



23 January 2018

A closer look at FX Value

In their 2013 paper, Asness, Moskowitz and Pedersen found 'value and momentum everywhere', or more specifically showed that statistically and economically significant value and momentum premia exist in commodities, currencies, and equity country indices. Here we take a closer look at valuation in the context of foreign exchange, following our recent deep-dive into [commodity value](#).

There is value in equilibrium

In theory, exchange rates should converge to their long-term equilibrium. In practice exchange rates are volatile, misalignments can persist for long periods of time, and the equilibrium level itself can often prove to be an elusive target. Nevertheless, valuation gives us a framework in which to think about exchange rates and provides an 'anchor', helping to differentiate structural moves from temporary swings and noise.

Brewing BEER

Purchasing Power Parity (PPP) or deviations from long-term Real Effective Exchange Rate (REER) levels are useful proxies for long-run equilibrium. However, high real FX rate volatility coupled with slow mean-reversion suggest that PPP cannot stand alone as an adequate measure of FX equilibrium. We turn therefore to equilibrium exchange rate models, specifically the Behavioral Equilibrium Exchange Rate (BEER) model to try to capture medium and long-run drivers of the FX rate. Latest [BEER model estimates](#) suggest CHF to be the most overvalued, followed interestingly by EUR in the G10. JPY, GBP and NOK make up the undervalued basket.

Adding value with BEER

Determining a measure of value is useful for investors, central bankers and other policy makers, as an input to their decision-making process. But can it also be useful as a systematic signal? We evaluate this using a variety of backtests, which suggest that equilibrium strategies can add value, but the choice of measure is important. We consider two variations, the OECD measure of PPP and a BEER model. Given variable selection driven by economic theory, timeliness of model estimates and the inclusion of medium as well as long-term FX drivers, we feel the BEER model addresses some weaknesses of the OECD approach, and overall argue for the choice of BEER over PPP.

Quantitative Cross Asset
Global

QIS Research
MLI (UK)

Myria Kyriacou
FICC Quant Strategist
MLI (UK)
myria.kyriacou@baml.com

Abhinandan Deb >>
Equity-Linked Analyst
MLI (UK)
abhinandan.deb@baml.com

Francisco Blanch
Commodity & Deriv Strategist
MLPF&S
+1 646 855 6212
francisco.blanch@baml.com

Peter Helles
Commodity Strategist
MLI (UK)
peter.helles@baml.com

KeyYong Park
Derivatives Strategist
MLPF&S
keyyong.park@baml.com

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In pursuit of FX value

- Valuation gives us a framework in which to view FX, helping us differentiate between structural moves and temporary swings and noise.
- We discuss various ways of measuring FX value – REER, PPP, BEER models – their pros and cons, our latest estimates of equilibrium & the potential impact of normalizing unconventional policies on FX rates.
- We also backtest the performance of the different valuation models and find that both the OECD PPP and BEER model would have delivered positive performance over the period since January 2000.

What is ‘value’ in the context of currencies? Can we truly model exchange rates despite the famous – or infamous – Meese and Rogoff ‘Random Walk’ result? And is a measure of equilibrium of any practical relevance in designing risk premia strategies in FX?

Long-term guidance – equilibrium as an anchor

In theory, exchange rates should converge to their long-term equilibrium. In practice exchange rates are volatile, misalignments can persist for long periods of time, and the equilibrium level itself can often prove to be an elusive target. Nevertheless, a measure of equilibrium exchange rates is useful in providing “long-term” guidance. Valuation gives us a framework in which to think about exchange rates and helps differentiate structural moves from temporary (cyclical) swings and noise.

EUR appreciated steadily throughout most of 2017, while USD spent most of the past year unwinding its ‘Trump trade’ gains. GBP has been remarkably resilient of late, but remains well below its long-term average in both real and nominal terms. Equilibrium estimates can help answer the question whether such behavior represents movements in the underlying equilibria, and therefore the currencies are correctly priced, or whether it represents misalignments that will gradually correct.

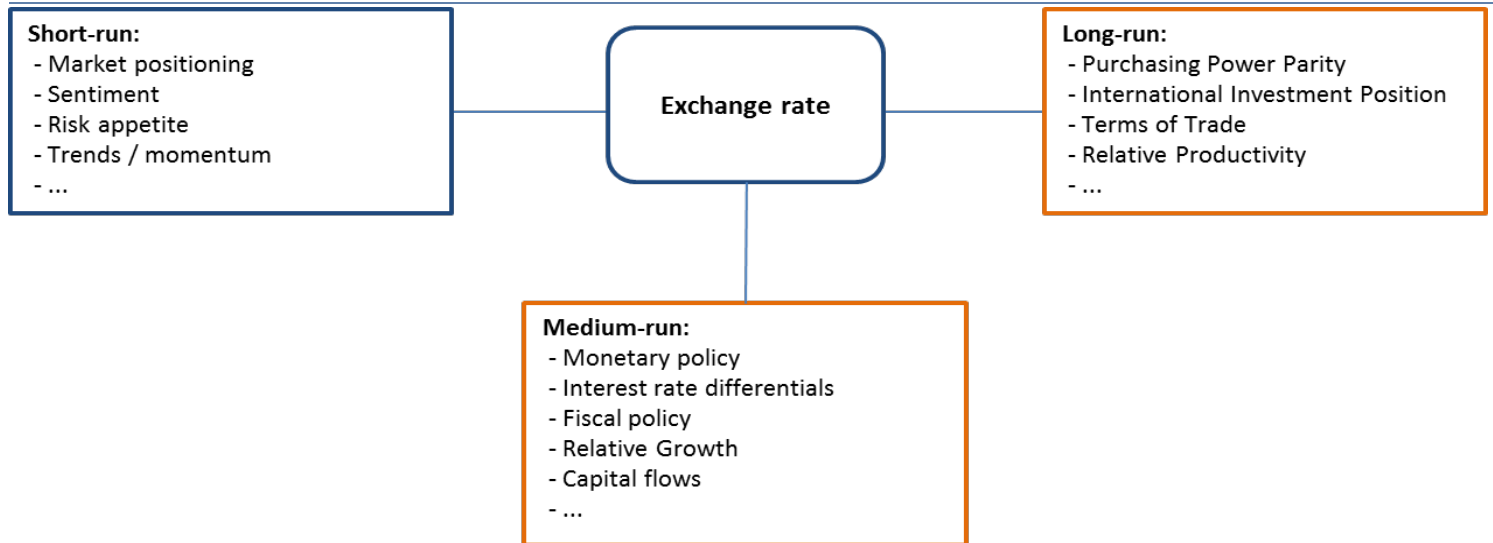
What is equilibrium?

Equilibrium represents the level of the exchange rate that is consistent with internal and external balance. The former suggests zero output gap. The latter suggests a balance of payments consistent with its long-term determinants. In equilibrium, the law of one price holds for tradable goods, and yield differentials have been arbitrated away.

Exchange rates are affected by a wide variety of short, medium and long-term factors however (Exhibit 1), and can deviate for very long periods from the estimated equilibrium. Furthermore, equilibrium estimates suffer from measurement errors, and the theoretical equilibrium itself can change because of unexpected domestic and external supply shocks. Indeed, the academic literature includes a very large number of equilibrium exchange rate models, which can result in a very large range of estimates.

Estimating the extent and duration of over/undershooting from equilibrium remains a mixture of art and science. However, large deviations from equilibrium are more likely to signal that a currency is becoming unsustainably detached from fundamentals and is due for correction, and make longer-term valuation more relevant for medium term movements. Including more medium-run drivers such as interest rates can also make models more applicable at horizons that are more relevant for trading.

Exhibit 1: What drives FX?



