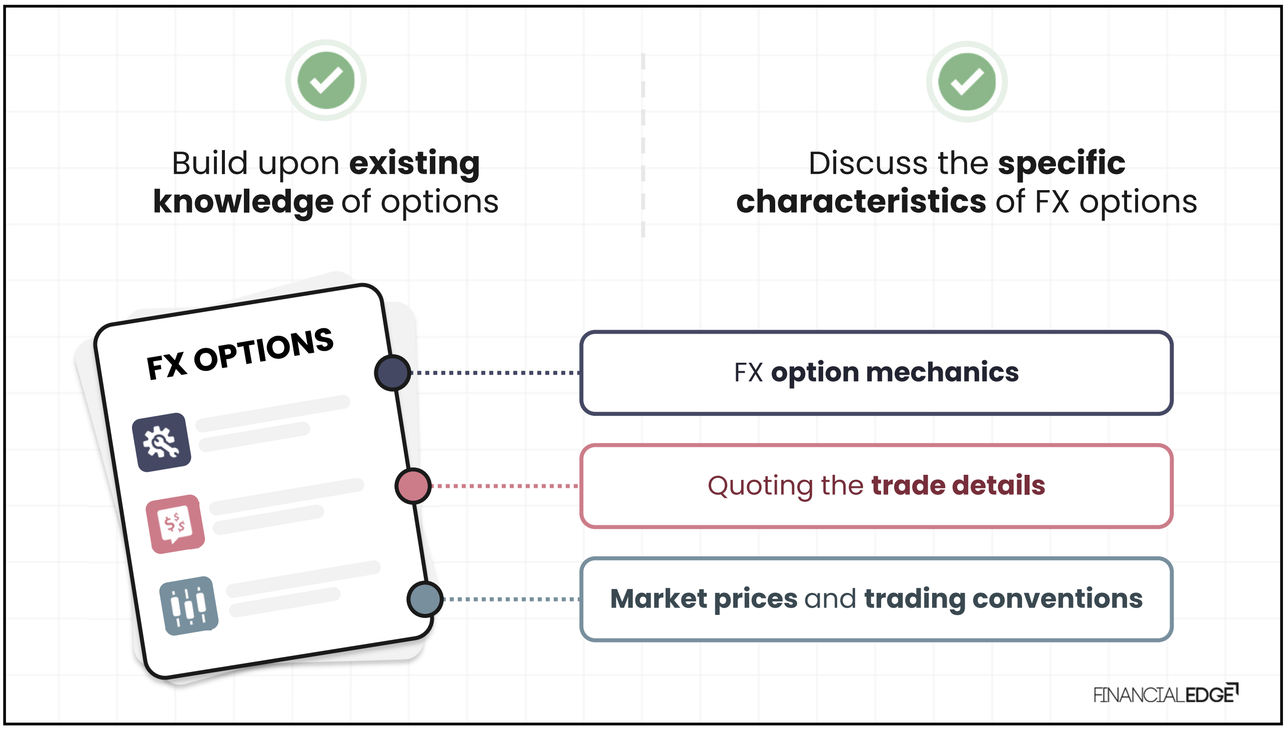
FX Option Definition, Terminology and Convention


Build upon existing knowledge of options
Discuss the specific characteristics of FX options
FX OPTIONS
FX option mechanics
Quoting the trade details
Market prices and trading conventions
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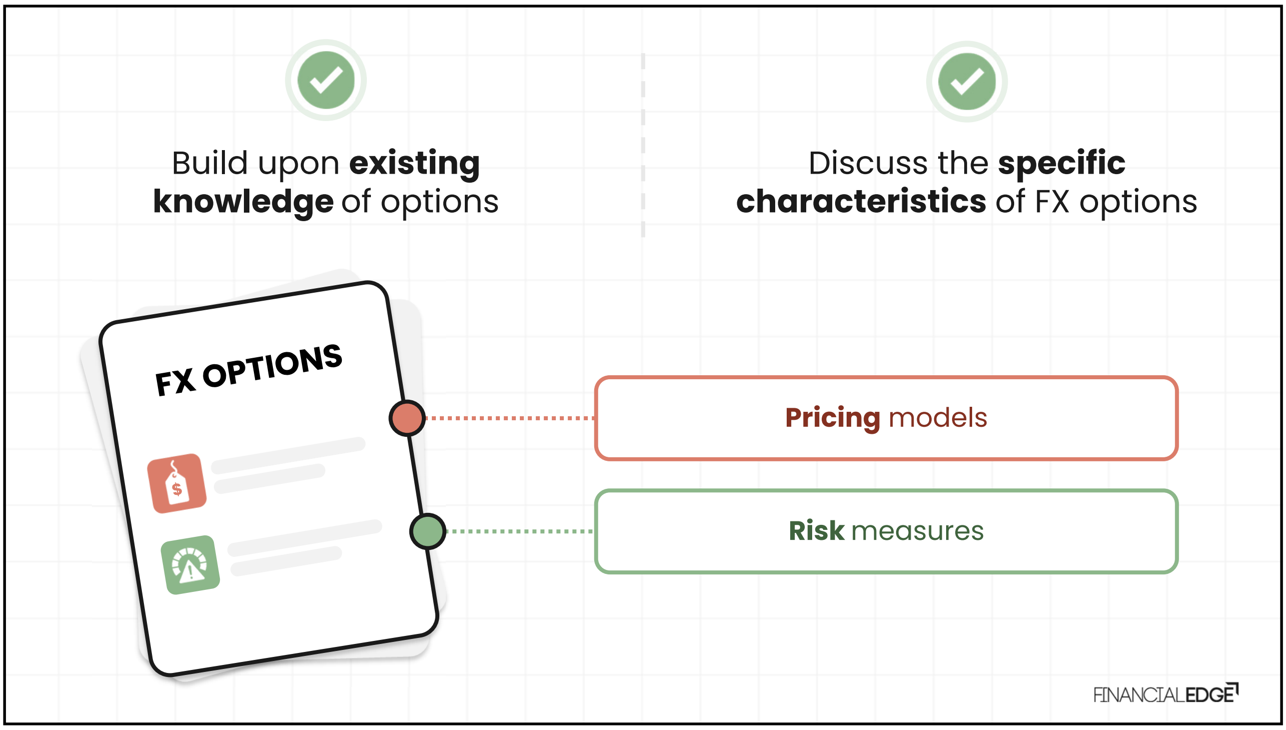
Build upon existing knowledge of options
Discuss the specific characteristics of FX options
FX OPTIONS
Pricing models
Risk measures
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Definition

The **right** to **buy** (call) or **sell** (put) an **underlying currency** at a defined **exchange rate** (strike) on a defined **future date** (expiry)

Do I have the right to **buy/sell?**

Which currency is **premium paid?**

Rather than having an **obvious asset** and **its price**

You have **two cash amounts** in **different currencies**

Example

6-month | **1.1000** | **EUR call (USD put)** in **EUR 10mn**

Expiry date

Strike (1.10 USD per EUR)

Call on base currency (and therefore, a put on quoted currency)

Notional (in this case in base currency)

Owner has the right to **buy EUR** and **sell USD**

1.1000
Rate

€10,000,000
Buy EUR

$11,000,000
Sell USD

Terminology

There are **many ways** to refer to the **same FX option**

Referring to the **same FX option**:

- EUR call / USD put
- EUR call
- USD put
- EURUSD call

Quoted with the **notional** in either currency:

- 1.1000 EUR call in EUR 10mn
- 1.1000 USD put in USD 11mn
- 0.9091 USD put in USD 11mn

(quoted on an **inverted** USDEUR rate)

NEED market conventions

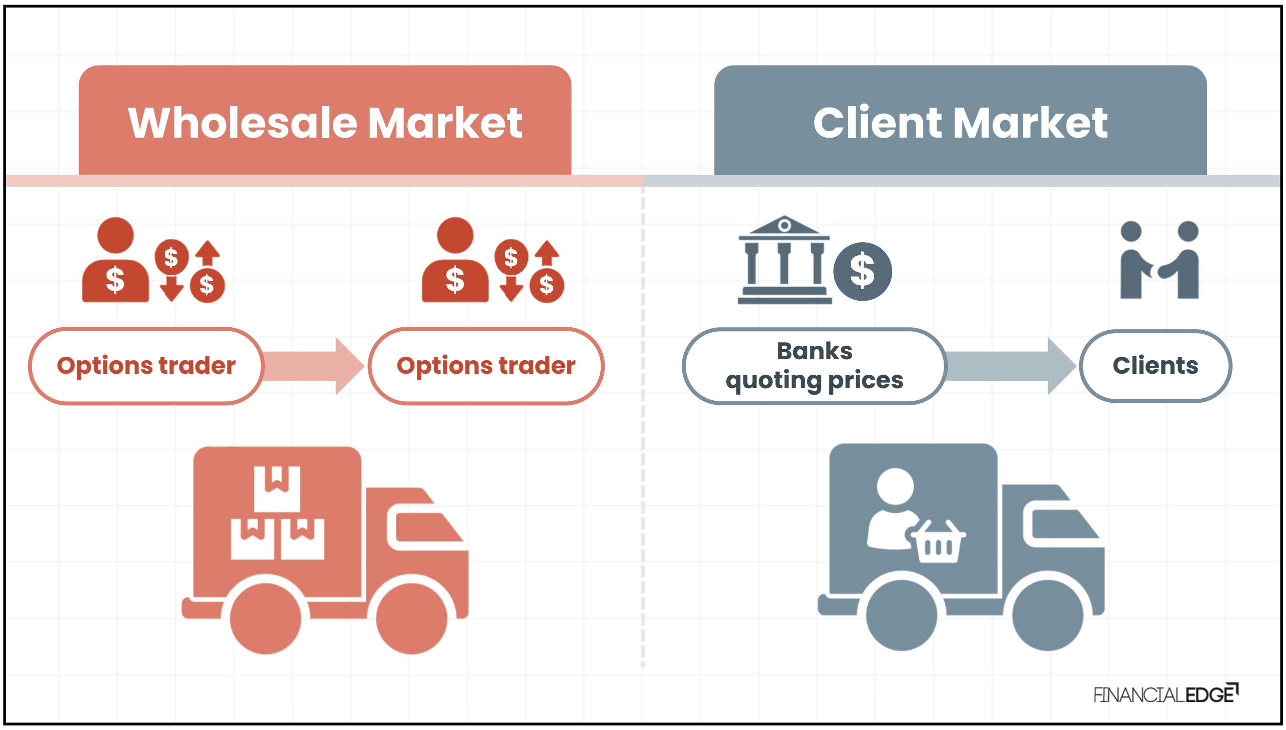
Market Conventions

ALWAYS describe in terms of the **base currency**

Notional	Strike	Type
Quoted in **EUR**	Quoted in **conventional wholesale market format** **EURUSD** (not USDEUR)	**EUR call/put**, or **EURUSD call/put**

Non-wholesale market counterparties may use **any quoting conventions**

"EUR call USD put" "EUR call" "EURUSD call"


