Behavioural Equilibrium Exchange Rate (BEER)

Abstract: In this article, we will introduce another method for evaluating the 'fair' value of a currency: the Behavioural Equilibrium Exchange Rate (BEER), a model which is widely used in practice. The BEER model was developed by Clark and MacDonald (1999) and estimates the fair value of currencies according to short, medium and long-run determinants. An important concept is that there is no prior theory for the choice of economic variables; hence, the choice of variables is based on economic intuition and data simplicity and availability.

We will also do an application of the BEER and run a Fixed-Effect panel regression on the G10 currencies, using the US Dollar as the base currency and three widely used macroeconomic variables - inflation, terms-of-trade and interest rates - for our regression. We will conclude by commenting the results and making a brief analysis on the Euro (Spot rate versus BEER value).

1 Introducing the BEER model: Behavioural Equilibrium Exchange Rate

1.1 The BEER Inception: Clark and MacDonald

The BEER model was developed by Clark and MacDonald (1999) and estimates the fair value of currencies according to short, medium and long-run determinants. An important concept is that there is no prior theory for the choice of economic variables; hence, the choice of variables is based on economic intuition and data simplicity and availability. The reduced-form equation proposed by Clark and MacDonald can be written as followed

$$e_t = \beta_1' Z_{1,t} + \beta_2' Z_{2,t} + \tau' T_t + \epsilon_t \tag{1}$$

where:

- Z_1 and Z_2 are vectors of economic fundamentals that are expected to have effect on the exchange rate over the medium and long term respectively

- β_1 and β_2 are vectors of reduced-form coefficients

- T is a vector of transitory factors affecting the real exchange rate in the short run

- τ is a vector of reduced form coefficients

- ϵ is the noise

As we are interested in modelling the medium-to-long run valuation of currencies, we can merge Z_1 and Z_2, skip the transitory matrix T and rewrite equation 1 as following:

$$e_t = \beta Z_t + \epsilon_t \tag{2}$$

We now have to specify the set of macroeconomic variables and the data that we used for our study.

1.2 Macroeconomic variables and data used for our study

The next step now is the choice of macroeconomic variables that are expected to affect the exchange rate in addition to explaining the economic intuition. Academic literature on modelling equilibrium exchange rates usually uses variables such as the productivity differentials, the fiscal policy, net foreign asset position, inflation differential, terms of trade or even proxies for capital controls. For our study and the frequency of the data, we chose to use the following macroeconomic variables:

- **Nominal Interest rates**: we will use the 10-year government bonds (relative to those of the US) to capture the effect of monetary policy divergence between countries. Due to the carry trade 'effect' (and violating UIP theory), a currency with higher interest rates will tend to appreciate in the medium term as high-interest-rate currencies will attract foreign capital inflows and put upward pressure on the currency.

- **Inflation** (CPI): a substantial increase in general prices is usually followed by a currency depreciation as a higher CPI in a specific country will lead to capital outflows as international investors will look for higher real interest rates in countries where the CPI is relatively lower. Therefore a widening spread should have a statistical and economic impact on a currency pair.

- **Terms of trade**: it reflects the evolution of the price of exports and imports of a specific country. This term could be viewed as the famous 'Dutch disease': a country with rich natural resources may attract investors and face a currency appreciation, then in the long term lose competitiveness due to a strong currency and may be forced to devalue leading to important ways of asset price inflation and deflation.

Data: Our study focuses on the G10 most liquid currencies, using the US Dollar as the base currency. In our reduced-form equation, the dependent variables is the nominal exchange rate relative to the USD (in log terms, Dollar is the base currency). We obtain a panel dataset with 892 observations, spanning from the 1991q1 to 2016q2. The dataset is unbalanced due to unavailable data for some countries. Note that to compute the Euro before 1999, we followed a synthetic currency approach using the following weights (Source: ECB):

Currency	Weight (%)
Deutsche Mark	34.66
French Franc	17.83
Italian Lire	14.34
Dutch Guilder	9.19
Belgium Franc	8.01
Spanish peseta	4.95
Irish punt	3.75
Finnish mark	3.27
Austrian shilling	2.91
Portuguese escudo	1.08

