Introduction

It's a pleasure to introduce you all to the world of FX and FX options. We'll be taking a tour through the world of FX, its origins and history, its products and users, its strategies and outcomes. But first I'm going to vandalise a quote from one of my favourite science fiction authors.

"FX is big. Really big. You just won't believe how vastly hugely mind-bogglingly big it is." [1]

The FX market is the largest and most liquid on the planet, trading 24 hours a day around the globe. No other market comes close to its size. Below is a graph from the Bank of International Settlements (BIS) which puts some numbers to it.

Global FX turnover per trading day

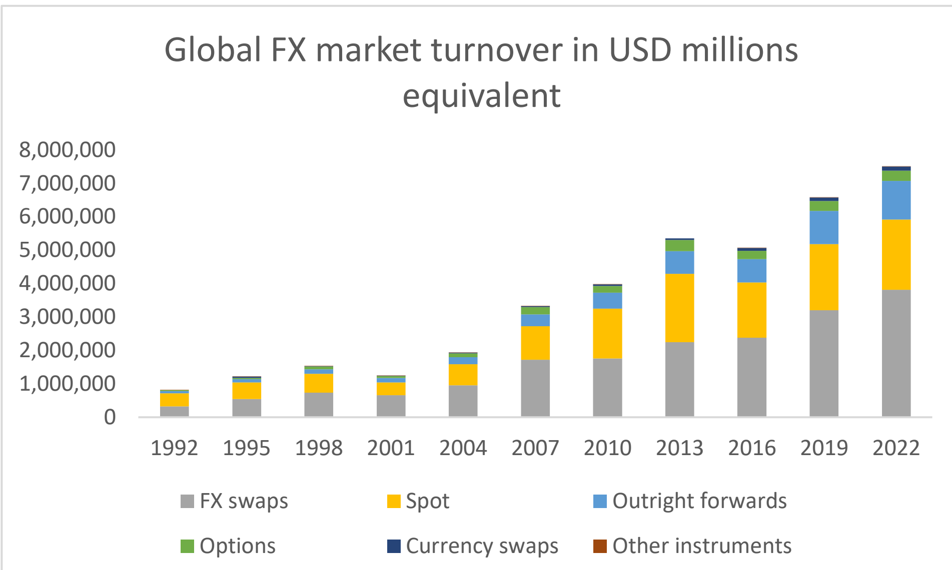


Figure 1

This is a graph which opens eyes unaccustomed to it. In 2022, the average trade flow every trading day of the year was nearly 8 trillion USD equivalent, that's 8,000,000,000 USD if we write it out in full. Why is it so enormous? Partly because so many other deal types have FX embedded in them. If a pension fund holds overseas investments (and most of them do) then every purchase and sale will involve an FX trade as well.

The FX option market though smaller, is still enormous.

Global FX option turnover

[1] Apologies to Douglas Adams, The Hitchhiker's Guide to the Galaxy, original quote "Space is big. Really big. You just won't believe how vastly hugely mind-bogglingly big it is. I mean, you may think it's a long way down the road to the chemist, but that's just peanuts to space."

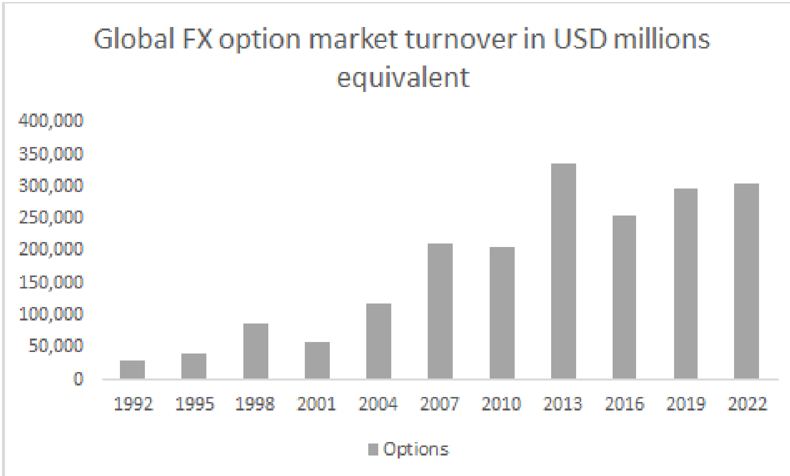


Figure 2

Apart from its size, there are other noteworthy features of the FX market. FX is not like other market rates. Every trade is an exchange; there is no absolute 'long' or 'short' in the FX market. It has no zero – a currency can always be worth less or more tomorrow than it is today. Rates are interdependent and intertwined; if one has a value for the FX rate GBPUSD, and USDJPY, they may be used to derive a value for GBPJPY. But which one of those three currencies is the driver, and which the driven? Their relationships are complex and shift with time. Thinking of FX rates as a time series, its distribution is fat tailed with non-constant properties. It affects and is affected by other market rates – commodities, interest rates and equities. Its correlation structure with these other rates and within the FX market itself is also complex and time-varying. It is certainly never boring.

Though this isn't a course about history or economics, we can finish this section with a brief note on how the FX market that we have today came into being. Because, it's a young market – freely floating FX rates are mostly a post WWII phenomenon. Equities and interest rates have been around for centuries (you can download 800 years of interest rates from the Bank of England website) but FX rates tended to be fixed by government or be related to gold or silver. Following the end of the war, the Western governments of the world decided to build an exchange system to create a stable global trading environment, and to help Europe rebuild. The USA's economy was in good shape, while those of Europe were in disarray. A system of fixed exchange rates was agreed upon at the Bretton Woods conference in 1944, with the US dollar pegged to gold (35 USD per troy oz), and other currencies pegged to the USD. This was soon supported by huge flows of aid to Europe from the US, starting in 1947 (the Marshall plan and other aid programs). In many ways the system was enormously successful, with free trade burgeoning in the Western world and a stable environment throughout. However, by the 1960s problems began to emerge as America entered a recession, and by 1973 Japan and most European currencies had gone back to floating currencies. The end of the Bretton Woods agreement was ratified in 1976, and by the early 1980s all industrial nations were using floating currency regimes.

FX conventions, contracts and operation

Quotation conventions

A foreign exchange (FX) rate is the number of units of one currency which may be exchanged for a single unit of another – for example, if "cable" (the US Dollar to Pound Sterling, usually designated GBPUSD) rate is quoted as 1.30, this means there are 1.30 US dollars per single British pound.