Wholesale Market
Client Market
Options trader
Options trader
Banks quoting prices
Clients
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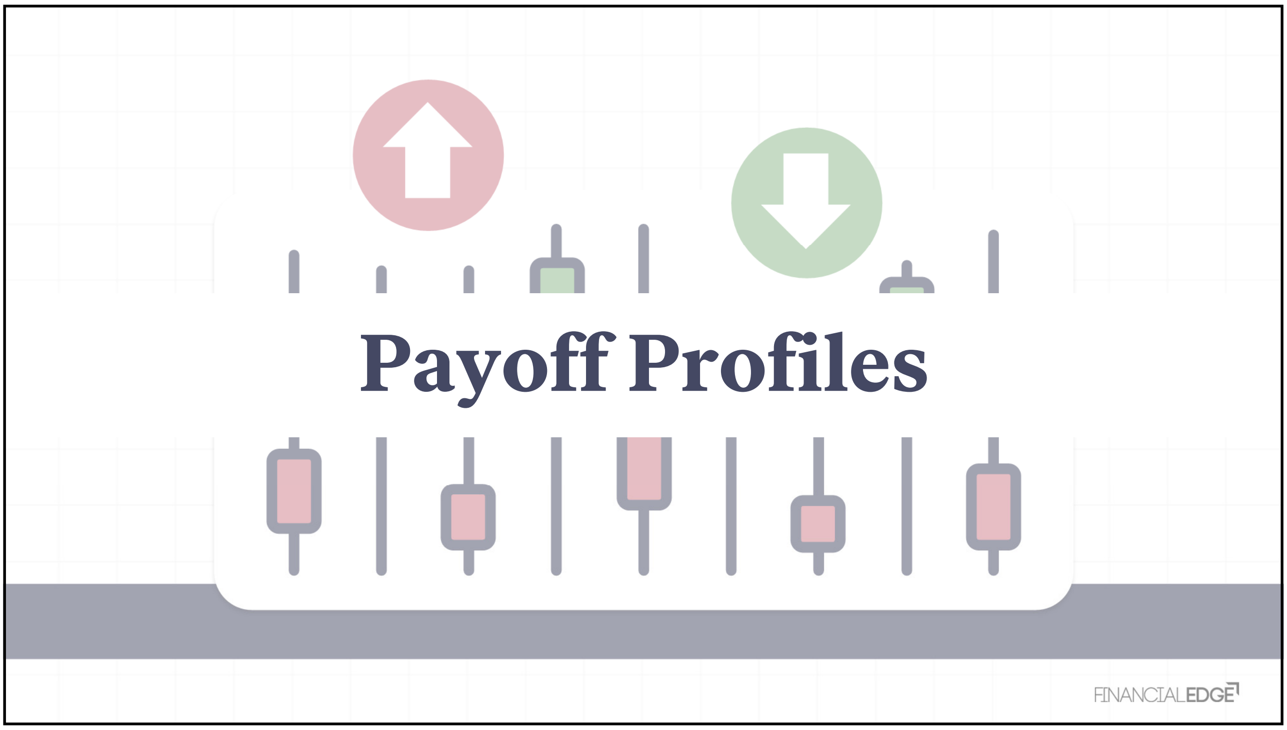
Payoff Profiles
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PAYOFF OF AN OPTION

Calculating what the **positive value** is to the buyer if the option is exercised

Stock Options

Own	Stock	Payoff
100 Call	110	$10 per share

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The payoff of an FX option naturally occurs in the **quoted currency**

Call

$$Payoff_{quoted} = Max\,(Spot_{expiry} - K\,,\,0) * N_{base}$$

Put

$$Payoff_{quoted} = Max\,(K - Spot_{expiry}\,,\,0) * N_{base}$$

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If we want the payoff in the base currency,
we **divide** by the spot at **expiry**

Base

$$\text{Payoff}_{base} = \frac{\text{Payoff}_{base}}{\text{Spot}_{expiry}}$$

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Payoff in Quoted Currency and Base Currency

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Payoff Examples

Quoted Currency

Base Currency

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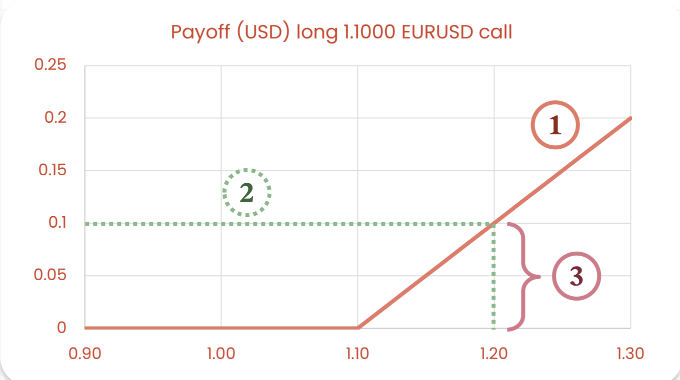
Quoted Currency



1 **Payoff** is **linear** in **quoted** currency

2 **Example:** **Spot** finishes at **1.2000**

3 **Payoff =** +0.1 USD per EUR
BUY spot @ 1.1000
SELL @ 1.2000

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Payoff Examples

Quoted Currency

Base Currency

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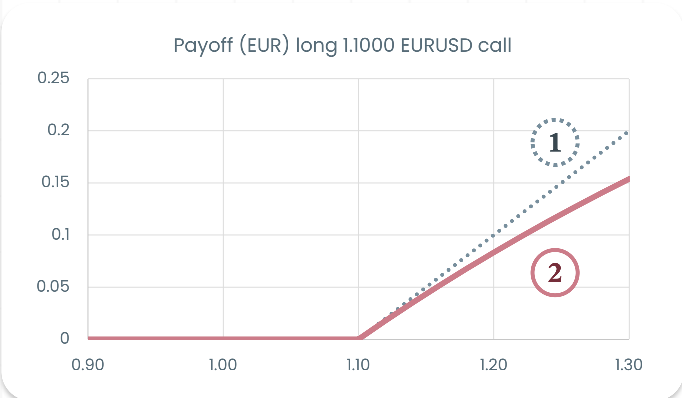
Base Currency