1.3 Panel Fixed Effect Model

To estimate the "fair" values of currencies we use a panel fixed effect (FE) model. The following reduced-form equation is used to estimate our long-run equilibrium relationship (all *log* expect for the IR differential as it can be negative):

$$e_{it} = \alpha_i + \beta_1 tot_{i,t} + \beta_2 irdiff_{i,t} + \beta_3 inflation_{i,t} + \epsilon_{it} \tag{3}$$

where

- e is the nominal exchange rate of currency i
- tot is the terms of trade differential between country i and the US
- irdiff is the interest rate differential
- inflation is the inflation rate differential
- α_i is the country specific fixed effect (captures the time-invariant characteristics of each country)

1.3.1 Results

We estimated the model in equation (3) by Ordinary Least Square (OLS), and the results of estimates for the β are reported in Table 1 (with the standard errors in parenthesis). Note that we assume the nominal exchange rate (in log terms) to be cointegrated with the set of macroeconomic variables, as through a series of tests, we find that the errors are stationary. We know that OLS regressions can lead to a spurious relationship when the variables are non stationary.

Table 1: Results of OLS-FE regression of model 3

Regressor	ln(e)
irdiff	**0.0564*****
	(0.0044)
inflation	**-0.977*****
	(0.0502)
tot	**0.564*****
	(0.0268)
Constant	**1.177*****
	(0.0205)
Observations	892
R-squared	0.457

Standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

We can see that all coefficients are statistically significant at a 1-percent level, and they all conform to economic intuition. A 1-percent increase in the relative terms of trade is associated with a 0.608 percent nominal currency appreciation, and a 1-percent increase in the interest rate differential is associated with 0.041 percent nominal currency appreciation. On the other hand, a 1-percent increase in the inflation differential is associated with a -0.987 depreciation in a country's currency against the US Dollar.

1.3.2 Consistency of our estimators

A first step before running the regression would be to test if the variables are non-stationary by running a series of ADF (Augmented Dickey-Fuller) unit root test on all variables, country by country. By doing so, the null hypothesis of a unit root could not be rejected for most of the cases; however, if we do the tests on the first-differenced series we can reject the null (with strong levels of significance). Therefore, we first conclude that the variables are non stationary and integrated of order 1 (i.e. I(1)).

Hence, due to the presence of non-stationarity, our OLS-FE regression will only provide consistent estimates if the included non-stationary variables are co-integrated. Our exercise will be to see if there exist a linear combination between the variables that is stationary, or in other words to check if the following combination:

$$e_{it} - (a_1 tot_{i,t} + a_2 irdiff_{i,t} + a_3 inflation_{i,t}) \tag{4}$$

is stationary (i.e. I(0)).

In order to check this, we ran a combined Fisher test for cointegration using our panel dataset and we found that the variables are cointegrated, giving us the *good* signal to run the OLS -FE regression.

1.3.3 Endogeneity issues

In econometrics, we know that Endogeneity is said to occur in a multiple regression model if:

$$E(X_j \epsilon) \neq 0 \tag{5}$$

for some $j = 1, ..., $ k.
And whenever there is endogeneity, OLS estimates of the β's will no longer be unbiased. There are three recognized sources of endogeneity:

1. Omitted Variables, or model mis-specification

2. Measurement Error

3. Simultaneity

From an academic perspective, an issue that will arise in the BEER model (equation 3) is the potential endogeneity between inflation and exchange rate movements, as it is possible that the rate of depreciation is not exogenous and correlated with the error term. A solution would be to lag inflation differentials by one period to mitigate endogeneity with the respect to the exchange rate. However, we won't do this exercise in this research as we look at the BEER model with a *practitioner* approach.

