



A primer on equilibrium G10 FX

We discuss theoretical and practical considerations, as well as problems involved in estimating equilibrium exchange rates, and present and compare estimates from the main models in the literature.

The (almost) impossible task of estimating the equilibrium exchange rate

We see a number of challenges inherent in estimating FX equilibrium levels, including: how to measure the Real Equilibrium Exchange Rate; how to determine the timeframe of interest; how to define and measure FX equilibrium in practice, including for all the variables involved in the analysis; the fact that FX may in fact rarely be at equilibrium, as economies themselves may rarely be at equilibrium and certainly almost never at equilibrium at the same time; measurement errors; and choosing the right methodology when estimates tend to differ substantially.

Despite the long list of issues, we still argue that estimates of the equilibrium exchange rate can be very useful.

An overview of equilibrium models

We discuss the main FX equilibrium models in the academic literature and present the latest estimates, including: x-EER, PPP and IMF models.

Main results

Although estimates for illustrative purposes differ depending on the model, in most cases they point to USD and CHF overvaluation, and SEK, JPY, EUR and GBP undervaluation. We also find that an FX-value strategy would have had broadly positive performance over the past two decades, and would be a positive addition to a portfolio, especially alongside carry and trend strategies.

G10 FX Strategy
Global

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The (almost) impossible task of estimating the equilibrium exchange rate

In what follows, we discuss a large number of problems and challenges with FX equilibrium estimates, including: how to measure the Real Equilibrium Exchange Rate (REER), and particularly the country weights; how to determine the timeframe of interest; how to define and measure FX equilibrium in practice, including for all the variables involved in the analysis; the fact that FX may in fact rarely be at equilibrium, as economies themselves may rarely be at equilibrium and certainly almost never at equilibrium at the same time; measurement errors; and choosing the right methodology when estimates tend to differ substantially.

Measuring the REER is challenging

The first problem is how to measure the REER, which is the target variable whose equilibrium level we want to estimate. In theory, the REER is the weighted average of bilateral exchange rates, using weights that measure the extent of competition among countries. In practice, this is much more difficult to measure.

The main challenge is what weights to use and how to determine the competitors of a country. The standard methodology is to use bilateral trade weights. However, this approach can have a number of problems. Just because two countries trade a lot with each other does not make them competitors. They may be part of a supply chain, with one country importing inputs from and exporting final output to the other country. Even if they produce in the same industry, the products may be differentiated enough that are not in direct competition. Furthermore, countries that may not be trading at all with each other may be competing in a third market. Although the IMF tries to adjust for third market competition, exporting to the same country also does not necessarily make two countries competitors if they export products that are supplements or are part of the same supply chain, or are sufficiently differentiated. There is a large academic literature trying to adjust for such problems, finding that the proper adjustment does tend to improve results, though at the cost of increasingly complex calculations. Unfortunately these studies usually control only for one or at best a few of these measurement issues at a time.

The appropriate timeframe is not always clear

Depending on the timeframe, the concept of the FX equilibrium can have very different meaning. One can say that all currencies are always in equilibrium because they are the prices that equalize demand and supply in the market. However, if FX responds to temporary flows, this is not a sustainable equilibrium. Extending the time horizon can address this issue. However, we could make a similar argument for variables that affect a currency, but are at temporary levels and therefore not at equilibrium, and could therefore change, in few weeks, months or years, depending on the variable. This suggests two concepts for an FX equilibrium, one during the cycle, which is likely to change, and one beyond the cycle, to which FX should eventually converge. However, this distinction itself raises new challenges, for example how to define the cycle and what variables we consider, and how we determine what defines the long term, beyond the cycle. Usually, analysts consider a 5-year horizon, but this is arbitrary.

Defining and measuring equilibrium in practice is difficult

The concept of the FX equilibrium typically focuses on the long term, beyond the business cycle, and is defined not based on a timeframe, but based on when the key FX determinants are in equilibrium. In theory, FX is in equilibrium when an economy has reached internal and external balance, meaning full employment and a zero output gap, growth at potential, neutral monetary policy and moderate inflation for internal balance; and a sustainable current account, meaning a relatively small balance that is easy to fund in the long term, for external balance.

Assessing when an economy has reached such a perfect state, of both internal and external equilibrium, suggests new challenges. There are many ways to estimate the natural level of unemployment and the equilibrium current account balance, but estimates and views vary, sometimes substantially. Getting the macro starting point wrong could lead to wrong FX estimates.