1 **Payoff** is **non-linear** in **base** currency

2 The equivalent in **stock options** would be **calculating the payoff in shares** rather than cash

Simpler to think of linear payoff in **quoted currency**

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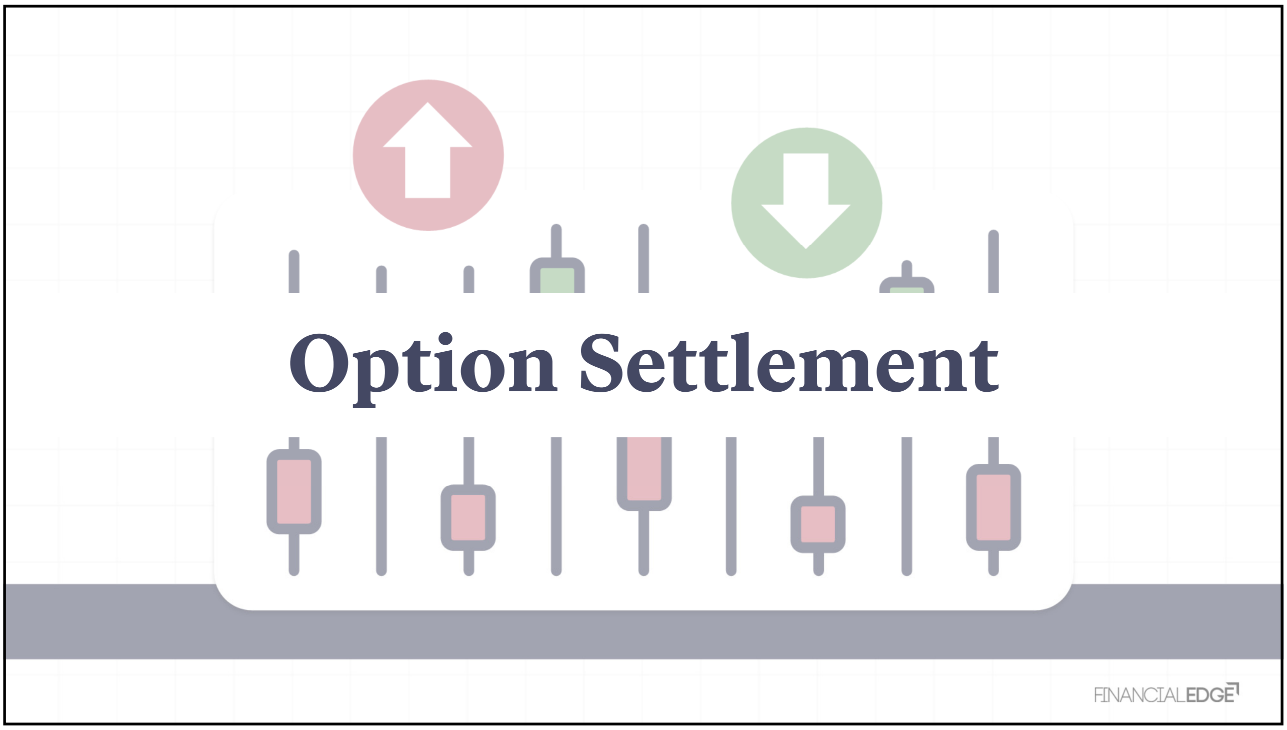
Option Settlement
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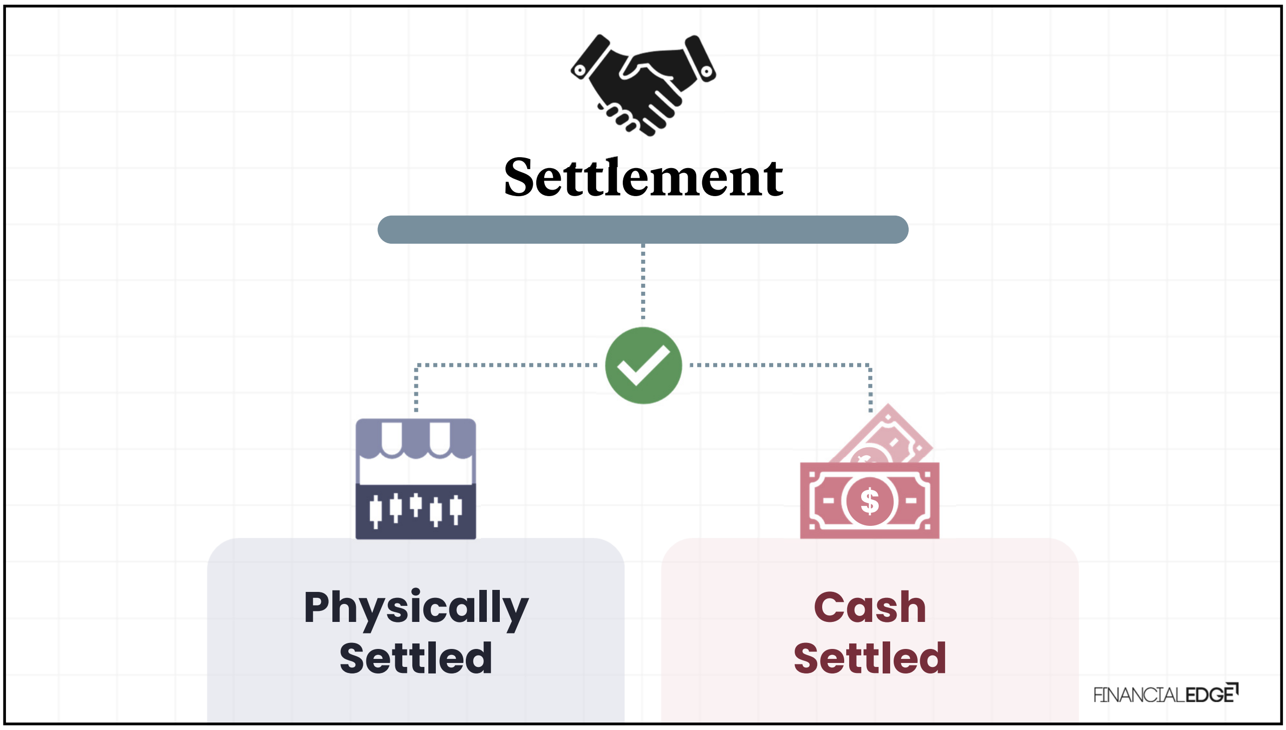
Settlement
Physically Settled
Cash Settled
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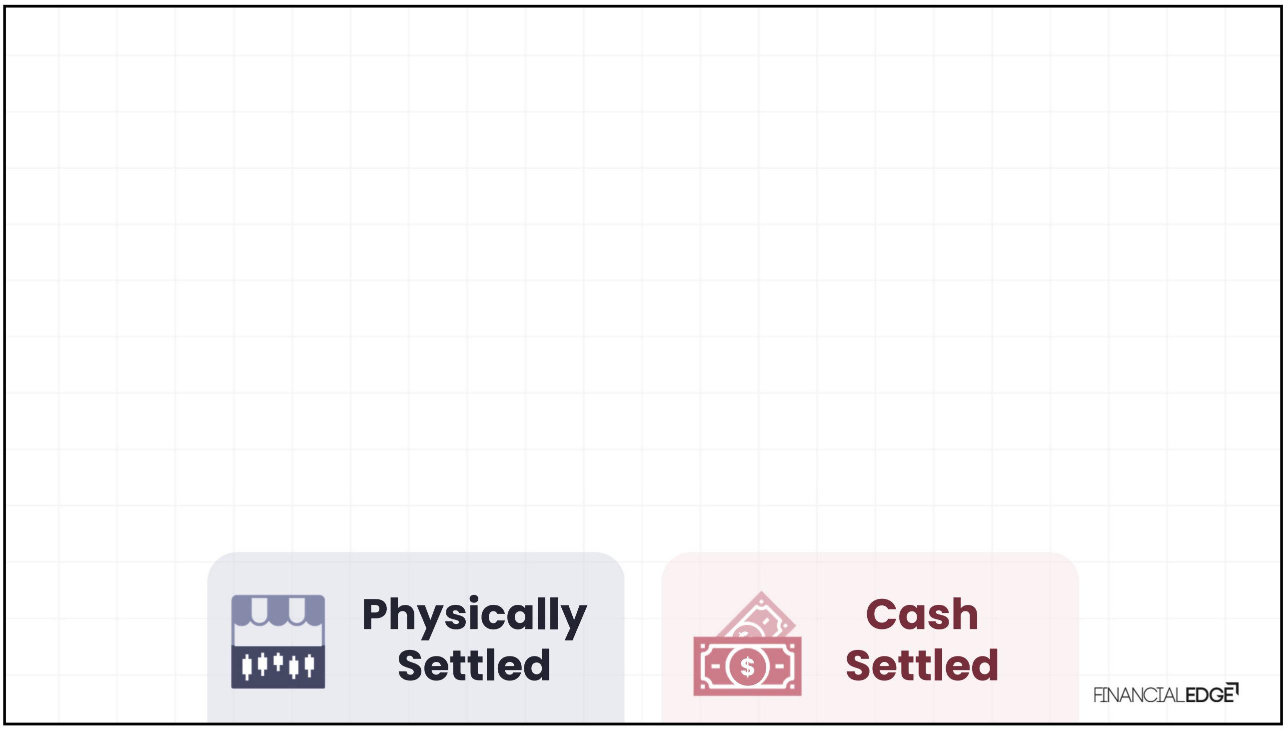
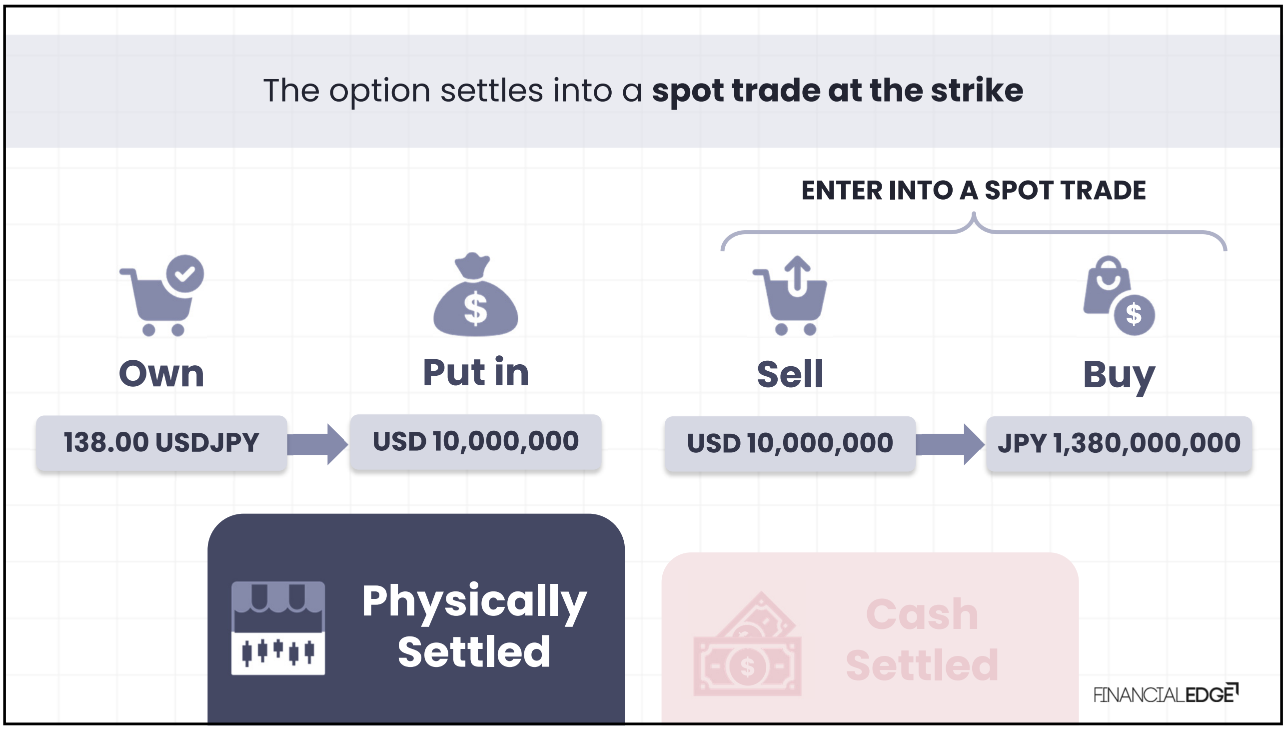

Physically Settled
Cash Settled
FINANCIALEDGE


The option settles into a **spot trade at the strike**
ENTER INTO A SPOT TRADE
Own
138.00 USDJPY
Put in
USD 10,000,000
Sell
USD 10,000,000
Buy
JPY 1,380,000,000
Physically Settled
Cash Settled
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The payoff is calculated relative to an agreed fixing source
and paid in either **quoted** or **base** currency

Own — 138.00 USDJPY

Put in — USD 10,000,000

Spot fixing on expiry — 135.00

Physically Settled

Cash Settled

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The payoff is calculated relative to an agreed fixing source
and paid in either **quoted** or **base** currency

Payoff(JPY) = 10,000,000 * (138 - 135) = JPY 30,000,000

Payoff(USD) = 10,000,000 * (138 - 135) / 135 = USD 222,222.22

Physically Settled

Cash Settled

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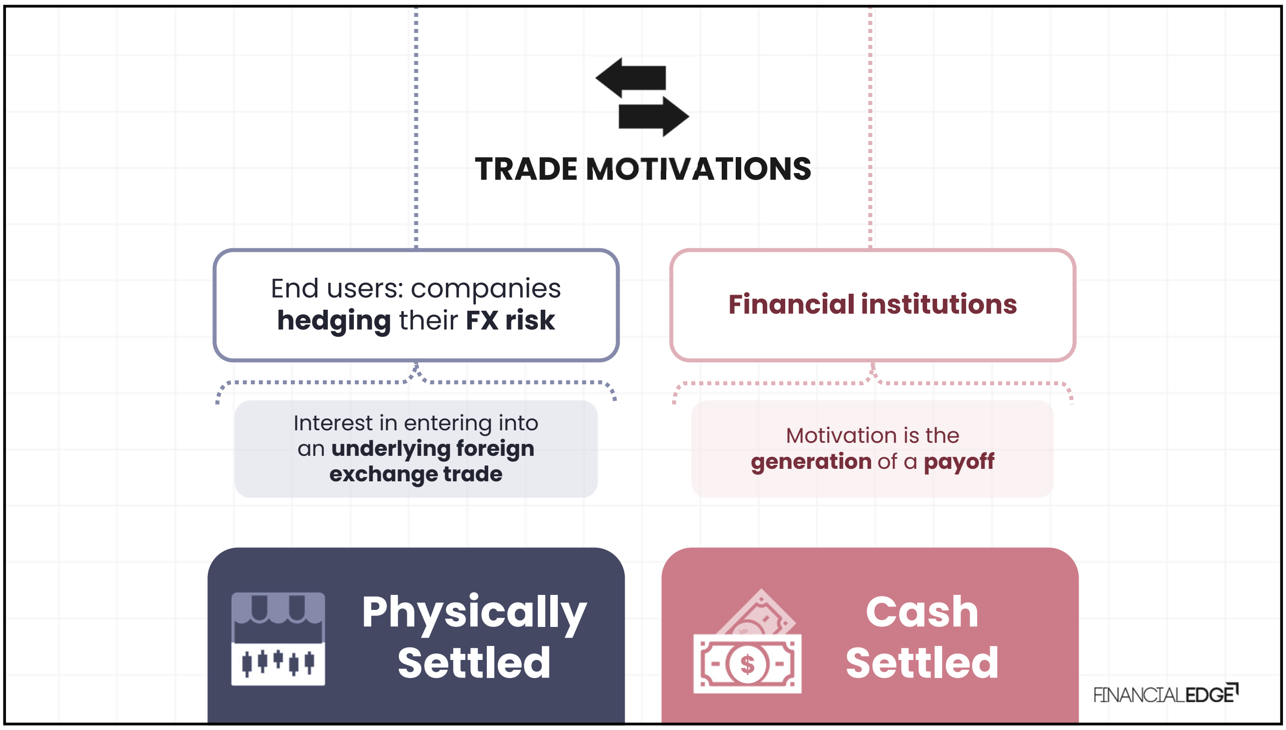
TRADE MOTIVATIONS
End users: companies hedging their FX risk
Interest in entering into an underlying foreign exchange trade
Financial institutions
Motivation is the generation of a payoff
Physically Settled
Cash Settled
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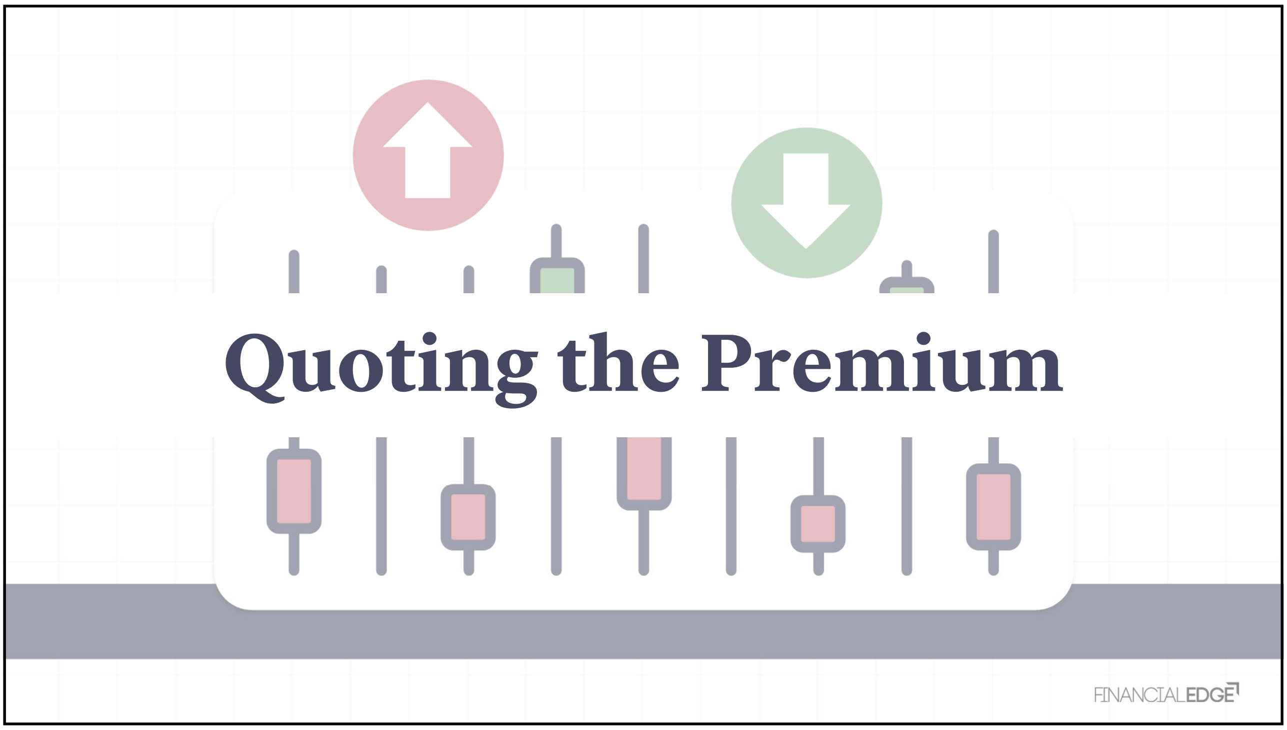
Quoting the Premium
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The Premium

