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2007

Online at https://mpra.ub.uni-muenchen.de/1981/
MPRA Paper No. 1981, posted 03 Mar 2007 UTC

Are Pound and Euro the Same Currency?

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Abstract

Based on long range dependence, some analysts claim that the exchange rate time series of the pound sterling and of an artificially extended euro have been locked together for years despite daily changes [1, 9]. They conclude that pound and euro are in practice the same currency. We assess the long range dependence over time through Hurst exponents of pound-dollar and extended euro-dollar exchange rates employing three alternative techniques, namely rescaled range analysis, detrended fluctuation analysis, and detrended moving average. We find the result above (which is based on detrended fluctuation analysis) not to be robust to the changing techniques and parameterizing.

PACS: 05.40.+j; 02.50.-r

Keywords: False euro; exchange rates; financial efficiency; Hurst exponent; R/S analysis; detrended fluctuation analysis; detrending moving average

1. Introduction

Some analysts have suggested that the pound sterling is redundant in that it behaves like the euro [1, 9]. The claim received reasonable media coverage in the financial press at the time. The authors devise a fictitious (“false”) euro to get the euro’s short time series extended. This is needed since their aim is to assess long range dependence. They find that before 1999 the pound fluctuated against the Deutschemark, the French franc, Finnish markka, Dutch guilder, and Austrian schilling in the same way as it fluctuated against the false euro. After 1999 the same matching pattern was seen between the pound and the euro itself. Apart from the Italian lira, the correlation coefficients of the pound, Deutschemark and French franc were all similar to those of the actual euro. According to the authors the results show that the pound and euro have been locked together for years despite daily changes in their respective exchange rates.

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We revisit the issue and take alternative techniques to calculating Hurst exponents [7, 8, 5], which are intended to capture long range dependence. We first consider time-varying Hurst exponents reckoned by rescaled range (R/S) analysis and find that while the pound-dollar exchange rate is getting more financially efficient as time goes by, the false (and actual) euro-dollar rate is not evolving toward efficiency. Then we reckon the Hursts employing detrended fluctuation analysis (DFA) and detrended moving average (DMA). Our findings show that the result that the pound and euro are the same currency depends on the technique employed.

The rest of this paper is organized as follows. Section 2 presents actual data, the false euro, and preliminary correlation tests. Section 3 reckons Hurst exponents over time for the exchange rates by R/S analysis, DFA and DMA. Section 4 concludes.

2. Data, False Euro, and Correlation

We take daily data for the actual exchange rates from the Federal Reserve website. The data set for the pound ranges from 2 January 1973 to 30 November 2006 (9012 data points). The false euro for the same time period is built on data from the euro itself.

Conversion rates at the launching of the euro are in Table 1. One euro can be represented as an unweighted sum of the eleven currencies C_i, i.e.

$$1euro = \sum_{i=1}^{11} \frac{\gamma_i}{11} C_i \tag{1}$$

where γ_i is a conversion rate.

To get the false euro, equation (1) can be extended backward [1]. A backward extension is needed because the series of the actual euro is too short to evaluating long range dependence. The series of the extended euro-dollar rate is built according to

$$\frac{1euro}{USD} = \frac{\sum_{i=1}^{11} \frac{\gamma_i}{11} C_i}{USD} \tag{2}$$

From 1 January 1999 on, the false euro-dollar rate series matches that of the actual euro-dollar rate. We follow Ausloos and Ivanova [1] and insert artificial data points wherever needed to cope with the problem of distinct official, national, and bank holidays, when banks are closed and official exchange rates are not defined in a country.

A first look at the problem through linear correlation suggests that the pound-dollar rate and the false euro-dollar rate are correlated (Figure 1). The linear correlation coefficient is of 0.875. Yet this finding seems to be related to first-moment correlation between the exchange rates. Indeed Figure 1 also suggests that the path changes direction and loops around. Second-moment correlation may also play a role. This might be the long range dependence that can be tracked by Hurst exponents.

3. Reckoning Hurst exponents by alternative techniques

Standard deviation in independent, normally distributed series behaves as $\sigma(t) \sim t^H$, where H = ½ and t is time [6]. The exponent of this scaling relationship between the standard deviation of a time series and the time increments used is the Hurst exponent. So an exponent H = ½ gives indication of a Brownian motion (random walk), i.e. a random process with no long range memory. The efficient market hypothesis thus assumes H = ½. Therefore values different from ½ suggest long range dependence. Values ranging from ½ to one are indicative of a persistent, trend-reinforcing series (positive long range dependence). And positive values that are shorter than ½ suggest that past trends tend to reverse in future (negative long range dependence).

