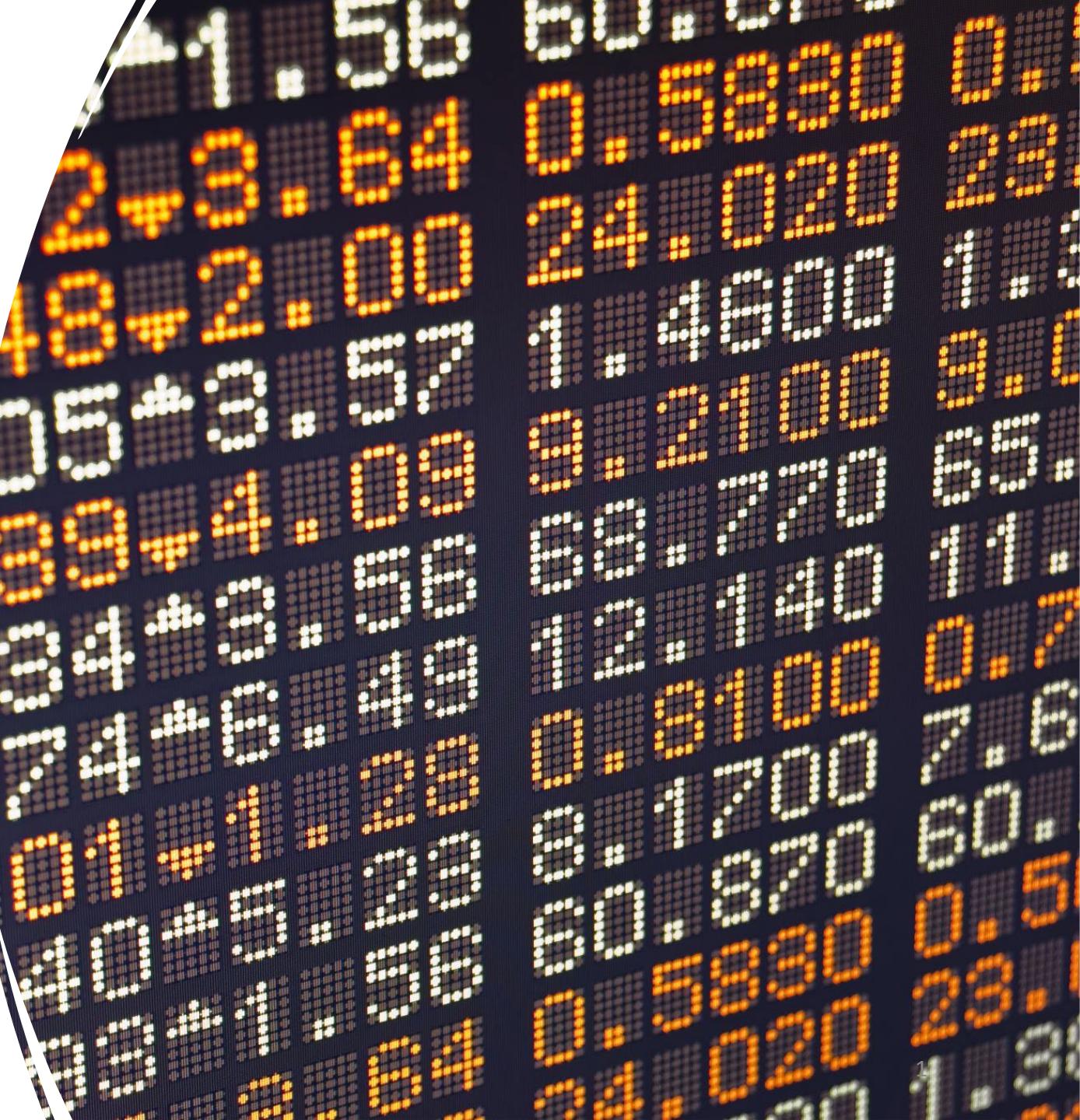


Foreign Exchange

Professor Jessica James



Professor Jessica James BSc DPhil FInstP

- Undergraduate physics at Manchester
- Doctorate (theoretical atomic and nuclear physics) at Oxford
- Nearly 30 years in finance – FNBC, Bank One, Citi, CommerzBank - designing and trading FX and interest rate products
- Visiting professor at UCL and Bayes
- Founding editor of Quantitative Finance
- Trustee of two pension boards
- Author...



Learning Outcomes: Part 1

Size and importance

Notable features

History and evolution

Operations and conventions

Beyond the basics

Learning Outcomes: Part 2

Uses of FX options

Volatility, “volatility surface”,
“out of the money”

Pricing simple options

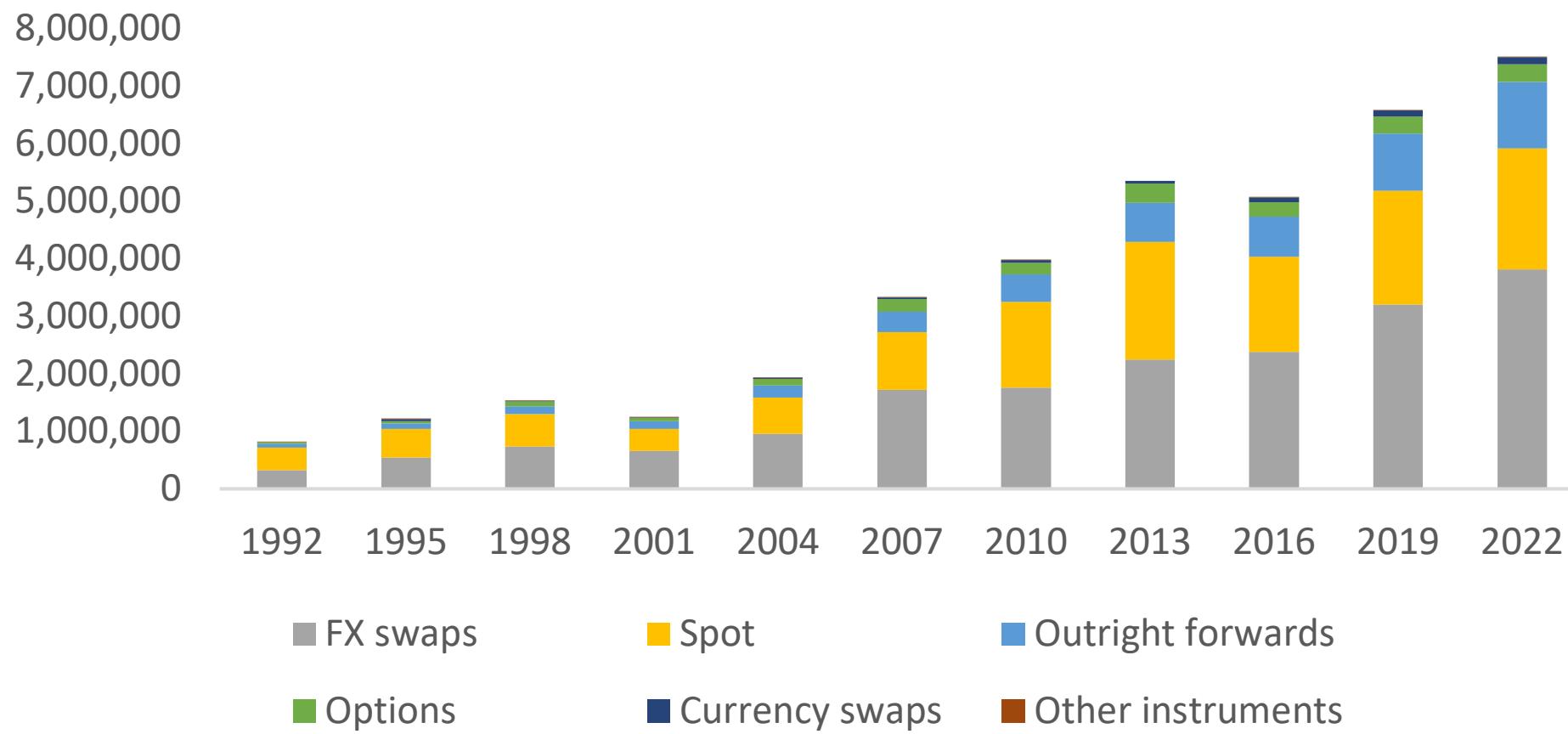
Risk management and basic Delta
hedging

Size and Importance

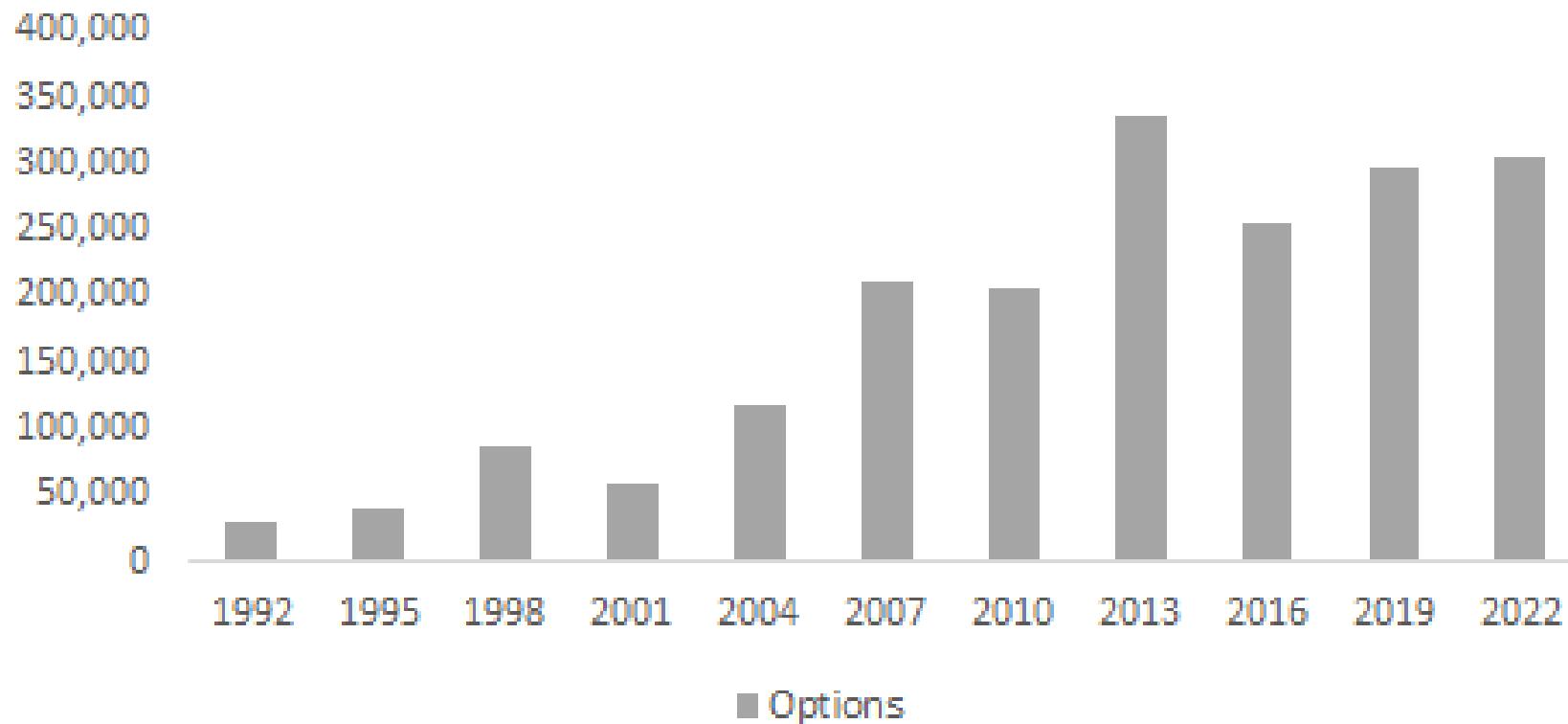
The largest global market



Global FX market turnover in USD millions equivalent



Global FX option market turnover in USD millions equivalent



Notable Features

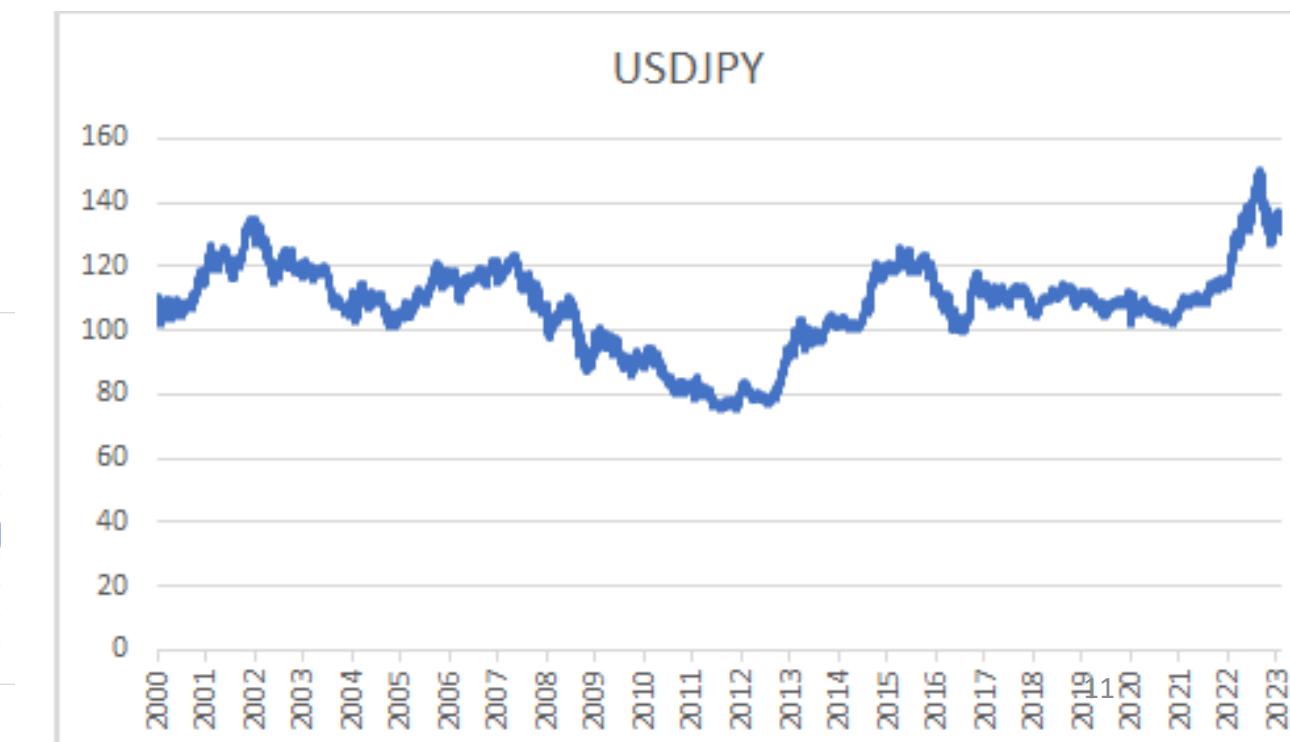
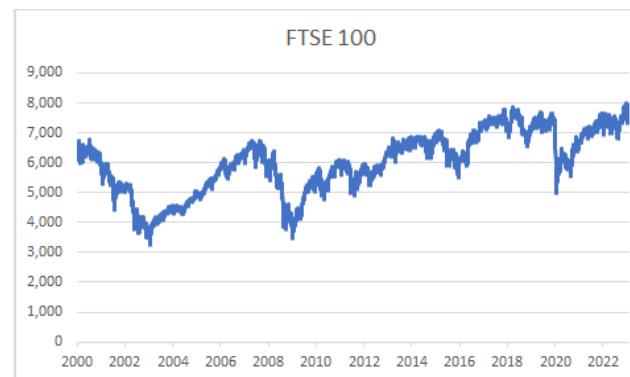
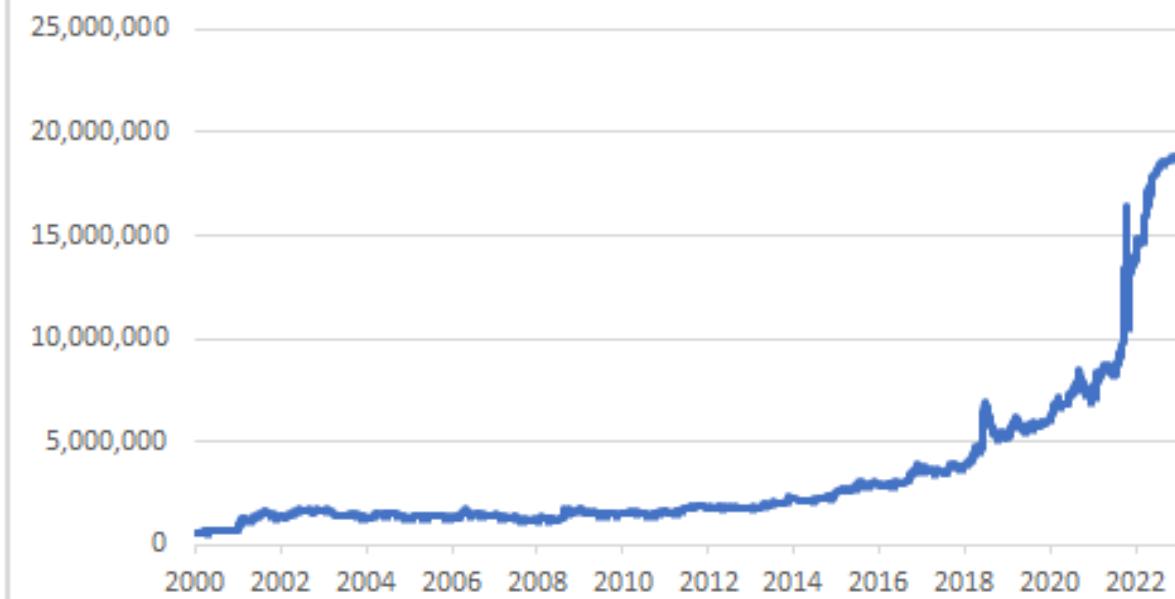
Size isn't everything...