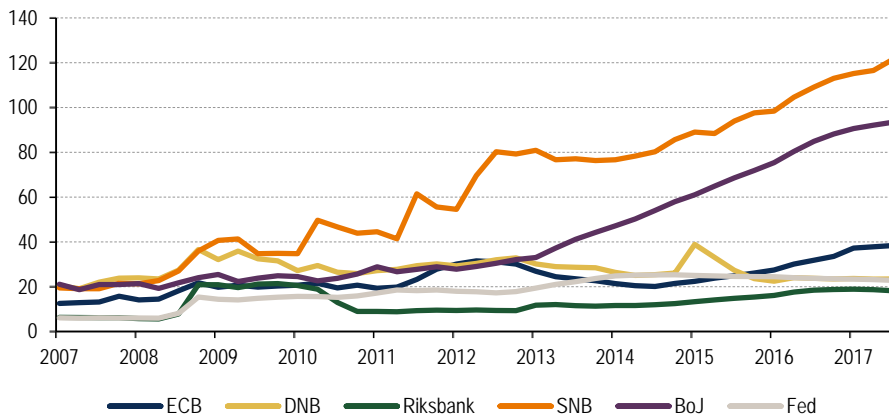
Source: BofA Merrill Lynch Global Research

Monetary policy and equilibrium

In theory, monetary policy should not affect the long-run equilibrium exchange rate and should, therefore, have no impact on long-term exchange rate projections. Internal and external equilibrium suggests zero output gap, low and stable inflation and policy rates equal to a Taylor rule – the latter could also hold during the adjustment to the equilibrium, depending on the intended monetary policy stance. As Central Banks begin the process of normalizing policies and unwinding extraordinary balance sheet expansion however, it would be unwise to ignore the potential impact this could have on valuation, not to mention the path towards equilibrium.

Unwinding this balance sheet expansion could take years, and is likely to affect both the actual and the equilibrium levels of exchange rates. As we will see in a subsequent section, Central Bank activism appears to have impacted the performance of FX value strategies post-crisis. It would be prudent to consider the potential impact of the path back towards more conventional policy.

Chart 1: Central Bank Balance Sheet as % GDP



Source: BofA Merrill Lynch Global Research, Bloomberg, Haver Analytics; Data through December 2017

Finding Equilibrium: The Models

"All models are wrong but some are useful" George E.P. Box (Statistician)

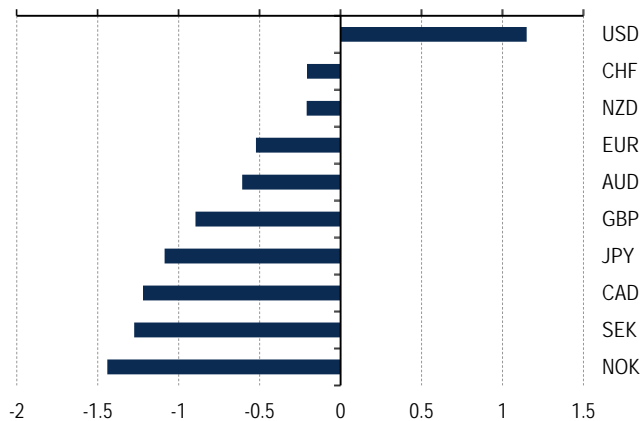
Empirical exchange rate models – and FX strategists – have long had to contend with the results of the 1983 paper by Meese and Rogoff¹, demonstrating that exchange rate models do not consistently outperform a naïve random walk in forecasting FX rates at horizons below two years. There is considerable academic evidence however that PPP holds in the long term (3-5 years), so while forecasting FX remains a tough nut to crack, academia provides a variety of tools to tackle longer-term valuation.

First pass at valuation: deviation from REERs

A quick initial way to gauge fair valuation for FX in the G10 is to look at the real effective exchange rate (REER), which creates a trade-weighted index that also takes into account differential inflation levels. Over long time periods, we would expect G10 REERs not to have sustained trends, but rather to be roughly stationary, as otherwise the implication is that a country would eventually be able to buy out the rest of the world with its ever-strengthening currency. This implication is in contrast to EM currencies, where we might expect these to have longer-run appreciation as standards of living increase over the development process.

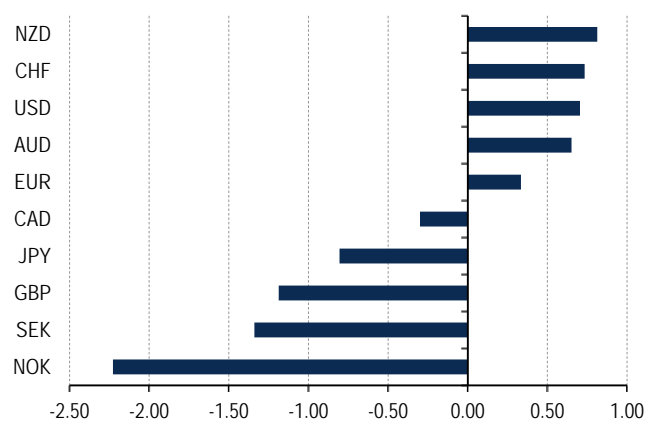
Formal statistical tests can be somewhat unclear in trying to distinguish between long-run stationarity and a random walk. Moreover, in a practical sense, the “long-run” can be difficult to define. A 10-year moving average is one straightforward definition, and here we show the implied misalignment ranked across the G10, by means of a z-score (Chart 2). By this measure, the USD is the only overvalued G10 currency, with the Scandies the most undervalued. Such valuation estimates are often not very robust to time period selection, as can be seen if we look at the 20-year deviation from REER (Chart 3) however, arguing for at least a second pass at valuation.

Chart 2: G10 REER Deviation: z-score from 10-year average



Source: BofA Merrill Lynch Global Research, Bloomberg, BIS; Data as of 31/12/2017

Chart 3: G10 REER Deviation: z-score from 20-year average



Source: BofA Merrill Lynch Global Research, Bloomberg, BIS; Data as of 31/12/2017

Purchasing Power Parity – the workhorse valuation model

The intuition behind REER deviations as a proxy for valuation is in fact PPP (Purchasing Power Parity). The ‘workhorse’ valuation model, PPP expresses the Law Of One Price - the equilibrium exchange rate is consistent with equilibrium in goods markets in domestic and foreign economies. In theory, higher prices lead to a weaker currency and any deviations from the PPP should disappear due to goods market arbitrage. In practice, frictions such as transportation costs, tariffs and other factors account for

¹ Meese, Richard A., and Kenneth Rogoff. 1983a. Empirical exchange rate models of the seventies: Do they fit out of sample? Journal of International Economics

short and medium-term deviations, and deviations from PPP can persist for very long periods of time, but PPP remains a good *long-run* anchor.

High real FX rate volatility coupled with slow mean-reversion – the PPP-puzzle – suggest that PPP cannot stand alone as an adequate measure of FX equilibrium. Nevertheless, it is a useful proxy, with the added benefit that it avoids the need for econometric estimation.

OECD vs CPI PPP

The simplest way to estimate PPP is simply to price an identical basket of goods – or one Big Mac – in two countries, and calculate the exchange rate that equalizes those prices. This is the OECD approach, and indeed the Economists' Big Mac Index approach.

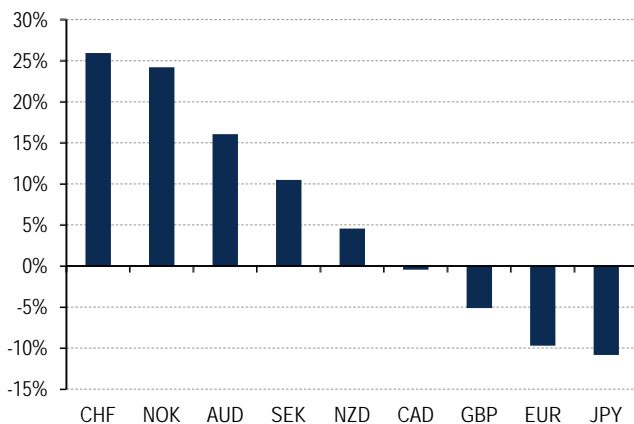
Alternatively, PPP can be calculated using consumer or producer price indices:

$$PPP = \bar{s} \times \frac{p_t^*}{\bar{p}_t}$$

Where \bar{s} = average FX rate, "p" and "p*" stand for domestic and foreign price indices and the 'base period' is chosen as a long-run average level to avoid base year effects.