R/S analysis was the technique to reckoning the exponent first employed by Hurst [7] himself. Given that the variable displacement scales as the square root of time, he expressed the absolute displacement in terms of rescaled cumulative deviations from the mean (R_n / S_n) and defined time as the number of data points (n) used. The scaling exponent of the relationship $R_n / S_n = cn^H$ (where c is a constant) is now the Hurst exponent. If data are independent, the distance traveled will increase with the square root of time and H = ½.

R/S analysis has been criticized for not properly distinguishing between short and long range dependence [10]. Yet the suggested modifications [10] bias against the hypothesis of long range dependence [11, 12]. This can be fixed by filtering the Hursts calculated by R/S analysis with an AR(1)–GARCH(1,1) process [2].

Our own calculations in here take the latter suggestion into account. We focus on time windows (subsets of the entire time series) of 1008 data points each (four-year size). Next we filter the first time window with an AR(1)–GARCH(1,1), and then reckon the Hurst using R/S analysis for the standardized residuals. We then move over to the next time window, which is built by discarding the first element of the previous one and inserting (at the end of the series) the subsequent point coming from the original time series. This routine is repeated successively.

These calculations thus consider the Hurst exponents evolving in time. One interpretation is that using time windows allows one to assess whether a series is getting more or less efficient [2]. Cautiously, histograms of the exponent plots must accompany the calculations. As the histograms are normally distributed, the exponent variations can be ascribed to measurement errors.

Employing R/S analysis, Table 2 shows that the average Hurst exponent for the false euro is 0.598 (standard deviation = 0.063). And Table 3 shows that the normality hypothesis for the Hurst is rejected for the false euro. In turn, Table 4 shows that the average Hurst exponent for the pound is 0.573 (standard deviation = 0.084). And Table 5 shows that the normality hypothesis is also rejected for the pound. At first glance all this suggests that there are slight departures from efficiency for both exchange rates.

Most studies in literature finding $H \neq ½$ fail to provide an accompanying significance test [4]. Thus we carried out Couillard and Davison's suggested test for the exponents above. For both cases, the estimated bias of the Hurst is of 0.037, and the 95 percent confidence limits under the null hypothesis that the time series follows and independent and purely random Gaussian process [4] is of 0.537 ± 0.035 (Figures 2 and 3).

Figures 2 and 3 show that while the pound-dollar exchange rate is getting more efficient as time goes by, the false (and actual) euro is not evolving toward efficiency. What is more, the pound's recent departure from its efficient trend (if permanent) coincides with the introduction of the euro itself. (Vertical bars in the charts show the date of launching of the euro.)

We check the cross correlations between returns of the pound and false euro as well as their Hurst exponents'. The biggest correlation between returns (0.42) is found between the pound at time period t and the false euro at $t - 23$. The remaining cross correlations are either short of 0.08 or practically zero. As for the cross correlations between the Hurst exponents, we find the biggest one (0.29) between the Hurst of the pound at t and the Hurst of the false euro at $t - 21$. All this suggests that the pound responds to false euro movements with a lag of one trading month. And thus it makes sense our interpretation that the launching of the euro may have driven the pound away from its road to efficiency.

We also calculate the Hurst exponents by DFA and DMA [3, 13]. Here we describe briefly the techniques. The steps for reckoning the Hursts by DFA are as follows. (1) Definition of the length of the sliding window (N); (2) splitting of the (nonstationary) time series $Z(t)$ in non-overlapping boxes of equal size n (starting, for instance, with $n = 1$); (3) fit of a q-degree polynomial function $\hat{Z}_{pol}(t) = \sum_{k=0}^{q} \beta_k^k t^k$ in every box; (4) calculation of the mean squared deviation for the sliding window, i.e. $\sigma_{DFA}^2 = \frac{1}{N} \sum_{t=1}^{N} (Z(t) - \hat{Z}_{pol}(t))^2$; (5) repetition of steps 1 to 3 to choosing a new n, and then going to step 4; (6) after collecting several values of n and σ_{DFA}^2, usage of the information that the standard deviation σ_{DFA} exhibits power law behavior with exponent H on n.