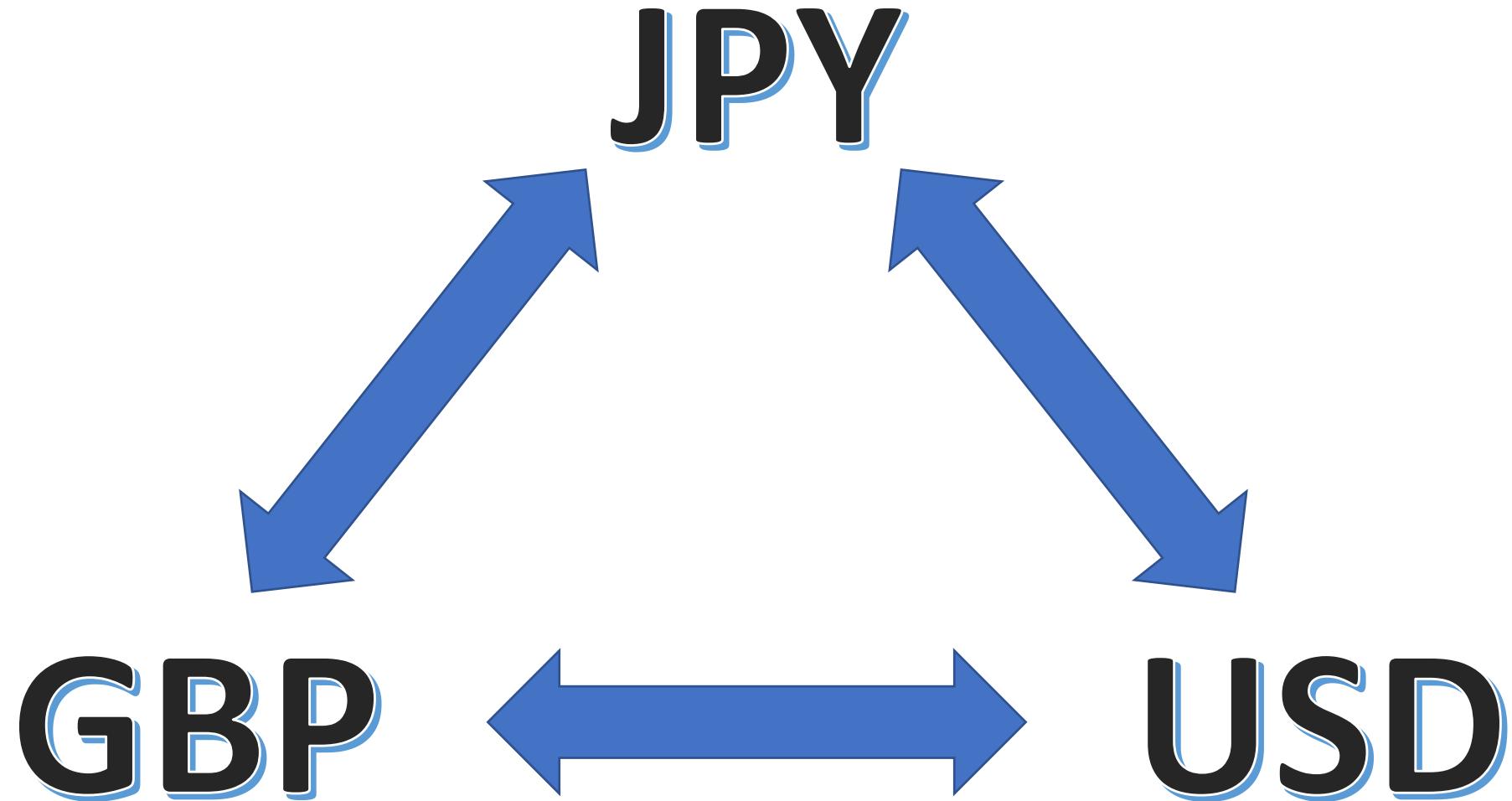
Exchange

GBP  USD

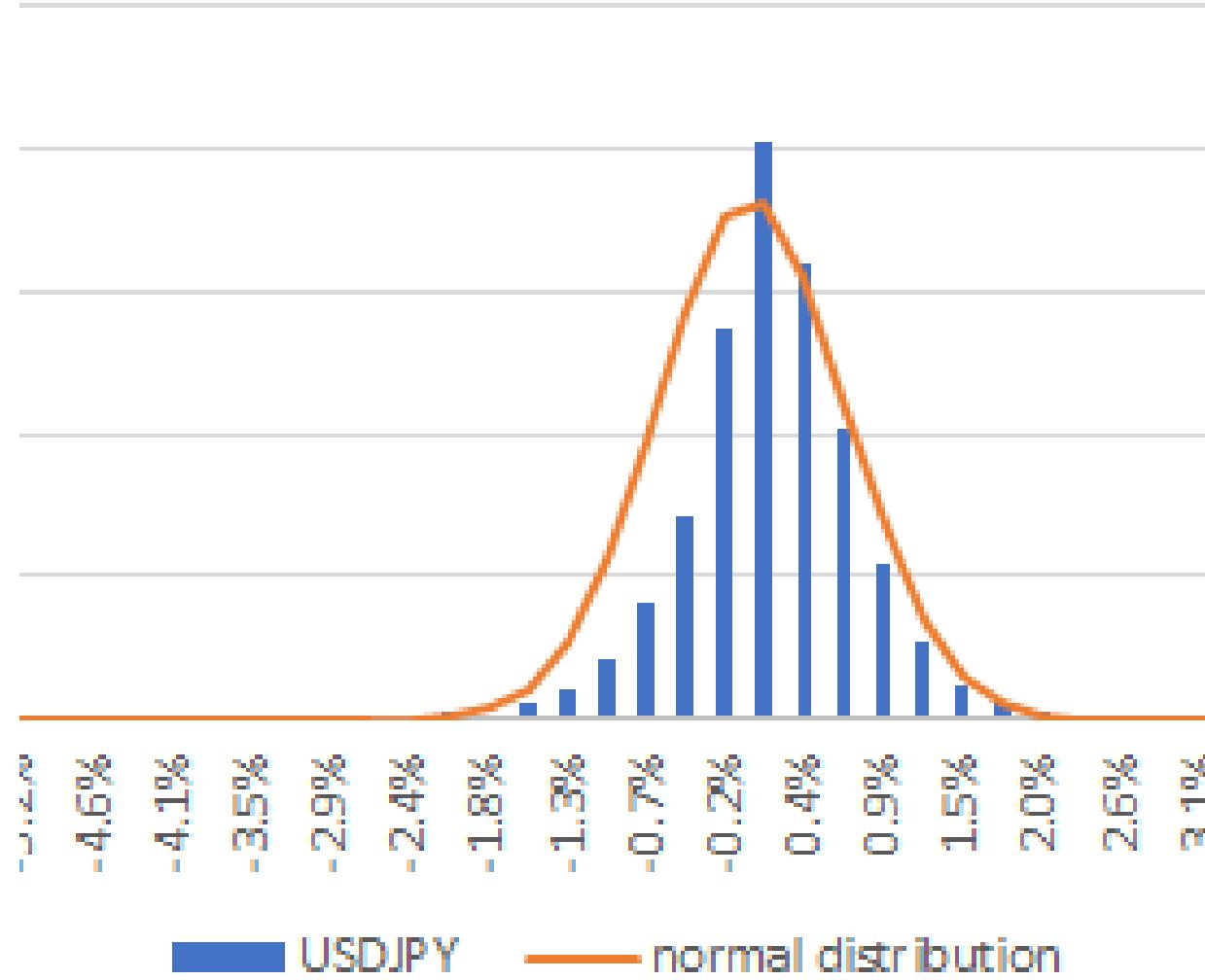
Old Turkish Lira



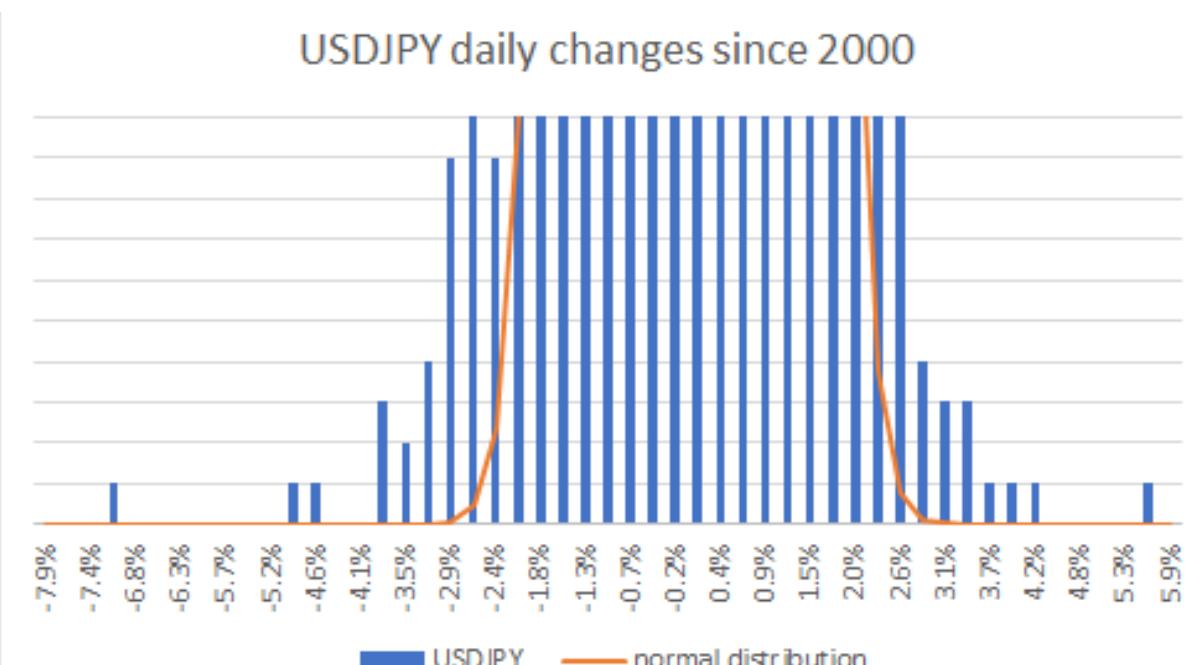
Interdependence



USDJPY daily changes since 2000



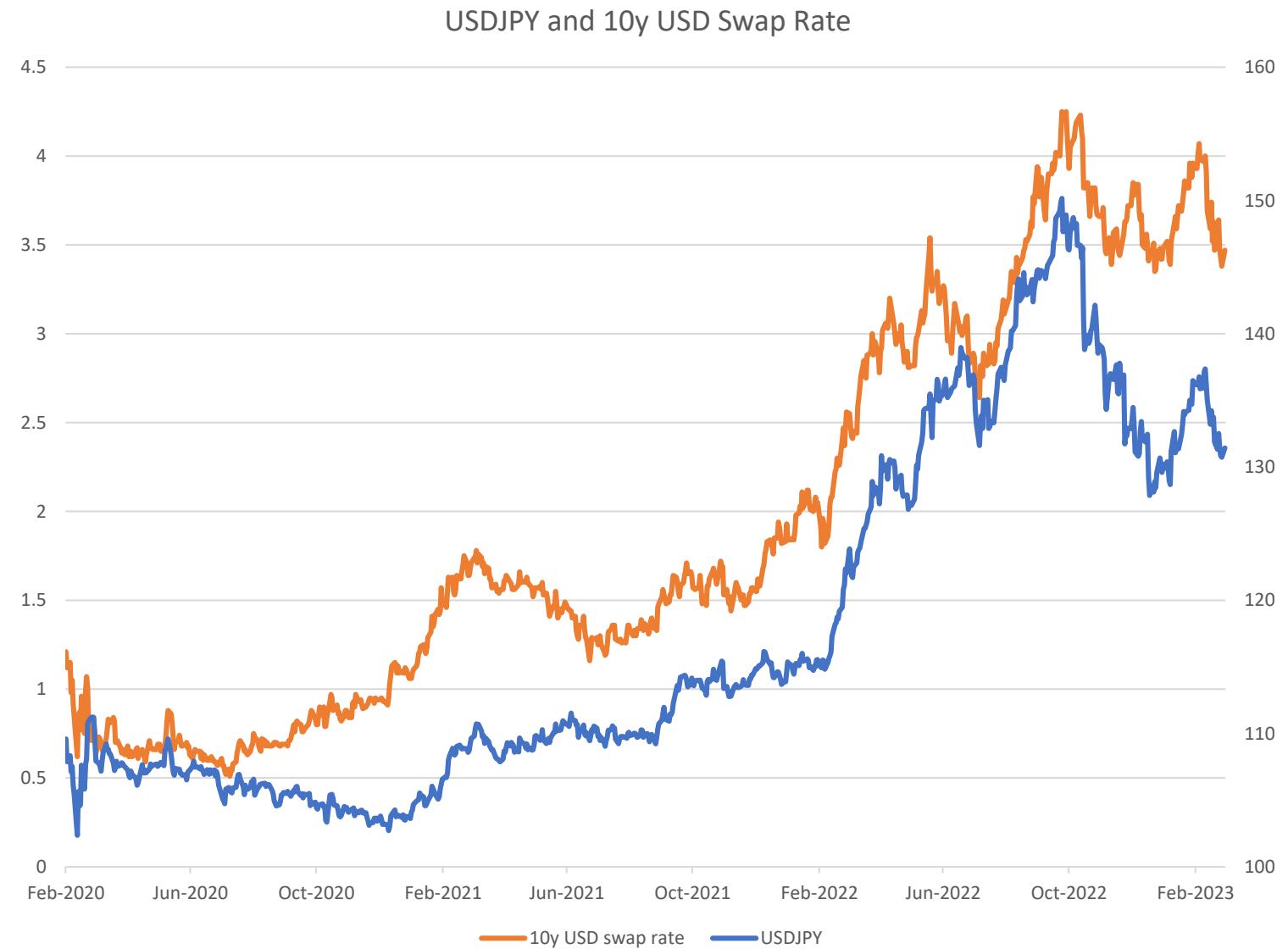
USDJPY daily changes since 2000



Interactions

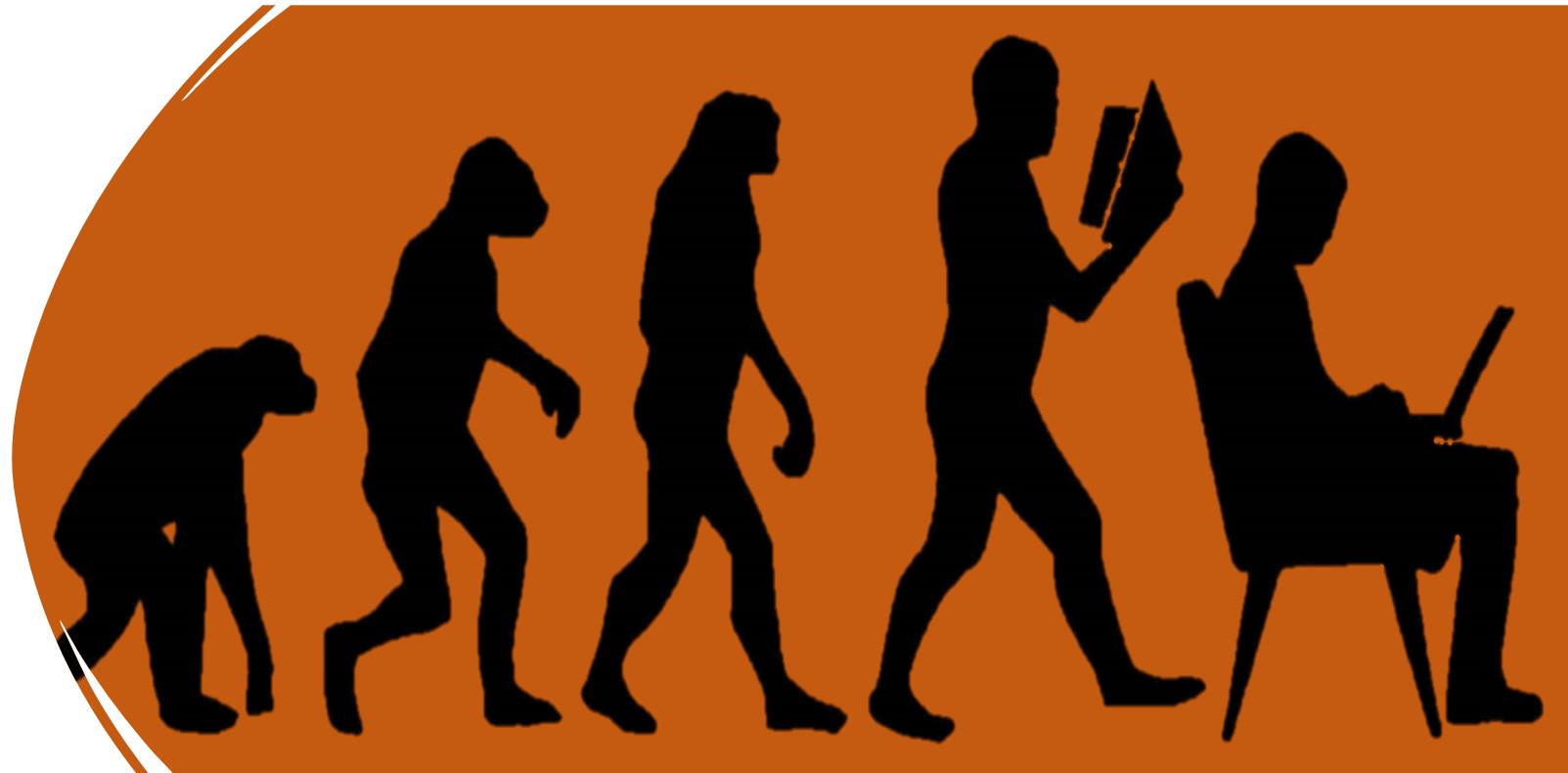


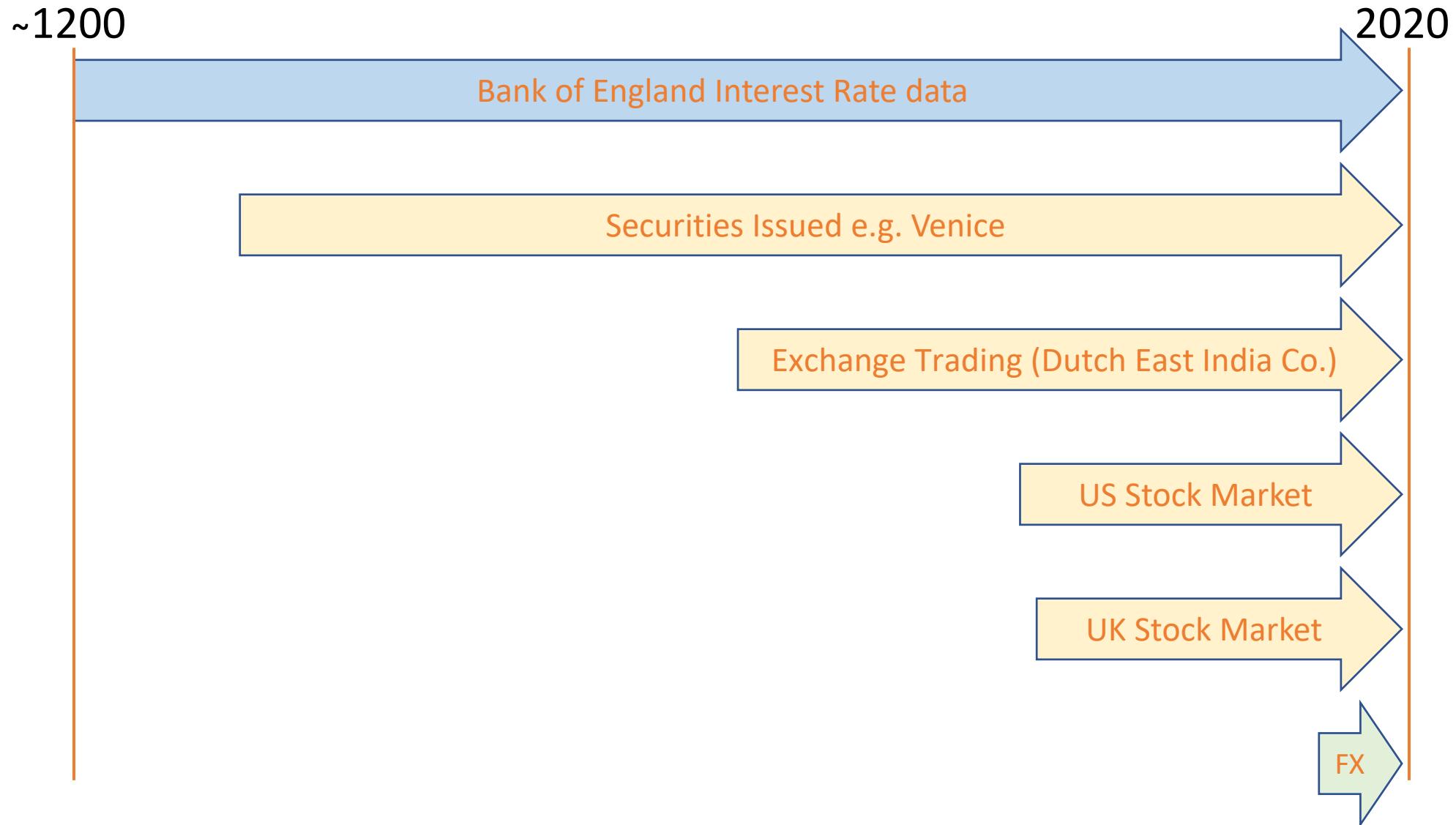
Correlations