Even if the estimates for internal and external equilibrium are accurate, they are backward looking. When we want to know the long-term equilibrium to which FX is supposed to converge, estimates based on macro variables and historical relationships may not reflect what will happen in the years ahead. Potential growth and the external environment can change, thus also changing the FX equilibrium. Such changes will take years to be reflected in backward looking methodologies.

Economies may (almost) never be at equilibrium

By definition, we would expect a variable to spend more time at its equilibrium than away from it, as the equilibrium is supposed to pull the variable to its level. However, this does not seem to be the case in FX. Currencies tend to be volatile in the short term and go over long cycles in the long term. Either both the short-term and long-term equilibriums change very often, or their pull force is very weak. Even if we can get the equilibrium estimate right, the respective currency is likely to be at this value rarely. And again, note that we need both an internal and an external equilibrium for the economy, and then the currency will have to converge to the value consistent with such equilibrium. This makes the FX equilibrium an interesting theoretical concept that may have limited use in practice.

Moreover, as the REER is a multilateral concept, its equilibrium requires that all economies included in the calculation are in both internal and external equilibrium. In practice, this may never happen. Even assuming that we are able to estimate what internal and external equilibrium requires for all economies involved and what level of the exchange rate would be consistent with these estimates, it is highly unlikely that we will ever be in a state of the world in which all the economies in our sample have reached and remain at this state, and then their currencies will converge to the respective levels.

Measurement errors

Measurement errors in estimating the equilibrium REER can be a serious problem. As we discuss below, most methodologies include a large number of variables, have to take approximations for most of these variables, and make a number of simplifying assumptions. The data may suffer from differences in methodologies over time and across countries. Even the same variables often differ when we compare alternative data sources, even for major advanced economies and even for what should be standard macro variables. Measurement errors are likely to worsen the longer we go back in time and the more EM and frontier markets we include in the sample. The quality of the output in every analysis depends on the quality of the inputs, suggesting that estimates of FX equilibrium could be affected by such measurement errors.

Estimates vary substantially

Not surprisingly, given all the above issues, FX equilibrium estimates tend to vary substantially across different methodologies. In theory, they should all give broadly similar results. However, in practice estimates differ, depending on the methodology used, and not only in magnitude but sometimes even in sign. There is no one 'correct' way to address this disparity, and typically analysts either express a preference for a specific methodology, which could also depend on the currency in question, or take the average from a number of different methodologies, which helps to smooth out the errors.

Still, a useful benchmark

Despite the long list of problems, we still believe that estimates of the equilibrium exchange rate can be very useful. It gives us a long-run anchor to keep in mind to determine the extent to which a currency may be misaligned, even if in practice it may take a long time to get to this level, if at all. It can be a useful input for assessing the appropriate monetary policy stance and the impact of FX on the real economy, as an input for making longer-run hedging decisions, or indeed even in a systematic model framework as discussed in a subsequent section. Despite measurement errors and a wide range of estimates, if most methodologies point in the same direction, then most likely they are providing relevant information that, together with other factors, could affect FX markets. Even if the estimates eventually prove to be wrong, assessing why this turned out to be the case can provide useful information. So equilibrium estimates are flawed, but useful - they are just not forecasts.

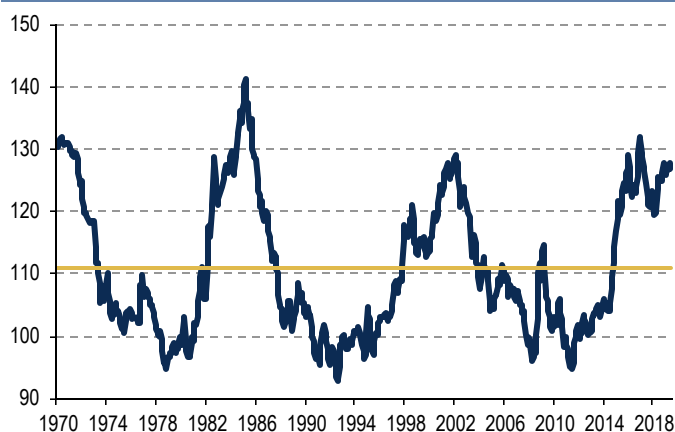
An overview of equilibrium models

Deviation of REER from historical average

The real effective exchange is the trade-weighted average bilateral exchange rate, adjusted for price differences. As we discussed above, there is a large literature on the proper weights, how to measure them and how often to change them, but the goal is to measure competitiveness compared with the rest of the world, with the latter defined as trading partners. For advanced economies, the REER should not have a sustained trend over the long term, or should even decline, but for EM it should be increasing, assuming economic convergence is in progress.