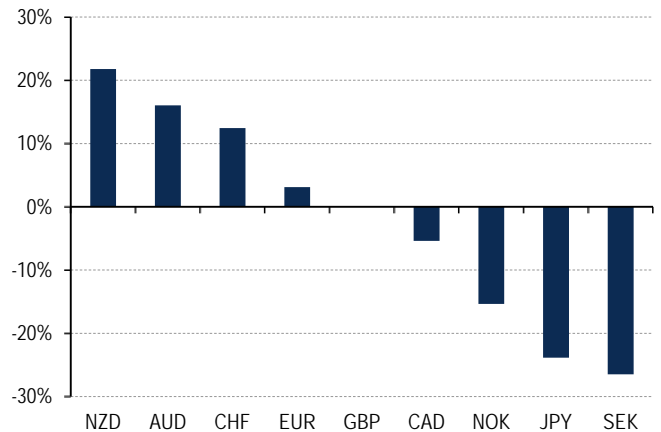
This is a relative PPP calculation, and the choice of base period is important as it can lead to significant differences in estimated PPP. To avoid 'base year' effects, a long-run average over at least one economic cycle is used, following the methodology proposed by Ohno (1990)².

Chart 4: Latest Misalignment vs USD using OECD PPP



Source: BofA Merrill Lynch Global Research, Bloomberg, OECD; Data as of 16/01/2018

Chart 5: Latest Misalignment vs USD using relative PPP-CPI



Source: BofA Merrill Lynch Global Research, Bloomberg; Data as of 16/01/2018

There are some notable differences in estimated misalignment between the OECD and relative-PPP methodologies (Chart 4, Chart 5) and arguments to be made in favor of both. The OECD approach is intuitive and not sensitive to estimation error, however it is only updated once a year and is subject to frequent revisions, making it less suitable for use in a backtesting framework.

Adding BEER for equilibrium

Given the limitations of PPP as a stand-alone measure of FX valuation, we turn now to one of the other approaches to valuation, that allows for explicit deviation from PPP, specifically the Behavioural Equilibrium Exchange Rate (BEER) model of Clark and

² Ohno, K., "Estimating Yen/Dollar and Mark/Dollar Purchasing Power Parities", Staff Papers (International Monetary Fund); Vol. 37, No. 3 (Sep., 1990), pp. 700-725

MacDonald (1999)³. Other models include the Fundamental Equilibrium Exchange Rate model (FEER)⁴, or indeed the Permanent Equilibrium exchange rate (PEER) or the capital enhanced equilibrium exchange rate (CHEER) models⁵.

In the x-EER approach, the equilibrium exchange rate is allowed to vary over time as a function of economic fundamentals. FEER models try to estimate a sustainable level of the current account and can be tricky to estimate. BEER models directly model the behavior of the exchange rate in terms of relevant economic variables. We choose to focus on BEER models as they allow us to directly model exchange rates using timely macroeconomic variables, also building on [previous work](#) we have done on equilibrium models.

The BEER methodology

The original Clark and MacDonald specification models the equilibrium rate using terms of trade, productivity and net foreign assets, while in subsequent papers the inputs are adjusted to incorporate variables available at higher frequencies.

For our purposes, variable selection was driven by economic theory, but also with an eye towards relatively timely availability. Our model is described in Exhibit 2 below. Most variables are available on a monthly basis, with the exception of the Current account balance and Terms of Trade and CPI for some countries (Australia and New Zealand release inflation and terms of trade data quarterly, and Norway terms of trade is also quarterly).

We chose to estimate our models using a panel estimation. This greatly increases our sample size and should therefore allow for greater precision in our estimates. This does assume homogeneity in the relationship between fundamentals and the exchange rate across currencies. While this is unlikely to be exactly true, it should be approximately valid and is a common estimation choice in academia.

We also estimate our models on two panels, one using only the G10 countries and one with both G10 and EM countries. The larger panel is arguably the better option in estimating ‘true’ equilibrium as it increases the information set and includes important trading partners such as China and Brasil. In generating a trading signal where the universe is confined to the G10 – as we do below – the smaller panel lends itself more readily as it should highlight the misalignments between the G10 specifically. In practice the patterns are similar.

We choose to begin our estimation in 1995, and estimate a rolling version of the regression with an expanding window. Monthly variables are lagged by one month and quarterly variables by one quarter, with previous value interpolation for any variable that does not yet have a new observation at the time of estimation. Our model is estimated in levels using a panel Dynamic OLS (DOLS) cointegrating regression, as in MacDonald and Dias (2007)⁶, and we estimate both bilateral and trade weighted models, using trade weights from the Bank for International Settlements (BIS).

³ Clark, P.B. and R. MacDonald, (1999), “Exchange Rates and Economic Fundamentals: A Methodological Comparison of BEERs and FEERs”

⁴ Williamson, J. (1983), Estimating Equilibrium Exchange Rates, Washington, DC: Institute for International Economics.

⁵ MacDonald, R. (2007), Exchange Rate Economics: Theories and Evidence (Second Edition of Floating Exchange Rates: Theories and Evidence), Routledge, 2007.

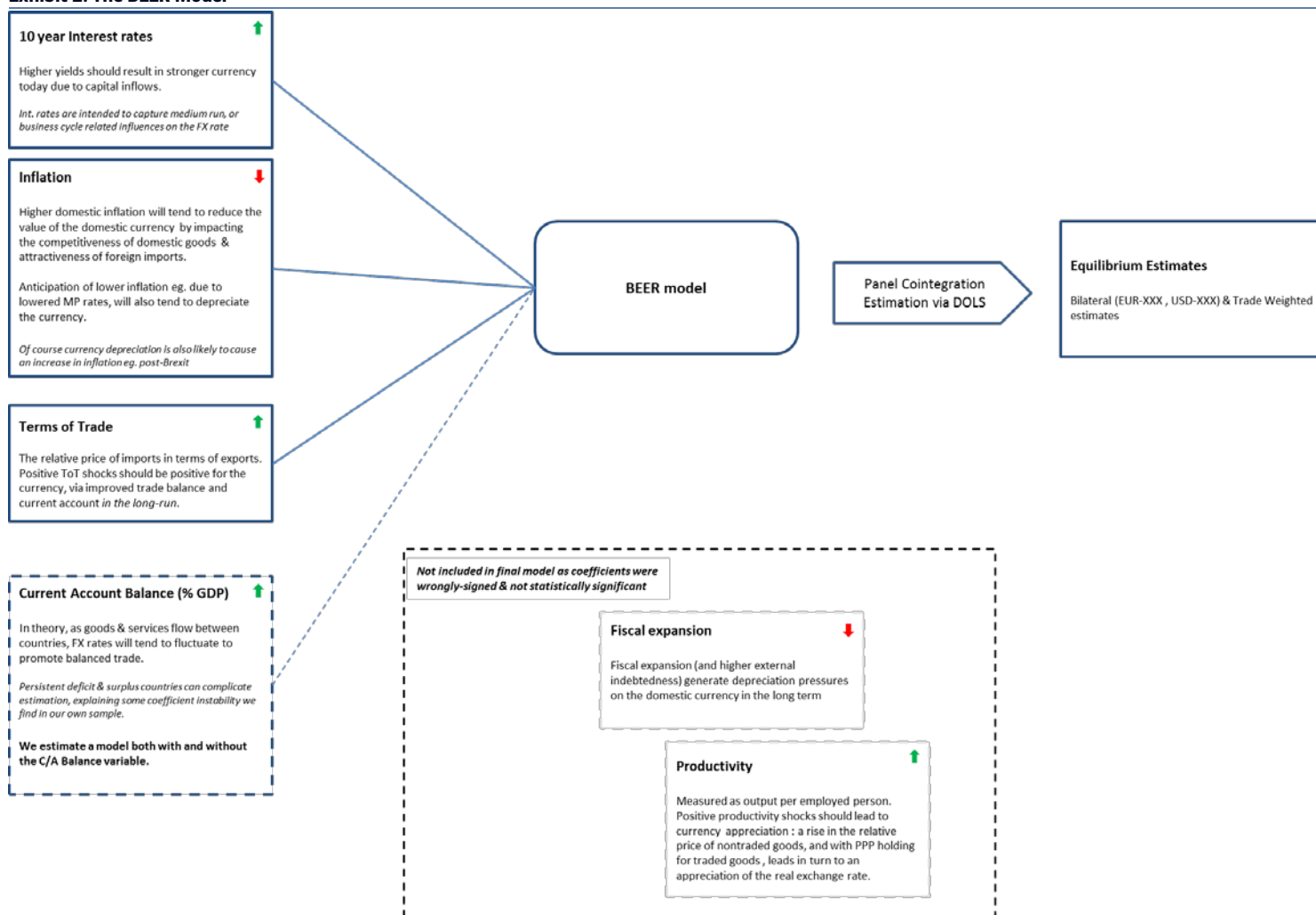
⁶ Behavioural equilibrium exchange rate estimates and implied exchange rate adjustments for ten countries. Ronald MacDonald and Preethike Dias. University of Glasgow and Peterson Institute of International Economics.

