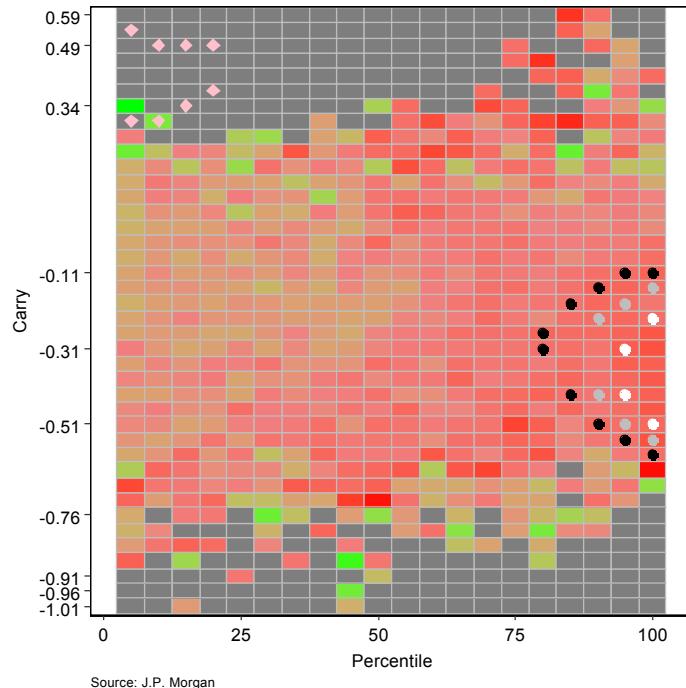


TRADE VOLATILITY AS AN ASSET CLASS

Systematic FX vol trading – a machine learning approach cont'd

Equity-G10 FX vols pair trading

SVM decision boundaries for equity-FX variance pair trades



Long	Short	1Y Variance Ratio (x)	1Y Percentile	EWMA Realized Ratio (x)	SVM Ranking
CHF	NDX	2.95	70%	2.12	1
NZD	SPX	1.81	46%	1.04	2
JPY	NDX	2.66	80%	2.48	3
NZD	NDX	2.31	67%	1.68	4
EUR	SPX	2.25	40%	1.19	5
CHF	SPX	2.31	43%	1.31	6
JPY	AS51	1.80	68%	1.55	7
CHF	EEM	3.09	63%	3.04	8
SEK	SPX	1.72	15%	0.85	9
NZD	EEM	2.42	53%	2.41	10
EUR	NDX	2.88	56%	1.92	11
CAD	NDX	2.83	55%	1.88	12
CAD	SPX	2.21	30%	1.17	13
EUR	HSI	2.85	57%	2.68	14
SEK	NDX	2.20	38%	1.37	15
AUD	SPX	1.84	28%	1.03	16
JPY	SPX	2.08	57%	1.54	17
CHF	AS51	1.99	43%	1.32	18
AUD	NDX	2.36	52%	1.67	19
CHF	NKY	2.78	59%	2.31	20

Source: J.P. Morgan

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FX-options-based signals as source of market intelligence for FX spot trading

- Exchange rate predictability using option-market information to the extent that options embed forward looking information
- The heuristics that have historically been able to deliver meaningful intelligence about FX spot dynamics:
 - at-the-money (ATM) volatility, realized volatility, ATM – realized volatility risk premia, vol curve slopes, risk reversals and butterflies as well as their simple mathematical transformations (z-scores, monthly changes, ...)
- G10 & EM ccy pairs (BRL, CLP, COP, MXN, CNY, IDR, INR, KRW, MYR, SGD, TWD, HUF, ILS, PLN, RUB, TRY, ZAR)