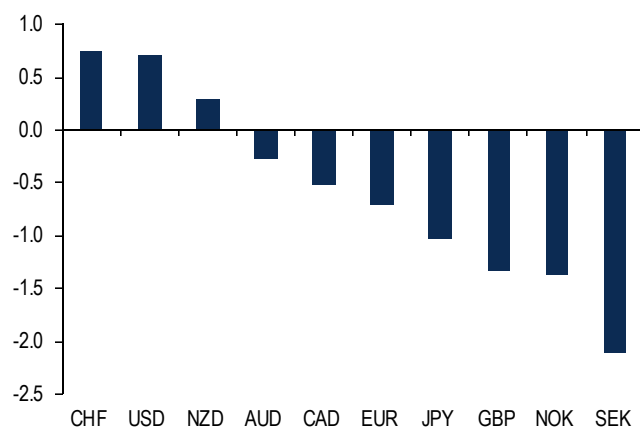
For G10 economies, it is safe to assume that the REER should mean revert over the long term. Indeed, the average USD REER has remained constant over the last 50 years (Chart 1). However, the REER can deviate from its long term average substantially and for sustained periods of time.

Chart 1: USD REER



Source: BofA Merrill Lynch Global Research, BIS and Bruegel.

Chart 2: Deviation from 20-year REER average (z-scores)



Source: BofA Merrill Lynch Global Research and BIS.

In this context, one of the simplest checks of whether a currency is above or below its long-term equilibrium is to compare it with its REER long-term average. We take the z-score deviation of the latest REER in G10 from its 20-year average, using BIS data. We assume that more than one standard deviation provides evidence of exchange rate misalignment, while more than two standard deviations provide evidence of substantial exchange rate misalignment (Chart 2). Based on this methodology, we find SEK to be substantially undervalued, followed by NOK, JPY and GBP, which are undervalued. The USD and CHF are the most overvalued currencies in G10 based on this methodology, but neither is necessarily overvalued, as the REER is above its long-term equilibrium but below one standard deviation. This approach would suggest that SEK, NOK, JPY and GBP could appreciate against USD and CHF in the long term. As we have flagged in previous

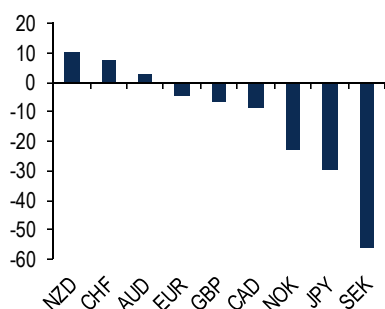
reports however, even in this simple approach the question of what constitutes the 'long term' remains. Taking a 10-year or 15-year average lookback could - likely would - change the outcome.

Law of one price: Purchasing Power Parity (PPP)

The PPP logic is simple. A product should have the same price everywhere, measured in the same currency. Starting with this broadly defined benchmark, in practice one will have to adjust for non-tradable goods and services, productivity differences (Balassa-Samuelson effects), transportation costs, tariffs, non-tariff barriers, regulations/red tape and other frictions, product differentiation, differences in consumer preferences, differences in market structure, different market structures and price discrimination, among possibly many others. Not surprisingly, empirical tests for PPP, usually testing for exchange rate stationarity/mean reversion, give weak results, with some improvement over long enough periods. Nevertheless, PPP is both intuitive and model-free, making it a simple and popular approach to estimating valuation. There are different approaches, but most use a measure of inflation (CPI or PPI), a single good (Big Mac Index) or basket of goods (OECD) to compare prices and back out the equilibrium exchange rate that would equalize the costs.

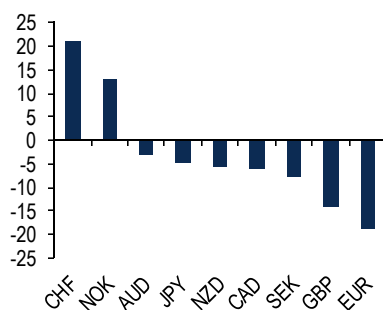
Using a 10% deviation from PPP as a threshold, which is somewhat arbitrary, the CPI-based PPP suggests that SEK, JPY, and NOK are undervalued, while NZD is overvalued (Chart 3). The OECD PPP measure suggests that EUR and GBP are undervalued at this threshold, while CHF and NOK, which was undervalued according to the CPI measure, are overvalued (Chart 4). Using the BigMac index, CHF is overvalued, while JPY, GBP, NZD, AUD and EUR are undervalued (Chart 5). Therefore, even for the same measure, different approaches can change the results, in some cases substantially.