A word on estimation history – the data sample is crucial

The choice of history to use when estimating econometric models is rarely cut and dried. In many cases the choice is driven by data availability, and the temptation is always to opt for the maximum amount of data. It is worth noting however, that there are arguments to be made for not extending our estimation sample too far back. In FX – even in G10 FX – the current environment of free-floating currencies and inflation-targeting Central Banks does not extend back as far as one might think – the first CB to move to an explicit inflation target was the RBNZ in 1989.

Moreover, macro relationships can and do change significantly over time. The Canadian dollar – now considered a petro-currency – showed little, or even negative, relationship to energy prices before the mid-1990s. Conversely, until the late 1990's GBP could well have been considered a petro-currency – oil extraction in the UK peaked in 1999.

Exhibit 2: The BEER Model



Source: BofA Merrill Lynch Global Research; Red and green arrows in the boxes above indicate the theoretical direction of the relationship the variable would have on the FX rate.

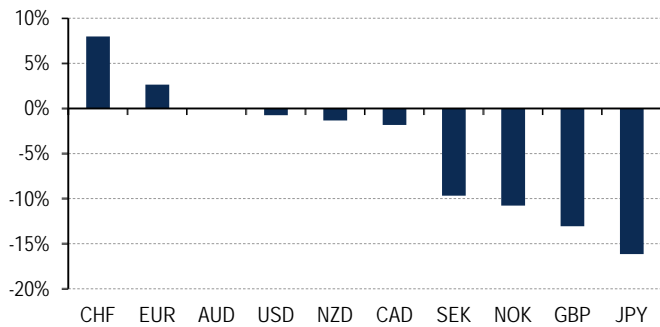
The latest BEER estimates

There is no 'correct' model for FX valuation, and as with any pricing exercise, the methodology itself introduces uncertainty. Although we chose our explanatory variables based on economic rationale, we dropped the two variables that were wrongly signed and statistically insignificant. Interest rates, inflation and terms of trade were correctly signed and significant, but the current account balance displayed some instability, sometimes switching signs. We have therefore estimated a model both with and

without the C/A balance. This has the added benefit of enabling us to use a model that is almost entirely based on monthly data, the exceptions being terms of trade and CPI for Australia and New Zealand, and terms of trade for Norway.

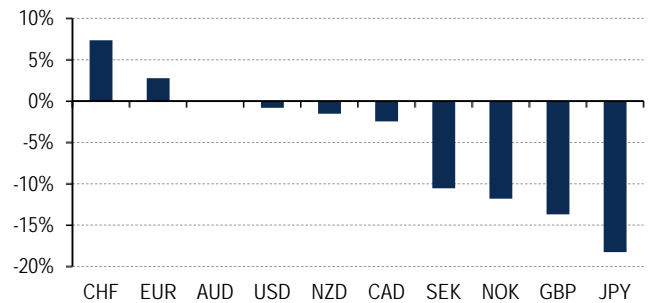
The misalignment for the trade weighted variables is very similar for both specifications (Chart 6, Chart 7). Focusing on the extreme misalignments, both versions suggest JPY, GBP and NOK are the most undervalued G10 currencies, with CHF the most overvalued.

Chart 6: Latest misalignment G10 TWI (3-variable BEER model)



Source: BofA Merrill Lynch Global Research, Bloomberg; Data as of 16/01/2018

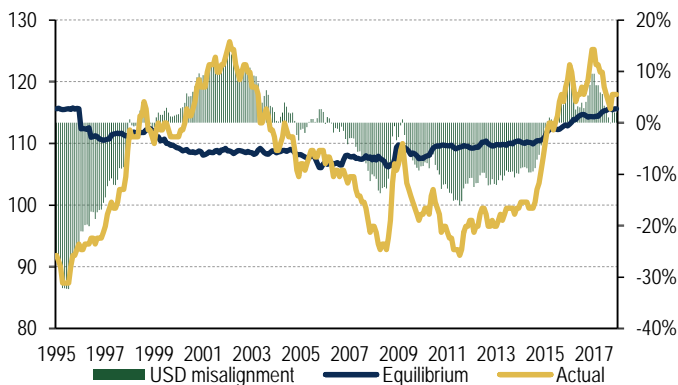
Chart 7: Latest misalignment G10 TWI (BEER model including C/A bal.)



Source: BofA Merrill Lynch Global Research, Bloomberg; Data as of 16/01/2018

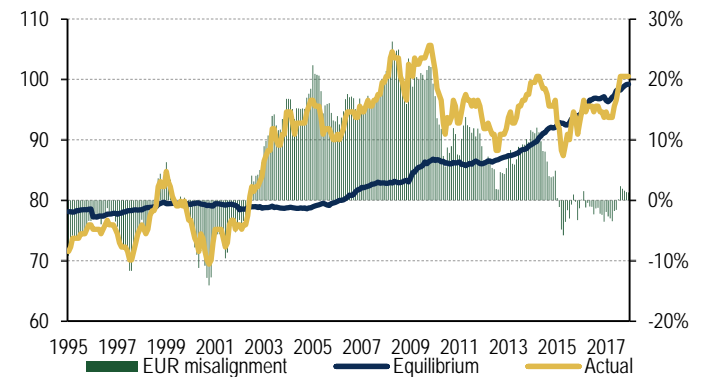
The time series of misalignments show some interesting patterns. Much of the USD overvaluation has now been corrected (Chart 8), while EUR is close to equilibrium (Chart 9).