2 EURUSD vs. EUR BEER

Now that we described our BEER model that estimates the 'fair' value of currencies according to fundamentals, we are going to plot the chart of the Euro BEER value overlaid with the EURUSD spot rate (on a quarterly frequency). As you can see it on Figure 1, the Euro BEER FX rate (orange line) is much less volatile than the EURUSD spot rate (blue line). This is normal as the BEER exchange rate is determined by macroeconomics fundamentals (inflation, Terms of trade and interest rates), which are not that volatile on a quarterly base. However, with the FX market overseeing 5 trillion US Dollars in volumes (Spot, forwards and options) on a daily basis, the FX spot rate is subject to speculation, hence is more volatile than the 'macro' rate.
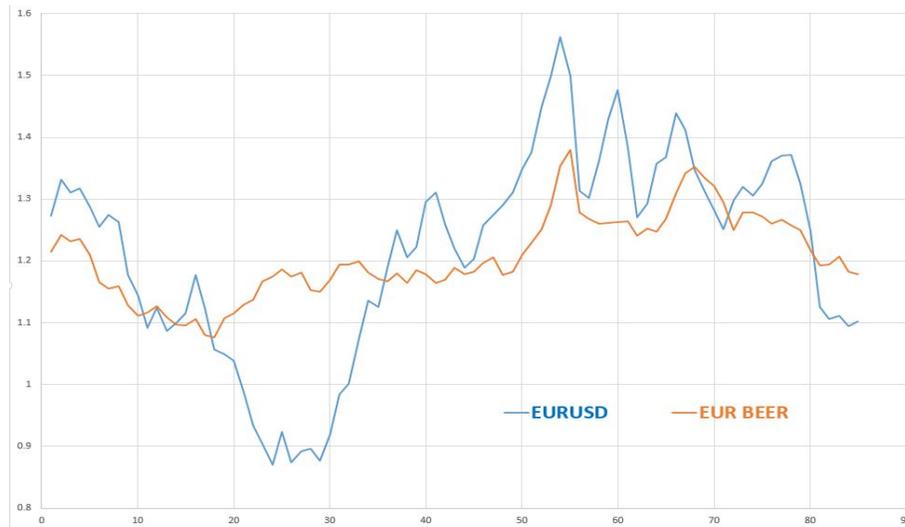

Figure 1: Euro BEER

Now the question is **'Does the FX spot rate (in that case the blue line) converge to its fundamental 'BEER' value (orange line) over the long run?'**

We saw some divergence in the early 2000s when the Euro was under pressure during the 1999-2002 period (see article **The History of the Euro (and the Euro Zone)** for more details), but the spot rate eventually converged back to its fundamental value a few years later.

In addition, the single currency continued to appreciate (against the greenback), eventually attaining its record high of 1.6037 in July 2008 in the wake of the Great Financial Crisis. At that period, there were thoughts that the Euro was potentially going to surpass the US Dollar as the World Leading Currency in the long run (Chinn and Frankel, 2008). On the other hand, fundamentals were *pricing* the single currency at $1.37 in Q3 2008, meaning that EURUSD was overvalued by roughly 17% according to the BEER model.

When the Financial Crisis spread around the world, the demand for US Dollars as a safe heaven asset rose dramatically and led to a sharp Euro depreciation in the second half of 2008; EURUSD plummeted from a high of 1.60 to 1.30 in Q1 2009.

While EURUSD spot rate (most of the time) traded above its fundamental 'BEER' value for more than a decade (Q4 2003 to Q4 2014), it eventually dropped below after the implementations of easing measures by the ECB: Draghi's major announcement was made in May 2014, followed by the negative interest rate policy (NIRP) in June 2014 and the launch of QE in January 2015.

In mid 2016, the Euro was worth roughly 1.18 USD according to the BEER model, while the spot rate was trading slightly below 1.10, meaning that the single currency was undervalued by 7 percent based on the fundamentals.

3 References

Clark P. and MacDonald R., *Exchange rates and economic fundamentals: A methodological comparison of BEERs and FEERs*, IMF, 1998

Clark P. and MacDonald R., *Filtering the BEER: A permanent and transitory decomposition*, IMF, 2000

G.M. Kuersteiner, D. Phillips, M. Villamizar, *Effective Sterilized Foreign Exchange Intervention? Evidence from a Rule-Based Policy*, 2016

L. Metzler, *Wealth, Savings, and the Rate of Interest*, 1951, JFE

J. E. Meade, *The Balance of Payments*, 1951

E. Fama, *Forward and Spot Exchange Rates*, 1984, JME

M. Damill, *Financial and Currency crisis in Latin America*, 2012

M. Evangelist, *Brazil's 1998-1999 currency crisis*, 2006

Bachman, Daniel. 1992. *The Effect of Political Risk on the Forward Exchange Bias: The Case of Elections*, 1992

J. Freeman,*The Politics of International Finance: A Pilot Study*, 1997, Paper presented at the Annual Meeting of the Midwest Political Science Association, Chicago, IL.

J. Freeman, *Democracy and International Finance: An Experimental Study* ,1997

W. Bernhard, D. Leblang *Political Processes and Foreign Exchange Markets*, 1999

A. Alesina, *Macroeconomic policy in a wo-party system as a repeated game*, 1987, QJE

T. Hasenzagl, *Party Ideology, Elections and the Exchange Rate: A Regression Discontinuity Design*, 2013