Option pricing models (e.g. Black-Scholes) naturally produce a price for an FX option in the **quoted currency**

3-month EURUSD 1.1000 call

R(base)	R(quoted)	Expiry	Spot	Forward	Strike	Type	Vol	Price (quoted)
3.50%	5.00%	0.25	1.0850	1.1041	1.1000	c	10.00%	0.0166

Price = 0.0166 USD per EUR of notional, or **166 USD pips**

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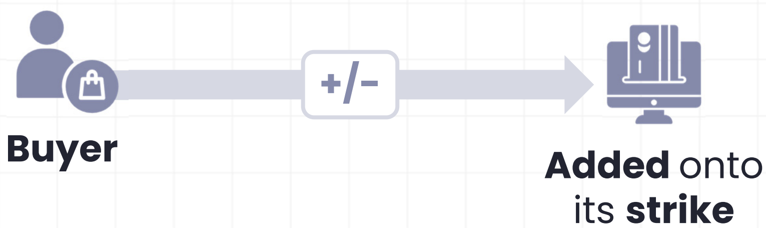
Breakeven



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Price = 0.0166 USD per EUR of notional, or **166 USD pips**

AAPL Stock

Quoting a **price** in the **quoted currency**

Equivalent to

Quoting a price in USD for an option on AAPL stock

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3-month EURUSD 1.1000 call in EUR 10,000,000

EUR notional	10,000,000
Strike	1.1000
USD notional	11,000,000
Premium	
USD per EUR	**0.0166**
USD cash	**166,000.00**
EUR cash	**152,995.39**
USD pips	**166**
% EUR	**1.53%**
% USD	**1.51%**
EUR pips	**139**

MOST POPULAR FORMATS:
Pips of quoted
% of base

The raw price: 0.0166 USD per EUR of notional

0.0166 * 10,000,000

0.0166 * 10,000,000 / Spot

0.0166 * 10,000

0.0166 / Spot

0.0166 / Strike

0.0166 / (Spot * Strike) * 10,000

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Quoting the
Wholesale Market
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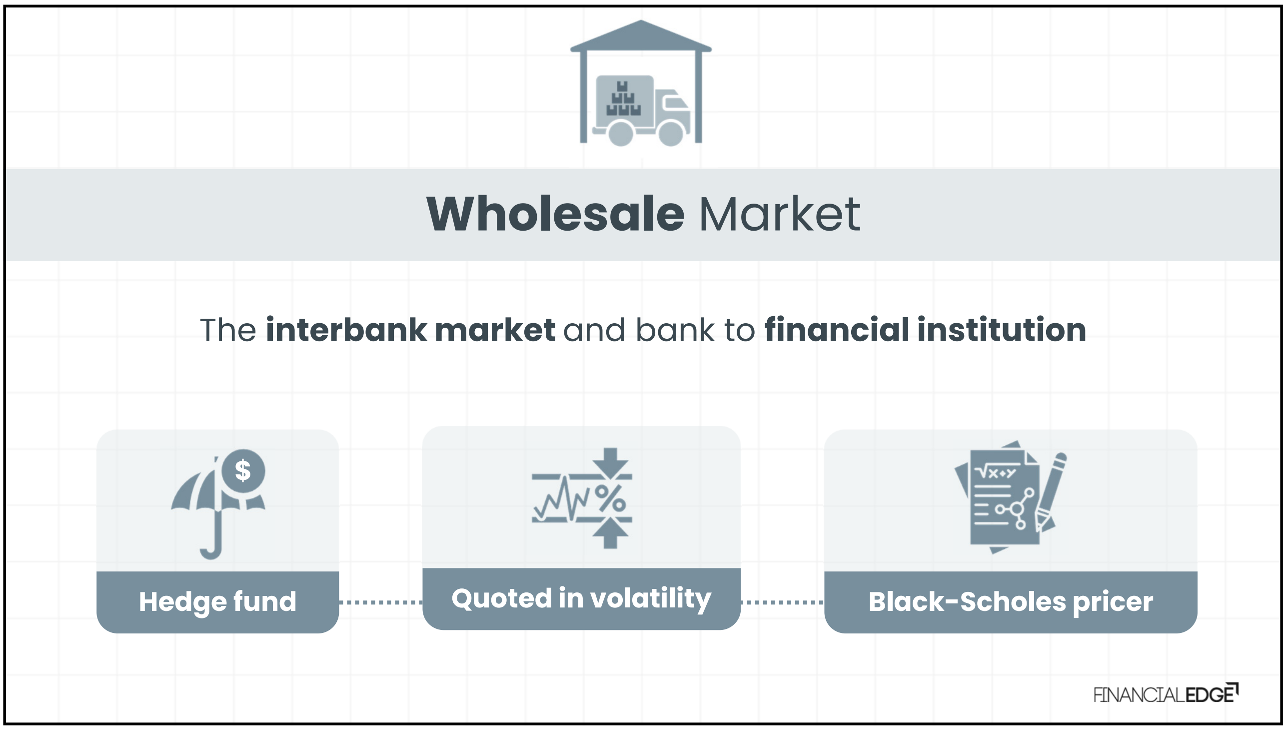
Wholesale Market
The interbank market and bank to financial institution
Hedge fund
Quoted in volatility
Black-Scholes pricer
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Wholesale Market

FX Forward Market

- Very liquid
- Tight bid offer spreads
- No uncertainty about price

Volatility prices not common in other markets

- Equities
- Rates

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Wholesale Market

Example of price **run of at-the-money** straddles:

1w		1m		2m		3m		6m		9m		12m	
Bid	Offer	Bid	Offer	Bid	Offer	Bid	Offer	Bid	Offer	Bid	Offer	Bid	Offer
8.50	9.50	9.30	9.40	9.35	9.45	9.20	9.30	9.15	9.20	8.90	9.10	8.95	9.00