Chart 8: USD overvaluation has been reducing since Dec 2016



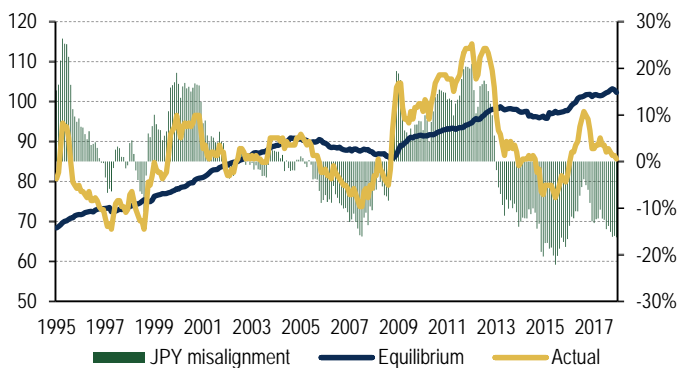
Source: BofA Merrill Lynch Global Research, Bloomberg; ; Data as of 16/01/2018

Chart 9: EUR is close to equilibrium



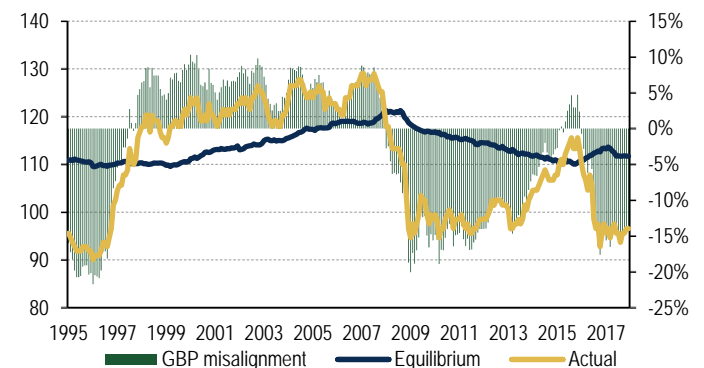
Source: BofA Merrill Lynch Global Research, Bloomberg; ; Data as of 16/01/2018

Chart 10: JPY undervaluation has increased



Source: BofA Merrill Lynch Global Research, Bloomberg; Data as of 16/01/2018

Chart 11: GBP undervaluation is Brexit driven; equilibrium slow to adjust

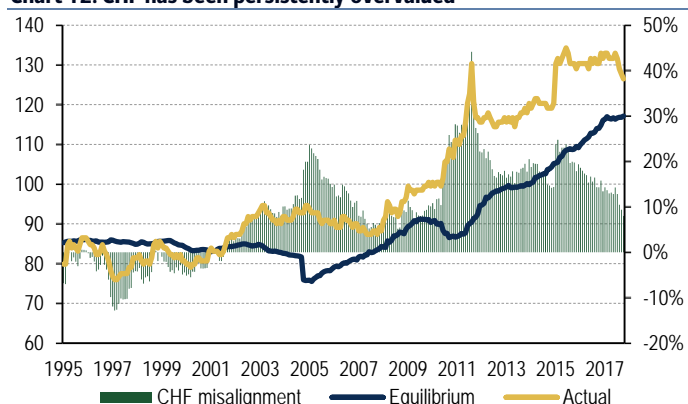


Source: BofA Merrill Lynch Global Research, Bloomberg; Data as of 16/01/2018

JPY misalignment, which had been correcting through the first quarter of 2016 is building again (Chart 10) and the undervaluation in GBP is clearly Brexit driven (Chart 11). GBP equilibrium has moved lower, but the adjustment is slow

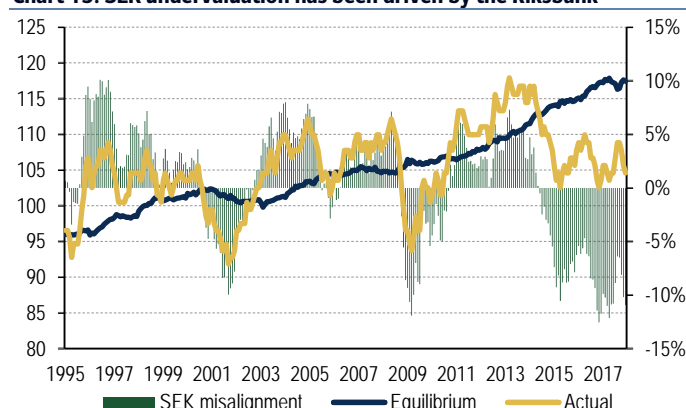
CHF has been persistently overvalued, and despite significant correction over recent years, remains misaligned (Chart 12). Lastly, SEK undervaluation is likely strongly influenced by Riksbank policies, with the Central Bank focused on preventing currency strength in recent years (Chart 13).

Chart 12: CHF has been persistently overvalued



Source: BofA Merrill Lynch Global Research, Bloomberg; Data as of 16/01/2018

Chart 13: SEK undervaluation has been driven by the Riksbank



Source: BofA Merrill Lynch Global Research, Bloomberg; Data as of 16/01/2018

Table 1: Bilateral Equilibrium Estimates

Equilibrium Estimates USD pairs									
	EUR/USD	USD/JPY	GBP/USD	AUD/USD	NZD/USD	USD/CAD	USD/NOK	USD/SEK	USD/CHF
Equilibrium Estimate	1.22	97	1.59	0.77	0.70	1.24	6.93	7.29	1.03
Spot	1.2260	110.45	1.3792	0.7961	0.7268	1.2435	7.8753	8.0405	0.9595
Misalignment	0.36%	13.76%	-13.17%	3.98%	3.88%	0.59%	13.66%	10.32%	-7.14%

Equilibrium Estimates EUR pairs									
	EUR/USD	EUR/JPY	EURGBP	EURAUD	EURNZD	EURCAD	EURNOK	EURSEK	EURCHF
Equilibrium Estimate	1.22	118	0.77	1.60	1.75	1.51	8.46	8.90	1.26
Spot	1.2260	135.42	0.8889	1.5402	1.6869	1.5245	9.6553	9.8590	1.1764
Misalignment	0.36%	14.18%	15.58%	-3.48%	-3.40%	0.94%	14.07%	10.73%	-6.81%

Source: BofA Merrill Lynch Global Research, Bloomberg; Data as of 16/01/2018

Do valuation models add value?

Determining currency value is useful for investors, central bankers and other policy makers, as an input to their decision-making process. Can it also be useful as a systematic signal however? We evaluate this using a variety of backtests, and find that FX value strategies can add value, but the choice of measure is important.

Testing value in G10 FX

Although we estimate equilibrium values using both G10 and EM data, we only test value strategies on G10 currencies here. The main rationale for not including EM at this stage is that there is little theoretical reasoning to expect mean-reversion in EM currencies. As mentioned earlier, we would not expect sustained trends in G10 over long periods, in contrast to EM which could display longer-run real appreciation as standards of living increase over the development process.

PPP would therefore not lend itself to EM strategies. BEER models could better model the dynamics, but it is important to bear in mind the increased importance of aspects like political risk and liquidity risk in EM, which could push currencies very far from levels implied by fundamentals. In all, EM Value FX strategies deserve further analysis, but this is beyond the scope of this report.

A simple PPP-CPI model

As a first step, we estimate a simple strategy using PPP estimates. As described in a previous section, we choose the relative PPP approach based on CPI. This is a reasonable 'benchmark' to choose as it involves no econometric estimation and uses CPI data for the G10 which is readily available.

To test the strategy we compare the latest one month average spot price of all the G10 USD-pairs to PPP at every rebalance date, and rank the misalignment. We then form portfolios by going long the three most undervalued pairs vs short the three most overvalued pairs in an equally weighted portfolio. Since inflation data is released monthly, we choose a monthly rebalance frequency, and choose a start date of January 2000, which allows us to have a common start date with our BEER model. Returns are calculated on a total return basis, i.e incorporating both the spot return and the interest return earned from the long position. We also incorporate transaction costs, which differ based on currency pair.

According to our backtested analysis, the strategy would have performed over the full period (Chart 14), and notably would have done well over the 2007-2009 crisis period. Performance would have deteriorated markedly since then however, and looking at different subperiods shows marked variation (Table 2). To some extent a deterioration in performance post-crisis makes sense. As Central Banks became more active and unconventional monetary policies multiplied, this understandably impacted markets. Nevertheless, this instability in the backtested performance suggests significant room for improving the strategy.