It is worth a quick note on quotation conventions. First, most communications within a country which are designed to be understood by the general public will use the convention 'n of foreign currency per 1 of domestic currency' – so in the UK, currencies will be USD per GBP, or EUR per GBP. However, in the financial markets this could get rather confusing given trades are likely to take place in different countries, so there is a standard way of quoting currencies. Though it is standardised it has its roots in history. In the first days of currency quotes, a century or so ago, the GBP was the most important trading currency, with London as the FX hub of the world. So, currencies were quoted 'per GBP'. Another way of saying this is that GBP was the 'base' currency. However, as international trade evolved, exchange rates between currencies which were not the GBP, like the USA and Switzerland for example, needed a convention. The British Commonwealth currencies became the next most important. So countries like Canada (CAD) and Australia (AUD) became the next-ranked 'base' currencies. After them came the USD, and after that a general preference to have numbers larger than one tended to dominate. The EUR, upon its inception, slid itself in as base to absolutely everything, which must have been somewhat satisfying to the newly-formed currency bloc. And after that, the conventions used for USD and CAD changed over, with USD becoming used as the base to the CAD. So the general rule for 'base ranking' is the following: EUR, GBP, AUD, USD, CAD, then less clear. They are written as in the example at the start of this section; the USD to GBP rate is quoted as USD per GBP, and it is usually denoted as GBPUSD. Why did we call it 'cable'? That's a completely different reason. In 1858 the first underwater transatlantic communications cable was laid by Cyrus West Field [1] and once various faults had been corrected and new cables laid, by 1868 one of its uses was to transmit financial data. Indeed Field could arrive at his desk in New York to find the London noon time Royal Exchange prices waiting for him. Thus the markets of the USA and the UK became intertwined by the 'cable'. Though there were numerous more or less successful attempts to maintain this link, the GBPUSD was always the 'cable' rate. It's still called this by older traders.

FX Trading regimes

Most sovereign nations have their own currency but the way that they trade varies and has changed over time. We can divide trading regimes roughly into three types – free float, managed, and fixed.

A free floating currency has its exchange rates with other currencies purely determined by the market. What it is worth is what others want to pay. Most of the large economies in the world would like to say that their currencies trade this way (it sounds fearless and rather cool) but it's not clear that any currency does more than approach this ideal. The value of a currency might change when the country changes economic policy, when key indicators such as interest rates change, or if there is regime change, for example.

A managed currency is one where the government, usually via the central bank, exerts pressure on specific exchange rates to keep them in a range, or above or below some critical level. How on earth does it do this? It can buy or sell its own currency in large amounts, or it can impose regulations upon traders, or a bit of both. Purely buying and selling the currency to influence its movements can get rather expensive, as the UK discovered in 1992 (the so-called "Black Wednesday" event). Another way for the central bank to influence FX rates is to adjust interest rates – a currency with very high interest rates will be attractive relative to others with lower interest rates, as an investor can buy some currency and lend it at the local high interest rate. Finally, it can 'print' extra money – in practice, it is electronically created – but this practice is best done very cautiously as uncontrolled money printing is unsustainable, leading to loss of confidence in the currency and hyperinflation. Printing extra money usually leads to higher inflation, for obvious reasons, which will tend to reduce the value of the currency relative to others.

A fixed currency is one where by decree, the currency may only be exchanged for others at pre-determined rates, set by a regulatory body like a central bank, which in turn is likely to be government controlled. These rates tend to be adjusted at intervals because unrealistic fixed rates mean that exchange becomes impossible as no-one will trade at them, so they have to be kept to 'reasonable' levels for markets to function.

A final currency regime can be described as 'dollarised' where the local currency is mostly fixed at a certain rate to the USD – the Singapore dollar is a good example of this.

Contract types

Foreign exchange transactions come in different types, as shown in **Figure 1**. In order of size these are:

Swap: This is the most common type of transaction. In a swap, two parties exchange currencies for a certain length of time and agree to reverse the transaction at a later date. This is a flexible transaction; though there are common tenors traded, the start and end dates may be those which suit the participants.

Spot: A spot FX transaction is a simple exchange between two currencies, where one is exchanged for a number of units of another. This exchange ratio or rate is the spot FX rate, and is the rate which is referred to as 'the exchange rate' when discussing the market situation. Interest is not included. The difference between buy and sell prices is known as the bid-offer spread, and is very small, a fraction of a basis point in many cases, which itself is only 0.01%. Thus the vast size of the market does not imply that vast profits are to be made as this effective transaction fee is very small.

Forward or outright forward: An FX forward is a contract that locks in the price at which a counterparty can buy or sell a currency on a future date. The exchange rate is typically today's rate, adjusted for the interest rate differential in the two currencies. If the interest rate in the local currency is higher than that of the USD (or whatever the reference currency is), the FX forward will include a devaluation expectation.

The calculation to discover the forward rate is trivial. It is found using the expression

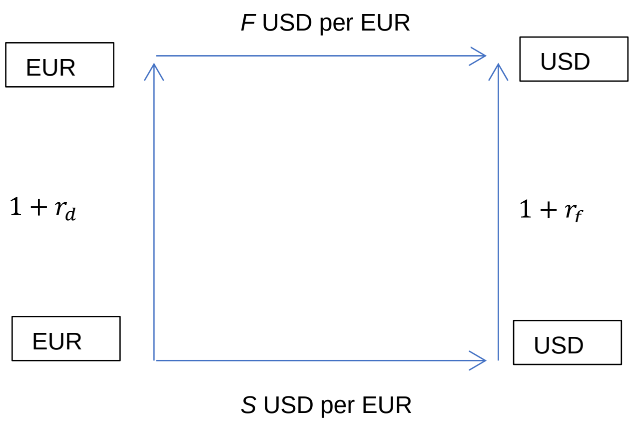
$$\frac{F}{S} = \frac{1 + r_f}{1 + r_d} \tag{1}$$

where F is the forward FX rate, S is the spot (current) FX rate, r_f is the foreign interest rate and r_d is the domestic interest rate . The FX rate must be quoted as units of foreign currency per domestic currency, for example, 1.1 USD (US Dollar) per EUR (Euro). EURUSD is the conventional way of quoting this in the market.

This calculation arises very simply. There are two ways of getting from holding the domestic currency now, to holding the foreign currency in the future.

Method 1: Invest now for the period in question, at the domestic interest rate, then exchange at the end of the period

Method 2: Exchange now so that you hold the foreign currency, and invest at the foreign currency rate for the period



Arbitrage pricing would tell us that Method 1 and Method 2 must be exactly the same, apart from perhaps some small trading spread effects, or there will be a chance to 'round trip' the system and make some risk free money (arbitrage). As we will see however, there is more to this than meets the eye.