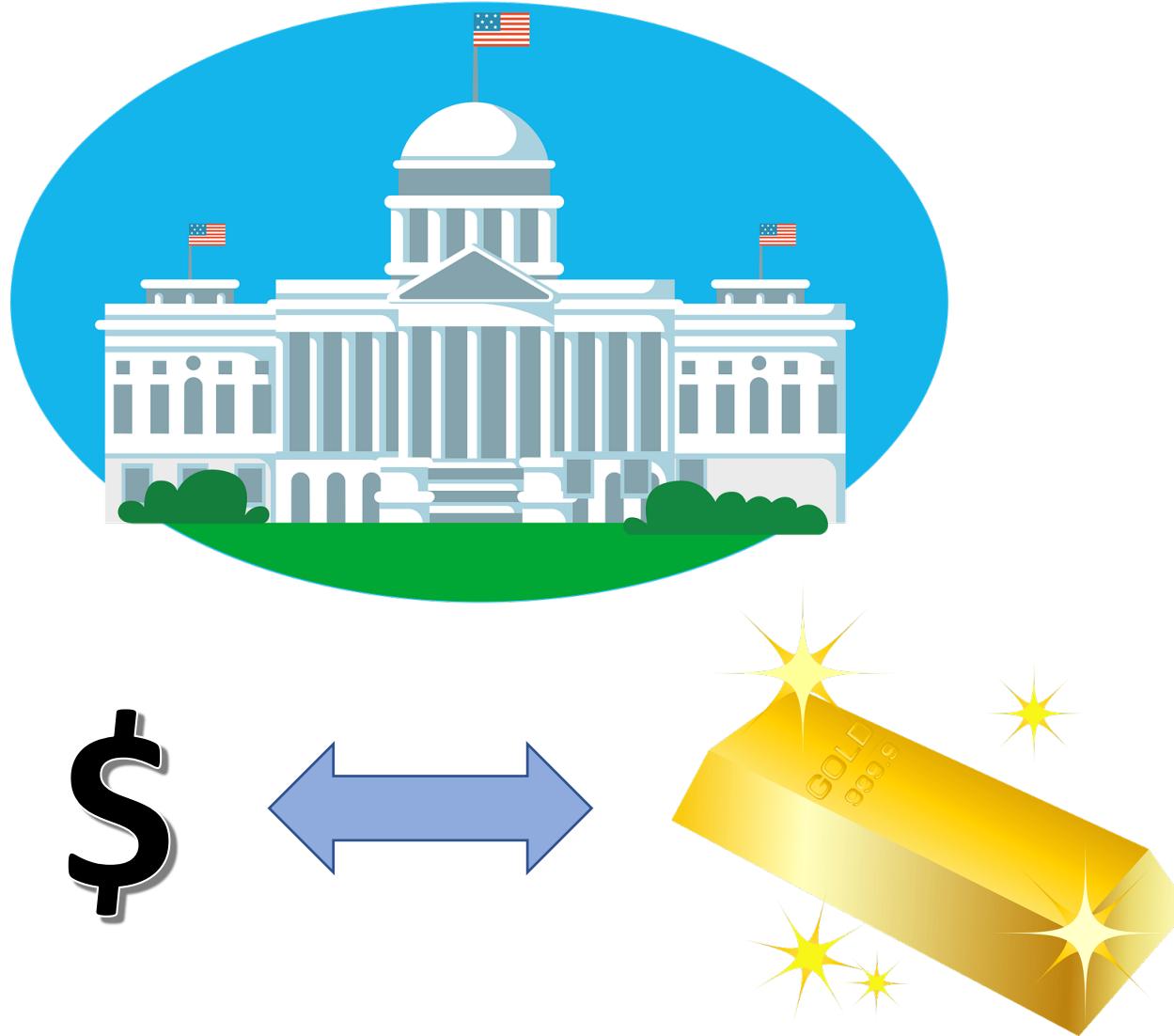
History and Evolution

Out of the Bretton Woods...

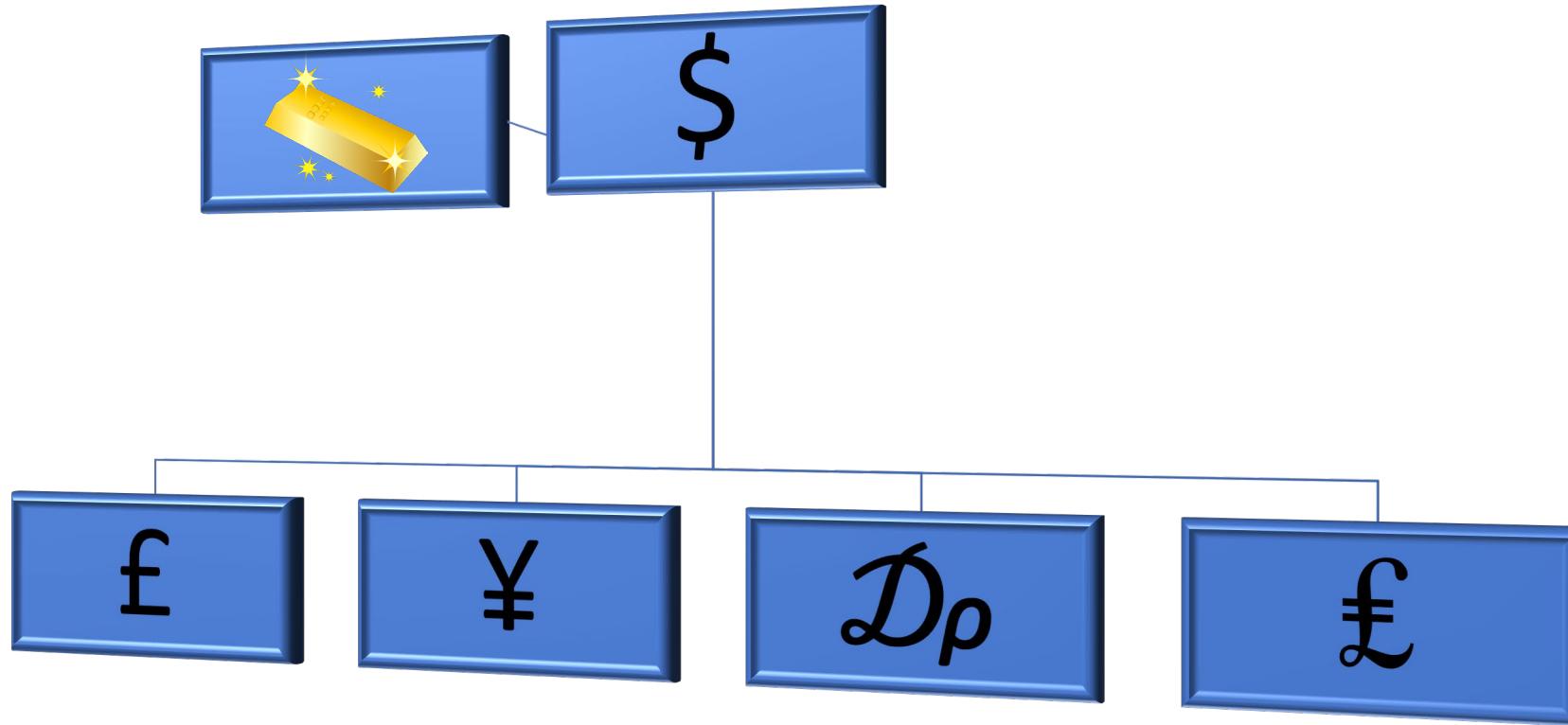




Pre-World War II



Bretton Woods (1944)



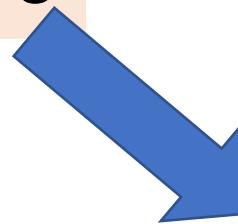
Operations and Conventions

Why “cable”?



Quoting Convention

GBPUSD = 1.30

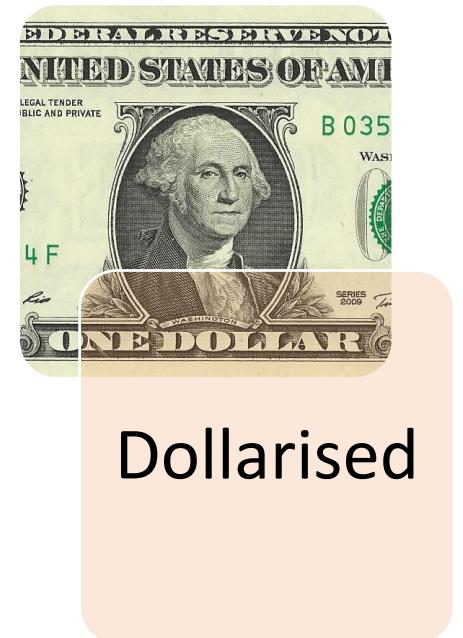
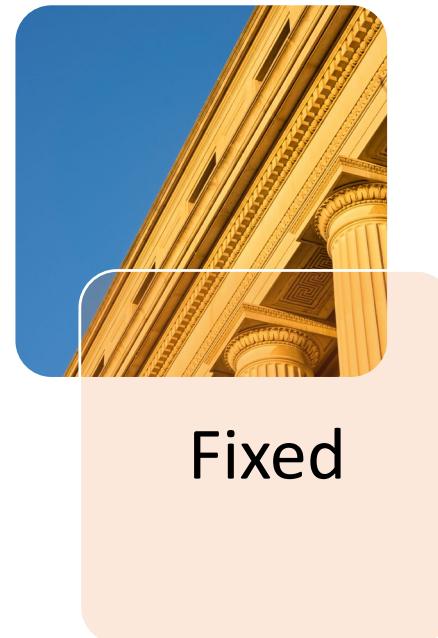
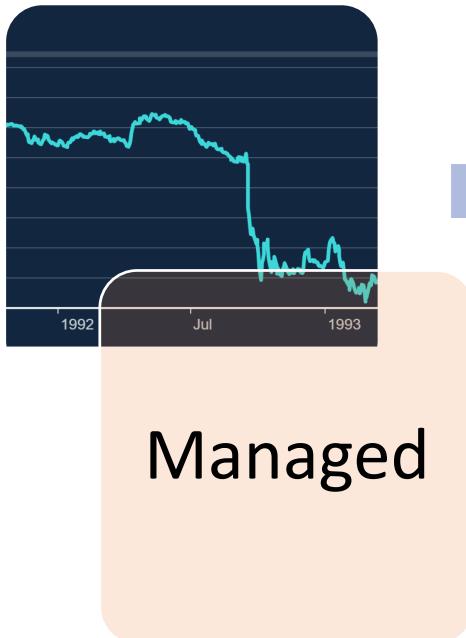