Option-market configurations tested as FX spot predictors

Characteristics	Specifications
Option tenors	1m, 3m, 6m, 9m, 1y
N of pairs in portfolio	1, 3
currency population	G10 (9 USD pairs) EM (17 most liquid USD pairs) G10 + EM (tot of 26 USD pairs)
transformation	1-y zscore period/period change & % change change in 1-y zscore ratio to ATM change in 1-y z-score of ratio
type of signal	ATM vols 1-mo trailing real vol: rmsvol (daily close data) high freq real vol (hourly): 1 wk & 4 wk trailing risk reversals butterflies vol curves
Tot # of signals tested	207
Tot # of portfolios	1242

Source: J.P.Morgan

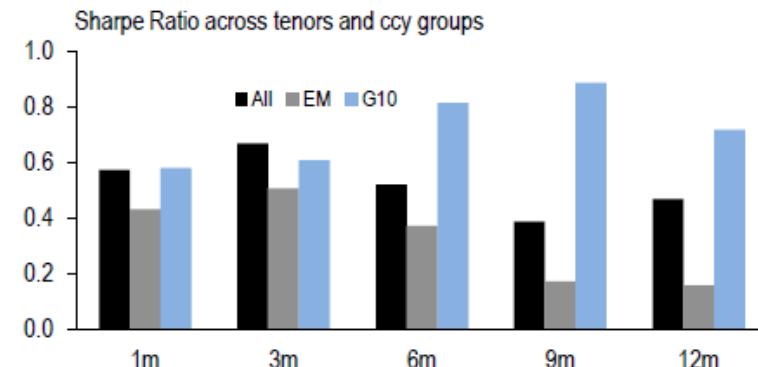
Vol signals performance summary in terms of Sharpe Ratio

Signal	Trading rule	Sharpe
ATM: risk aversion play		
$\Delta m/m$ in 1-year ATM z-score	buy (sell) FX with largest down tick (uptick) in vol signal	0.7
%m/m in ATM vols		0.5
realized: risk on/ risk off		
%m/m in realized vol	buy (sell) FX with largest down tick	0.4
$\Delta m/m$ in realized/ATM ratio	(uptick) in realized vol or realized	0.4
$\Delta m/m$ in z-score of realized/ATM	vol/ATM ratio	0.5
realized/ATM ratio	buy (sell) FX with lowest (highest)	0.4
z-score of realized/ATM	realized vol/ATM ratio	0.6
risk reversals: flow driven		
%m/m in RR	buy (sell) FX with largest down tick	0.3
$\Delta m/m$ in RR z-score	(uptick) in RR/ATM ratio, where RR is	0.8
$\Delta m/m$ in RR/ATM z-score	USD/CCY call - USD/CCY put	0.5
B-fly: risk aversion play		
B-fly/ATM	buy (sell) FX with lowest (highest) B-fly vol/ATM ratio	0.7
%m/m in B-fly vols	buy (sell) FX with largest down tick (uptick) in B-fly vol/ATM ratio	0.5
vol curves		
$\Delta m/m$ vol curve	buy (sell) FX with quickest	0.5
$\Delta m/m$ of vol curve z-score	normalization (inversion) in vol curve	0.5

Source: J.P.Morgan

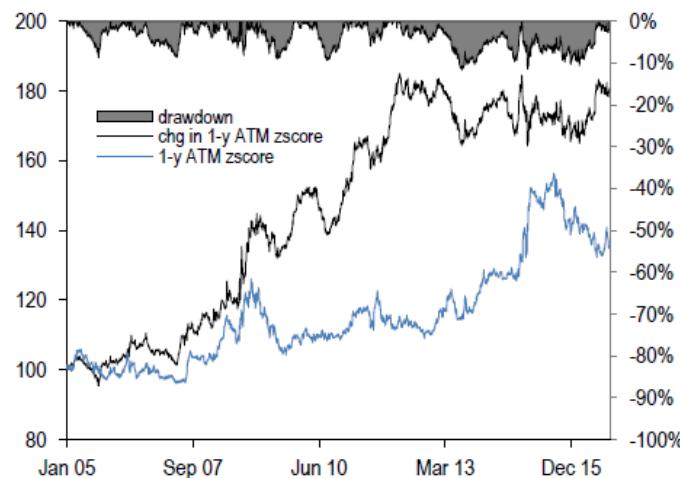
ATM, risk premium and vol curve show tradable spot market intelligence