Foreign exchange (FX) option: A foreign exchange option (commonly shortened to just FX option) is a derivative where the owner has the right but not the obligation to exchange money denominated in one currency into another currency at a pre-agreed exchange rate on a specified date. Interest rate effects are included. The FX options market is the deepest, largest and most liquid market for options of any kind in the world.

FX Option turnover

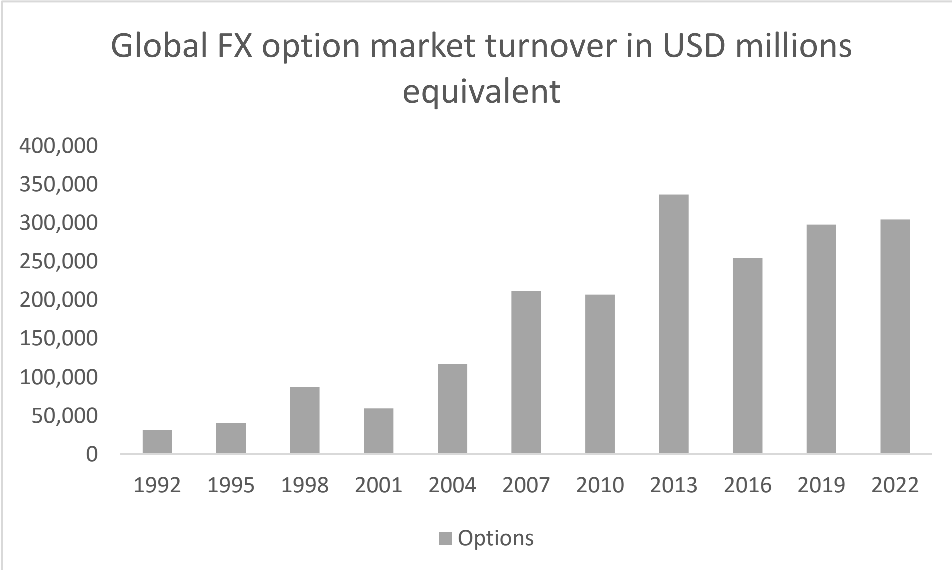


Figure 3

Other: There are various other commonly traded contract types – these include currency futures and NDFs.

Currency futures contracts are contracts specifying a standard volume of a particular currency to be exchanged on a specific settlement date, usually traded on an exchange created for this purpose. The average contract length is roughly 3 months. Thus the currency futures contracts are similar to forward contracts in terms of their obligation, but differ from forward contracts in the way they are traded. In addition, Futures are daily settled removing credit risk that exist in Forwards. Futures trade in a very liquid manner on exchanges but are not included in the BIS flow data; their trading data however is usually available from the exchanges.

Non-deliverable forward or NDF contracts mimic the value of forward contracts in currencies which for some reason cannot be directly traded. They deliver their final value not in their reference currency but in another currency selected by the participants like EUR or USD.

Operation

FX contracts are, with the exception of futures, mostly traded OTC, standing for Over-The-Counter. This means there is a decentralized market in which market participants directly between two parties without a central exchange or broker. Dealers act as market-makers by quoting prices at which they will buy and sell. A trade can be executed between two participants in an OTC market without others being aware of the price at which the transaction was completed.

Things you maybe didn't know about FX

We have discussed the various contract and trade types extant in FX, and the size and nature of the market. Now let us focus in on some of the properties of some of those contracts – we will discover that there are subtleties and corrections which are essential to trading and valuation.

The Cross-Currency Basis

Recall our discussion of how an FX forward price is calculated using the no-arbitrage technique. Conventionally, and in the pre-crisis world, this will only occur in a small and transient manner, as sharp eyed traders look out for the chance and thus keep pressure on the forward rate to comply with equation **(1)**.

This type of situation traditionally (pre-crisis) has arisen in small and temporary forms, quickly eliminated by arbitrage trading. Thus this method of calculating the forward rate was thought to be completely robust. How could it possibly be incorrect in any substantial way?

But as we will see, even this apparently unbreakable piece of mathematics is vulnerable to unforeseen market effects. The existence of a non-zero cross currency basis 'breaks' equation **(1)**

How the calculation distorts no-arbitrage pricing

The relationship in equation (1) is protected by arbitrage constraints, which one would think, in this era where both humans and machines comb the market for strategies and opportunities, would be sufficient to ensure its integrity. However, market size and liquidity are not enough to ensure perfect efficiency. Later, we show that the FX market has been by some definitions markedly inefficient since its origins as a floating rate, by allowing a profitable carry trade to persist. And we can present simple evidence that an acute distortion of equation **(1)**has occurred, and moreover persists to this day.

Let us go back to the equation.

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

If EUR is the domestic currency, and USD the foreign, then a quick re-arrangement gives us

$$r_d = \frac{S}{F} \times (1 + r_f) - 1 \tag{2}$$

Now, all of these rates are readily observable in the market. To check it out precisely, we calculated r_d using equation **(2)**, and compared it to the market rate since 2000. Before about 2008, the calculated value of r_d matches the value of r_d obtained from the time series of the EUR 1 year swap rate. But after that date, they vary considerably, sometimes by up to 1%. If we plot the difference (called the basis), calculated using r_d-theoretical - r_d-market, then we obtain the following graph (yellow line). We have added to the graph the quoted xccy (shorthand for cross-currency) EURUSD 1y basis swap (black line). i.e. we have both a calculated and a market-quoted value for the basis, so it will be important to be clear which we are talking about!

The degree to which the arbitrage pricing is violated is almost exactly equal to the market quantity known as the cross currency basis swap.[2]

[2] These graphs are created using Libor-based rates which have the longest history but are being replaced by OIS rates in the market. The OIS-based graphs would look very similar but would only go back to 2021 in many cases.