Chart 14: A simple G10 PPP-CPI Strategy



Source: Bloomberg, BofA Merrill Lynch Global Research estimates

This performance is back-tested and does not represent the actual performance of any account or fund. Back-tested performance depicts the theoretical (not actual) performance of a particular strategy over the time period indicated. No representation is being made that any actual portfolio is likely to have achieved returns similar to those shown herein. Transaction costs are incorporated in the backtests. Please contact us for further details. Time series shown 31/12/1999 to 16/01/2018

Table 2: PPP-CPI Backtested Strategy Performance

	Time Window Analysis PPP CPI Strategy						
	1Y	18m	2Y	30m	3Y	5Y	All
Return *	2.02%	-1.65%	-1.49%	0.62%	1.00%	-1.70%	1.53%
Standard Deviation*	4.72%	4.77%	5.08%	5.36%	5.61%	6.52%	7.33%
Down Dev	4.82%	5.02%	5.02%	5.02%	5.42%	7.06%	7.34%
Maximum Drawdown	-3.17%	-6.82%	-9.35%	-9.35%	-9.35%	-19.62%	-24.88%
Sharpe (IR)	0.43	-0.35	-0.29	0.12	0.18	-0.26	0.21
Sortino	0.42	-0.33	-0.30	0.12	0.18	-0.24	0.21
Calmar	0.64	-0.24	-0.16	0.07	0.11	-0.09	0.06

* annualised

Source: Bloomberg, BofA Merrill Lynch Global Research estimates

This performance is back-tested and does not represent the actual performance of any account or fund. Back-tested performance depicts the theoretical (not actual) performance of a particular strategy over the time period indicated. No representation is being made that any actual portfolio is likely to have achieved returns similar to those shown herein. Transaction costs are incorporated in the backtests. Please contact us for further details. ; Data as of 16/01/2018

A note regarding back-tested performance analysis in this report: Back-tested performance does not represent the actual performance of any account or fund. Back-tested performance depicts the theoretical (not actual) performance of a particular strategy over the time period indicated. In future periods, market and economic conditions will differ and the same strategy will not necessarily produce the same results. No representation is being made that any actual portfolio is likely to have achieved returns similar to those shown herein. In fact, there are frequently sharp differences between back-tested returns and the actual results realized in the actual management of a portfolio. Back-tested performance results are created by

applying an investment strategy or methodology to historical data and attempts to give an indication as to how a strategy might have performed during a certain period in the past if the product had been in existence during such time. Back-tested results have inherent limitations including the fact that they are calculated with the full benefit of hindsight, which allows the security selection methodology to be adjusted to maximize the returns. Further, the results shown do not reflect actual trading or the impact that material economic and market factors might have had on a portfolio manager's decision-making under actual circumstances.

An OECD PPP strategy does better

As perhaps the most intuitive measure of PPP, the OECD valuation also lends itself to be used as a strategy signal. We follow the same basic approach as with the PPP-CPI strategy, but incorporating the OECD measure of fair value. We also amend our weighting scheme for this strategy. Rather than allocating equal weights to the top 3 and bottom 3 positions, we assign weights that incorporate the relative strength of each signal. We do this by calculating the z-score across the signals at each rebalance date, which allows us to allocate a higher weight to pairs with larger misalignments. All other aspects of the strategy are identical to the PPP-CPI approach.

According to our backtests, this strategy would have performed markedly better than our previous approach, with remarkable stability in performance over different subperiods (Chart 15, Table 3). Much of the improvement stems from the signal itself, not the weighting strategy, although variable portfolio weights do push the full-sample IR from 0.45 to 0.50.

One significant caveat in this signal stems from the OECD measure itself. The OECD PPP values are updated only on an annual basis, and are subject to significant revisions through each year. Unfortunately, the OECD does not maintain an original release database for the PPP levels, so we are not able to test how much the revision process may have affected the backtest.

Chart 15: OECD PPP Strategy



Source: Bloomberg, BofA Merrill Lynch Global Research estimates

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Table 3: OECD PPP Backtested Strategy Performance

Time Window Analysis OECD PPP Strategy							
	1Y	18m	2Y	30m	3Y	5Y	All
Return *	4.92%	1.55%	2.91%	4.93%	4.65%	3.84%	4.00%
Standard Deviation*	3.85%	3.82%	4.09%	4.22%	4.46%	6.49%	8.01%
Down Dev	3.67%	3.81%	3.81%	3.81%	4.20%	7.69%	8.45%
Maximum Drawdown	-3.26%	-4.36%	-4.72%	-4.72%	-4.72%	-9.34%	-14.77%
Sharpe (IR)	1.28	0.41	0.71	1.17	1.04	0.59	0.50
Sortino	1.34	0.41	0.76	1.29	1.11	0.50	0.47
Calmar	1.51	0.36	0.62	1.05	0.98	0.41	0.27

* annualised

Source: Bloomberg, BofA Merrill Lynch Global Research estimates

This performance is back-tested and does not represent the actual performance of any account or fund. Back-tested performance depicts the theoretical (not actual) performance of a particular strategy over the time period indicated. No representation is being made that any actual portfolio is likely to have achieved returns similar to those shown herein. Transaction costs are incorporated in the backtests. Please contact us for further details. ; Data as of 16/01/2018

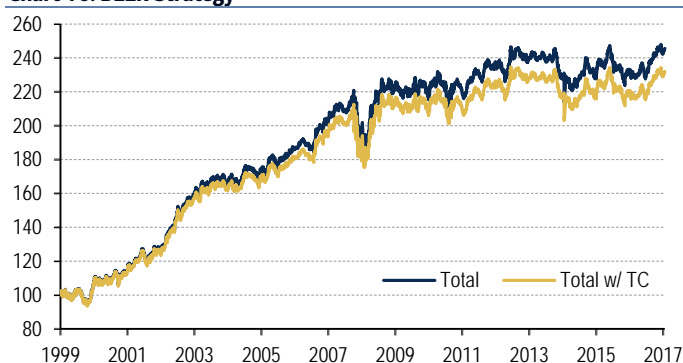
Does BEER improve equilibrium?

It is hard to judge definitively whether any valuation model is ‘better’ than another. Valuation models are not forecasts per se. Nonetheless, the BEER model specification is taking into account more underlying drivers of exchange rates than PPP, and the inclusion of interest rates adds a medium-term component to the longer-term fundamentals. Overall, therefore, we believe this should improve the model estimates of equilibrium. Does it improve strategy performance though?

We follow the same strategy construction as with the OECD version described above, and overall the BEER model signals would have performed well according to our backtest, with some notable exceptions, namely a sharp drawdown in 2008 (Chart 16, Table 4). We generally would expect value strategies to perform well in crisis periods, but in this case the BEER model gets both CHF and JPY wrong, leading to a significant underperformance.

As discussed in the model results section, valuation models suffer from a ‘CHF-problem’. CHF is consistently flagged as overvalued in much of our sample. The SNB establishing and then dropping the EUR/CHF floor also complicates performance. This is a common drawback of all valuation models, particularly approaches that estimate a common model specification across multiple currencies, and suggests two avenues for future refinements. One is to build a better model, perhaps by estimating country-specific models. This is no guarantee of success – the Swiss National Bank (SNB) has been saying for years that CHF is overvalued. The other is to account for persistent misalignments in generating the trading strategy.