Base  1 GBP = 1.30 USD

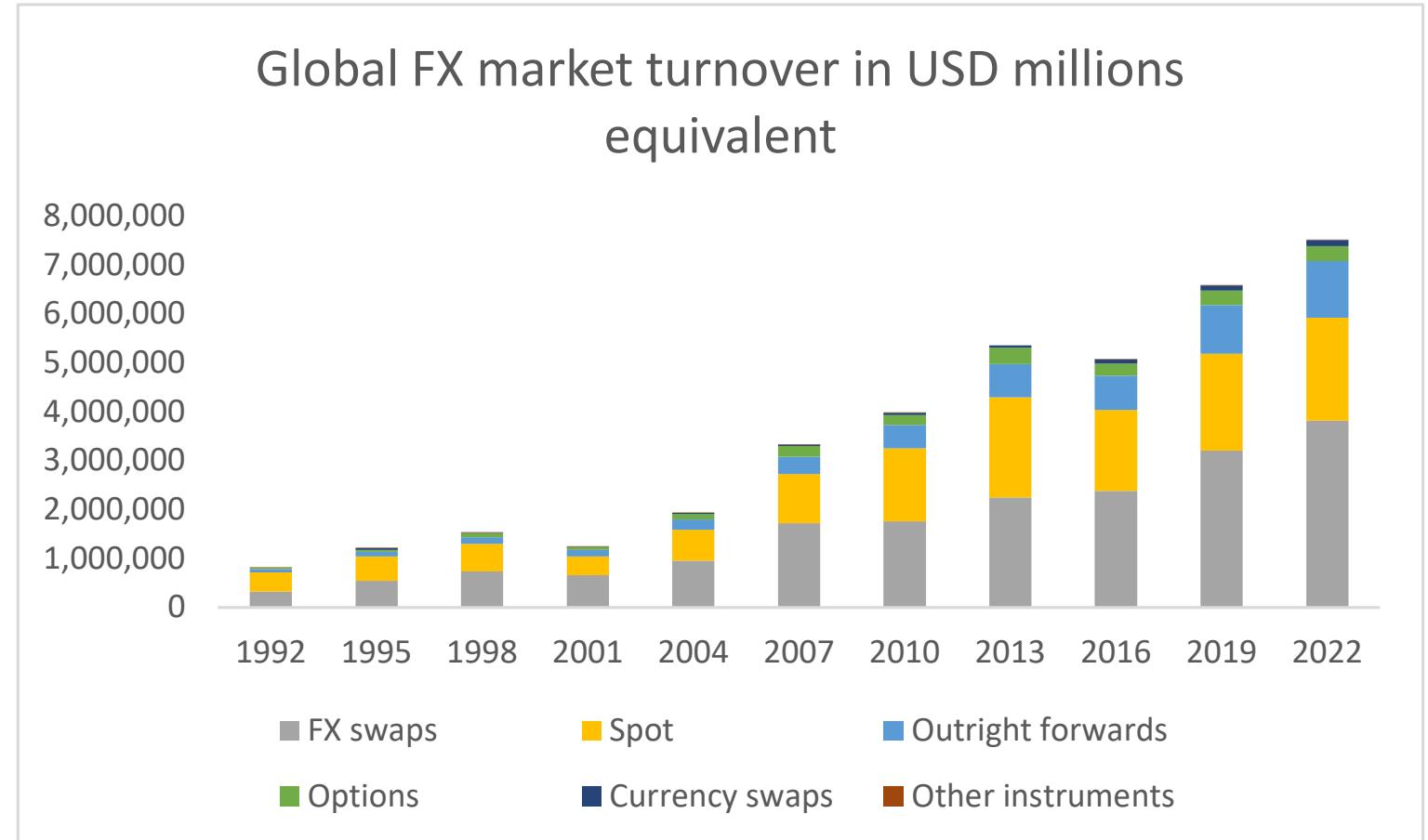
Base Ranking



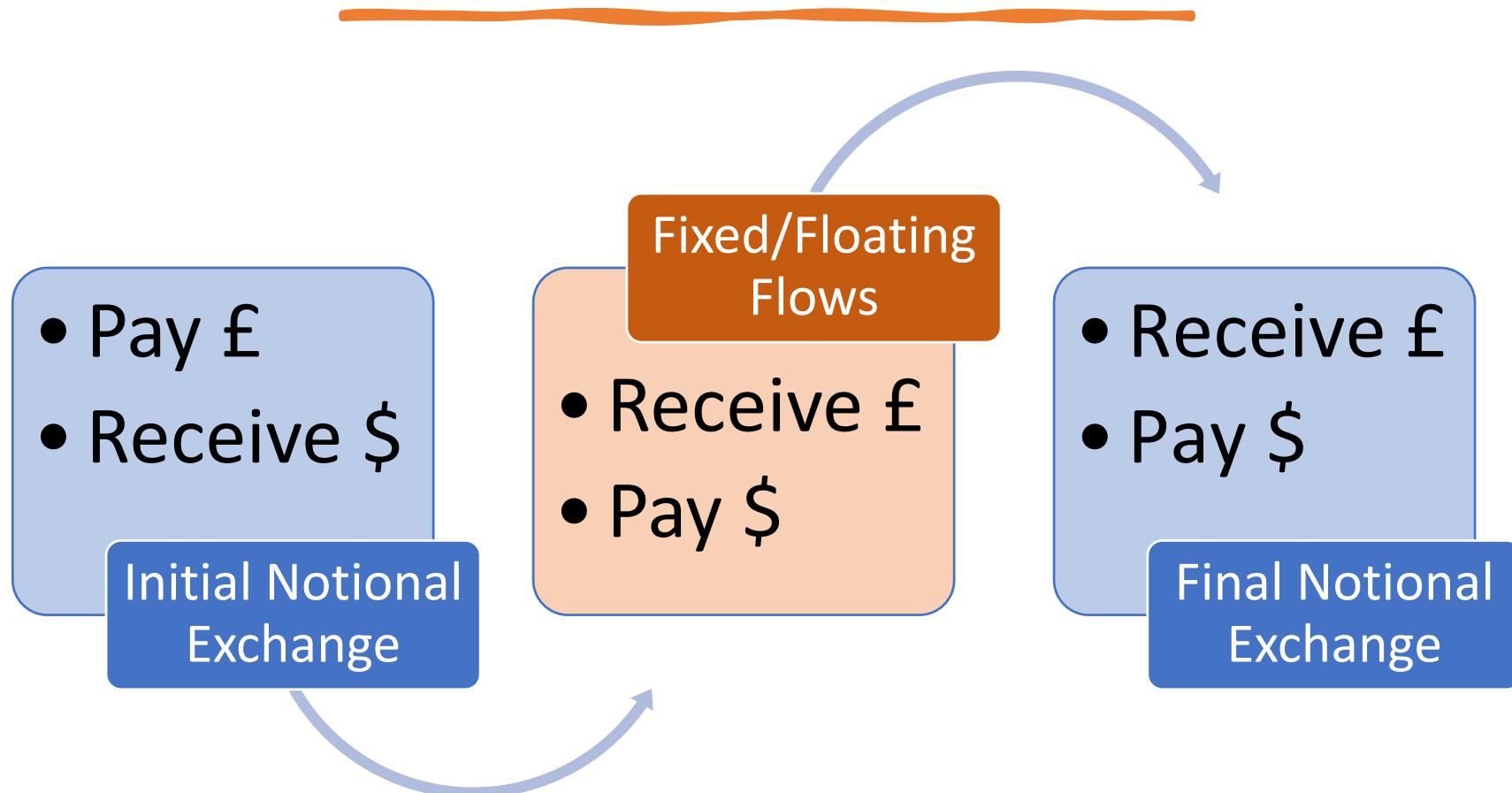
Trading Regimes



Contract Types



Swaps



Spot



Forward


$$\frac{F}{S} = \frac{1 + r_f}{1 + r_d}$$

F = forward FX rate

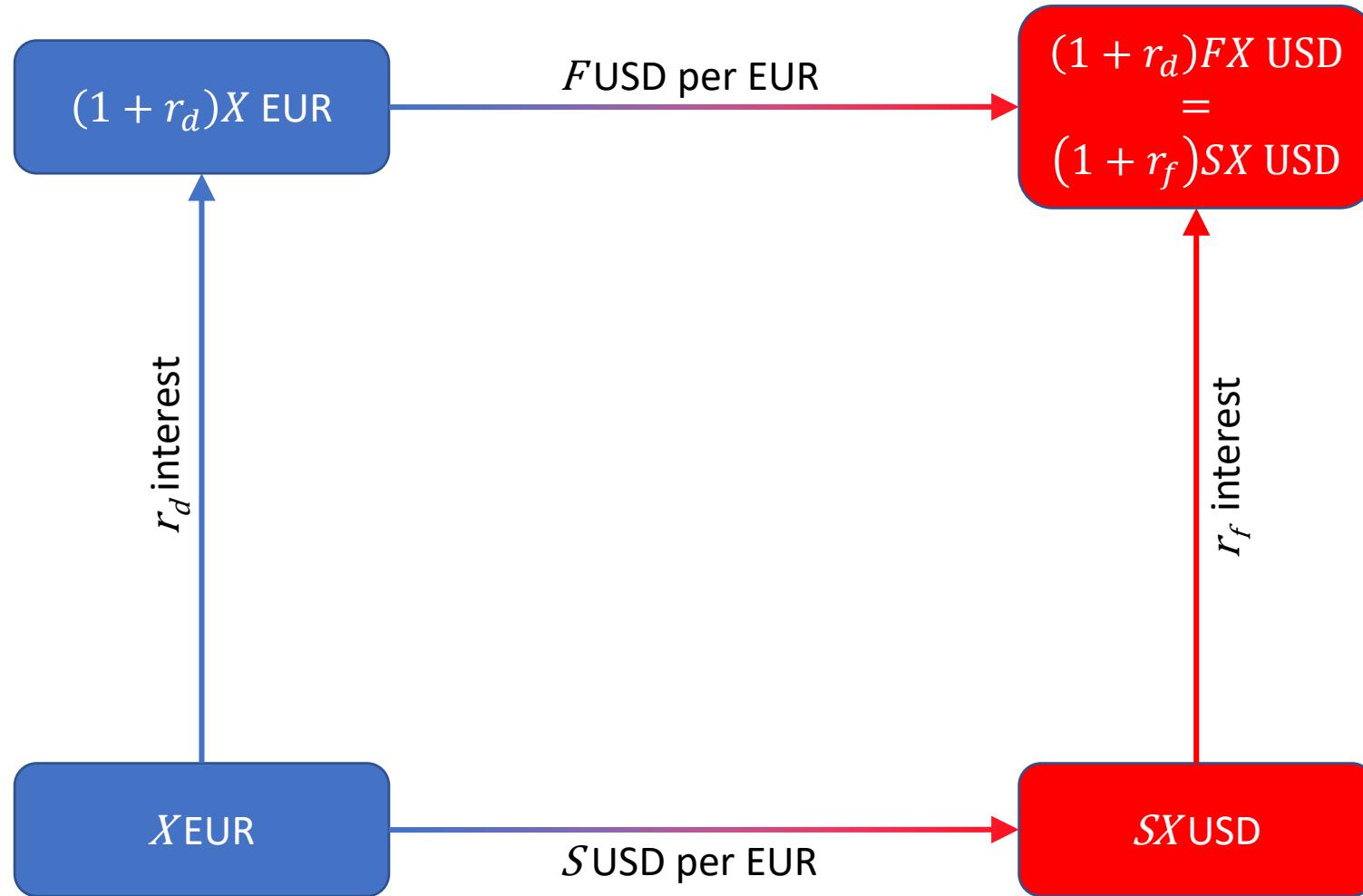
S = spot rate

r_f = foreign interest rate

r_d = domestic interest rate

Rate quoted as “**foreign per domestic**”

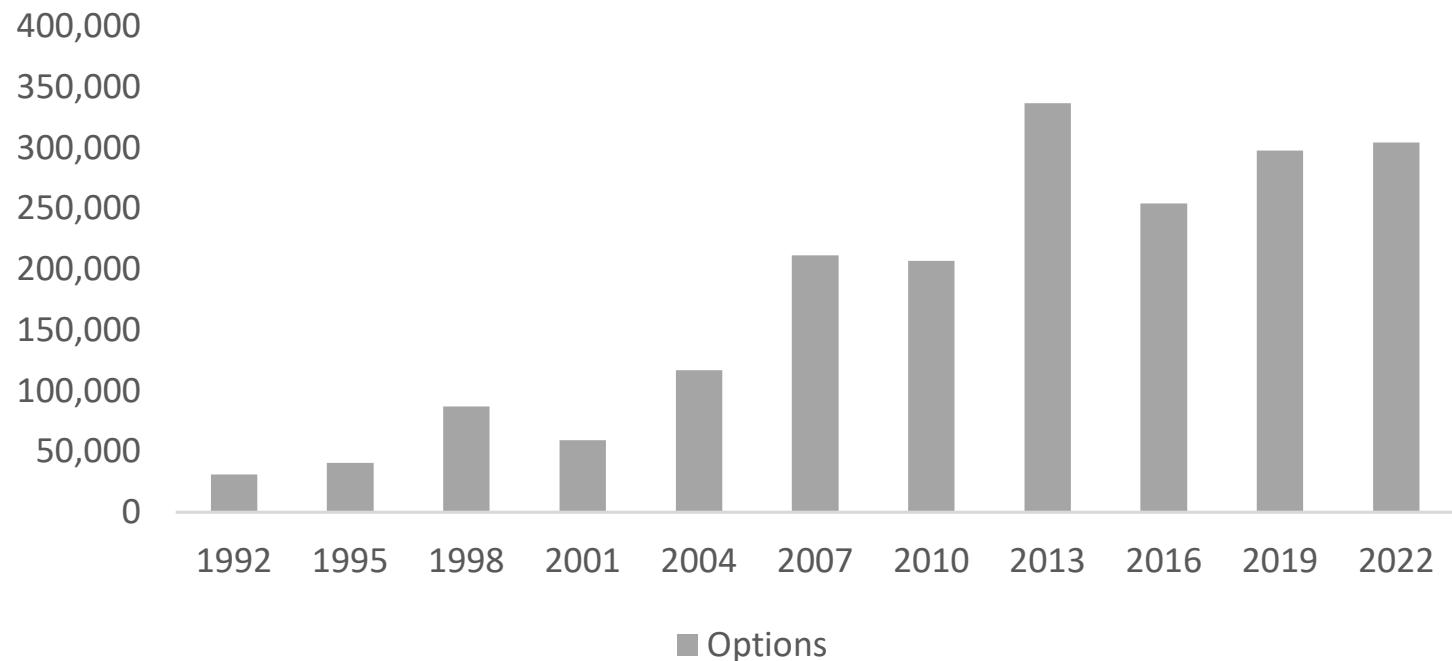
e.g. **1.1USD per EUR (EURUSD)**



FX Options



Global FX option market turnover in USD millions equivalent



Others

Futures

- Fixed term
- Settled daily
- Not included in BIS flow data
- Special exchanges

Non-deliverable forward (NDF)

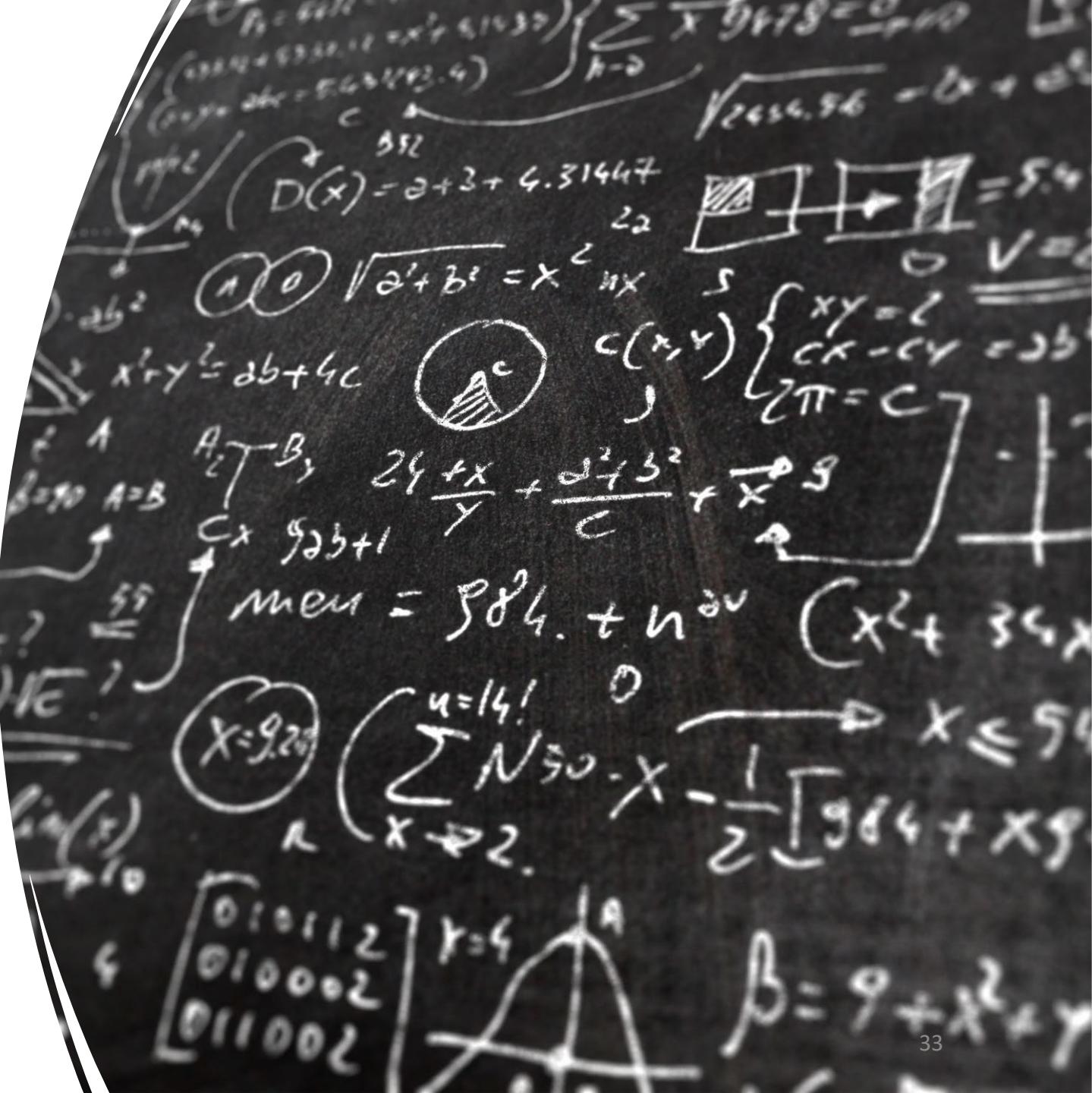
- For untradable currencies
- Mimic forwards of another currency, but deliver in e.g. EUR or USD

Over-The-Counter (OTC)



Beyond the Basics

Subtleties and surprises...



Cross-Currency Basis

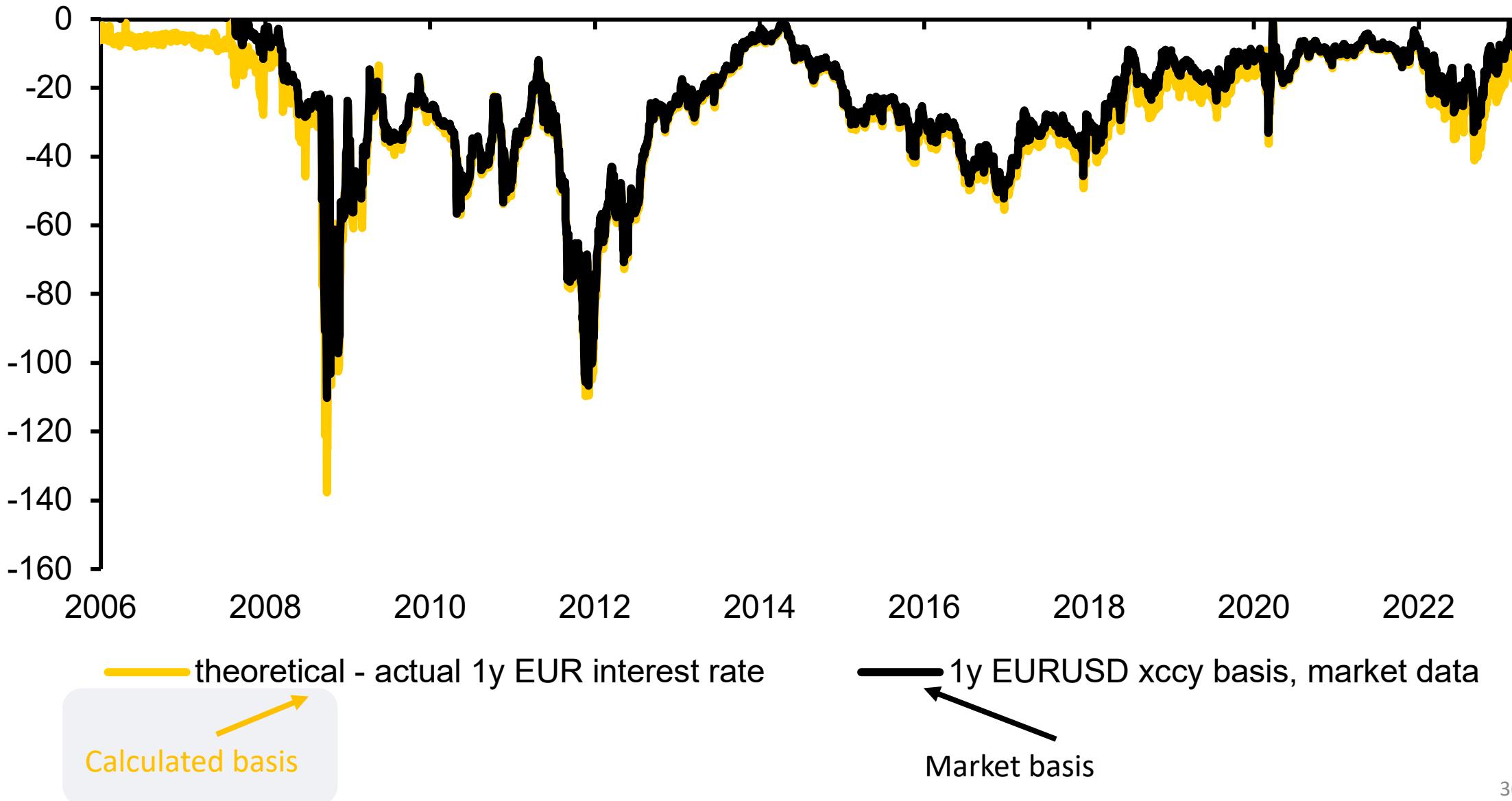
$$\frac{F}{S} = \frac{1 + r_f}{1 + r_d}$$

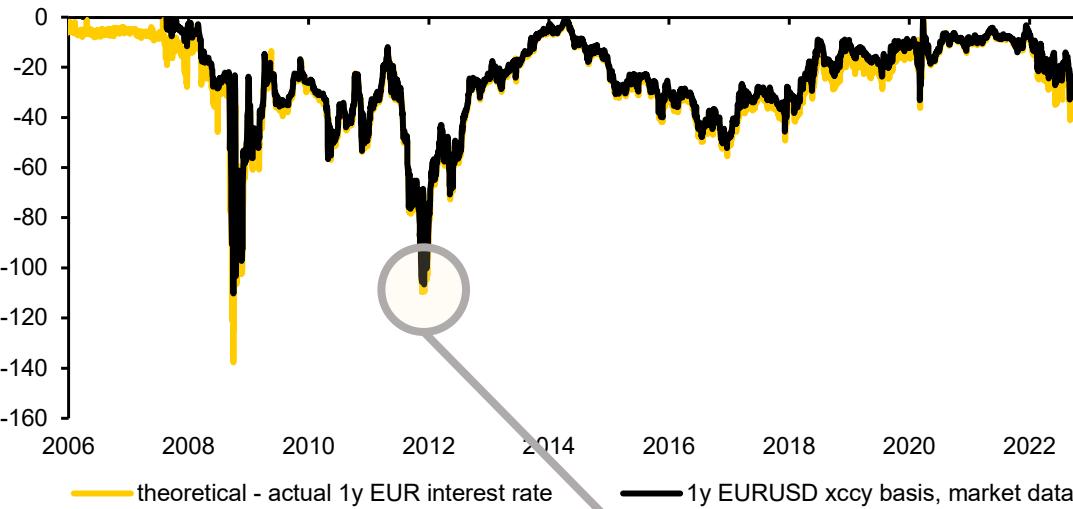
- Relies on no-arbitrage
- But *can* be broken if a non-zero cross-currency basis exists
- Obvious question – what is a cross-currency basis? Be patient...