e.g. the market is offering the **3-month expiry** at **9.30% vol**

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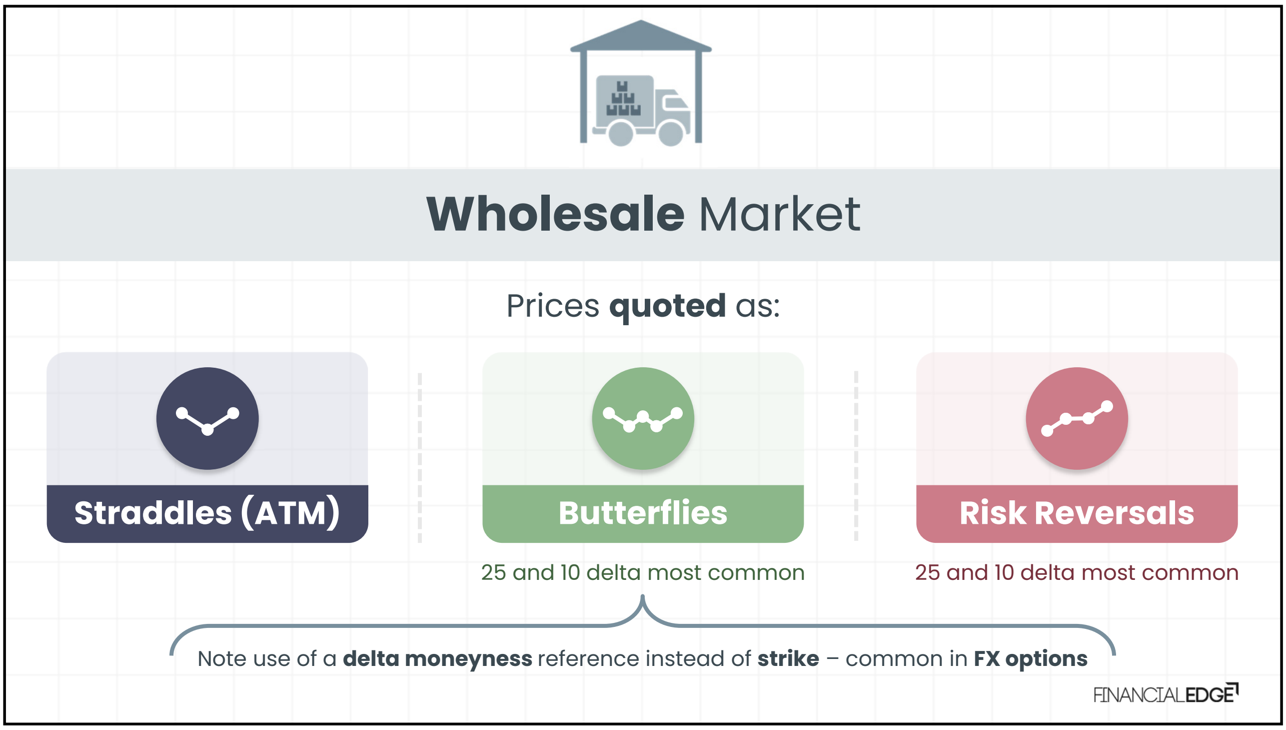
Wholesale Market
Prices quoted as:
Straddles (ATM)
Butterflies
25 and 10 delta most common
Risk Reversals
25 and 10 delta most common
Note use of a delta moneyness reference instead of strike – common in FX options
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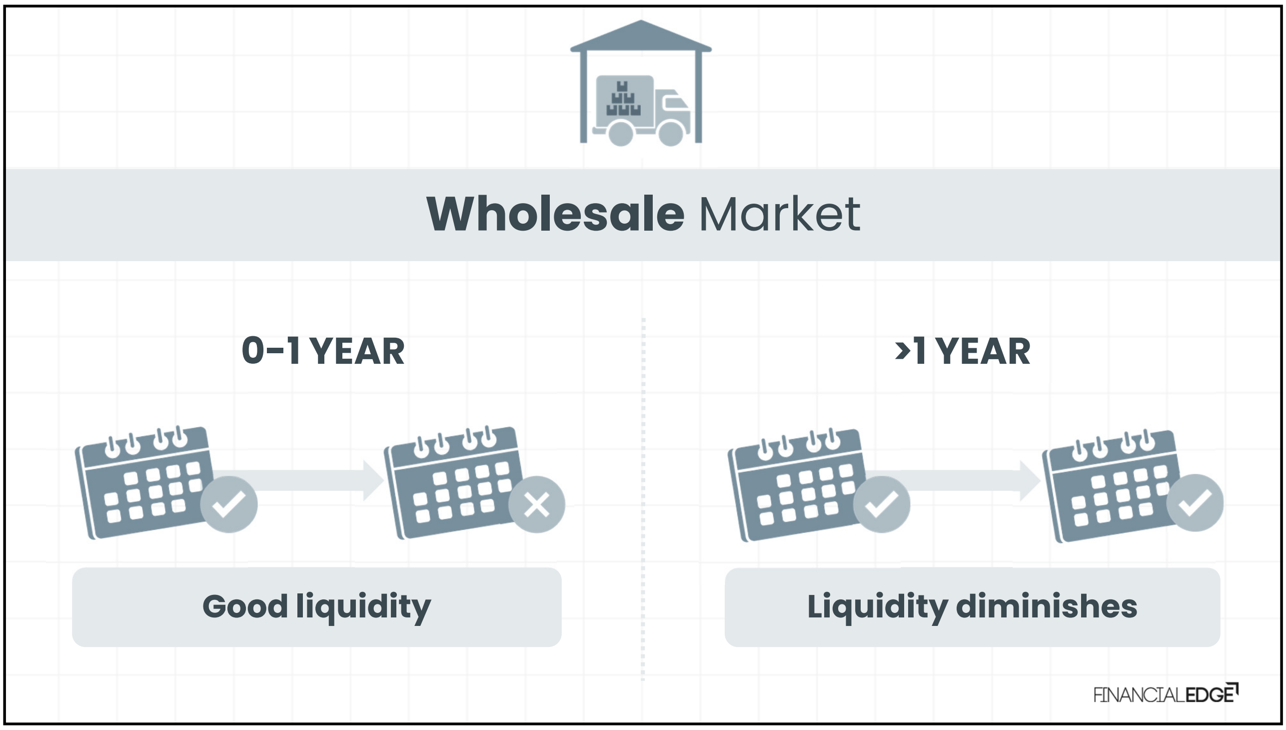
Wholesale Market
0-1 YEAR
Good liquidity
>1 YEAR
Liquidity diminishes
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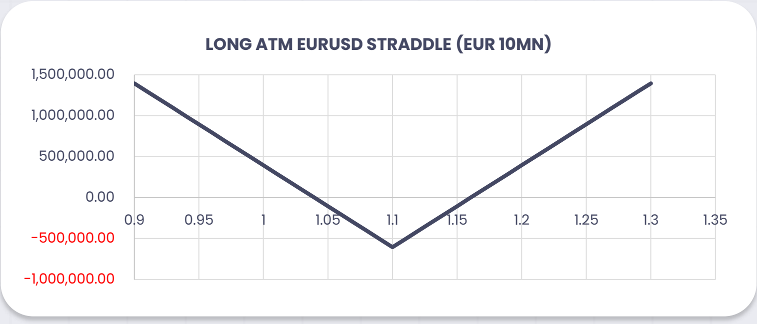
The Interbank Products

Straddles

Most common **interbank** trading product



Combination of:

ATM put and ATM call

ATM = AT THE MONEY

Long both or short both

Allows traders to:

Trade volatility **without** getting a **delta position**

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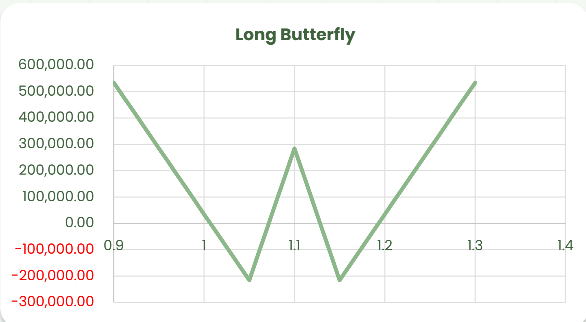
Butterflies

Long strangle + short straddle (or vice versa)

Tend to be done in **vega-neutral amounts**



Risk Reversal

Long call + short put (or vice versa)

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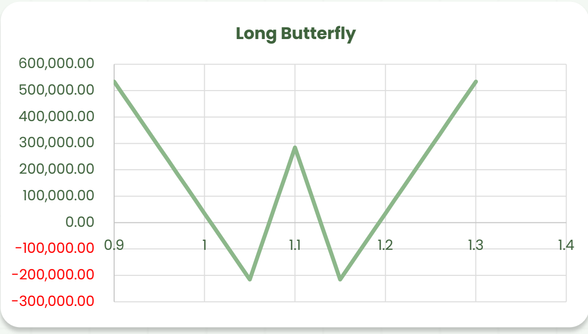
Butterflies

Trade the **smile element**

Quoted in **delta terms**



Risk Reversal

Trade the **skew**

Quotes in **delta terms**

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Quoting Butterflies and Risk Reversals in Vol

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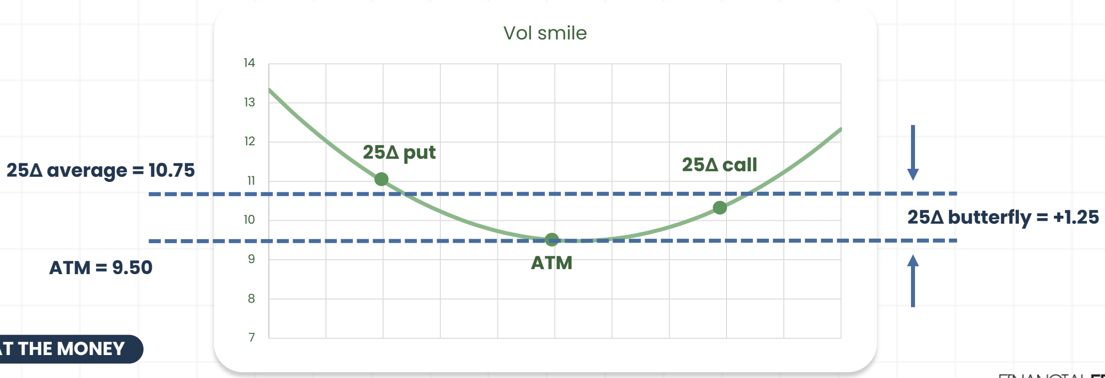
Butterflies

Risk Reversal

Butterflies

$$\text{25}\Delta\text{ Butterfly vol} = \frac{\text{25}\Delta\text{ call vol} + \text{25}\Delta\text{ put vol}}{2} - \text{ATM vol}$$



ATM = AT THE MONEY

Butterflies

Risk Reversal

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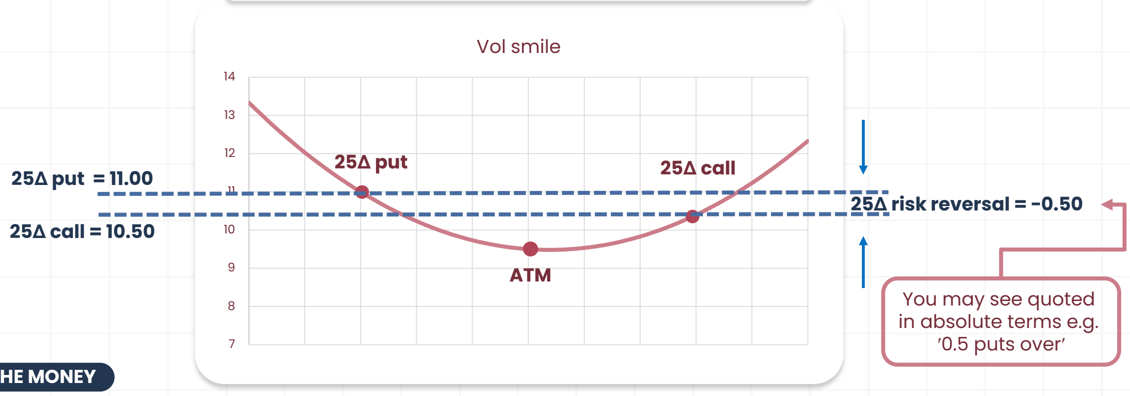
Risk Reversal

25Δ Risk Reversal vol = 25Δ call vol − 25Δ put vol



ATM = AT THE MONEY

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Volatility for Strike

Use the **interbank quotes** to get the vols for the **commonly quoted points**, that is **25- and 10-delta strikes**

	Vol
ATM	8.00
25d BF	0.75
25d RR	-0.50

Call

$$25\Delta \text{ call vol} = \text{ATM} + 25\Delta \text{ BF} + \left(\frac{25\Delta \text{ RR}}{2}\right)$$

$$25\Delta \text{ call vol} = 8.00 + 0.75 - 0.25 = 8.50$$

Put

$$25\Delta \text{ put vol} = \text{ATM} + 25\Delta \text{ BF} - \left(\frac{25\Delta \text{ RR}}{2}\right)$$

$$25\Delta \text{ put vol} = 8.00 + 0.75 + 0.25 = 9.00$$

ATM = AT THE MONEY

BF = BUTTERFLIES

RR = RISK REVERSAL

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Modelling Choices

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Standard Lognormal Approach

FX options tend to use the standard **lognormal** distributional assumption in the **Black-Scholes** formula