Chart 16: BEER Strategy



Source: Bloomberg, BofA Merrill Lynch Global Research estimates

This performance is back-tested and does not represent the actual performance of any account or fund. Back-tested performance depicts the theoretical (not actual) performance of a particular strategy over the time period indicated. No representation is being made that any actual portfolio is likely to have achieved returns similar to those shown herein. Transaction costs are incorporated in the backtests. Please contact us for further details. Time series shown 31/12/1999 to 16/01/2018

Table 4: BEER Backtested Strategy Performance

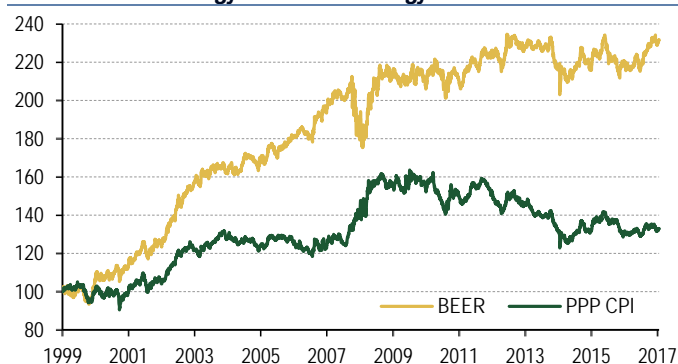
	Time Window Analysis BEER Strategy						
	1Y	18m	2Y	30m	3Y	5Y	All
Return *	6.36%	3.32%	1.52%	2.47%	2.35%	1.00%	4.50%
Standard Deviation*	4.87%	5.10%	5.34%	5.60%	5.74%	6.67%	8.37%
Down Dev	4.84%	5.34%	5.34%	5.34%	5.67%	7.47%	8.67%
Maximum Drawdown	-4.01%	-5.23%	-9.61%	-9.61%	-9.61%	-13.48%	-17.51%
Sharpe (IR)	1.31	0.65	0.29	0.44	0.41	0.15	0.54
Sortino	1.32	0.62	0.29	0.46	0.42	0.13	0.52
Calmar	1.59	0.64	0.16	0.26	0.24	0.07	0.26

* annualised

Source: Bloomberg, BofA Merrill Lynch Global Research estimates

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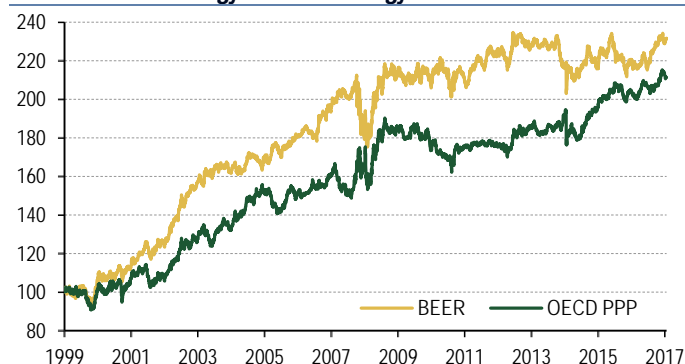
Chart 17: BEER Strategy vs PPP-CPI Strategy Performance



Source: Bloomberg, BofA Merrill Lynch Global Research estimates

This performance is back-tested and does not represent the actual performance of any account or fund. Back-tested performance depicts the theoretical (not actual) performance of a particular strategy over the time period indicated. No representation is being made that any actual portfolio is likely to have achieved returns similar to those shown herein. Transaction costs are incorporated in the backtests. Please contact us for further details. ; Time series shown 31/12/1999 to 16/01/2018

Chart 18: BEER Strategy vs OECD Strategy Performance



Source: Bloomberg, BofA Merrill Lynch Global Research estimates

This performance is back-tested and does not represent the actual performance of any account or fund. Back-tested performance depicts the theoretical (not actual) performance of a particular strategy over the time period indicated. No representation is being made that any actual portfolio is likely to have achieved returns similar to those shown herein. Transaction costs are incorporated in the backtests. Please contact us for further details. Time series shown 31/12/1999 to 16/01/2018

Evaluating BEER signals

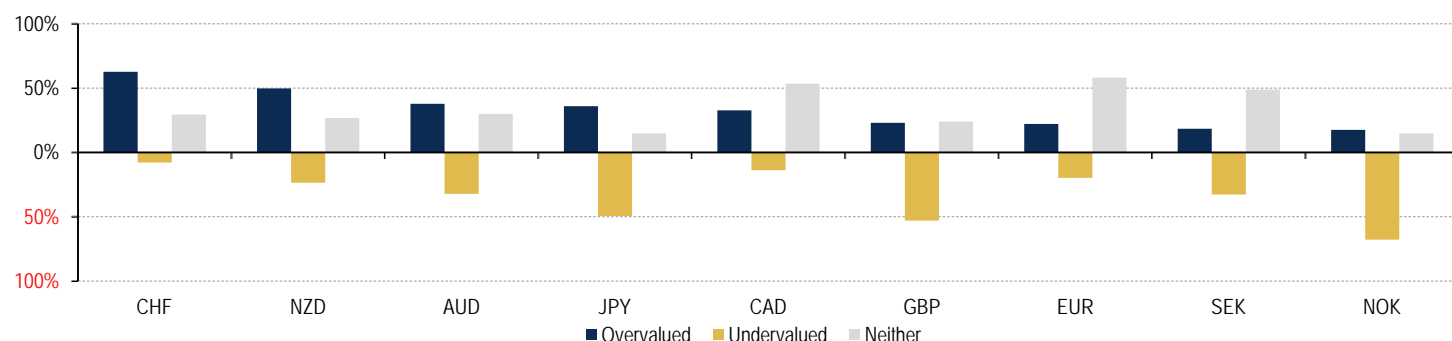
In evaluating the performance of the BEER model as a strategy signal, it is immediately obvious that there is a difference in performance in the pre and post-crisis (2008) period (Chart 16, Table 4). This is also apparent in the CPI-PPP approach, as well as in the OECD version, albeit less so (Chart 14, Chart 15).

As we have already discussed, this is not an unexpected result considering the change in the global economic environment post2008, given substantial central bank activism and increasingly unconventional policy. Nevertheless, it is instructive to see the differences – if any – in the signals under different macro environments.

We first establish the full-sample baseline, looking at each currency's representation in the portfolio overall. Chart 19 shows some fairly intuitive results – CHF is frequently flagged as overvalued, and conversely NOK, GBP and JPY often make up part of the undervalued basket.

NOK represents somewhat of an outlier in all the charts below, with its persistent undervaluation likely predominantly driven by Norway's substantial current account surplus in the first part of the sample, and post-2014 by Central Bank action as the Norges Bank kept persistent downward pressure on the currency.

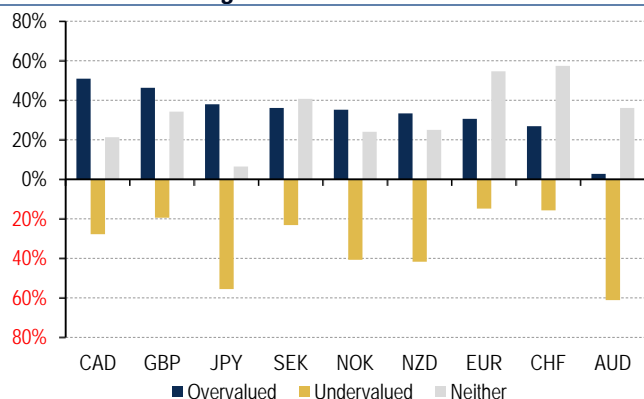
Chart 19: BEER model signals over the period 2000 to present



Source: BofA Merrill Lynch Global Research estimates *Y-axis shows the % of times each currency was in the 3 most overvalued or 3 most undervalued each month from Dec-99 to Dec-17

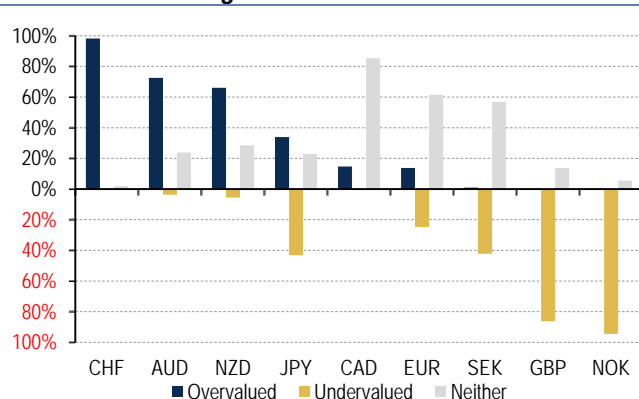
Interestingly enough, we see that the dominance of CHF in the overvalued basket is driven by the post-crisis period (Chart 21), likely influenced by CHF's 'safe-haven' status and importantly by the actions of the SNB over the period. Indeed the pre-crisis sample shows more balance across the G10 in terms of long and short positions (Chart 20).