Chart 3: G10 FX misalignment from equilibrium PPP estimates vs. USD (CPI-based)



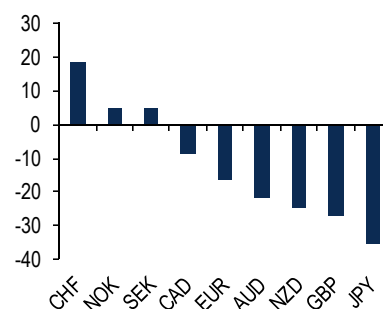
Source: BofA Merrill Lynch Global Research, Bloomberg

Chart 4: G10 FX misalignment from equilibrium PPP estimates vs. USD (OECD)



Source: BofA Merrill Lynch Global Research, Bloomberg

Chart 5: G10 FX misalignment from equilibrium PPP estimates vs. USD (BigMac)



Source: BofA Merrill Lynch Global Research, Bloomberg

Uncovered interest rate parity (UIP) and carry

UIP is related to the law of one price, and interest rate differentials (and carry), are a significant focus for FX market participants, so it is a natural addition to our exposition. The main logic behind UIP is that the expected path of interest rate differentials from the rest of the world should determine the deviation of the exchange rate from its long-term equilibrium.

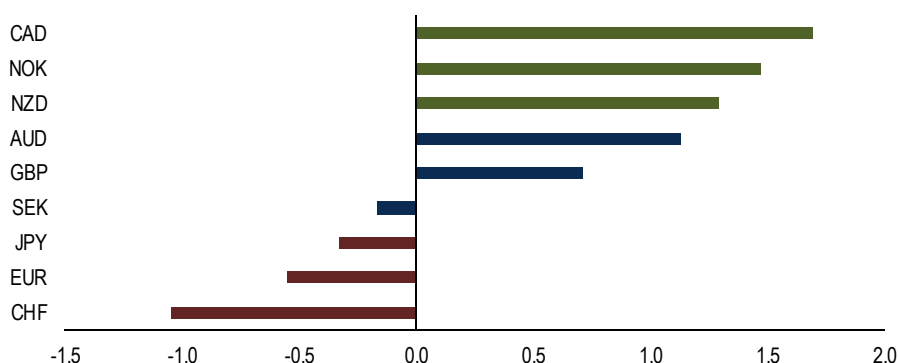
In practice, analysts use interest rate differentials to gauge whether an exchange rate is at the appropriate level and whether it is likely to move towards the higher interest rate because of carry, which is of course the opposite of the UIP predictions. Carry trades support the currency with the highest interest rate. In contrast, the UIP prediction is that markets expect the currency with the higher interest rate to weaken, which then equates expected returns with the rest of the world

The empirical failure of UIP is well-documented, and indeed well-known via the persistent profitability of FX carry trades, which themselves offer one possible explanation of why the exchange rate could deviate from its equilibrium in the short

term. Other factors of course also play a role, such as one-off flows, M&A flow, reserve diversification, and official foreign exchange interventions, among many others.

Current carry ranking using the 3-month forward implied yield would support long CAD, NOK and NZD positions vs. short JPY, EUR and CHF (Chart 6).

Chart 6: Carry ranking based on 3m forward implied yield



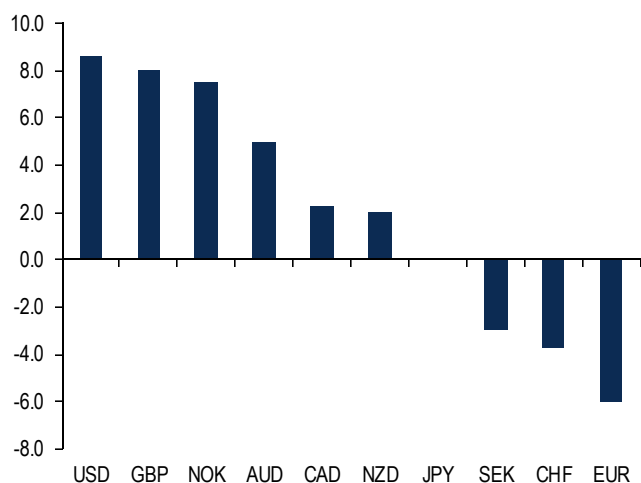
Source: BofA Merrill Lynch Global Research, Bloomberg