Interest rate difference, with quoted xccy basis

'Theoretical' 1y EUR interest rate – actual 1y interest rate, in bp, with quoted basis

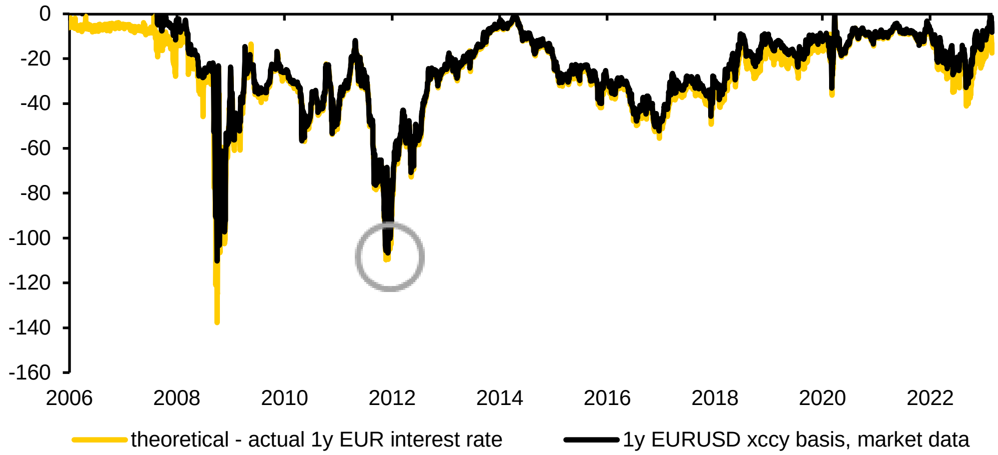


Figure 4

It's clear to see that apart from a few not-so-good data points they are essentially the same. So what is going on?

Essentially, equation (1) is no longer holding, and has not held since 2008, even between EUR and USD, the world's largest currencies. This degree of violation is called the 'basis' or 'basis swap' and it is expressed as the difference between the non-USD interest rate (in this case the 1 year EUR swap rate) implied by the FX forward, and the actual market value of this rate.

Here's a quick example taken from one of the more extreme recent periods (grey circle in the graph above).

On 29th December 2011

EUR-USD xccy basis = 101.9bp (EUBS1 Curncy) [3]

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)

Using equation (2), we calculate the 'theoretical' EUR 1Y swap rate

EUR 1Y swap rate (theoretical) = $r_d = S/F \times (1+r_f) - 1$ = 1.296/1.304 x (1+0.691%) -1

EUR 1Y swap rate (theoretical) = 0.073%

[3] These are the Bloomberg tickers for the Libor-based rates if the reader wishes to try it for themselves. Please be aware however that occasionally Bloomberg does change historical data!

But the actual swap rate is not 0.0733%, it is 1.094%. The difference is

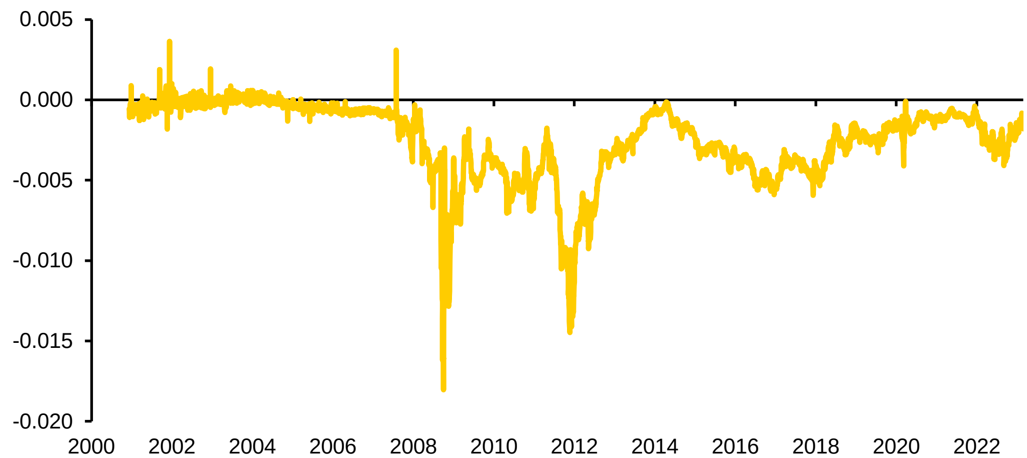
0.073% - 1.094% = -1.021% = -102.1bp

And this is almost exactly equal to the quoted basis in the market, -1.019%.

Of course, that is not the only way to express the inequality! We could equally well plot the difference between the theoretical FX forward rate, derived from the spot rate and the interest rates available in the market, and the actual quoted rate, $F_{theoretical}$ - F_{market}. Then we would create the following:

Forward rate difference

'Theoretical' 1y EURUSD forward rate – actual 1y forward rate, units are rate difference



And if we wanted, we could rotate the whole situation once more and arrive at a spot FX rate difference. Though this is probably not the best way to view the issue, a shift to the spot rate would be just as valid to explain the market mismatch!

We have illustrated the situation using the 1 year rates, only because they involve the least amount of arithmetic. But one may exactly repeat this analysis for tenors from 3M to 30Y, and the same relationships will hold. So however we look at it, the forward rate calculation is broken and not even in a transient way – the basis seems to have moved in and is here to stay.

Calculating bases not normally quoted

We have shown that it is possible to calculate the EUR/USD cross-currency basis, and match it very well to a quoted market rate. However, not all liquid currency crosses have a corresponding quoted xccy basis. Almost all quoted xccy bases are to the USD, with just a few to the EUR. So, if an opportunity arises in, say, GBPJPY, it is more difficult to spot and may go unnoticed by market participants who could take advantage of it – we will explore this idea later, but for certain market participants the existence of the basis can be useful. Fortunately, it is possible to calculate almost all of these cross rate xccy bases. These calculations, while not the same as market quotes, are excellent indicators of where opportunities may be found in liquid but less explored crosses.

How can we fill in some of these data series? Let's consider the basis for GBP and JPY, which is not quoted, but the volume of currency flow between the two countries is considerable. First of all, there is a useful additive property of basis swaps. We may say that

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

where A, B and C are currencies, and XCCY is the basis. So for USD, EUR and JPY, we have

$XCCY_{JPY\text{-}GBP} = XCCY_{USD\text{-}JPY} - XCCY_{USD\text{-}GBP}$

Thus we can use the USD basis swaps to construct many of the missing JPY ones. We can see that the relationship holds well in the case of EUR, USD and JPY, where the EURJPY basis swap is available both by construction and quoted in the market. Below we graph the quoted and the constructed rates for the 10y case. Note that it does not go to the present day as we selected the longest continuous series from Bloomberg without inserting splices and interpolations!