Performance statistics for signal based on monthly changes in one-year ATM z-score across tenors



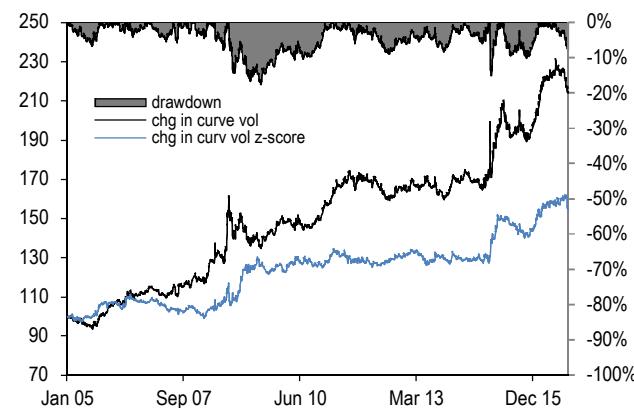
Source: J.P. Morgan

Cumulative P/L for signals based on ATM vol: change in z-score (S.R. of 0.67) vs. level of ATM z-score (S.R. 0.36).



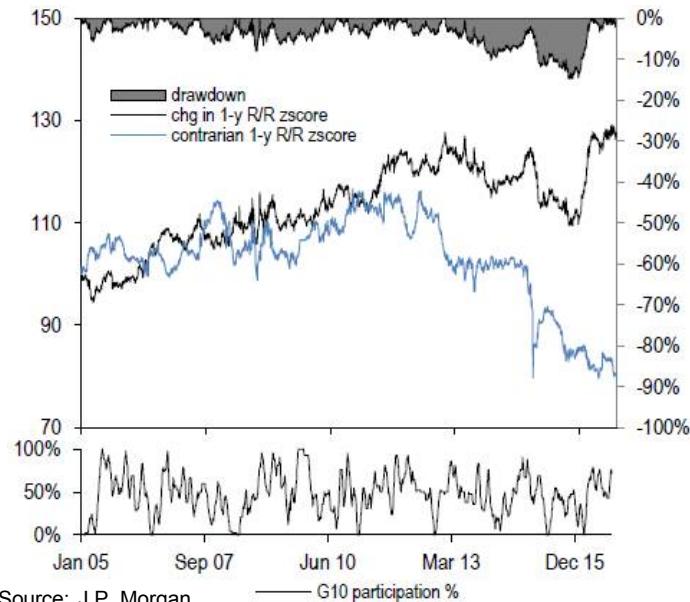
Source: J.P. Morgan

Cumulative P/L for signals based on vol curve: momentum change in vol curve and the corresponding change in vol curve z-score