Chart 20: BEER Model Signals Pre-Crisis



Source: BofA Merrill Lynch Global Research estimates. *Y-axis shows the % of times each currency was in the 3 most overvalued or 3 most undervalued each month from Dec-99 to Dec-17

Chart 21: BEER Model Signals Post-Crisis



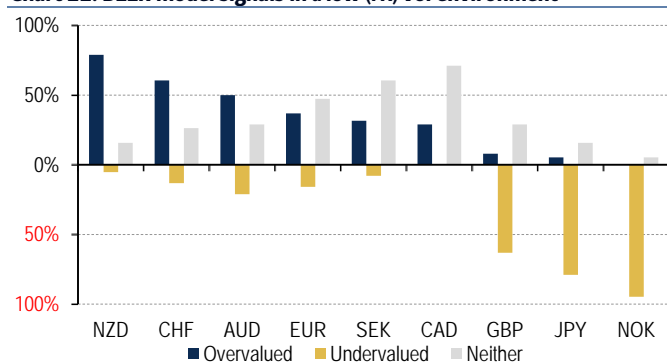
Source: BofA Merrill Lynch Global Research estimates. *Y-axis shows the % of times each currency was in the 3 most overvalued or 3 most undervalued each month from Dec-99 to Dec-17

Turning to a distinction between low and high volatility periods, we also see some intuitive differences in behaviour. We identify low vs high vol environments using the FX vol component of the Global Financial Stress Indicator (GFSI™), defining high (low) volatility as the standardized FX vol measure being above (below) 0.5 standard deviations from the average (see our [GFSI primer](#) for details). In high vol environments (Chart 23) we note the jump of JPY into the overvalued bucket, demonstrating JPY's 'safe-haven' status, while the low vol states show the 'high-betas' like AUD and NZD dominate the overvalued category.

Lastly, looking at the strategy behaviour in rising vs falling vol environments (Chart 24, Chart 25) demonstrates the 'stickiness' of value estimates. As vol is falling for example, spot can diverge ever further from equilibrium as high beta currencies attract flow.

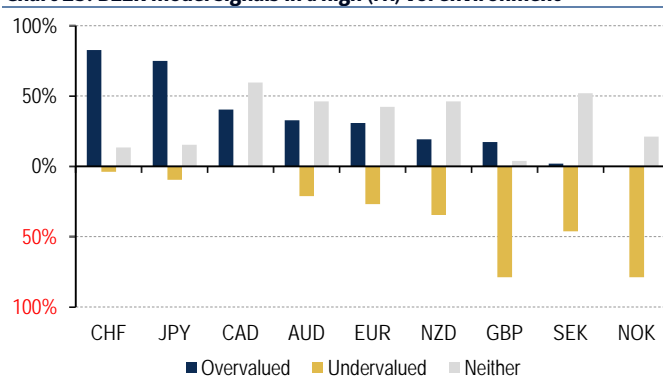
This is a particular feature of value strategies, and illustrates one reason why they often function well as part of a portfolio with momentum and carry strategies, two risk premia we will be examining in detail in future work.

Chart 22: BEER model signals in a low (FX) vol environment



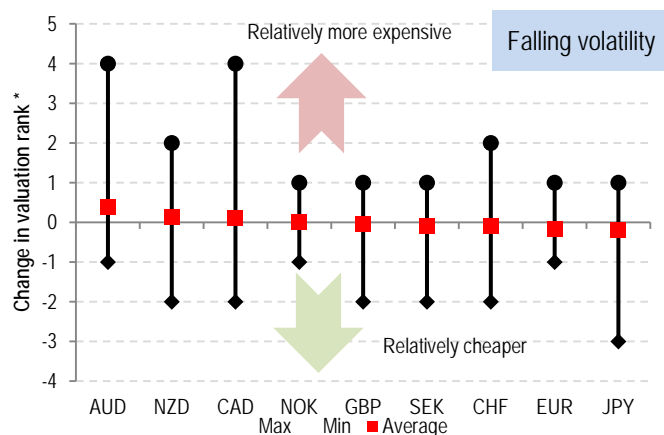
Source: BofA Merrill Lynch Global Research estimates. *Y-axis shows the % of times each currency was in the 3 most overvalued or 3 most undervalued each month from Dec-99 to Dec-17. We define high (low) vol as the standardized GFSI™ FX vol measure being above (below) 0.5 standard deviations from the average

Chart 23: BEER model signals in a high (FX) vol environment



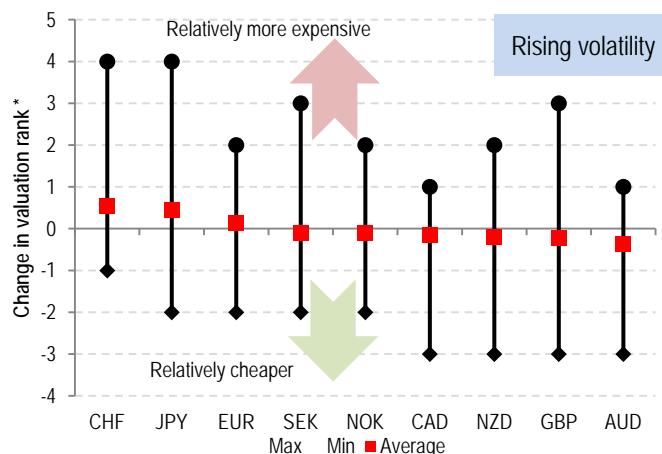
Source: BofA Merrill Lynch Global Research estimates. *Y-axis shows the % of times each currency was in the 3 most overvalued or 3 most undervalued each month from Dec-99 to Dec-17. We define high (low) vol as the standardized GFSI™ FX vol measure being above (below) 0.5 standard deviations from the average

Chart 24: BEER model signals in a falling (FX) vol environment



Source: BofA Merrill Lynch Global Research estimates. *Monthly change in relative valuation rank (among 9 currency pairs) whenever FX vol fell by more than its average absolute monthly move

Chart 25: BEER model signals in a rising (FX) vol environment



Source: BofA Merrill Lynch Global Research estimates* Monthly change in relative valuation rank (among 9 currency pairs) whenever FX vol rose by more than its average absolute monthly move

We prefer BEER

Clearly the choice of valuation model makes a significant difference in strategy performance according to our backtests. Judging on performance alone, on a backtested basis, the OECD version of PPP would have been the preferred choice, considering the consistent performance in backtests, as well as the outperformance over the crisis years. Nevertheless, the BEER model addresses some weaknesses of the OECD approach, and overall argues for the choice of BEER over OECD PPP.

As already discussed, OECD estimates are released only annually and are subject to sometimes significant revision. Without access to original release data we cannot gauge how much of an impact the revisions would have on the strategy. Data revisions are a problem for all models, but in the BEER model – particularly the 3-variable version including 10 year rates, inflation and terms of trade – this is far less of an issue.

A common (and fair) argument against valuation-based FX signals, is that it is counter-intuitive to use the PPP relationship, estimated in academic studies to have a half-life of 3-5 years, to generate monthly or even quarterly signals. Including interest rates in the model attempts to address this drawback, as they are intended to capture medium run influences on the exchange rate, transforming the model into a more medium-term one.

Indeed all the BEER model inputs are chosen with an underlying economic rationale, which in our view should capture the medium to long-run drivers of the FX rate. While such an approach need not generate the best performing back-tested strategy, we are comforted that the BEER-driven value strategy would nevertheless have done well in the long run.

Of course the counter argument is that there is greater model risk in choosing BEER, considering that the OECD measures are in fact model-free. As we have already touched upon, unconventional monetary policy has clearly affected markets in general, and FX rates in particular over the post-crisis years. The unwinding of unconventional policy will very likely also have an impact and relationships that held in the past could change. We cannot drive this risk to zero, but frequent evaluation of our models and our assumptions can mitigate it in our view.

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