Fundamental Equilibrium Exchange Rate (FEER)

Moving quite a bit further along the scale of complexity brings us to FEER models. The FEER model estimates the equilibrium current account balance and then assesses by how much the exchange rate would have to move to allow the trend current account to reach its equilibrium, with the latter being different from the actual current account balance primarily because of cyclical forces and one-off shocks. It defines the equilibrium exchange rate as the level consistent with full employment, moderate inflation, and a sustainable current account balance—internal and external equilibrium. In this context, FEER is primarily a current account equilibrium model, based on a sustainable savings and investment balance, with the exchange rate the main channel through which the current account will reach its equilibrium in the long term. A variation of the FEER model is the Desire Equilibrium Exchange rate model (DEER), which assumes an appropriate path for fiscal policy and then estimates the exchange rate that would be consistent with it. This is similar to the IMF equilibrium estimates based on the appropriate macro policies (see below).

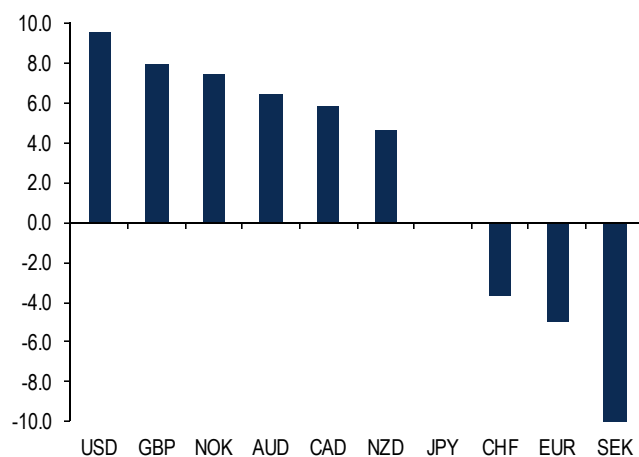
In what follows, we use the IMF FEER estimates for the G10 economies, updated for the REERs up to May 2019 (Chart 7). The results suggest that USD, GBP and NOK are overvalued, while EUR is undervalued. GBP is undervalued in most other methodologies, particularly after the Brexit referendum. However, the FEER model focuses on the large UK current account deficit and the need to adjust it. Also, these estimates do not suggest any substantial misalignment in G10 FX. Part of the reason is that [global imbalances](#) have declined since the global crisis.

Chart 7: G10 FX misalignment from equilibrium based on FEER



Source: IMF and BofA Merrill Lynch Global Research.

Chart 8: G10 FX misalignment from equilibrium based on IMF assessment



Source: IMF and BofA Merrill Lynch Global Research.

IMF external sector assessment

The IMF's approach combines FEER and REER exchange rate estimates with an analysis of external sustainability and views from IMF country teams to come up with range estimates of exchange rate misalignments. The IMF updates these estimates annually for each of its country members during its Article IV consultations. The logic behind the IMF approach is that model estimates can differ for various reasons, justifying looking at more than one methodology, and may not always capture everything, hence the adjustment based on country views and preference for range estimates.

The variables in the IMF analysis include: GDP, government consumption, exports and imports, population, population below working age, population above retirement age, employment, current account balance, fiscal balance, oil trade balance, official aid receipts, remittances, net foreign asset position, net government debt, real interest rate (short term and long term), and terms of trade.