Source: J.P. Morgan

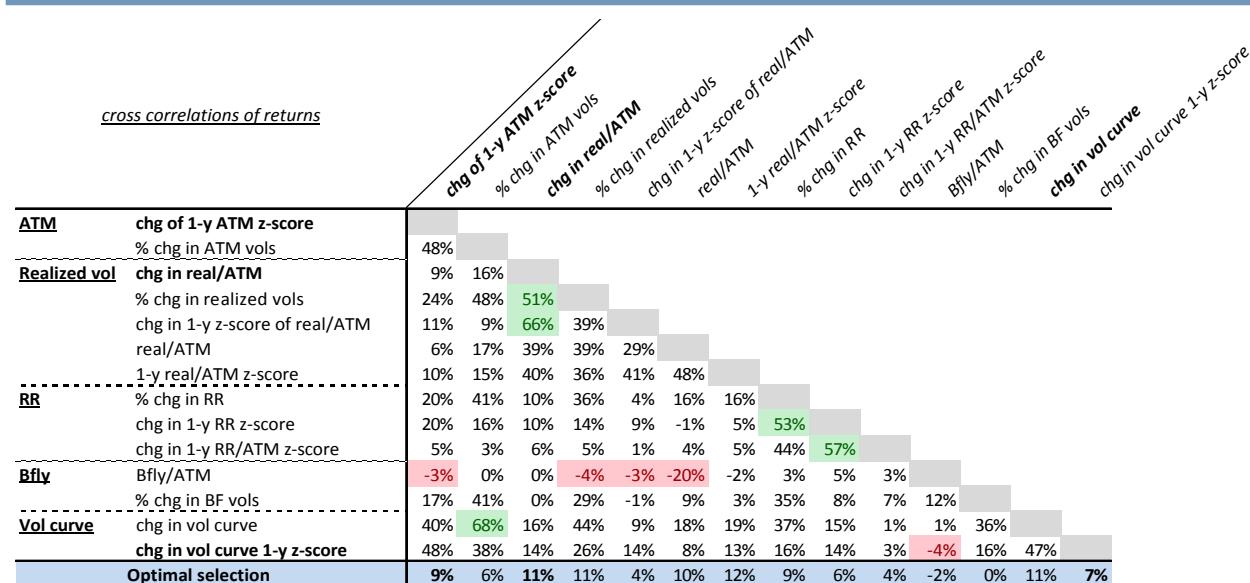
Cumulative P/L for signals based on R/R vol



Source: J.P. Morgan

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Some redundancy | performance only skimming the surface