Constructed and quoted EURJPY xccy basis

10y xccy basis, in bp

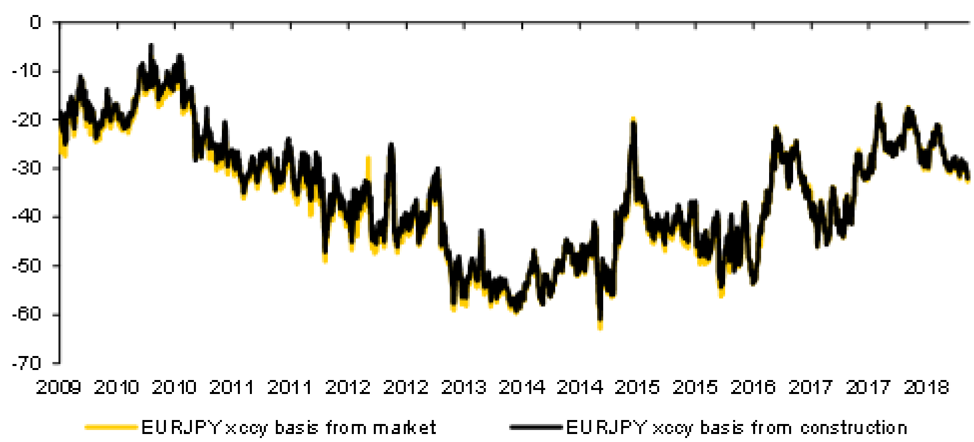


Figure 5

In some cases, particularly the shorter tenors, not even the USD and EUR bases will be available – in this case they can be derived from spot FX rates, forward FX rates and short dated interest rates. As an example, to find the EURJPY 3m basis, we can do the below

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

where

F = 3m forward FX rate for EURJPY

S = spot rate for EURJPY

r_d = domestic interest rate (EUR)

r_f = foreign interest rate (JPY)

Where does it come from?

Pre-2008, the cross currency basis hardly existed, and was not considered as a traded market rate. Afterwards it appeared and persists to this day. How does this happen? One would think that arbitrage considerations would deny it.

To understand what stops market participants from taking arbitrage advantage of the cross-currency basis, we turn to the mechanics of doing such an arbitrage deal. Let us assume that a rookie trader decides that he or she is going to trade the xccy basis and make some money on it!

The following data is taken from trading screens on 6 July 2017, for deals with start date 10th July 2017, end date 10th July 2018 (interest rates are 1y IRS/3M).

EUR interest rate	-0.30%
USD interest rate	1.48%
Spot FX rate	1.1423
Market FX Forward Rate	1.1660 (forward points are 237)
Implied FX Forward	1.1627 (implied from interest rates)

The implied forward is calculated using the expression

$$\frac{FX2}{FX1} = \frac{1 + r_2}{1 + r_1}$$

where

FX1= Spot FX rate

FX2 = 1y implied forward FX rate

r_2 = USD 1y interest rate

r_1 = EUR 1y interest rate

The above expression is broken by the existence of the xccy basis – prior to 2008 the implied forward rate is always very close to the actual market rate. The xccy basis is -28 basis points – so one could also imply a USD 1y interest rate of 1.48% + 0.28% = 1.76%. The negative sign attached to the basis is due to the fact that the xccy basis is quoted as a spread to the non-USD interest rate. Thus if one applied the 'correction' to the EUR interest rate it would come out as -0.58%.

What does our hypothetical rookie trader think? This is what might be going through his or her head. 'The difference between the interest rate derived FX forward and the actual traded forward is -28 basis points. So, I will do the two interest rate contracts, and the actual traded forward, to lock in the basis.'

But now reality begins to bite. Those interest rates above are NOT depo rates. They are 1y swap rates vs 3m Libor. The USD depo rate is, guess what, about 28 basis points higher, at 1.77%. This is one way of appreciating that the basis (expressed like this) is due to credit. With a swap, the principal is never at risk, only the differences between fixed and floating rates. With a deposit, the principal is at risk, and the rate is higher. So our hopeful trader cannot borrow and lend at these rates at all. This is part of the 'multiplication of curves' which we mentioned right at the start – the yield curve for swaps (less credit risk) and for deposits (more credit risk) are not the same, whereas before the crisis they were almost the same .

Ok, says the still-hopeful trader. Let's do the two interest rate components of this set of deals with two fixed-floating IRS. Fine, we can now access the above interest rates.

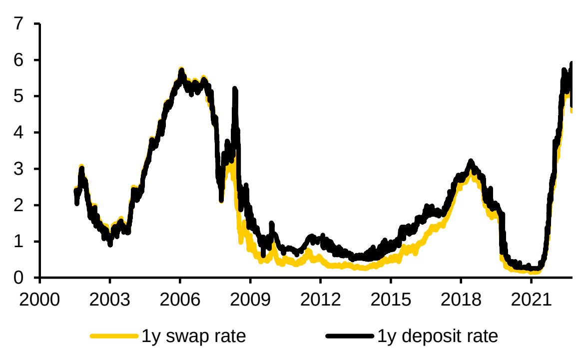
But, because the trader is not now doing the deposit contracts, he or she will have to fund the cashflows, so will need to hold the principal amount on the books until the deal expiry. This needs to be funded. Oh no! That means once more accessing the deposit market – and the deposit rates include the basis! There is no escape, the poor trader will have to borrow at an effective rate close to that available in the deposit market. Even though a trading desk usually funds by rolling overnight or short term, the implied forward cost of the accumulated overnight funding will still add up to not the 1y swap rate, but to something like the 1y depo rate . So, though there is uncertainty as the overnight rate may of course change during the course of the deal, it is *not possible* to lock in a profit, and the implied P/L is flat.

Before the crisis, the trader would have funded at Libor, and the depo and swap rates would have been very little different, so if a basis had existed, it would have been a good opportunity for arbitrage.

Below we show the 1y US swap rate and deposit rate since 2000 in the left hand graph, and the spread between them together with the xccy basis on the right. It's clear they are closely connected, though not identical as the basis also responds to pressure from the EUR side.

1y USD swap rate and deposit rate

In %



1y USD swap-deposit spread, with 1y xccy EURUSD bas

In %, spread is swap - deposit

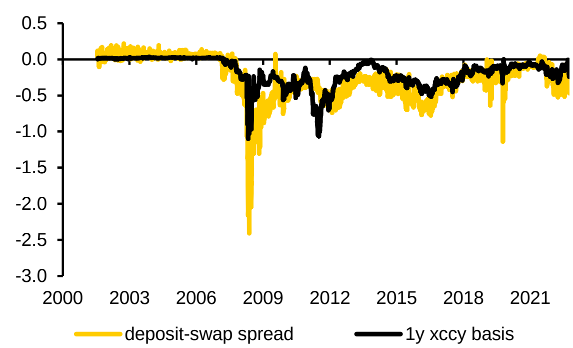


Figure 6

Now, as our young trader, now a little older and wiser, sadly abandons plans to make money on the basis, is there anyone who *can* do the trade? Yes! Under some circumstances, bank Treasuries can borrow at close to the swap rates from the central banks. This is one way that central banks inject liquidity. So these desks can make a profit from this situation. Similarly, some high quality credits can do it, or come close. Some entities (for example, large investors or insurance companies) can at times lock in at least part of the basis when hedging fixed income investments. There is an excellent analysis in [5], showing that the very top tier banks in some markets have, at some points in the past, been able to fund at levels which allow them to treat the xccy basis as at least a partial arbitrage. Thus, there is pressure on the basis not to widen too far, but not the kind of old-style risk free arbitrage pressure.