Experimental Financial Maths?

$$r_d = \frac{S}{F} \times (1 + r_f) - 1$$

- Let domestic (d) = EUR, foreign (f) = USD
- All these rates are observable in the market
- Calculate r_d
- Compare EUR 1 year swap rate time series since 2000
- Plot r_d (theoretical) – r_d (market value) (a *calculated* value of the basis)





On 29th December 2011

EUR-USD xccy basis = 101.9bp (EUBS1 Curncy)

EURUSD spot FX rate = 1.296 (EURUSD Curncy)

EUR 1Y swap rate = 1.094% (EUSW1V3 Curncy)

USD 1Y swap rate = 0.691% (USSA1 Curncy)

EURUSD 1Y FX forward = 1.304 (EUR12M Index)

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USD 1Y swap rate = 0.691% (USSA1 Curncy)

EURUSD 1Y FX forward = 1.304 (EUR12M Index)

$$r_d \text{ (theoretical)} = \frac{S}{F} \times (1 + r_f) - 1$$

$$r_d \text{ (theoretical)} = \frac{1.296}{1.304} \times (1 + 0.691\%) - 1$$

$$r_d \text{ (theoretical)} = 0.073\%$$

On 29th December 2011

EUR-USD xccy basis = 101.9bp (EUBS1 Curncy)

EURUSD spot FX rate = 1.296 (EURUSD Curncy)

EUR 1Y swap rate = 1.094% (EUSW1V3 Curncy)

USD 1Y swap rate = 0.691% (USSA1 Curncy)

EURUSD 1Y FX forward = 1.304 (EUR12M Index)

$$r_d(\text{theoretical}) = 0.073\%$$

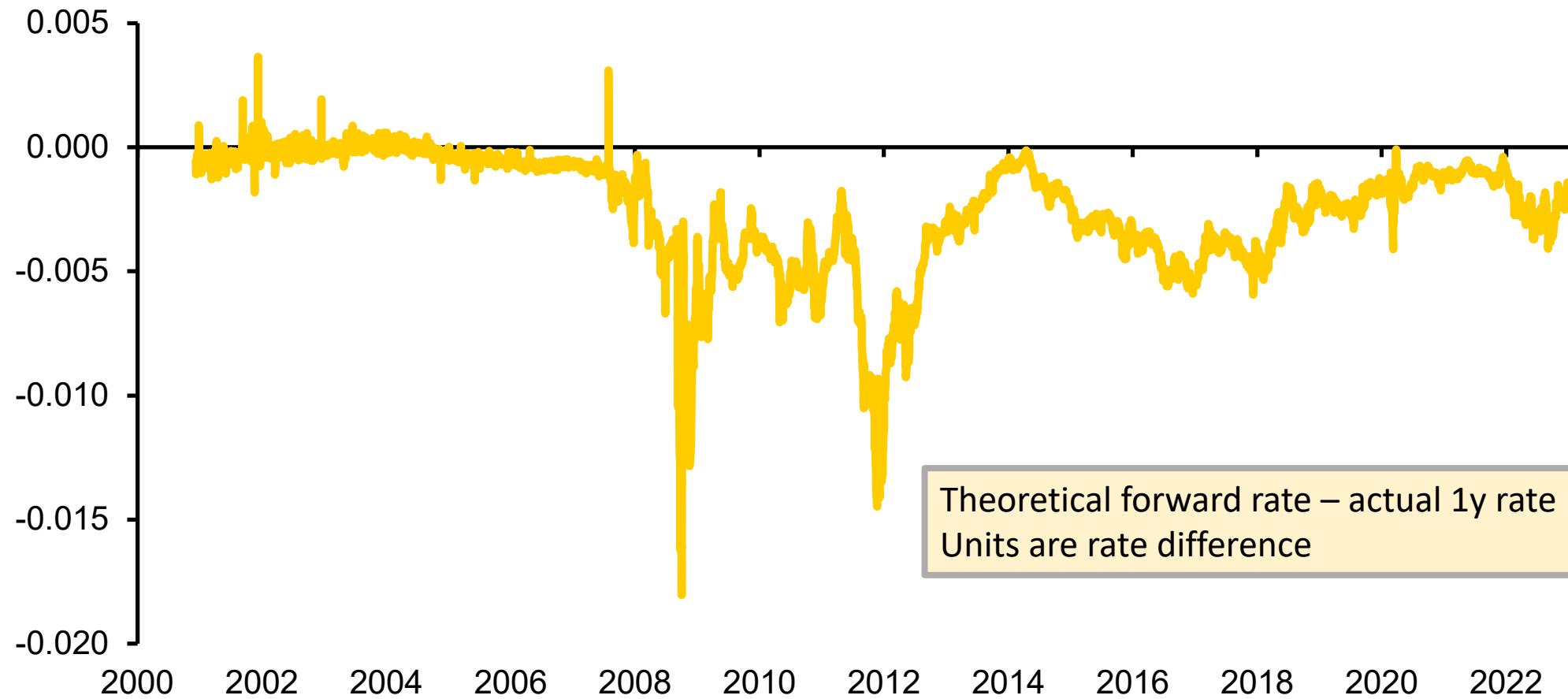
$$r_d(\text{market}) = 1.094\%$$

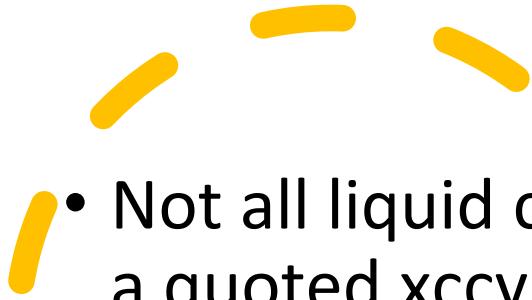
$$r_d(\text{theoretical}) - r_d(\text{market}) = 0.073\% - 1.094\%$$

$$r_d(\text{theoretical}) - r_d(\text{market}) = -1.021\%$$

$$r_d(\text{theoretical}) - r_d(\text{market}) = -102.1\text{bp}$$

Forward Rate Difference





- Not all liquid currency crosses have a quoted xccy basis
- Most are quoted to USD
- A few quoted to EUR
- So what about GBPJPY (for example)?
- Calculate to look for opportunities

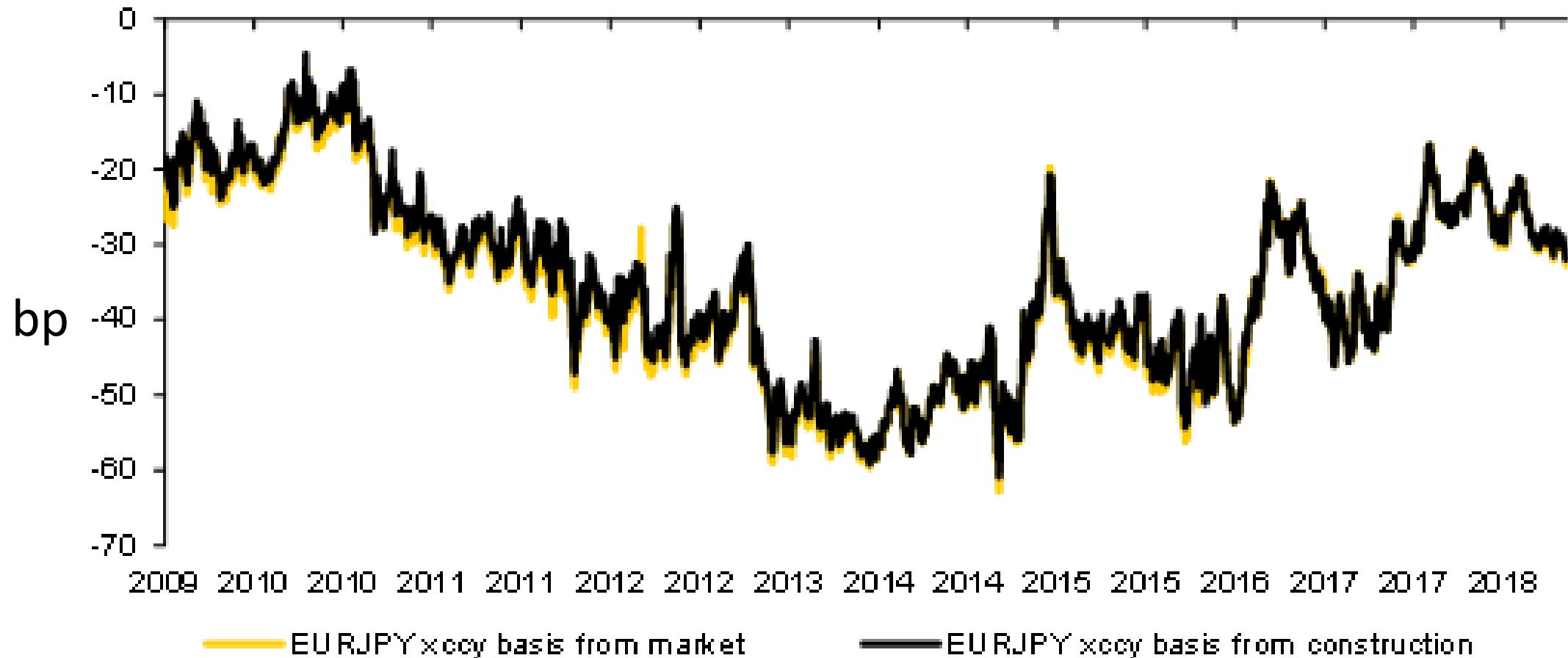


Calculating Unquoted XCCY Bases

$$XCCY_{AB} = XCCY_{CA} - XCCY_{CB}$$

$$XCCY_{JPYGBP} = XCCY_{USDJPY} - XCCY_{USDGBP}$$

Constructed and Quoted 10y XCCY_{EURJPY}



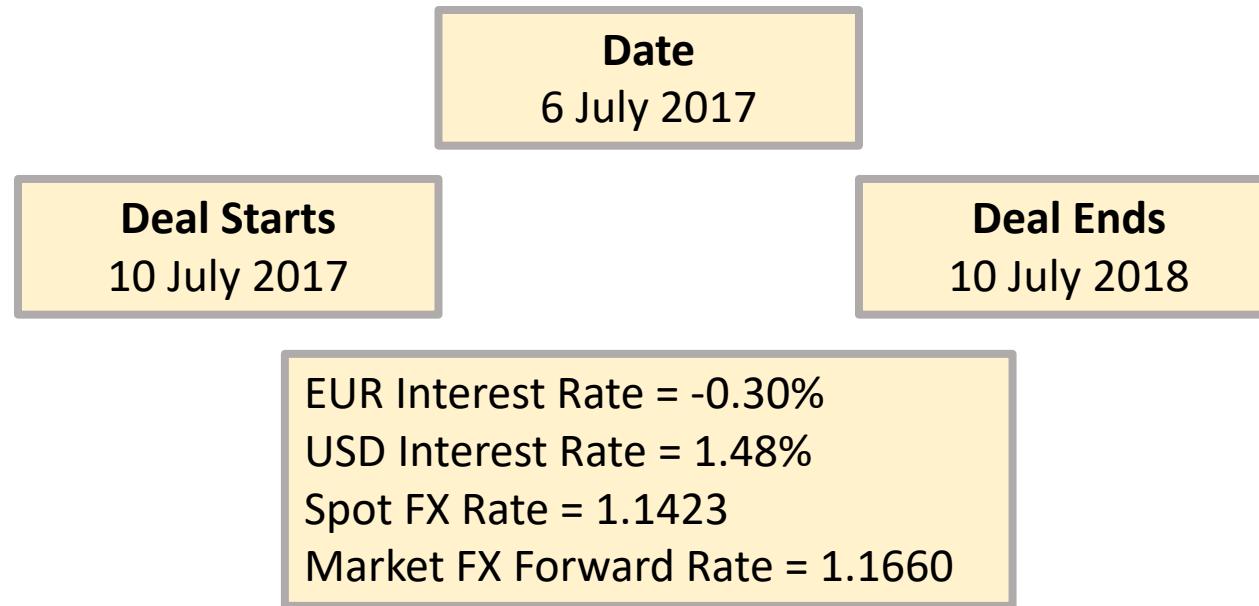
If USD and EUR Bases Unavailable?

- E.g. shorter tenors
- Derive basis using:
 - Spot FX rates (S = spot rate for EURJPY)
 - Forward FX rates (F = 3m forward FX rate for EURJPY)
 - Short-dated interest rates (r_d = EUR (domestic) rate, r_f = JPY)

$$\text{e.g. EURJPY 3m basis} = 100 \times \left[\left(\frac{F}{S} \times \left(1 + \frac{r_d}{400} \right) - 1 \right) \times 400 - r_f \right]$$

So It Exists (Post-2008)...But Why?

I am going to trade the XCCY basis to make an arbitrage killing...



Data taken from trading screens on date above

Calculate Implied Forward Rate

$$\frac{FX_2}{FX_1} \neq \frac{1 + r_2}{1 + r_1}$$

FX_1 = Spot FX Rate

FX_2 = 1y implied Forward Rate

r_2 = USD 1y Interest Rate

r_1 = EUR 1y Interest Rate

$FX_2 = 1.1627$

(Market rate = 1.1660)

Implied Forward Rate Is Wrong...