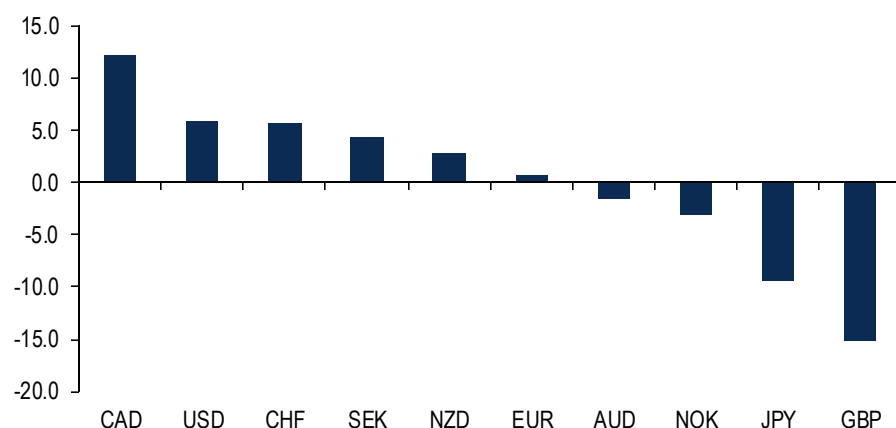
Based on the latest IMF estimates for G10 economies, USD, GBP, NOK, AUD, CAD and NZD are overvalued against SEK, EUR and CHF. Based on this methodology, only SEK seems to be substantially misaligned, particularly against USD, GBP and NOK.

Bloomberg-IMF REER model

Bloomberg has recently replicated the IMF's REER methodology. The list of independent variables include: net foreign assets, real GDP growth, government social spending, market volatility, dummy variable for currency reserve status, output gap, terms of trade, openness to trade, private credit, foreign reserve accumulation, population growth, population age, short-term interest rate differentials, productivity, financial home bias, and share of administered prices. This is a panel regression with 40 economies and fixed effects.

Based on the latest estimates, CAD is the most overvalued G10 currency, while GBP is the most undervalued (Chart 9). USD, CHF and SEK are also somewhat overvalued, while JPY is undervalued.

Chart 9: REER misalignment based on REER-model equilibrium estimates



Source: IMF, Bloomberg and BofA Merrill Lynch Global Research.

Behavioural Equilibrium Exchange Rate (BEER)

Another popular methodology from academia is the BEER model. In the x-EER approach, the equilibrium exchange rate is allowed to vary over time as a function of economic fundamentals. While FEER models try to estimate a sustainable level of the current account as explained above, BEER models directly model the behaviour of the exchange rate in terms of relevant economic variables. BEER models are our model of choice for our equilibrium estimates as they allow us to directly model exchange rates using timely macroeconomic variables, and offer a fairly intuitive interpretation of output.

The BEER methodology explains econometrically the REER based on a set of independent variables, which includes interest rate differentials plus fundamental factors that should in theory drive the exchange rate in the medium and long term, but do not necessarily have to be at their equilibrium levels. Examples of such variables include the terms of trade, the current account balance, ratio of tradable to non-tradable prices, net foreign assets and government debt. This is effectively a UIP equation with fundamentals. Analysts try different fundamental variables and keep the ones with a statistically significant impact in the preferred specification. Instead of trying to estimate a long-term exchange rate equilibrium, BEER focuses on fundamental factors and their changes that could explain changes in the REER in the short term, based on historical patterns. The forecasted values from the model are then compared with the latest REER level. A variation is the Permanent Equilibrium Exchange Rate model (PEER), which is a BEER, but using the equilibrium values of the fundamental variables—usually by removing cyclical components using statistical techniques.

In our version of the BEER we estimate our model using a panel regression, including only G10 economies, or including both G10 and EM economies. This methodology assumes homogeneity in the relationship between fundamentals and the exchange rate across economies. We 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, and we estimate both bilateral and trade weighted models, using trade weights from the Bank for International Settlements (BIS).

Our latest estimates are summarised below, both for the USD and EUR pairs (Table 1, Table 2), and on a trade weighted basis we find that NOK, GBP, SEK and AUD are undervalued, while CHF and USD are overvalued (Chart 11).

Table 1: Bilateral Equilibrium Estimates

Equilibrium Estimates USD pairs (current estimate)									
21-Aug-19	EUR/USD	USD/JPY	GBP/USD	AUD/USD	NZD/USD	USD/CAD	USD/NOK	USD/SEK	USD/CHF
Equilibrium Estimate	1.22	96	1.59	0.80	0.69	1.24	6.82	7.47	1.00
Spot	1.11	106	1.23	0.68	0.64	1.33	8.98	9.68	0.98
Misalignment	-9.14%	11.30%	-22.82%	-15.54%	-7.68%	7.28%	31.68%	29.54%	-1.63%