Call Price

$$\text{Call Price} = PV\left(F * N(d1) - K * N(d2)\right)$$

$$d1 = \frac{LN\left(\frac{F}{K}\right) + \sigma^2 T}{\sigma\sqrt{T}}$$

$$d2 = d1 - \sigma\sqrt{T}$$

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As per other markets, **corrections** are then made by using a **volatility smile/skew**

Smile

All vols for **out-of-the-money options** tend to be **higher** than the **at-the-moneys**

To adjust for **stochastic volatility**

Skew

Vols will display a **systematic bias** to puts or calls

To adjust for **spot/vol correlation**

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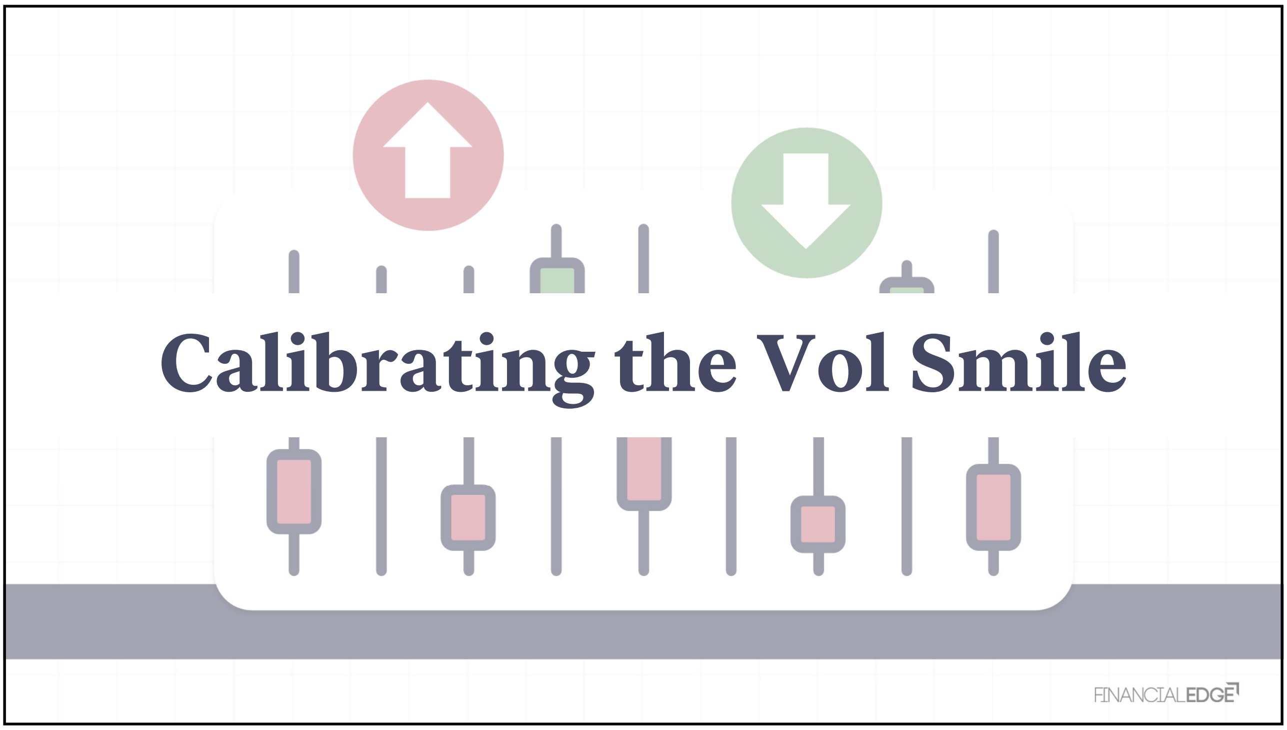
Calibrating the Vol Smile
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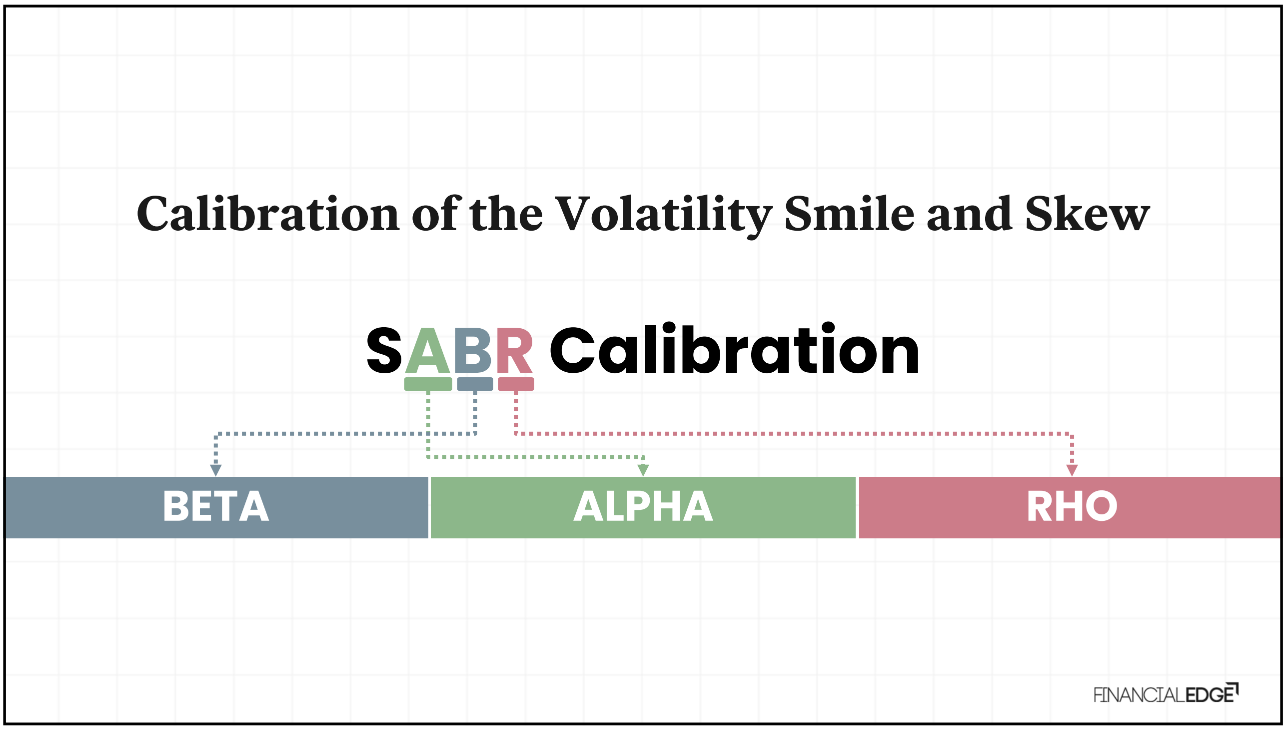
Calibration of the Volatility Smile and Skew
SABR Calibration
BETA
ALPHA
RHO
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Calibration of the Volatility Smile and Skew

BETA

$$dF = \sigma F^{\beta} dW_1$$

***β* = CEV parameter (skew)**

CEV = Constant Elasticity of Variance

ALPHA

$$d\sigma = \alpha \sigma dW_2$$

***α* = vol of vol (smile)**

Can be varied between **zero** and **one**

Beta = 0 – Normal distribution
Beta = 1 - Lognormal distribution

RHO

$$dW_1 dW_2 = \rho dt$$

ρ = correlation between the two processes (skew)

Used to further **refine the skew**

Calibrated to **match the skew** of **visible risk reversal prices**

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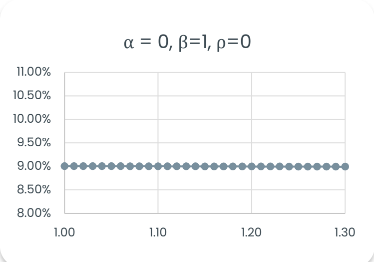
FLAT

$$dF = \sigma F^{\beta} dW_1$$

Black-Scholes assumption

Lognormal process

Constant vol per strike

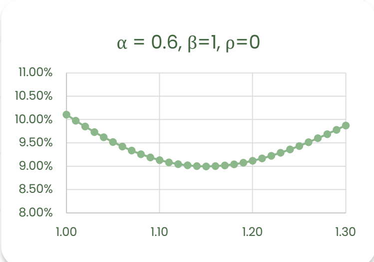


SMILE

$$d\sigma = \alpha \sigma dW_2$$

'Smiley' volatility shape created by increasing **Alpha**

Non-zero butterfly prices but **neutral risk reversals**

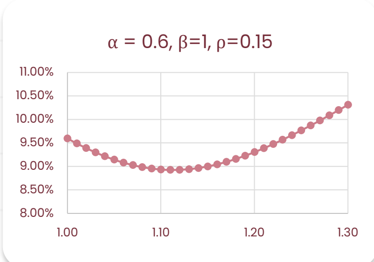


SMILE AND SKEW

$$dW_1 dW_2 = \rho dt$$

Effect on **increasing Rho**

Adds an **increase to call over puts** whilst retaining the **smiley-ness** already present



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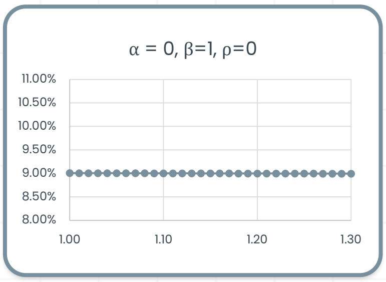
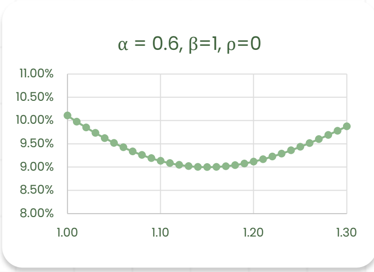
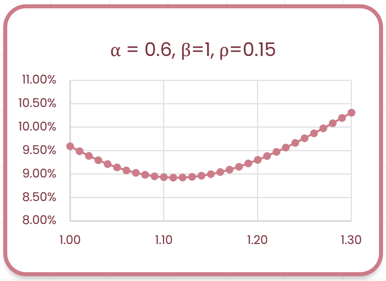
FLAT



SMILE



SMILE AND SKEW



A trader can calibrate their **volatility smile** and **skew**

Hit the **visible market** for all **liquid expiry dates**

Be confident of quoting any **bespoke trade**

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Typical Smile/Skew Seen in FX

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What we **DON'T** see

Strong and **persistent bid** for **puts over calls** in risk reversals

Rates

The tendency to use a **normal** rather lognormal **distribution**

Equities

Commonly **negative correlation** between **spot** and **implied vol**

Market moves down are accompanied by a **rise in volatility**

Supply and demand effects from end user trading that can keep the **skew bias** in place