- Apply “correction” to either interest rate
- Calculate an “implied” value for r_1 or r_2
- Difference is the xccy basis

$$\text{Implied } r_1 = \frac{FX_1}{FX_2} \times (1 + r_2) - 1$$

$$\text{Implied } r_2 = \frac{FX_2}{FX_1} \times (1 + r_1) - 1$$

$$\text{Implied } r_1 = \frac{FX_1}{FX_2} \times (1 + r_2) - 1 = -0.583\%$$

$$\text{Implied } r_2 = \frac{FX_2}{FX_1} \times (1 + r_1) - 1 = 1.77\%$$

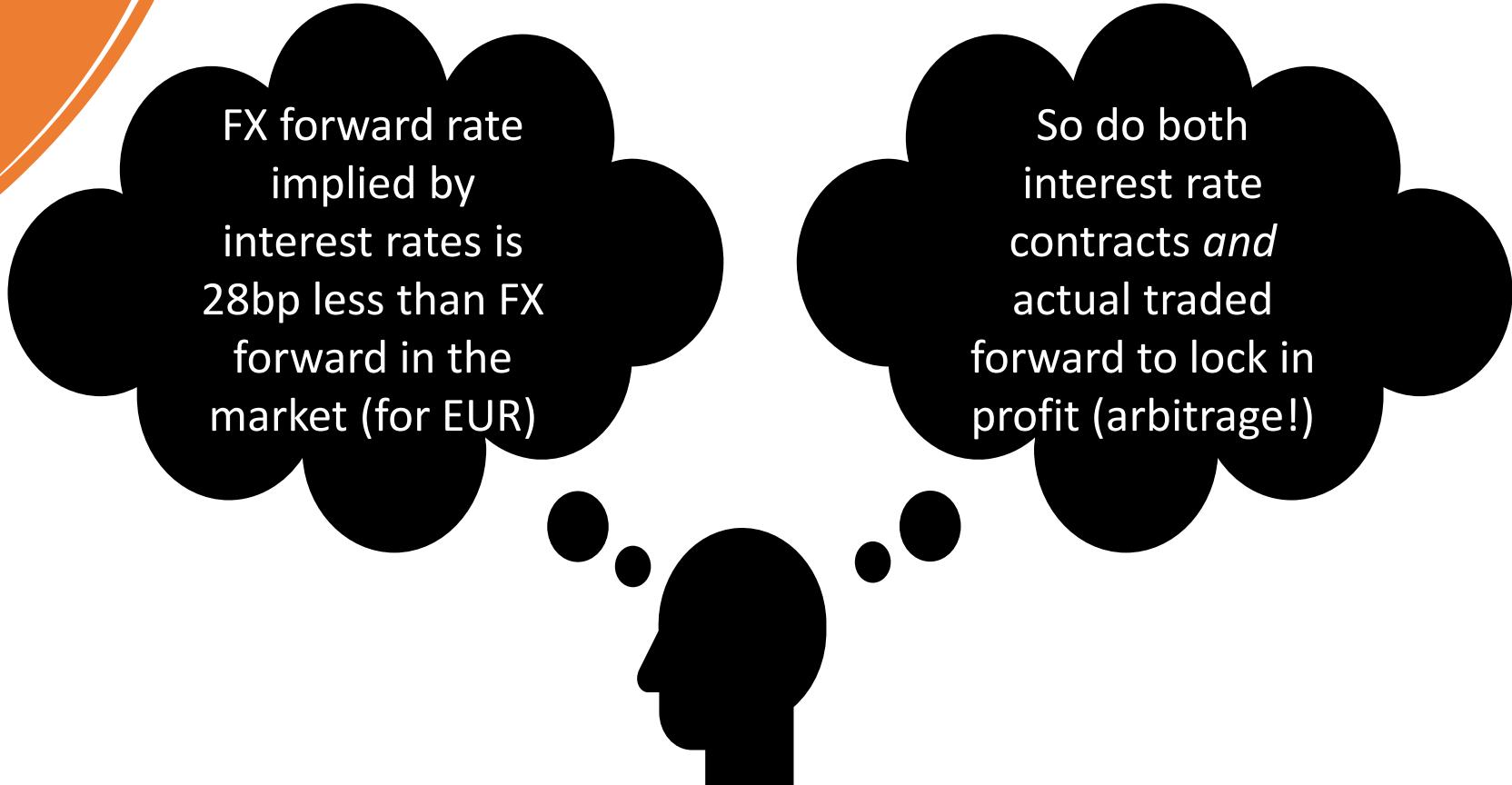
Market $r_1 = -0.30\%$

Market $r_2 = 1.48\%$

Calculated xccy basis using EUR = $-0.58\% - 0.30\% = -28\text{bp}$

Calculated xccy basis using USD = $1.48\% - 1.77\% = -29\text{bp}$

The Rookie Trader



FX forward rate implied by interest rates is 28bp less than FX forward in the market (for EUR)

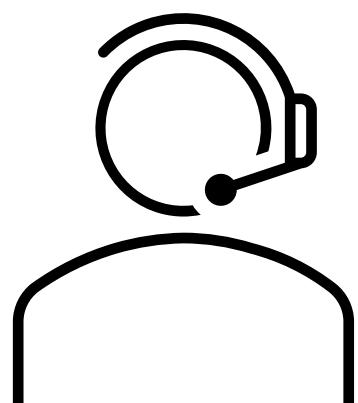
So do both interest rate contracts *and* actual traded forward to lock in profit (arbitrage!)



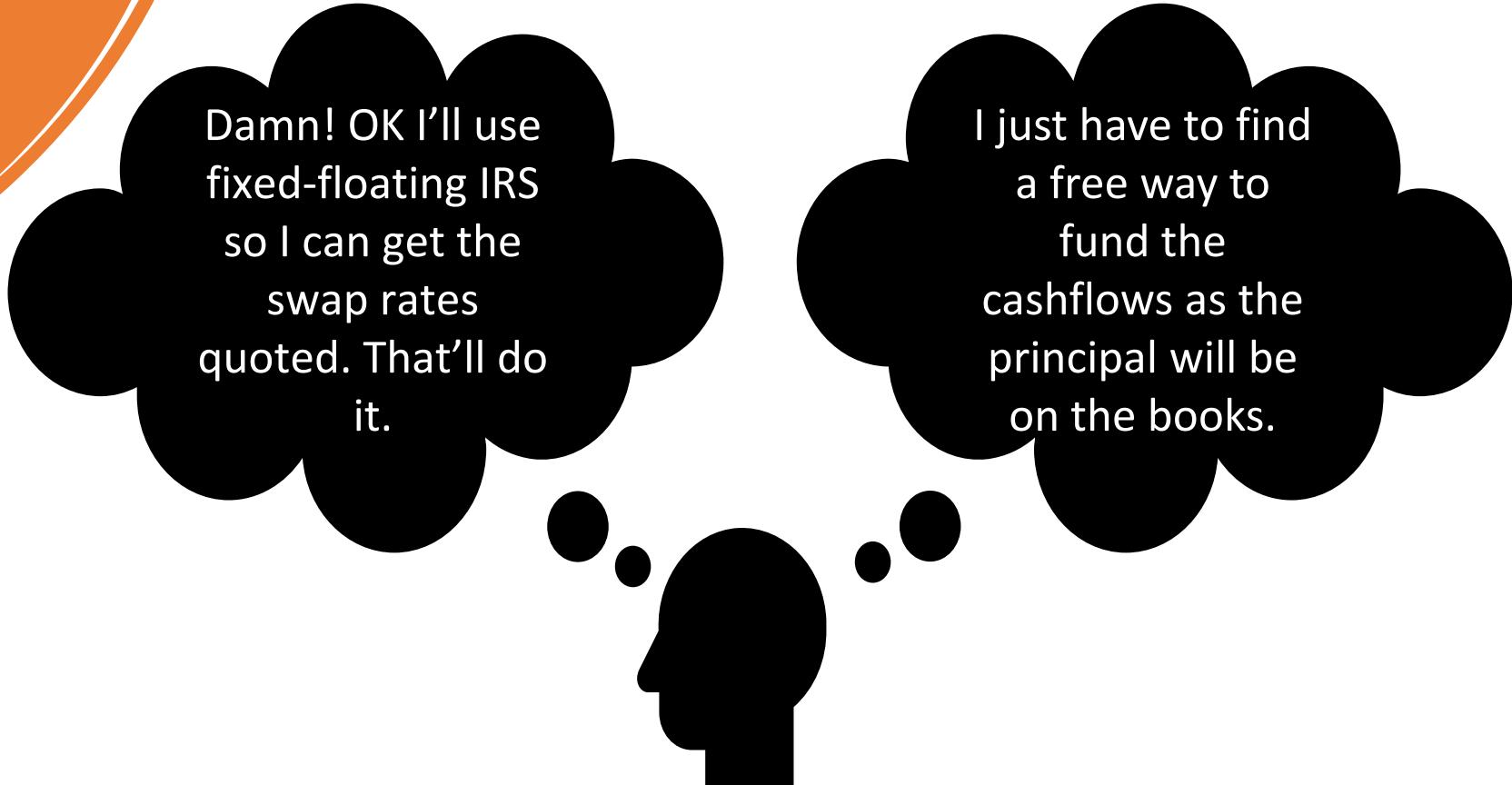
What rate can you
give me on USD for
1y?



Depo rate is 1.77%.
That 1.48% you
saw? It's 1y swap
rate vs 3m Libor.



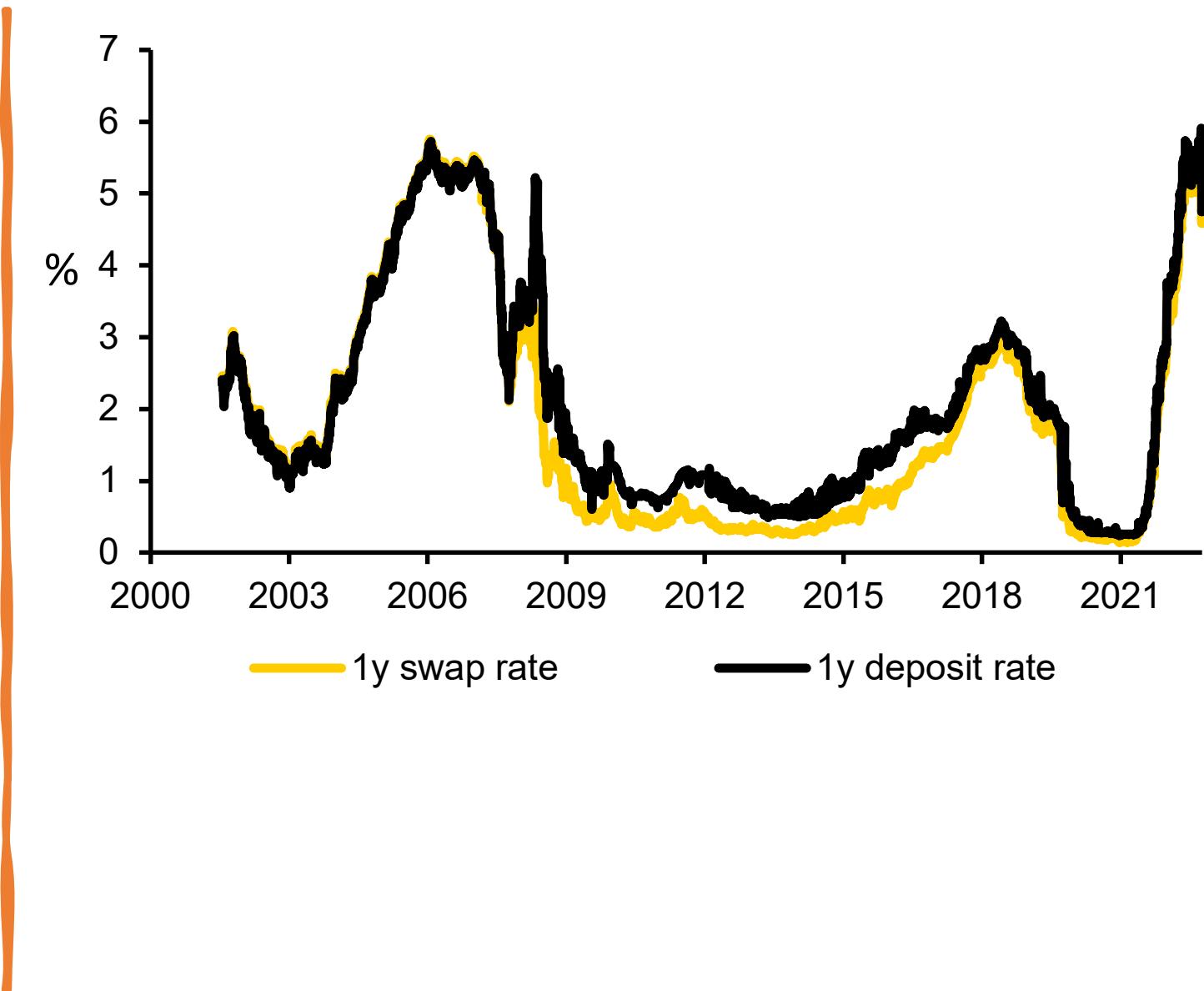
The Rookie Trader



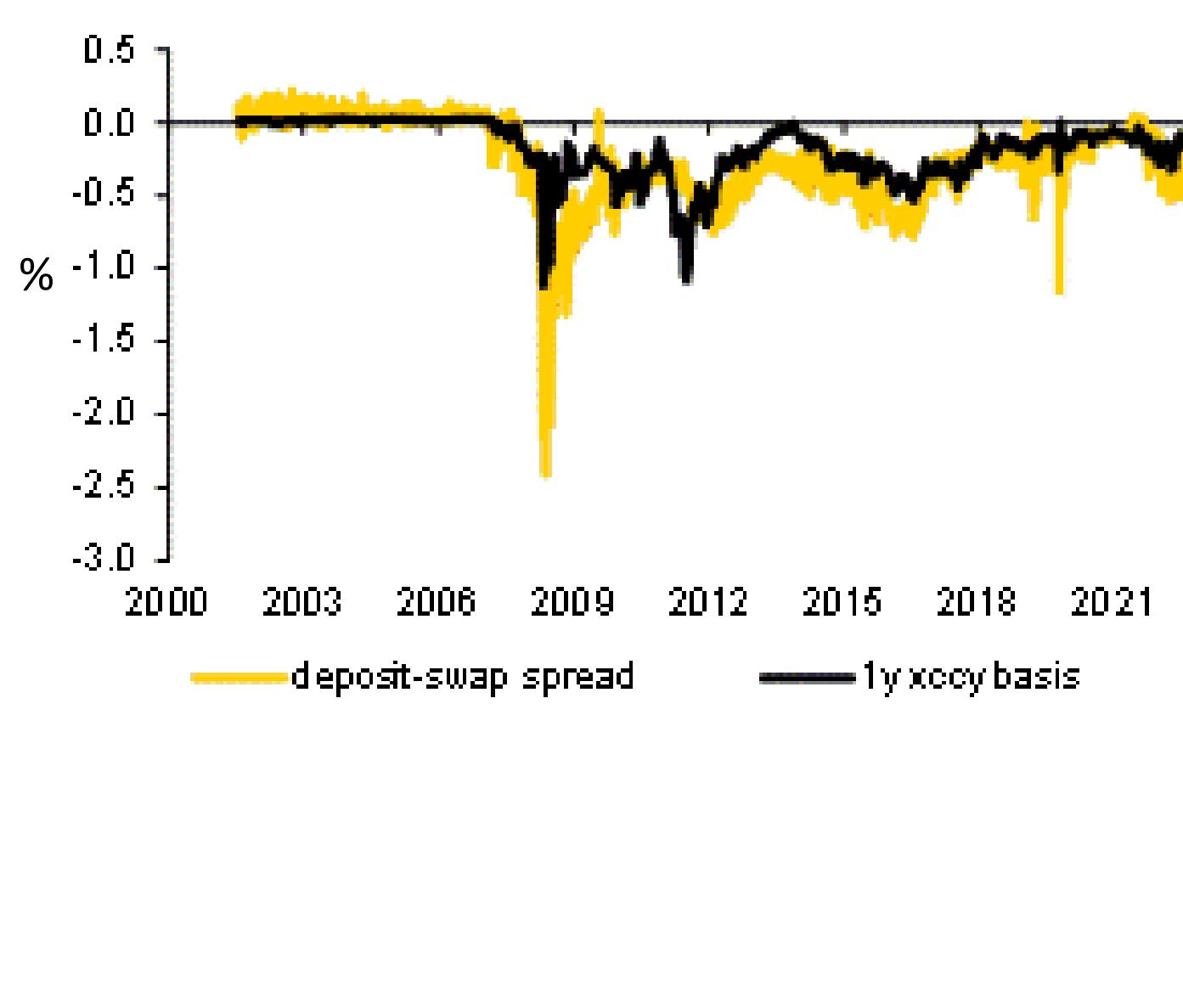
Damn! OK I'll use fixed-floating IRS so I can get the swap rates quoted. That'll do it.

I just have to find a free way to fund the cashflows as the principal will be on the books.

USD Swap and Depo Rates



USD Swap -
Depo
Spread and
1y xccy
EURUSD
Basis



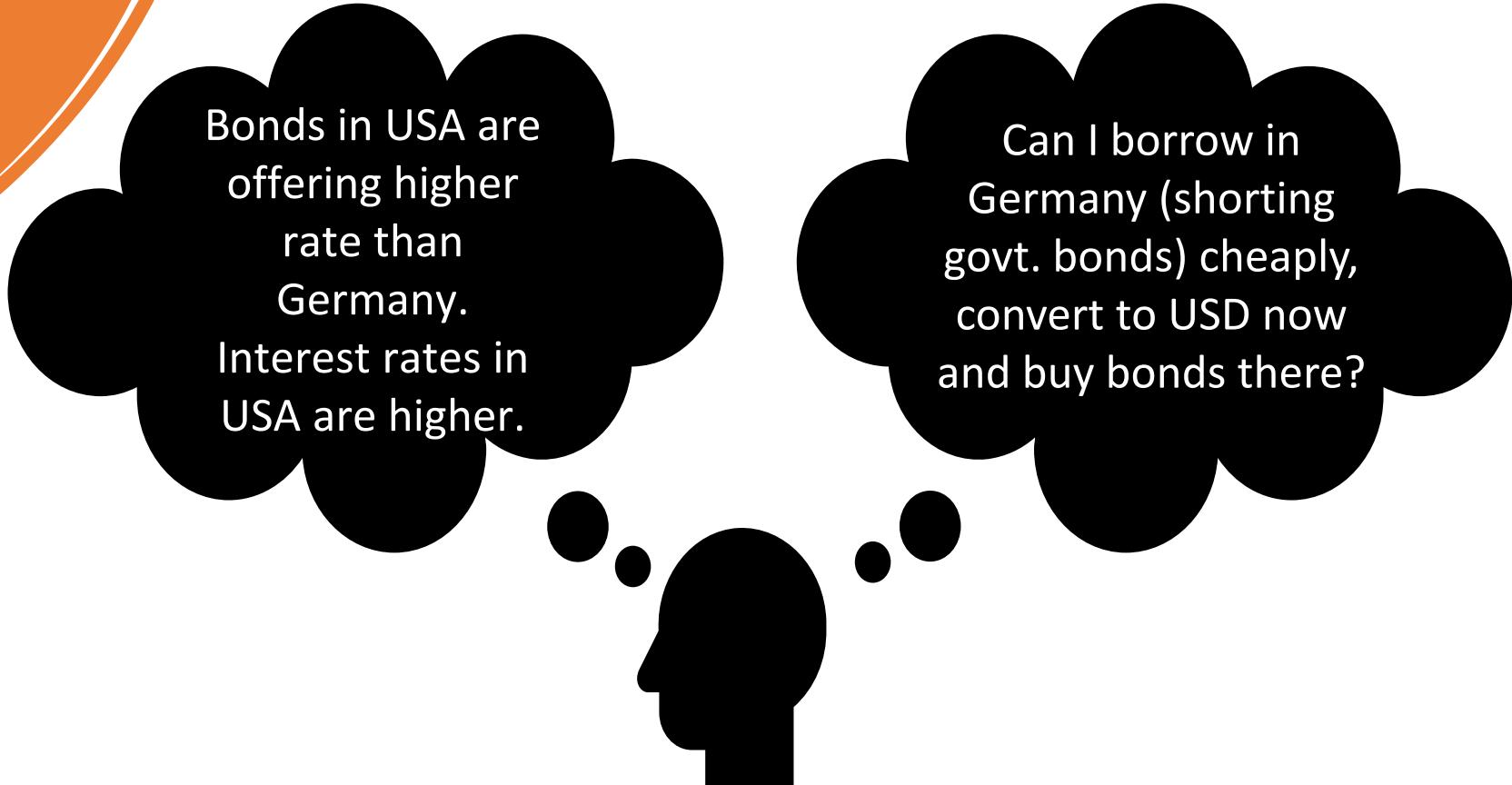
Exceptions (to prove the rule)

- Bank treasuries borrowing from central banks
- High-quality credits – large investors, large insurance companies
- ‘Segmented Money Markets and Covered Interest Parity Exchange’, BIS working papers #651, July 2017, <http://www.bis.org/publ/work651.pdf>
- Speculation – if basis widens it might move back

FX Hedged Pickup (A free lunch?)