Source: BofA Merrill Lynch Global Research, Bloomberg

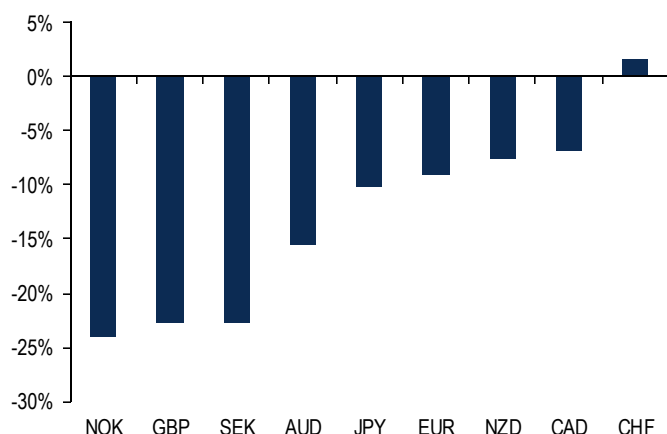
Misalignment against USD calculated with spot relative to estimate

Table 2: Bilateral Equilibrium Estimates

Equilibrium Estimates EUR pairs									
21-Aug-19	EURUSD	EURJPY	EURGBP	EURAUD	EURNZD	EURCAD	EURNOK	EURSEK	EURCHF
Equilibrium Estimate	1.22	116	0.77	1.53	1.76	1.50	8.30	9.10	1.21
Spot	1.11	117	0.90	1.64	1.74	1.47	9.95	10.72	1.09
Misalignment	-9.18%	1.27%	17.44%	7.17%	-1.12%	-1.73%	19.88%	17.82%	-9.91%

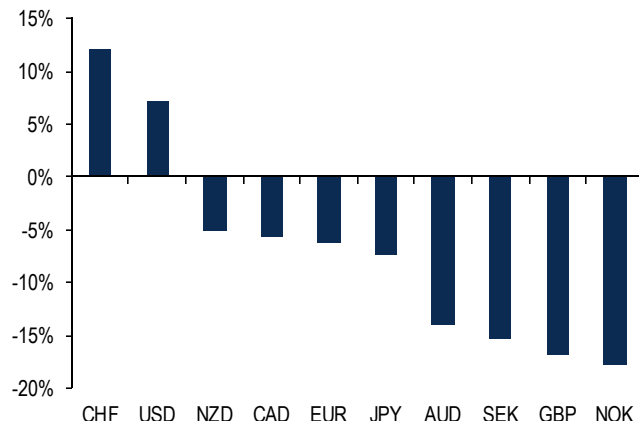
Source: BofA Merrill Lynch Global Research, Bloomberg, Haver Analytics

Chart 10: BEER misalignment from equilibrium for G10 currencies against the USD (in percent; negative for undervaluation against the EUR)



Source: BofA Merrill Lynch Global Research

Chart 11: TWI misalignment (3-variable BEER model)



Source: BofA Merrill Lynch Global Research

GBP again lends itself to make the point for a limitation of equilibrium exchange rate models. As mentioned in previous sections, estimates based on macro variables and historical relationships are backward looking. Macro variables change slowly and it can take years for equilibrium models to adequately adjust to reflect changes such as Brexit. Moreover, a risk such as Brexit implies that even very large deviations from equilibrium – which may itself be miss-specified – and which we may ordinarily expect to correct, can persist for long periods of time.

Bottom line

Results may vary, but consensus adds value...

As our discussion and the results above suggest, FX equilibrium estimates can differ substantially, depending on the methodology. However, when most methodologies point in one direction, most likely this is a sign of misalignment.

In our case, connecting the dots of all the above estimates flags the USD and CHF as overvalued, and SEK, JPY, EUR and GBP as undervalued (Table 3 and Chart 12). All methodologies show the USD as being overvalued, while most also show the CHF as being overvalued. Therefore, we don't really have to choose between these models in this case, as they seem to agree and only differ on the extent of overvaluation. Although estimates for illustrative purposes differ depending on the model, USD and CHF are

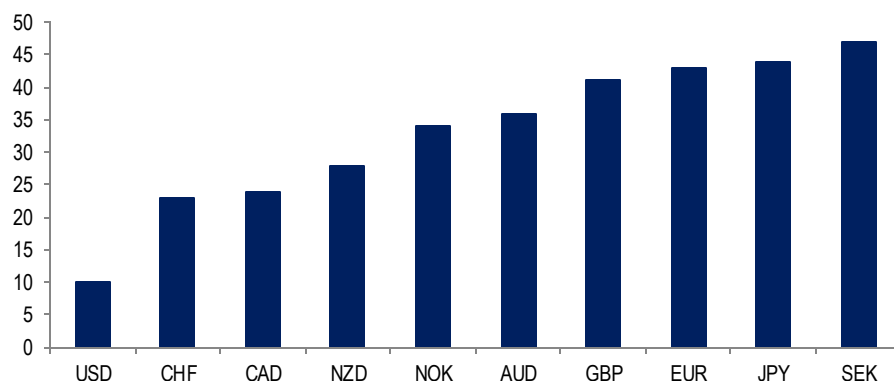
particularly overvalued against SEK, JPY, EUR and GBP, which are undervalued according to most methodologies.