Would it ever make sense for our trader to do this trade? Yes indeed. If the basis widened too far he or she might put on the trade believing that the actual funding (as opposed to the implied) would not stay at these elevated levels. But it would be a trade with risk attached, and not a traditional arbitrage.

Thus pressure on the basis not to widen has no 'hard' level at which it comes in. Those who can make risk-free money on the basis do so only because they can access cheap USD funding. Those who make money on the basis with a risk-based trade do so because they correctly judge when it is too extended. The basis is a natural consequence of greater sensitivity to credit risk, and demand for and access to USD. For a useful discussion of forces operating on the basis, see [2] and [3], and for an excellent explanation of multiple curve discounting, see Hull and White 2014, [4].

A free lunch? Really? – the FX hedged pickup

We have just been discussing why the xccy basis does NOT yield arbitrage profits – or only rarely – but just now and then, there are opportunities for some institutions to take advantage of it in a different way. One of the best examples is the case of an investor who can trade government bonds easily – and has good enough credit to 'short' a government bond via a repo transaction.

We can calculate a 'yield pickup' for 1Y government bonds. We assume that the investor is based in Germany, and can hold (and short via repo if necessary) bonds in Germany, the USA, Japan, the UK and Australia, i.e. with similar rating or perceived credit risk. Bonds and swap rates in the different countries vary: the difference between bond yield in (say) Germany and the USA we shall the *bond differential* (Δ_{bond}) and similarly for the swap rates, Δ_{swap}.

As an example, the investor notices that bonds are paying higher coupons in the USA than in Germany and also that US interest rates are (unsurprisingly) higher than at home. He is at a high-credit quality institution so can borrow by shorting German government bonds today – that gets him the "repo" rate which is the same rate as the bond[4]. In a year's time he'll have to pay back the capital borrowed plus this interest rate, in EUR.

Now armed with a nice stack of EUR he converts it to USD at the spot rate and buys those nice high-yield US bonds. However, in a year's time he will need to convert the coupon(s) paid and capital back into EUR, as the US bond pays in USD. The investor wishes to hedge the risk of FX volatility over that period by locking in a forward FX rate. This is essential as the bond differential might be at most a few percentage points but FX movements can wipe that out in a single day's trading.

What forward rate will he be quoted? Pre-2008, it would have been pretty much exactly the rate which removes all profit from the deal. This is because the forward rate would have been calculated using

[4] In practice there will be a cost to doing the repo but we ignore for the time being

$$\frac{FX2}{FX1} = \frac{1 + r_2}{1 + r_1}$$

where r_1 and r_2 are the market interest rates (swap rates). The only way there is a profit to be made is if the bond differential is different from the swap differential as then the forward rate would not completely cancel out the bond profit. So the investor would be interested in situations where

$$\Delta_{bond} - \Delta_{swap} \neq 0$$

Pre-2008, even if in Germany (say) bond and interest rate swap rates were different (which they were, but only by a very small amount), they would be different by a very similar amount from their USD equivalents. Thus any profit relied on a small difference of a small difference which would be wiped out by trading costs, cost of capital, actual repo costs (ignored until now) etc.

Post-2008 the situation is different for a number of reasons. First of all, the market is vastly more credit-sensitive than it was so the difference between government bond rates and swap rates is larger, varies more from country to country and can change quickly. Secondly, the xccy basis is no longer zero so

$$\Delta_{bond} - \Delta_{swap} \neq 0$$

Is expected rather than unusual. However, the basis is now “priced in” to the forward rate the investor asks for so now to make a profit he is interested in the situation where

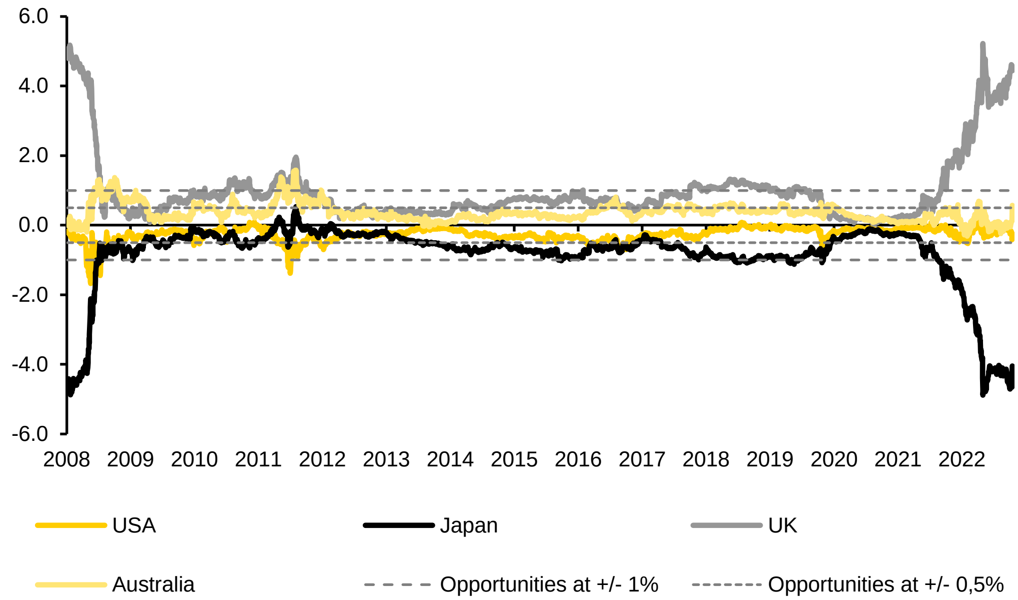
$$\Delta_{bond} - \Delta_{swap} + \text{basis} \neq 0$$

This is the amount he can lock in for the entire transaction. Unlike pre-2008 the quantity on the left, the *yield pickup* is frequently non-zero and changes day-to-day. It is also not a small fraction of a small fraction and at times can be sufficient to defray the costs of the trade.