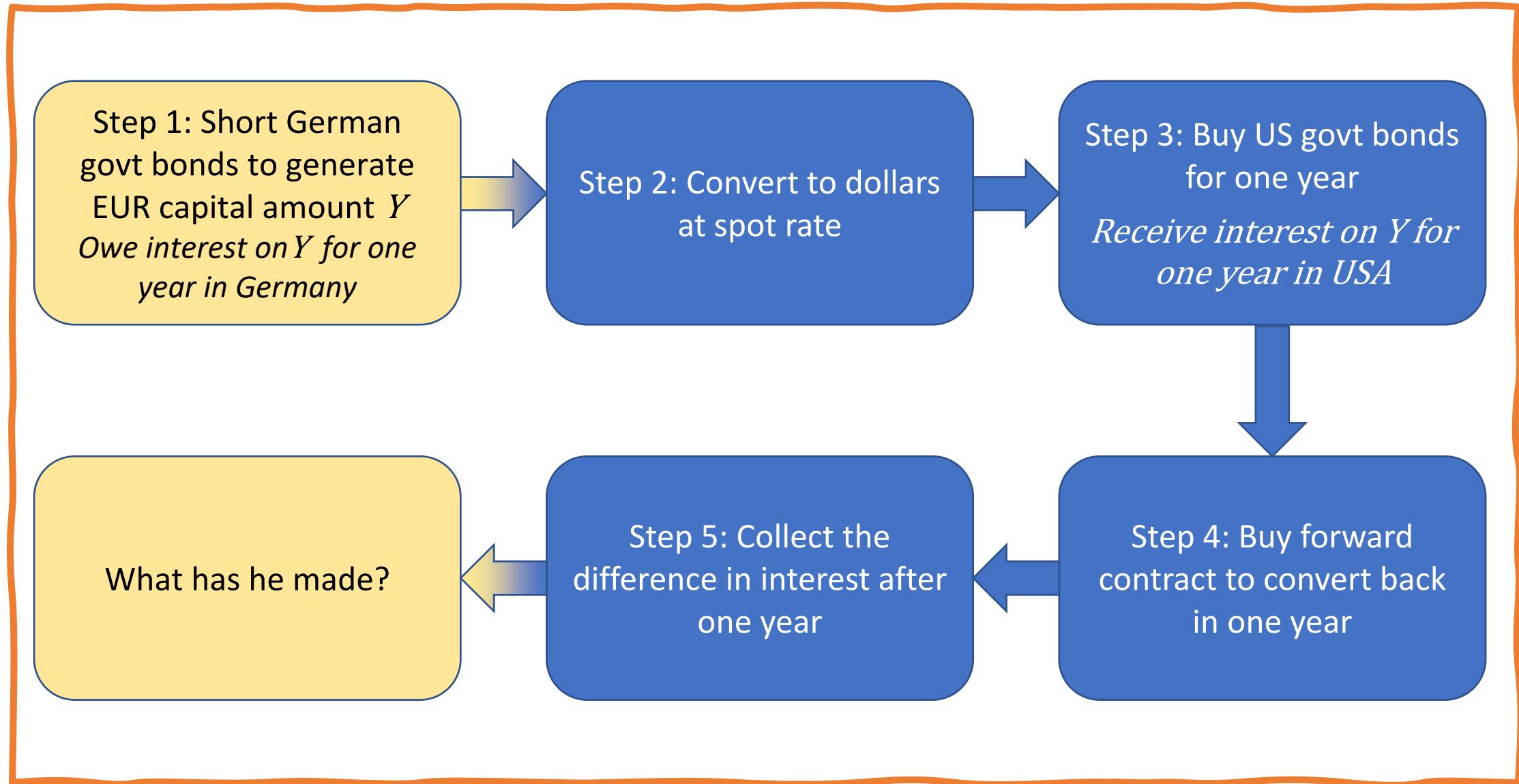
- Trade government bonds easily
- Good credit to short government bonds via *repo* transaction
- E.g. Germany-based but access to bonds in Germany, USA, Japan, UK, Australia
- Rating/credit risk similar across countries

The Rookie Trader



Bonds in USA are offering higher rate than Germany. Interest rates in USA are higher.

Can I borrow in Germany (shorting govt. bonds) cheaply, convert to USD now and buy bonds there?

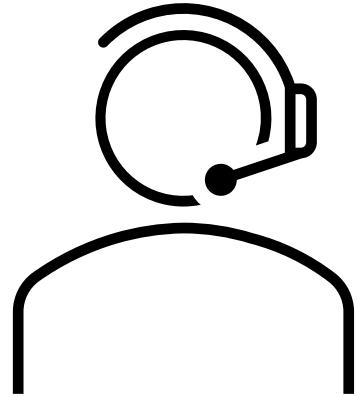




I need a USD to EUR FX rate a year from now to hedge the volatility of the FX...can you quote me?



Sure – I'll get you a rate but you're not going to like it...



Pre-2008

$$\Delta_{\text{bond}} - \Delta_{\text{swap}} \approx 0$$

- $\Delta_{\text{bond}}, \Delta_{\text{swap}}$ are small
- $\Delta_{\text{bond}} \approx \Delta_{\text{swap}}$

$$\frac{FX_2}{FX_1} = \frac{1 + r_2}{1 + r_1}$$

- Forward rate calculated using swaps
- Nearly identical if use bond yields
- So zero profit

Post-2008

$\Delta_{\text{bond}} - \Delta_{\text{swap}} \neq 0$ (basis!)

- $\Delta_{\text{bond}}, \Delta_{\text{swap}}$ may be substantial
- $\Delta_{\text{bond}} \neq \Delta_{\text{swap}}$ most of the time

$$\frac{FX_2}{FX_1} \neq \frac{1+r_2}{1+r_1}$$

- Forward rate includes xccy basis

Post - 2008:Yield Pickup

$$\text{Pickup} = \Delta_{\text{bond}} - \Delta_{\text{swap}} + \text{basis} \neq 0$$

Bond interest rate differential hedged for the 1Y period via the cross-currency swap market, including the basis

The Senior Trader

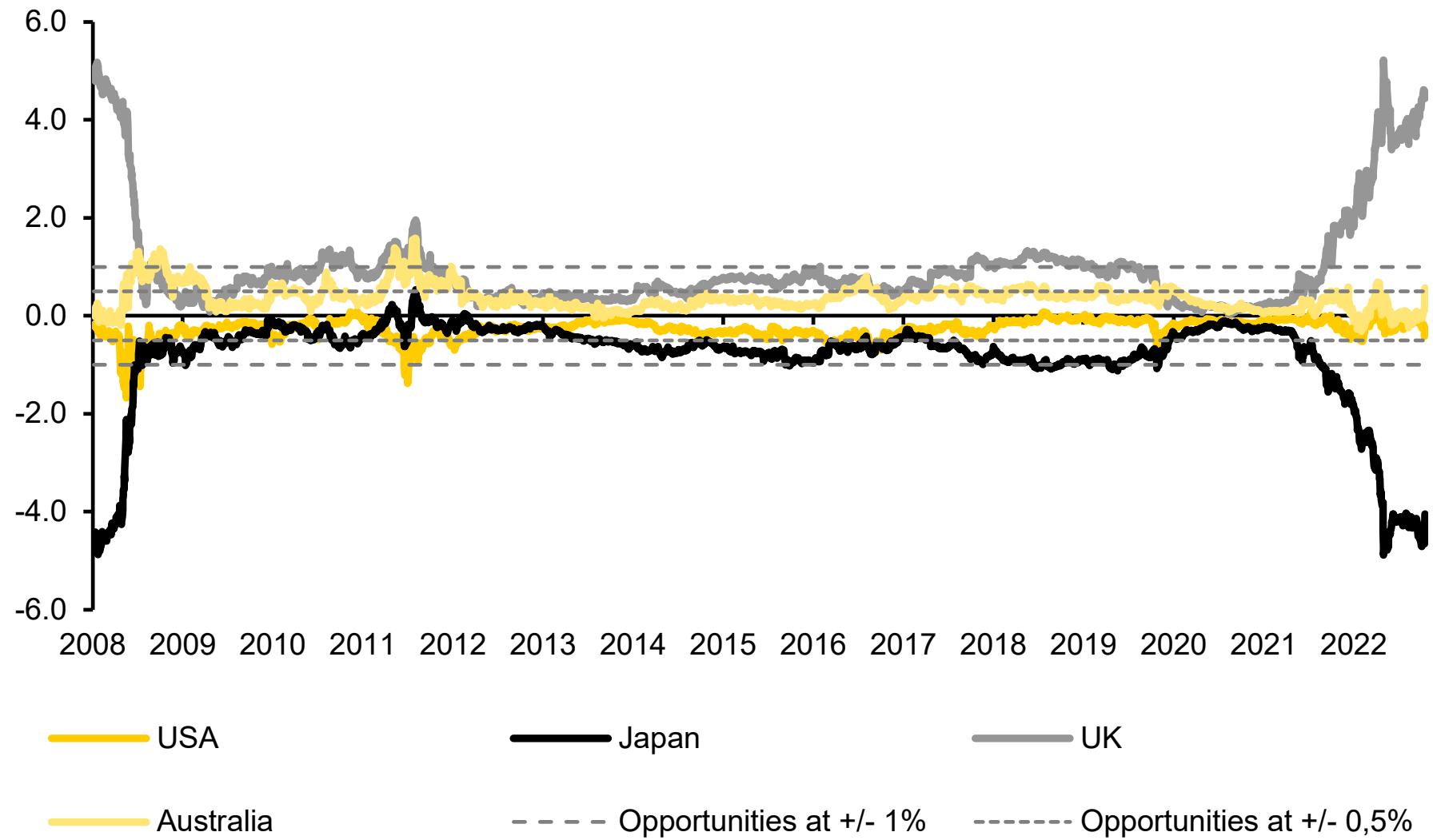


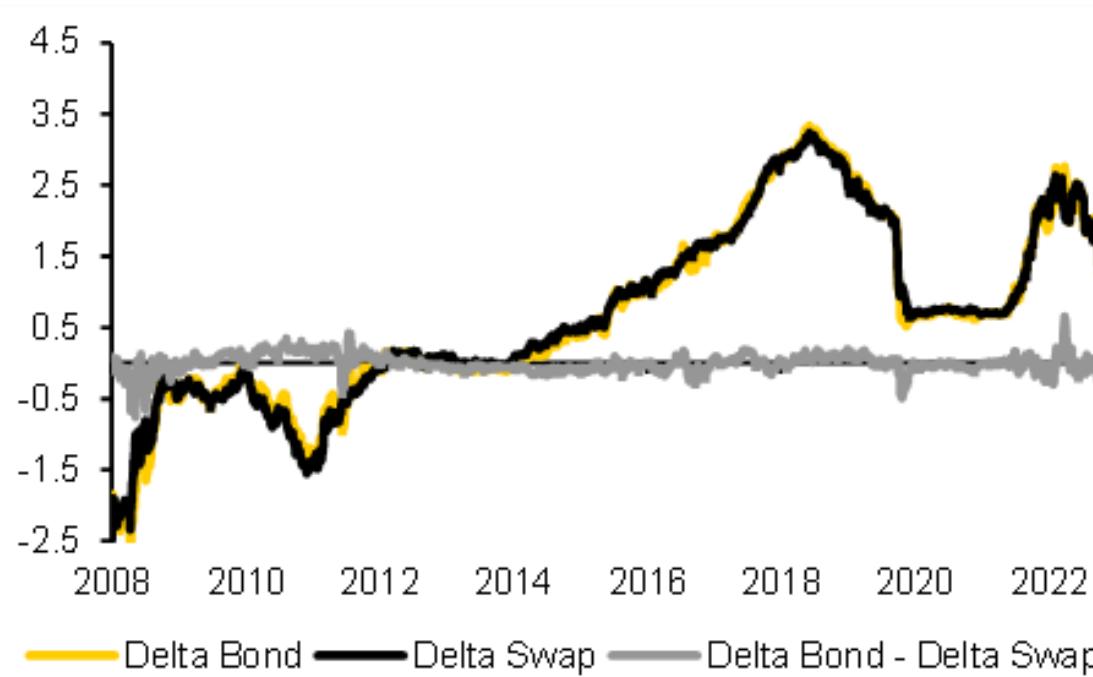
Occasionally
there might be an
opportunity to
lock in a profit!

But what about
trading costs, costs of
capital, borrowing
costs etc?



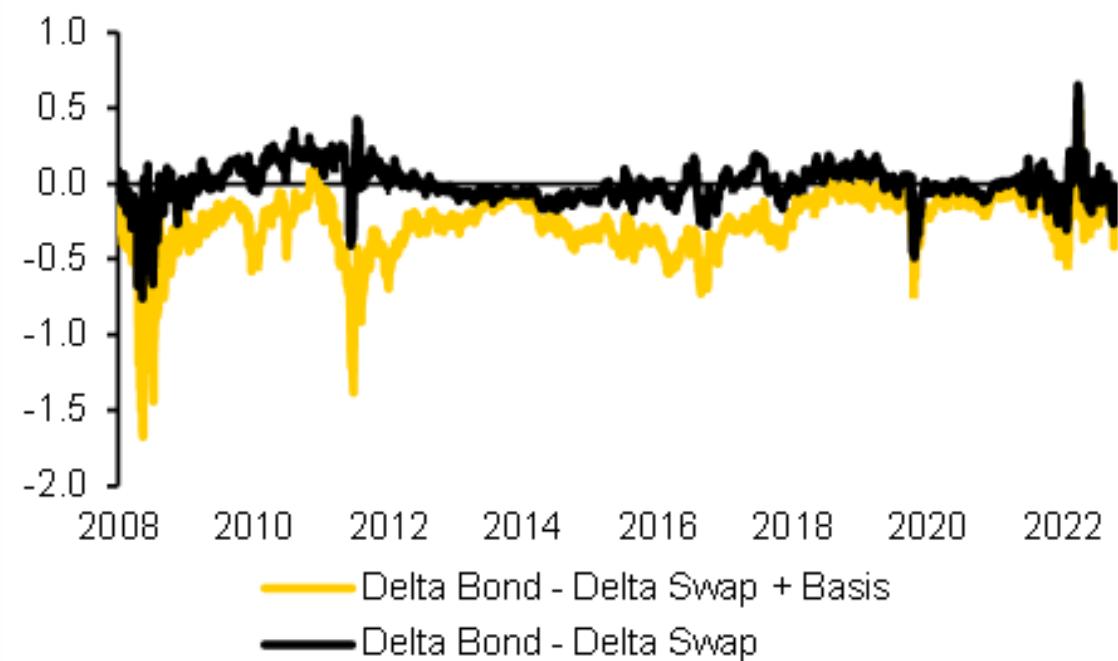
Pickup for a EUR-based investor, using 1Y foreign govt bonds, in %

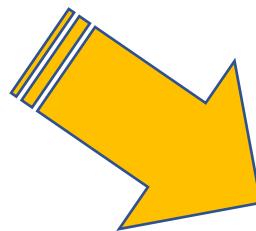
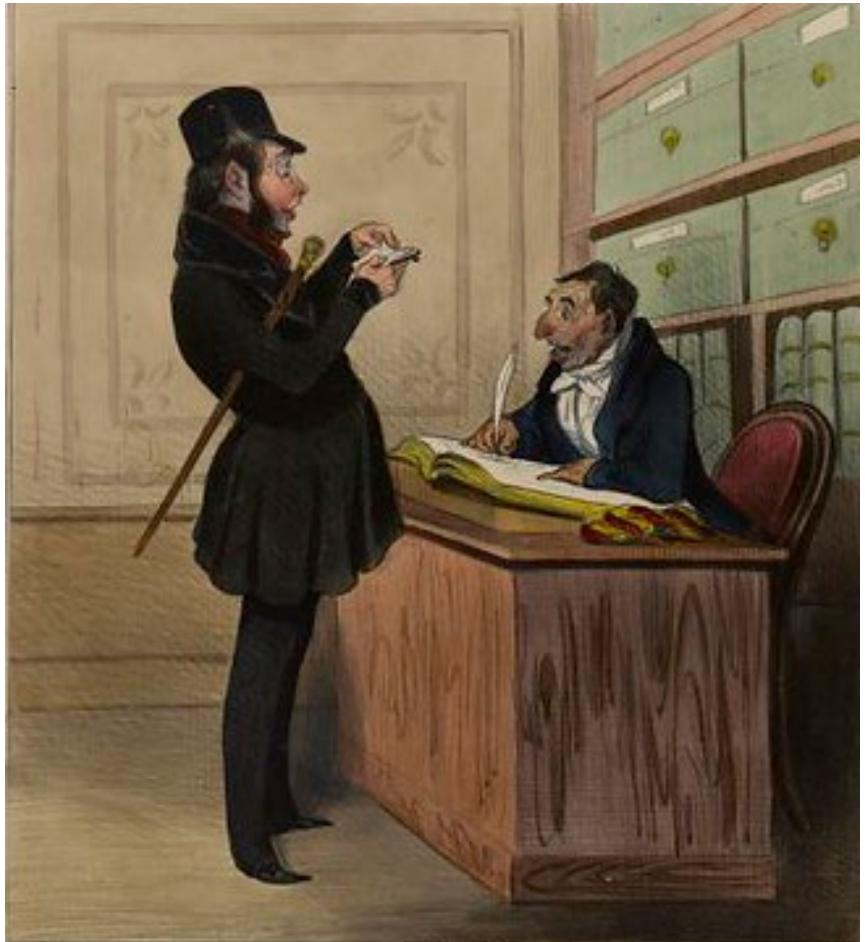




EUR and USD 1y govt bonds and swaps

Basis makes all the difference





Conversion Factor

- Little-known effect
- Important when issuing debt
- Affects companies with large credit spread

A (Too-) Simple Example

- You are a US corporate issuing a 1 year bond and basis is zero
- You have a credit spread of 2%
- EUR swap rate = 1% so you can issue a EUR bond at 3% coupon
- USD swap rate = 5% so you can issue a USD bond at 7% coupon
- Coupon is paid at the end of the year (once)

Issue in EUR or USD?