Table 3: Misalignments summary (in %)

Method/Currency	USD	EUR	GBP	JPY	AUD	CAD	CHF	NZD	NOK	SEK
PPP (CPI-based)		-4.4	-6.5	-29.7	2.6	-8.8	7.5	10.5	-22.9	-56.1
PPP (OECD)		-18.9	-14.3	-4.8	-3.1	-6.3	20.9	-5.7	13.2	-7.8
PPP (BigMac)		-16.8	-27.0	-35.5	-22.0	-8.9	18.7	-24.9	5.0	4.6
BEER		-9.1	-22.8	-10.2	-15.5	-6.8	1.7	-7.7	-24.1	-22.8
IMF FEER	8.6	-6.0	8.0	0.0	5.0	2.3	-3.7	2.0	7.5	-3.0
IMF CGER	9.6	-5.0	8.0	0.0	6.5	5.8	-3.7	4.6	7.5	-10.0
TWI	6.0	-10.4	-16.7	-9.2	-15.9	-5.6	10.3	-5.4	-15.2	-15.6
REER	6.0	0.7	-15.2	-9.5	-1.5	12.2	5.7	2.9	-3.2	4.4

Source: BofA Merrill Lynch Global Research.

Chart 12: Sum of rankings in models of FX equilibrium (low ranking for overvaluation)



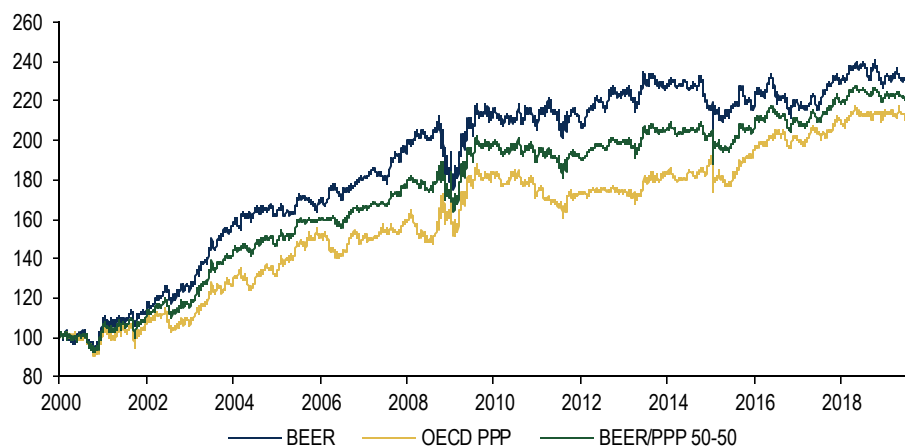
Source: BofA Merrill Lynch Global Research.

... even as a trading signal

Given the considerable list of weaknesses and limitations discussed so far, it may seem surprising to contemplate using an equilibrium model signal as part of a trading strategy. Indeed, although value strategies have a long history in other asset classes, the very difficulty of pinpointing what exactly value is in FX and how to measure it has made it less popular as an FX strategy. Our analysis however finds that FX value strategies can in fact add value, especially as part of a portfolio alongside trend and carry strategies.

The details of our methodology and trading strategy can be found [here](#), but the results suggest that an FX Value strategy would have had broadly positive performance over the past almost 2 decades of our backtest (Chart 13). We do note some marked differences in performance in the pre and post-crisis period, with substantial central bank activism and increasingly unconventional policy impacting performance as valuation mattered less and less. The past year has also shown the influence of the macro environment on the strategy, with a positive first quarter, followed by declines as central bank policies and trade war rhetoric took their toll.

Chart 13: FX Value Strategy Backtested Performance



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 Dec 1999 to 01 April 2019.

Source: BofA Merrill Lynch Global Research, Bloomberg

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