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What we **DO** see

FX options generally **more balanced** in terms of **skew**

Risk reversals **favor puts** in **certain circumstances**

Also common to **favor calls** depending on **market conditions**

More 'smiley rather than skewed' compared to both **equities** and **rates**

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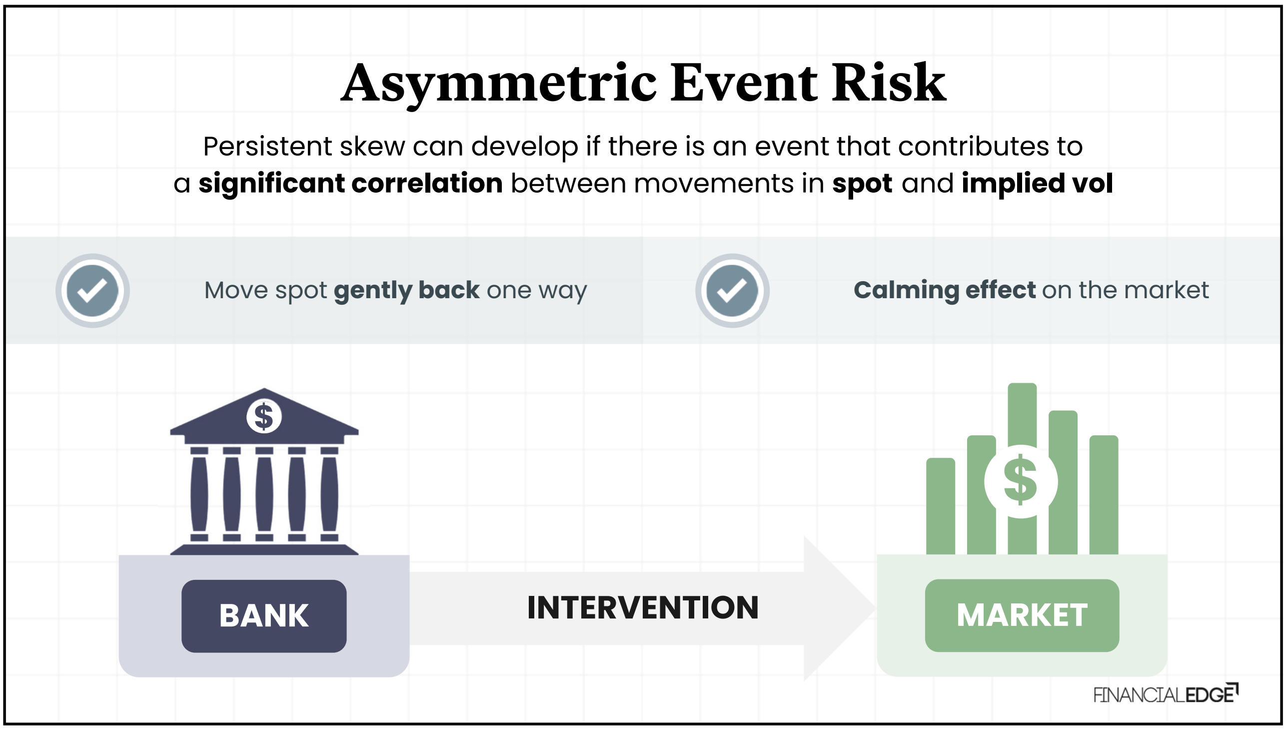
Asymmetric Event Risk
Persistent skew can develop if there is an event that contributes to a significant correlation between movements in spot and implied vol
Move spot gently back one way
Calming effect on the market
BANK
INTERVENTION
MARKET
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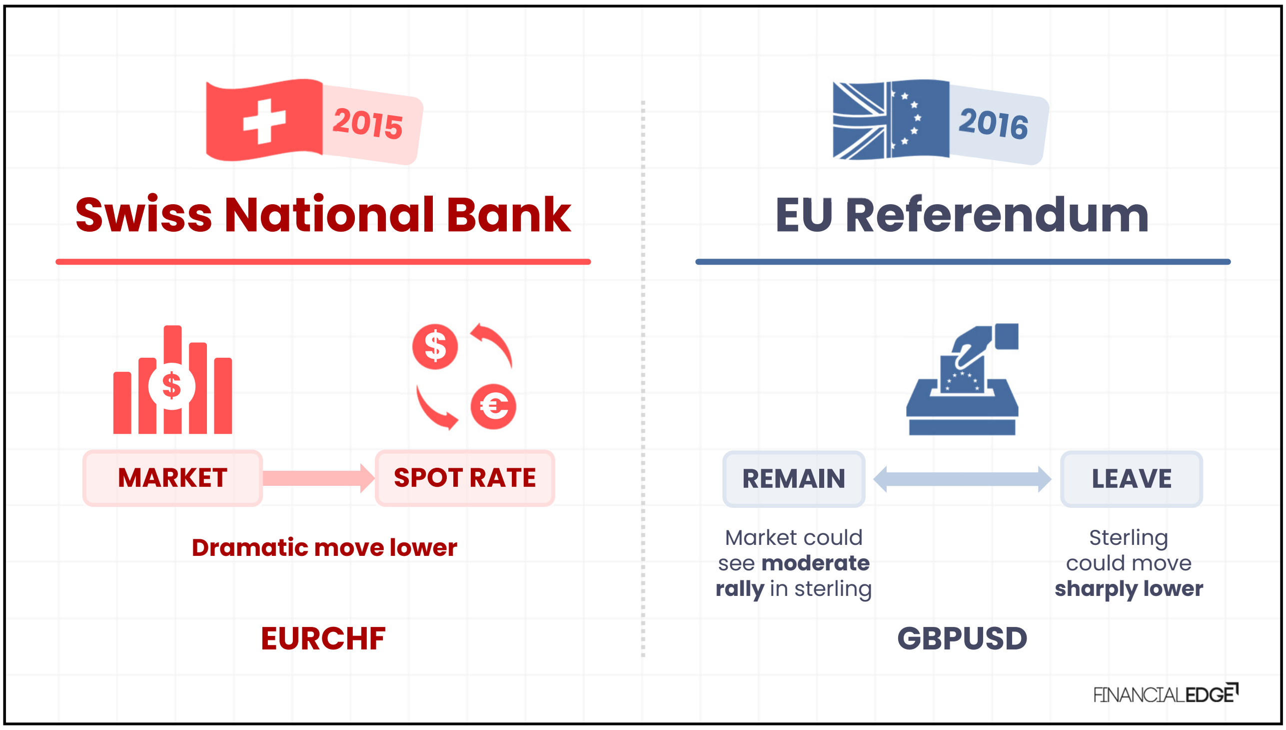
2015
Swiss National Bank
MARKET
SPOT RATE
Dramatic move lower
EURCHF
2016
EU Referendum
REMAIN
LEAVE
Market could see moderate rally in sterling
Sterling could move sharply lower
GBPUSD
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FX Option Risk Metrics

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Risks Generated on a 6-month Call and Put

			1.10 call	1.10 put
R(quoted)	5.00%	**Price**	0.0286	0.0205
R(base)	3.50%	**Delta (spot)**	0.55412	-0.42853
Expiry	0.50	**Delta (fwd)**	0.56390	-0.43610
Spot	1.1000	**Gamma (spot)**	6.19394	6.19394
Forward	1.1083	**Gamma (fwd)**	6.25657	6.25657
Strike	1.1000	**Vega**	0.00301	0.00301
Vol	8.00%	**Theta**	-0.00006	-0.00006

Strike	Spot	Forward	Vol
1.10	1.10	1.1083	8.0%

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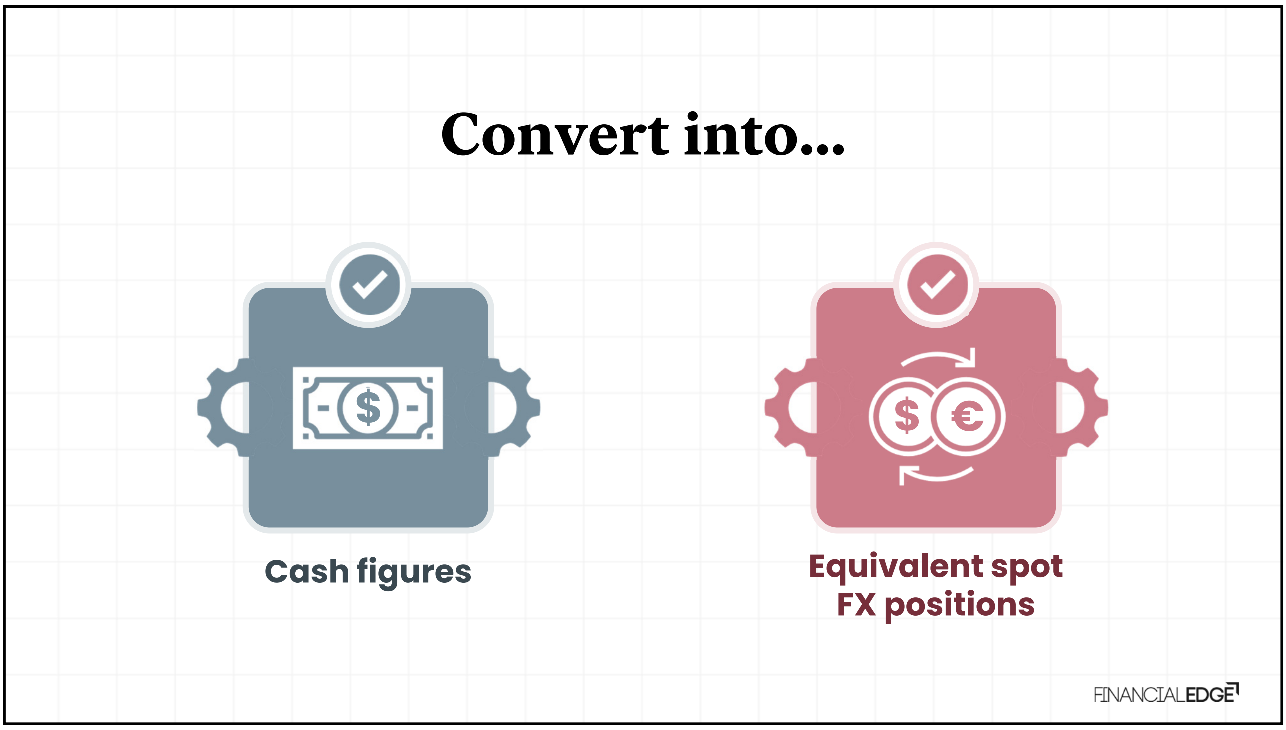
Convert into...
Cash figures
Equivalent spot FX positions
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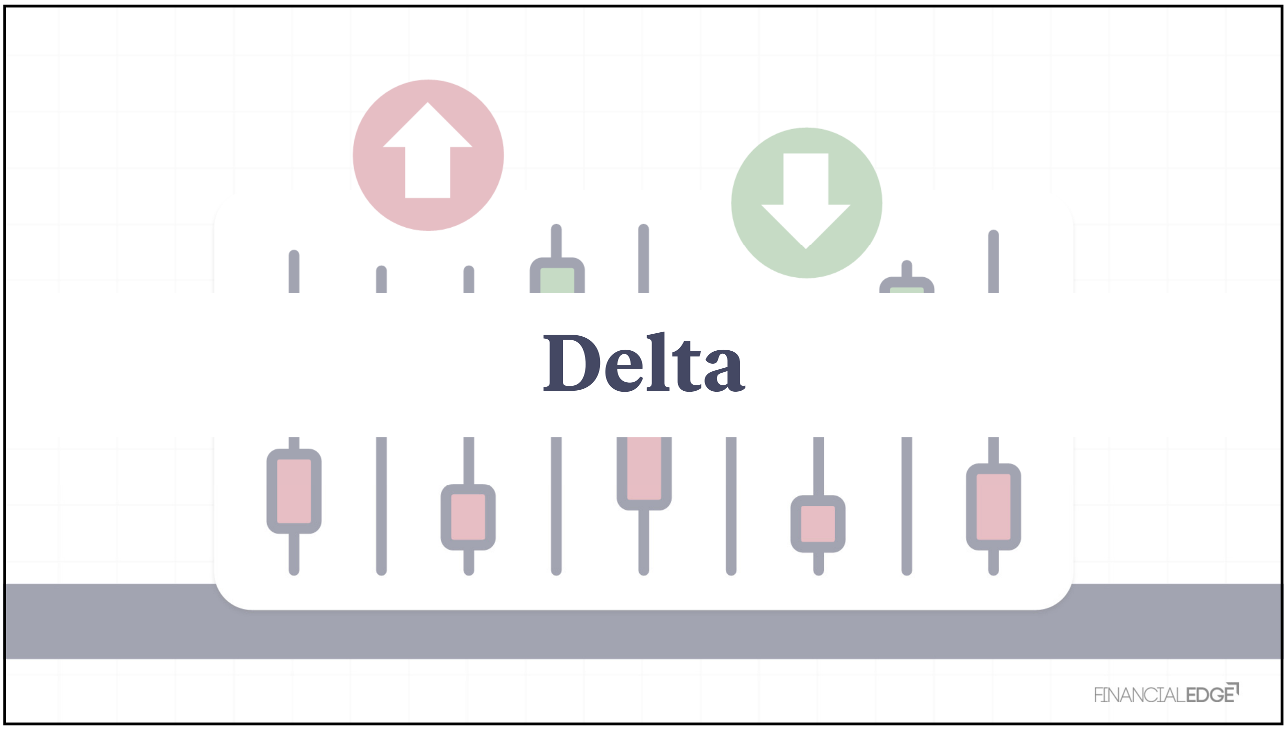
Delta
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Converting FX Option Risk Metrics