Issue in USD



Pay 7% (2% over
swap rate)

Issue in EUR,
hedge FX risk



Pay 3.0% (2% over
swap rate)

PV of Credit Spread...

- $PV = \frac{\text{Amount}}{1+r}$
- $PV_{\text{EUR}} = \frac{2\%}{1+0.01} = 1.98\%$
- $PV_{\text{USD}} = \frac{2\%}{1+0.05} = 1.90\%$
- Conversion Factor = $PV_{\text{EUR}} / PV_{\text{USD}} = 1.04$
- \therefore USD spread = 2.08% from EUR perspective



A large orange circle is positioned on the left side of the slide, partially overlapping the white background. It is centered vertically and has a smooth, rounded edge.

Once more
with
realism...

Coupons vary in frequency

Swap rate varies with tenor

Need to sum PV of each payment

E.g. 10 year conversion factor for
annual payments

Still simplified because of day count
conventions

	USD										
Date	1Y	2Y	3Y	4Y	5Y	6Y	7Y	8Y	9Y	10Y	
Swap rates	1.404	1.616	1.788	1.920	2.027	2.102	2.177	2.253	2.309	2.356	
Discount Factor	0.9862	0.9685	0.9482	0.9267	0.9046	0.8827	0.8600	0.8367	0.8143	0.7922	

	EUR										
Date	1Y	2Y	3Y	4Y	5Y	6Y	7Y	8Y	9Y	10Y	
Swap rates	-0.221	-0.154	-0.065	0.032	0.155	0.275	0.396	0.516	0.627	0.736	
Discount Factor	1.0022	1.0031	1.0020	0.9987	0.9923	0.9836	0.9727	0.9597	0.9453	0.9293	
Conversion Factor	1.0163	1.0259	1.0360	1.0461	1.0558	1.0650	1.0738	1.0821	1.0900	1.0974	

$$= \frac{\sum_{i=1}^n \text{EUR DF}_i}{\sum_{i=1}^n \text{USD DF}_i}$$

DF = discount factor for given tenor i

Interpolated

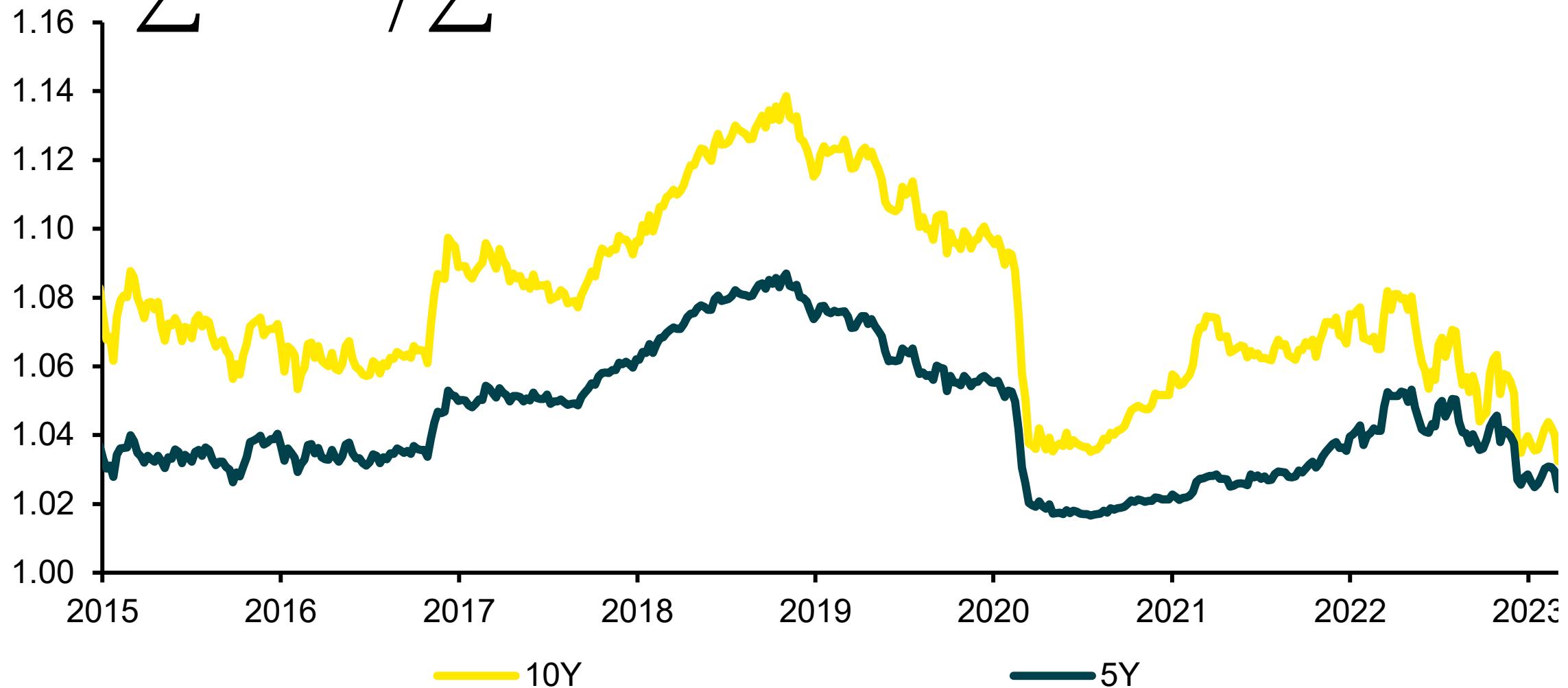
USD
Yield
Curve

EUR
Yield
Curve

$$= 1/(1+r^n)$$

r = swap rate
 n = tenor

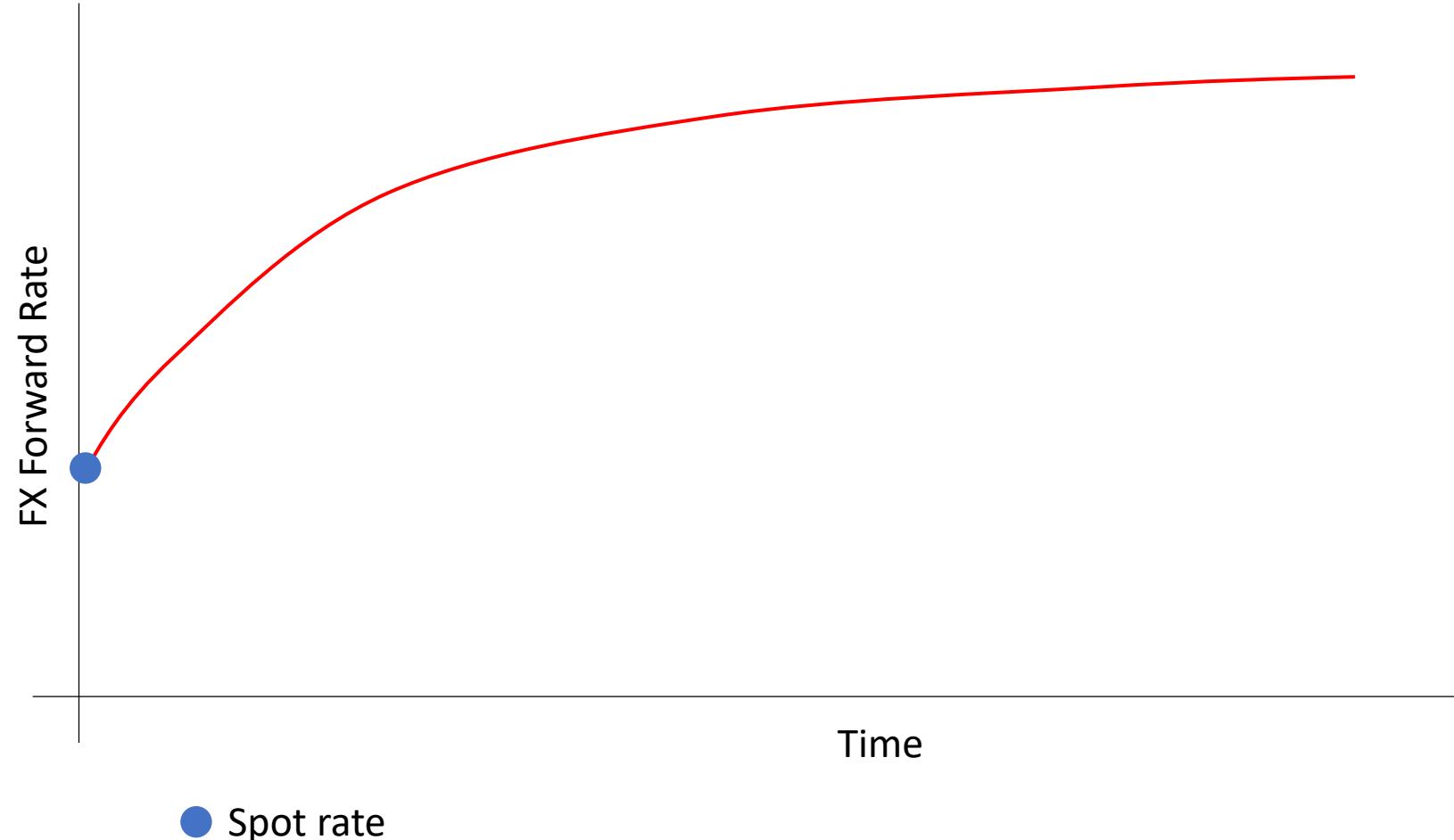
$$\sum \text{EUR } DF / \sum \text{USD } DF$$



Possibly the first FX
surprise

Do forward rates
predict the future?

If not, is there money
to be made?



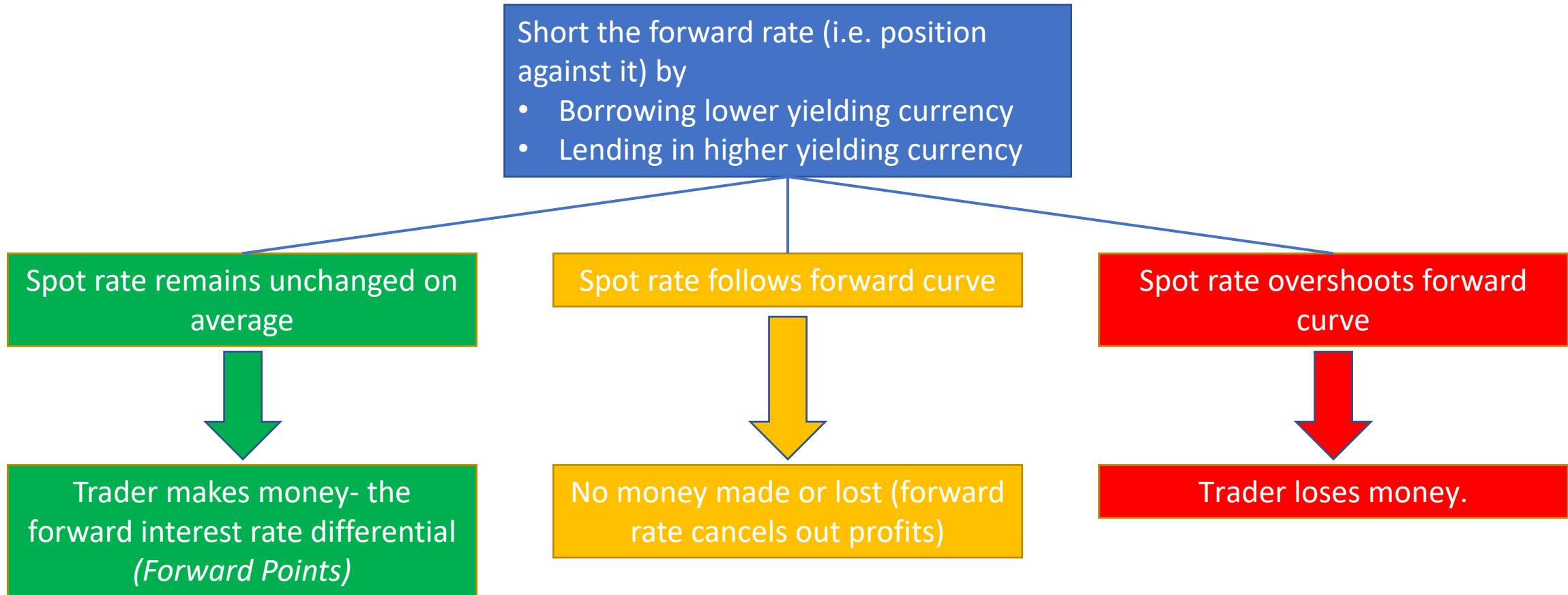
(Great?) Expectations

- Two currencies A and B
- A bears higher interest than B
- Forward rate predicts A depreciates relative to B

$$\frac{F}{S} = \frac{1 + r_f}{1 + r_d}$$

- Seems reasonable – higher risk, higher reward
- Uncovered Interest Rate Parity (UIP) holds if spot rate follows forward
- Consequences?

Time to test – Carry Trades



Example: EUR/BRL Feb 2017, 1y trade

$$\frac{F}{S} = \frac{1 + r_f}{1 + r_d}$$

F = Forward FX rate = 3.60 (weaker, higher yield currency)

S = Spot FX rate = 3.29

r_f = Foreign interest rate = 9.15%

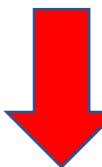
r_d = Domestic interest rate = -0.11%

$S < 3.60$ on expiry



Long forward makes a loss
Short forward makes a profit

$S > 3.60$ on expiry

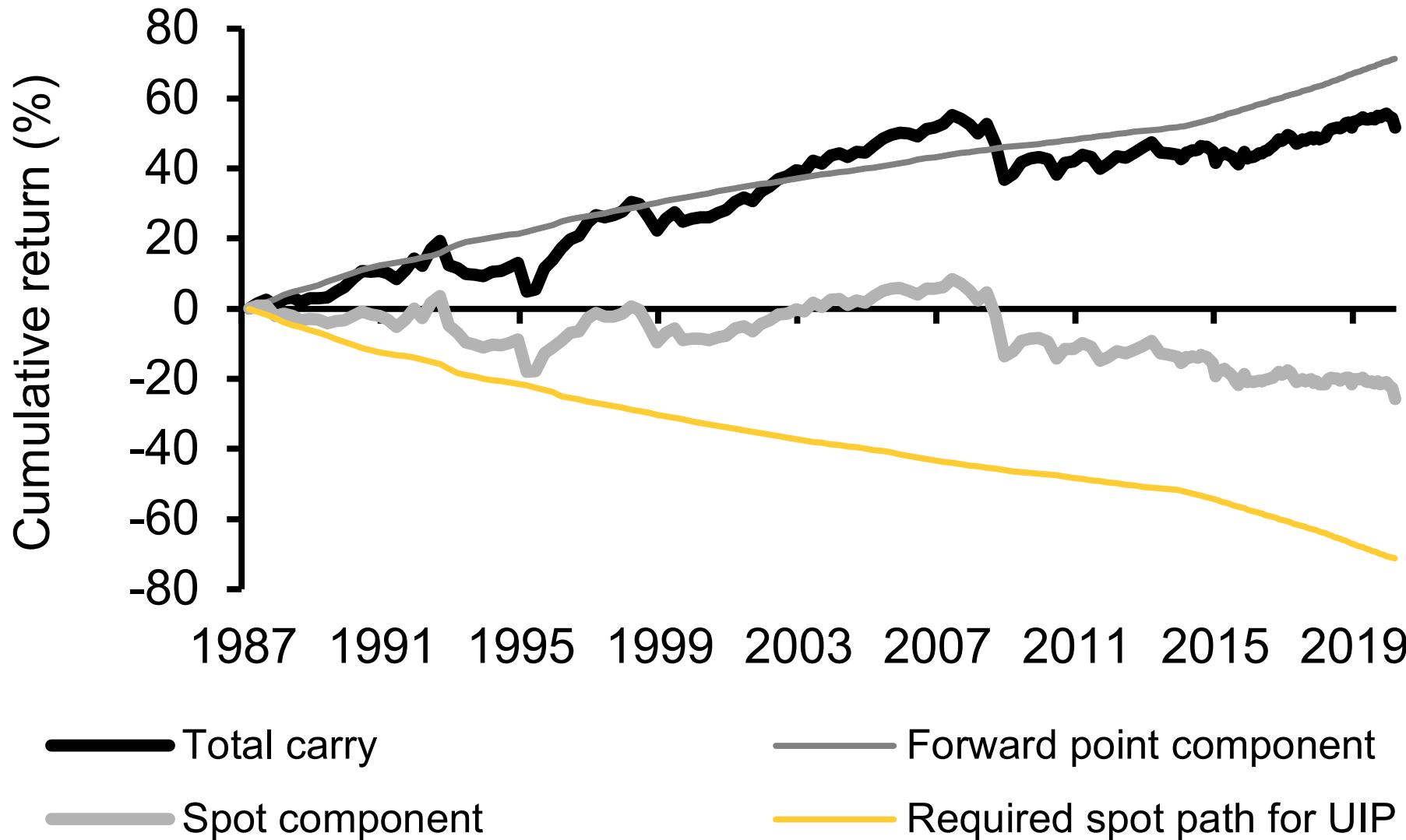


Long forward makes a profit
Short forward makes a loss



So what happens in reality...?

- Measure cumulative returns to FX carry trade (i.e. shorting the forward)
- Use all liquid G10 and EM crosses and average
- Follow a systematic, rules-based quarterly strategy





Time for a break...

15 mins