One can think of the yield pickup as the bond interest rate differential hedged for the 1Y period via the cross-currency swap market, including the basis. Writing it in this way shows clearly where the dislocations arise. If the spread of bond yield to swap was the same in both currencies, the first two terms would cancel out. So it is due to differential market views on credit and to the basis. Below is the time series of this yield pickup since the end of 2008 for the different currencies. The second graph focuses on the EURUSD case, showing Δ_{bond} and Δ_{swap} and the basis separately. We see that opportunities frequently arise at the sub-1% level, and in turbulent times, far more.

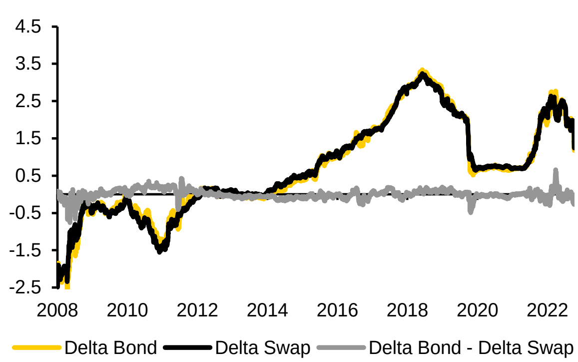
Yield pickup, with potential arbitrage opportunity levels

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

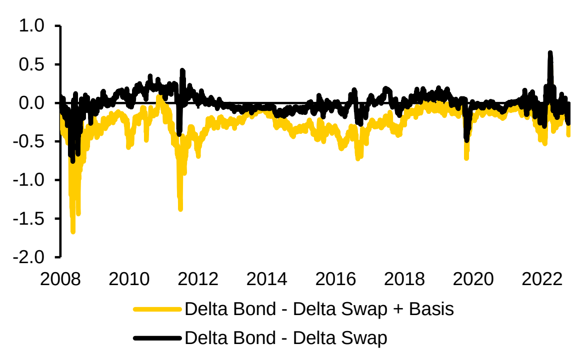


EURUSD yield pickup components (%)

Swap-bond differences for 1y EUR and USD govt bonds



The addition of the basis makes a significant difference



Is this pickup really available in the market? Not entirely – this assumes no repo costs and ignores credit issues and cost of capital. But nevertheless, it is rarely lower than 30bp for any currency, and often greater than 50bp. For different institutions, there could be opportunities at some level.

The Conversion Factor

This is a little known effect which ends up being critically important when issuing debt, for companies with substantial credit spreads. It comes from the relative cost of credit in different yield environments and the structure of interest rates in the two currencies in question. It is not connected with the FX rate between the two currencies, but is purely a function of the level of interest rates and the shapes of the yield curve. An institution may correctly identify an opportunity to issue overseas debt when it is cheap but fall foul of the conversion factor.[5]

The conversion factor is the number of basis point per annum in one currency which equals 1 basis point in the other currency

Or equivalently

The conversion factor is the factor which equates the PV's of identical future cashflows in different currencies.

It arises because credit spreads in the post-crisis world are so much more significant than they were before. A highly rated corporate whose credit spread is close to zero (ie, it can borrow at a rate close to the prevailing local swap rate in the market) need not worry about conversion factors. As long as its bonds are highly rated in both its home currency and the currency it wants to issue debt in, then nothing more is needed, and the cross-currency basis swap level will be the only significant consideration.

However, this may not be the case! A credit spread of some hundred basis points is nothing unusual for some issuers, and this is where the conversion factor becomes important.

We can think about the issuance situation of a corporate with a large credit spread either as a completely different yield curve, or as the local swap curve with a factor added on. As the latter is the market convention, the conversion factor arises as an approximation to the mathematically correct approach of using issuer specific yield curves and forward rates for each currency under consideration.

Simplest possible example – 1 year bond, zero basis, USD corporate

Let's take an unrealistically simple example for the sake of clarity.

EUR issue – swap rate 1%, credit spread 2%, thus coupon = 3%

USD issue – swap rate 5%, credit spread 2%, thus coupon = 7%

The single coupon is paid at the end of the year.

If we assume that the basis is zero then the corporate cannot gain an advantage by issuing in Europe where rates are lower, and then hedging the FX risk. The US corporate, if it hedges the FX risk it acquires by issuing at 1% in EUR, will come back to the home value of 5% via the FX hedge.

Now, as the credit spreads are the same, there should be no difference between issuing in either currency, right? Wrong!

We need to think about the Present Value (PV) of the credit spread. In EUR, we would discount the spread using the 1% swap rate – so ignoring any day count issues and assuming that all rates are in annual terms, we have

[5] Note that this is not the 'conversion factor' extant in the futures market, they are not related apart from having the same name…

$$PV_{EUR} = \frac{2\%}{1+1\%} = 1.98\%$$

However, in USD, there is a different swap rate, so we have

$$PV_{USD} = \frac{2\%}{1+5\%} = 1.90\%$$

To equate the two PVs, we must increase the USD spread by a factor of 1.98%/1.90% = 1.04. This is the conversion factor. So now the total USD spread is 2.08%, from the point of view of the EUR corporate.

So this means that unless the corporate can find an advantage of more than 8bp from other factors, it's not worth issuing in USD. If for example the credit spread were lower in USD, at perhaps 1%, then indeed it could be worth doing, though the conversion factor would eat into that differential, transforming the effective EUR credit spread to 1.04% from the point of view of the EUR issuer.

For the purposes of this example we have exaggerated the difference between the two interest rates – in reality a 1Y conversion factor would be small.

More realistic – using the yield curve

If only life were as simple as the example above. But, bonds pay coupons at different frequencies, and swap rates vary with the tenor. What's important to realise is that you have to find the relevant conversion factor for the coupon stream of the bond. Not only does the conversion factor vary with the tenor, but it will also vary with the payment frequency (though to a lesser extent). So although it's popular to quote a '10y conversion factor', strictly it should be a '10y conversion factor for annual payments'. Let's have a look at these features.

The easiest way to calculate the conversion factor between two cashflow streams is to look at the PV of the sum of 1 basis point at each payment date in each currency. In practice this is as simple as calculating a discount factor for each payment date, adding them up for each currency, and taking the ratio of the sum. Here's an example.

Conversion factor calculation out to 10y as of 7 Apr 2017, for EUR and USD, for annual payment dates

Rates in %, discount factors and conversion factors are numbers with no unit

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

As can be seen, the longer dated conversion factor can add another 9% of spread value to the total cost of the issuance in April 1917 – and it is more now.