Δ γ ν Θ

Delta Gamma Vega and Theta

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Δ

Delta

It is **conventional** for an FX Options trader to **hedge their delta** using **spot**

It may be deemed **purer to measure delta to the forward rate**

Spot FX is **easier** to **trade** and **hedge**

The exposure to **forward points** may be **hedged less frequently**

Extra Greeks, usually ρ and ε, are used to measure sensitivity to R_q and R_b respectively

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Δ Delta

To convert the raw Black-Scholes delta into **something more useful**

SPOT FX AMOUNT

	1.10 call
Delta (spot)	0.55412
Notional (EUR)	10,000,000
Delta (EUR)	5,541,184

If you **BUY** the **1.10 call in EUR 10mn**

You are long **EUR 5.5mn** of **spot delta**

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Δ Delta

Incorporate the **premium** into **(initial)** delta hedge

If you don't **convert premium back** into the **currency** in which you account for your **P/L,** then you are **running a spot FX risk**

	1.10 Put
Notional (EUR)	10,000,000
Price	0.0205
Price (USD Pips)	205
Price (USD)	204,742
Price (%EUR)	1.86%
Price (EUR)	186,129
Delta (Spot)	-0.42853

Client...

1. **BUYS** the option
2. **PAYS** the premium in **EUR**
3. Your P/L currency is **USD**

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Δ

Delta

Need to account for the fact you have an **extra amount of EUR to sell**:

	1.10 put
Notional (EUR)	-10,000,000
Raw Delta (EUR)	4,285,338
Prem (EUR)	186,129
Full Delta (EUR)	4,471,468

To **hedge the option** and **convert the premium** into **USD**

Need to **sell EUR 4.5mn**

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What is the ATM Strike?

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ATM Strike

There are three ways deciding the at-the-money strike in FX options

ATMS	ATMF	ATM (DNS)
At-the-money-spot	**At-the-money-forward**	**Delta-neutral straddle strike**
Not common in FX	Commonly used in **trades** with **clients**	Call and put have the **same delta**
	Call and put have **the same price**, but **different deltas**	Standard for **interbank** trading

Gamma

Converting FX Option Risk Metrics

Δ γ ν Θ

Delta

Gamma

Vega and Theta

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γ

Gamma

Gamma tells us how **delta changes** and the **delta of an option** can only be between **0 and 1**

	1.10 call	1.10 put
Delta (spot)	0.55412	-0.42853
Gamma (spot)	6.19394	6.19394

Delta can change by **6.2**

Abs (delta) is bound **0 < Δ < 1**

Gamma is trying to 'predict' a delta change for a **1.0 change in spot** using the **local delta gradient**

Scale gamma to a **realistic spot move** and **turn** it into an **equivalent spot FX position change**

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γ

Gamma

FX options traders are likely to want to see their gamma as a change in their **spot FX delta position**

	1.10 call
Notional (EUR)	10,000,000
Gamma (per big figure)	0.06194
Delta change (per big figure)	619,394

Black-Scholes gamma multiplied by 0.01

The **trader** now knows that as **spot moves**

±0.01

Delta position changes by

EUR ±0.6mn

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γ

Gamma

FX options traders are likely to want to see their gamma as a change in their **spot FX delta position**

	1.10 call
Notional (EUR)	10,000,000
Gamma (per big figure)	0.06194
Delta change (per big figure)	619,394

Black-Scholes gamma multiplied by 0.01

Change the increment (maybe to 10 pips)

OR

Run a **table of delta versus spot**

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Below is a **delta versus spot** table for a **long 6-month 1.1000 EURUSD straddle** in **EUR 10,000,000** (@8% vol)

Spot	P/L	Delta	Gamma (per big figure)
1.1500	139,783	5,186,019	769,483
1.1450	114,840	4,786,467	828,711
1.1400	91,968	4,357,383	887,486
1.1350	71,314	3,899,187	945,021
1.1300	53,023	3,412,707	1,000,482
1.1250	37,232	2,899,195	1,053,007
1.1200	24,074	2,360,335	1,101,724
1.1150	13,668	1,798,249	1,145,773
1.1100	6,126	1,215,478	1,184,331
1.1050	1,543	614,961	1,216,634
1.1000	0	0	1,242,003
1.0950	1,561	-625,789	1,259,862
1.0900	6,269	-1,258,535	1,269,765
1.0850	14,151	-1,894,177	1,271,408
1.0800	25,209	-2,528,541	1,264,644
1.0750	39,427	-3,157,422	1,249,490
1.0700	56,767	-3,776,664	1,226,135
1.0650	77,171	-4,382,248	1,194,932
1.0600	100,561	-4,970,372	1,156,392
1.0550	126,840	-5,537,526	1,111,171
1.0500	155,896	-6,080,560	1,060,052

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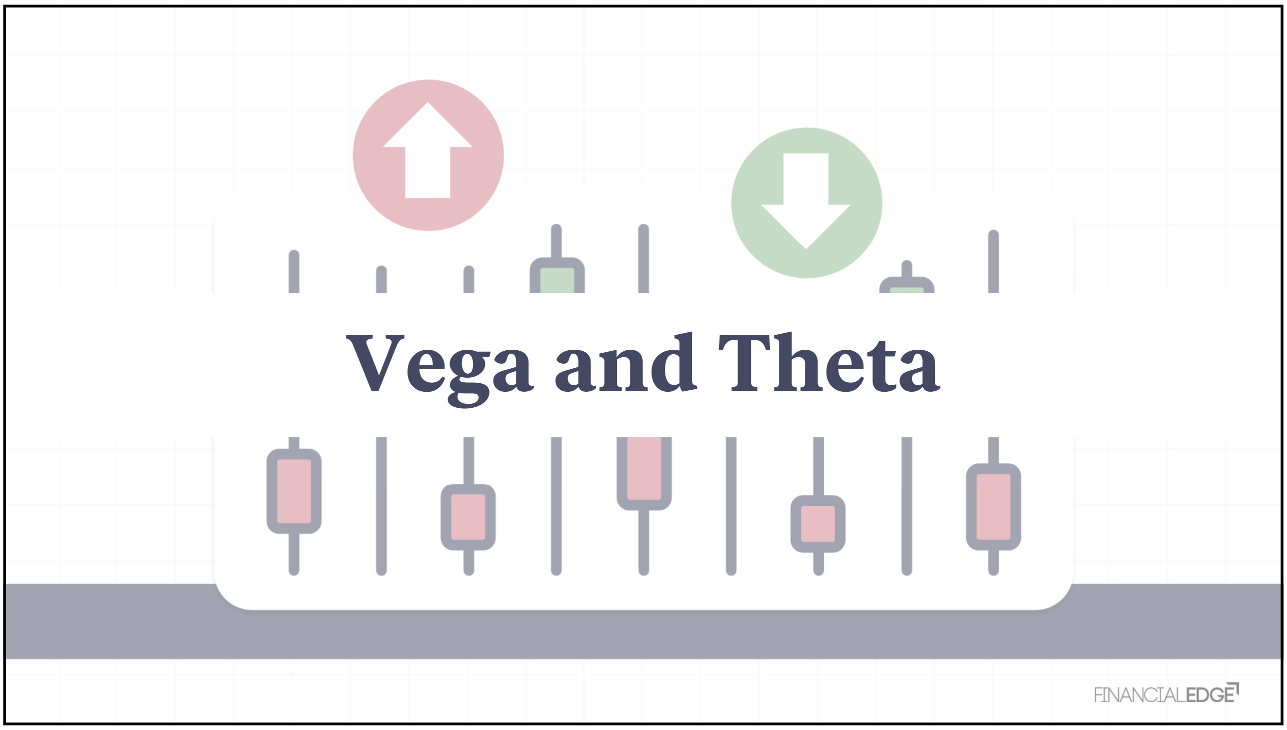

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Converting FX Option Risk Metrics

Δ	γ	ν	Θ
Delta	Gamma	Vega and Theta	

$\nu\Theta$

Vega and Theta

Can be multiplied by the **notional (in base currency)** to get their amounts in the **quoted currency**

	1.10 call
Notional (EUR)	10,000,000
Vega	0.00301
Vega (USD)	30,100
Theta	-0.00006
Theta (USD)	-622

Vega ν

Naturally quoted **per 1%** absolute move in vol

May **reduce increment** to see our **risk** to a more **realistic move** in vol

Not all vols move by the **same fixed increment**

$\nu\Theta$

Vega and Theta

Can be multiplied by the **notional (in base currency)** to get their amounts in the **quoted currency**

	1.10 call
Notional (EUR)	10,000,000
Vega	0.00301
Vega (USD)	30,100
Theta	-0.00006
Theta (USD)	-622

Vega ν

10% → **11%**

15% → **16.5%**

Possibly gives a more **useful aggregate** Vega number

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$\nu\Theta$

Vega and Theta

Can be multiplied by the **notional (in base currency)** to get their amounts in the **quoted currency**

	1.10 call
Notional (EUR)	10,000,000
Vega	0.00301
Vega (USD)	30,100
Theta	-0.00006
Theta (USD)	-622

Theta Θ

Naturally quoted **per day**

Can be changed to **per hour** for very short-dated options

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