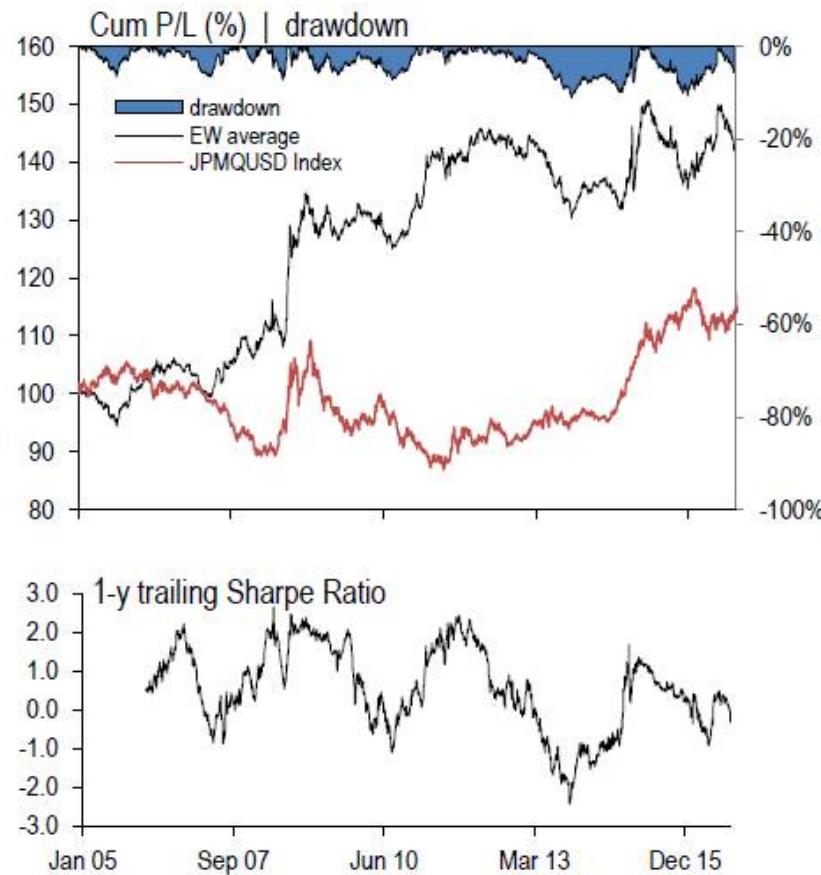


Transaction costs trim returns, increase volatility

(LDN)	12PM	1PM	2PM	3PM	4PM	5PM	6PM	7PM	8PM	9PM	10PM	11PM	12AM	1AM	2AM	3AM	4AM	5AM	6AM	7AM	8AM	9AM	10AM	11AM
AUDUSD	4.6	4.6	4.5	4.6	4.5	4.5	4.6	4.7	4.6	4.7	6.1	5.2	4.5	4.5	4.6	4.5	4.5	4.5	4.5	4.6	4.6	4.5	4.5	4.5
EURUSD	2.4	2.4	2.5	2.4	2.4	2.4	2.5	2.5	2.5	2.5	3.5	3.3	2.5	2.5	2.5	2.4	2.4	2.4	2.4	2.4	2.5	2.5	2.5	2.4
GBPUSD	3.0	3.0	2.9	3.0	3.0	2.9	3.0	3.0	3.0	3.1	4.3	4.3	3.1	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
USDCAD	3.6	3.6	3.6	3.6	3.4	3.5	3.6	3.1	3.6	3.7	5.2	5.5	3.8	3.7	3.7	3.7	3.4	3.7	3.7	3.6	3.6	3.6	3.6	3.6
USDCHF	6.1	6.1	6.1	6.2	6.1	6.0	5.9	5.9	5.9	6.1	8.7	7.9	6.9	6.7	6.3	6.2	6.2	6.2	6.1	6.2	6.2	6.1	6.1	6.1
USDJPY	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	4.2	3.7	3.3	3.3	3.2	3.2	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3
USDNOK	7.7	7.6	7.8	8.0	7.6	8.5	8.8	9.8	9.2	9.7	13.5	14.0	11.2	10.7	10.4	10.1	10.2	10.1	10.0	9.6	8.3	8.7	7.9	7.7
USDSEK	6.2	6.1	6.2	6.4	5.9	7.3	7.6	7.8	7.8	8.4	12.2	13.0	10.0	9.5	9.0	8.7	8.7	8.4	8.1	8.0	6.7	6.7	6.3	6.2
NZDUSD	5.9	5.9	5.9	6.0	5.9	5.8	6.3	6.8	6.3	6.3	8.8	7.3	6.0	5.9	6.0	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9
USDBRL	4.8	4.5	4.1	4.1	4.0	4.2	4.3	3.9	4.4	4.7	5.1	5.1	5.1	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.0	5.0
USDCLP	10.8	9.9	8.2	7.6	7.6	8.6	9.0	9.2	11.3	11.9	13.7	14.4	13.9	13.9	14.1	14.2	14.4	14.4	14.6	14.6	11.7	11.8	11.8	11.7
USDCOP	7.7	8.8	9.1	7.6	7.2	7.2	7.6	8.9	7.5	7.8	8.4	8.1	8.2	8.2	8.2	8.0	7.8	7.8	7.9	7.9	7.7	7.7	7.6	7.5
USDMXN	3.9	3.1	2.8	2.9	2.1	2.4	2.6	3.5	2.9	3.7	7.5	9.0	7.1	6.5	6.3	6.0	5.9	5.8	5.8	5.4	4.7	4.4	4.3	4.2
USDCNH	2.7	2.6	2.6	2.6	2.9	2.7	3.0	3.1	3.1	3.4	4.3	5.4	4.2	3.0	2.3	2.2	2.3	2.2	2.2	2.3	2.3	2.3	2.3	2.4
USDIR	7.9	7.9	7.9	7.9	7.9	7.9	7.9	5.2	8.0	8.0	8.0	8.2	8.0	8.0	8.3	8.5	8.4	8.3	8.7	8.6	8.2	7.9	7.9	7.9
USDINR	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.6	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.7	1.7	1.7	1.7	1.7	1.7	1.7
USDKRW	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.9	3.5	3.5	3.5	3.5	3.5	4.4	4.3	3.8	3.7	3.7	3.7	3.5	3.5	3.5	3.5	3.5
USDMYR	10.6	10.6	10.6	10.6	10.6	10.6	10.6	10.6	10.6	10.6	10.6	10.3	11.5	11.8	11.0	9.1	8.8	10.6	10.8	10.2	10.0	10.2	10.4	10.6
USDSGD	5.0	4.9	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	6.6	6.7	5.4	5.4	5.0	5.0	4.9	4.9	5.0	5.0	5.0	5.0	5.0	5.0
USDTWD	3.2	3.2	3.2	3.2	3.2	3.2	2.9	3.2	3.2	3.3	3.3	3.3	3.3	3.4	3.0	2.1	2.2	2.6	2.5	2.3	3.2	3.2	3.2	3.2
USDHUF	12.6	12.7	12.7	12.7	12.6	13.4	14.3	14.3	14.8	15.8	20.4	22.9	22.1	21.0	20.5	20.1	19.9	19.8	19.5	17.5	13.2	12.7	12.7	12.7
USDILS	6.1	6.0	6.6	6.6	5.1	9.2	10.8	11.1	11.4	13.7	20.7	23.3	25.8	25.3	25.0	24.8	24.6	24.2	16.4	9.0	6.5	5.9	5.8	6.1
USDPLN	7.5	7.6	7.6	7.8	7.5	8.9	10.2	11.7	11.1	11.9	17.5	19.9	19.0	18.2	17.7	17.2	16.8	16.7	16.6	13.8	8.4	7.7	7.5	7.6
USRUB	6.3	6.4	6.6	7.1	21.6	22.3	23.7	40.6	25.3	32.3	37.9	36.8	39.4	39.3	39.8	40.0	39.8	39.3	31.9	25.4	9.7	6.4	6.2	6.2
USDTRY	3.7	3.7	3.9	4.0	3.8	5.8	6.6	8.1	7.6	8.6	12.7	13.7	12.7	11.9	11.2	10.9	10.4	10.2	8.5	5.6	4.1	3.7	3.7	3.8
USDZAR	9.8	9.6	9.7	9.8	9.4	18.3	18.5	16.4	18.9	19.7	24.3	23.5	20.7	19.2	17.0	15.9	15.0	14.1	19.3	18.7	10.1	9.9	9.8	9.8