It is easy to check the calculation – for the 5 year conversion factor for annual payments, add up the first 5 discount factors for each currency, and divide the USD result by the EUR result

Another way to think about it

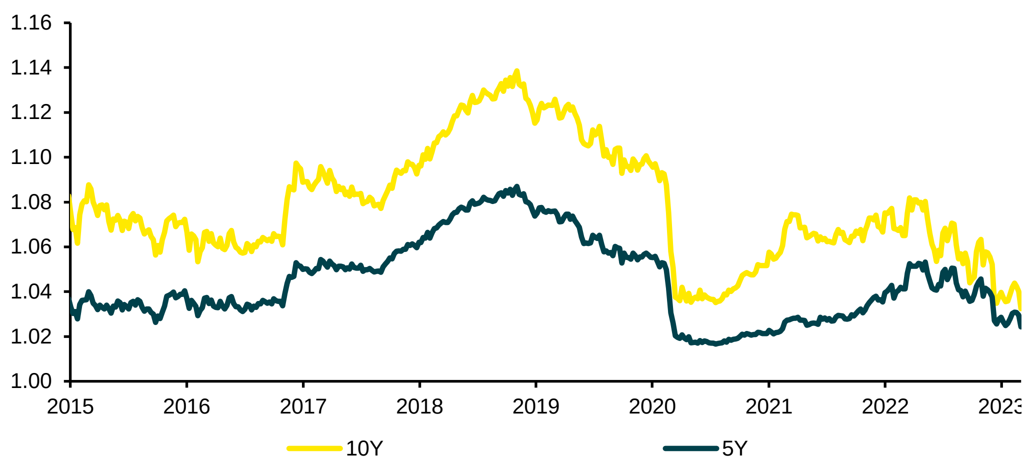
Why does the conversion factor arise? One final way in which it might be useful to think of it is a consequence of the individual credit curve of a corporate vs the swap curve. Forward FX rates, and indeed all FX hedge valuation, are calculated using the swap curves in different currencies. But the credit curve of a corporate will (almost always) trade above the swap curve. So the FX hedge cost does not take into account this differential, which is the credit spread. If it did we would have no need to calculate conversion factors! But then different companies would have different forward rates and liquidity for any one credit curve would be very low. Far better to calculate all hedges using the highly liquid swap curve and then separately account for credit spreads using conversion factors.

Still, we need to keep in mind, that conversion factors calculated from swap rates remain only an approximation as the shape of the credit curves can vary as well in the currencies under consideration. So theoretically, even if the swap rates would be the same in both currencies, i.e. the above calculated conversion factors would equal 1, the PVs of a future cash flows in different currencies can vary.

Below we have plotted conversion factors for EURUSD over time. DF denotes Discount Factor. It can be seen that it reaches values of 14% - a highly significant factor.

EURUSD conversion factor

Σ[EUR DF]/ Σ[USD DF] (ratio)



The Carry Trade

The cross-currency basis was not the first way that the FX market declined to obey market expectations. This was arguably the collapse of Uncovered Interest Rate Parity (UIP). In the early days of the floating FX rate regime, it was assumed that spot rates would on average follow the path laid out by the forward rates. The forward rate path predicts (from equation (1)) that the higher nominal interest bearing currency will depreciate relative to the lower interest rate bearing currency. This does not on the face of it seem unreasonable – investors in higher-yielding (higher inflation) currencies get compensated for the currency weakening by higher interest rate income. Put differently, higher interest rates exist due to higher levels of risk (for example regarding inflation and central bank expectations), thus to assume that more risky currencies will depreciate relative to less risky ones is plausible. Uncovered Interest Rate Parity is said to hold if currencies follow, on average, the forward rate path .

It is useful for market participants, risk managers and quants if UIP does hold. It means that the arbitrage pricing is correct on average and does not allow for systematic trading strategies to deliver profit, and it means that the middle office risk management of long term positions within financial institutions can use the same valuation models as the front office traders.

But, it does not hold. The devaluation of currencies implied by their interest rate regimes does not, on average, occur. As the evidence mounted that UIP is violated, and that forward rates have no predictive power over the path of spot rates, the market and various academic institutions reluctantly had to admit that this particular assumption was invalid. We may summarise the evidence with the following graph.

Cumulative returns to the FX carry trade, %

Quarterly returns from all EM and G10 FX crosses, averaged

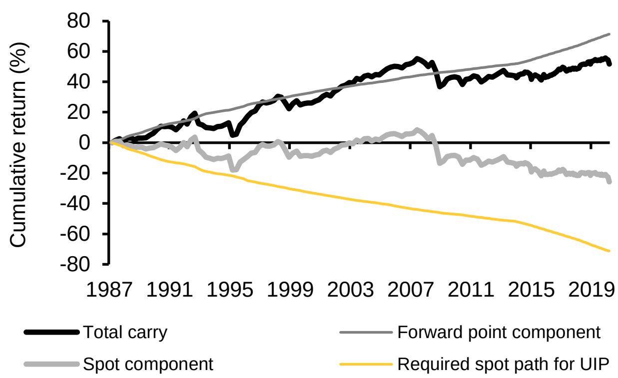


Figure 7

This is the result of pursuing a systematic rules based quarterly carry trading strategy in all liquid currency crosses, both G10 and EM (heavy black line). A carry trade is where the trader takes a position against the forward rate (same as doing a short forward trade), borrowing in the lower yielding currency to lend in the higher yielding one. If the spot rate does move to the forward rate, then the trader will make no profit. If the spot rate stays the same and does not move over the course of the deal, the trader will make exactly the forward interest rate differential (known as forward points) – this 'perfect carry trade' is represented by the fine grey line. The central heavy grey line is the actual average path of the spot FX rates.

Numerical example EUR/BRL, Feb 2017, 1y trade

$$\boldsymbol{F = S \times \left[\frac{1 + r_f}{1 + r_d}\right]}$$

Where

F = forward FX rate = 3.60 = weaker high yield ccy
S = spot FX rate = 3.29
r_f = foreign interest rate = 9.15%

r_d = domestic interest rate = -0.11%

If spot at expiry < F = 3.60, long forward trade makes a loss/ sold forward trade makes a profit
If spot at expiry > F = < 3.60, long forward trade makes a profit/ short forward trade makes a loss

As can be clearly seen, the actual carry trade gives almost identical results (with some noise) to the 'perfect' carry trade. This is the same as saying that on average, FX rates do not move toward the forward rates, they are more likely to be the same as the spot rate at the start of the deal.

So UIP bites the dust. And CIP, though it was thought to be a much harder nut to crack. Covered Interest Rate Parity is said to hold if equation (1) holds. However, as we have shown, the existence and persistence of the non-zero cross currency basis clearly shows that indeed, CIP has fallen as well.

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