Putting it all together: a composite signal

Equal weighted average signal from the three favored signals



Source: J.P. Morgan

Current ranking of currency pairs in G10+EM population based on three signals: $\Delta m/m$ in 1) ATM z-score, 2) real vol/ATM ratio, 3) vol curve

	Δ 1-y ATM z-score of 3M ATM vol	Δ 3M real vol/ATM ratio	Δ 3M-1Y vol surface slope
GBP	-1.27	-0.11	-0.47
TRY	-1.14	-0.08	-1.09
INR	-1.01	-0.26	-0.10
HUF	-0.49	-0.18	-0.05
RUB	-0.75	-0.15	0.01
ILS	-1.06	0.13	-0.17
ZAR	-3.06	0.91	-1.64
JPY	-0.82	0.10	-0.11
SEK	-0.87	0.15	-0.27
KRW	-0.46	-0.32	0.06
CLP	-1.55	0.49	-0.97
CHF	-0.46	0.13	-0.06
EUR	-0.27	-0.16	0.17
NOK	-0.43	-0.03	0.05
PLN	-0.39	0.04	-0.03
AUD	-0.72	0.26	0.19
NZD	-0.73	0.23	0.25
SGD	0.33	0.10	0.19
MYR	0.37	-0.17	0.92
IDR	-0.02	0.01	0.42
MXN	0.27	0.15	0.23
BRL	-0.23	0.16	0.26
CAD	0.51	-0.05	0.49
CNY	-0.09	0.18	0.26
TWD	0.48	0.32	0.16
COP	0.43	0.20	0.40

Buy

Sell

Source: J.P. Morgan

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