The routine to get the Hursts from DMA is as follows. (1) Definition of the length of the sliding window (N); (2) smoothing of the (nonstationary) time series $Z(t)$ using an n-term moving average (starting, for instance, with $n = 3$), i.e. $\hat{Z}_{ma}(t) = \frac{1}{n} \sum_{k=0}^{n-1} Z(t-k)$; (3) calculation of the mean squared deviation for the sliding window, i.e. $\sigma_{DMA}^2 = \frac{1}{N-n} \sum_{t=1}^{N-n} (Z(t) - \hat{Z}_{ma}(t))^2$; (4) repetition of steps 1 to 3 to choosing a new n, and then going to step 4; (5) after collecting several values of n and σ_{DMA}^2, usage of the information that the standard deviation σ_{DMA} shows power law behavior with exponent H on n.

Ausloos and Ivanova [1] themselves employ the DFA but take the linear case ($q = 1$) for the pound and false-euro series. To check for robustness, we repeat their calculations but now take $q = 3$ and $N = 1008$. Then we run the DFA with the same sliding window length ($N = 1008$). Unlike in Ausloos and Ivanova [1, 9], Figure 4 shows that behaviors of the currencies look distinct. Figure 5 displays the Hursts over time calculated by DMA, but this time we find dependence. Figures 6 and 7 present the exponents for the pound $H_{pound}(t)$ plotted against those for the false euro $H_{false-euro}(t)$ for the DFA and DMA respectively. The linear trend for the DFA is $H_{pound}(t) = 0.51 + 0.009\ H_{false-euro}(t)$, while the one for the DMA is $H_{pound}(t) = -0.18 + 1.3 H_{false-euro}(t)$. Thus while there is small correlation between the two using DFA (Figure 6), there is strong correlation using DMA (Figure 7), i.e. $H_{pound}(t) \propto 1.3 H_{false-euro}(t)$.

4. Conclusion

Based on long range dependence, some authors claim that the exchange rate time series of the pound sterling and of an artificially extended euro have been locked together for years despite daily changes [1, 9]. They conclude that pound and euro are in practice the same currency. We assess the long range dependence over time through Hurst exponents of pound-dollar and extended euro-dollar exchange rates employing three alternative techniques, namely rescaled range analysis, detrended fluctuation analysis, and detrended moving average. We find the result above (which is based on detrended fluctuation analysis) not to be robust to the changing techniques and parameterizing.

Acknowledgements. We are grateful to the SAS Institute for the software. Sergio Da Silva, Annibal Figueiredo, and Iram Gleria also acknowledge financial support from the Brazilian agencies CNPq and CAPES-Procad.

Table 1. Euro Conversion Rates as in 31 December 1998

Currency	**1 euro =**
Austrian schilling	13.7603
Belgian franc	40.3399
Finnish markka	5.94573
Deutschemark	1.95583
French franc	6.55957
Irish pound	0.787564
Italian lira	1936.27
Luxembourg franc	40.3399
Dutch guilder	2.20371
Portuguese escudo	200.482
Spanish peseta	166.386

Table 2. False Euro-Dollar Rate: Statistics for the Hurst Exponents over Time Calculated by R/S Analysis

Moments

Mean	0.59824632	Sum Observations	4477.87372
Std Deviation	0.06347701	Variance	0.00402933
Skewness	-0.1291315	Kurtosis	0.16584527
Uncorrected SS	2709.027	Corrected SS	30.1555133
Coeff Variation	10.6105143	Std Error Mean	0.0007337

Table 3. False Euro-Dollar Rate: Goodness-of-Fit Tests for Normal Distribution of the Hurst Exponents over Time Calculated by R/S Analysis

Test	Statistic		p Value	
Kolmogorov-Smirnov	D	0.02269011	Pr > D	<0.010
Cramer-von Mises	W-Sq	1.05002233	Pr > W-Sq	<0.005
Anderson-Darling	A-Sq	5.78502250	Pr > A-Sq	<0.005

Table 4. Pound-Dollar Rate: Statistics for the Hurst Exponents over Time Calculated by R/S Analysis

Moments

Mean	0.57354023	Sum Observations	4648.5436
Std Deviation	0.08398359	Variance	0.00705324
Skewness	0.61359367	Kurtosis	0.36429293
Uncorrected SS	2723.28627	Corrected SS	57.1594859
Coeff Variation	14.6430165	Std Error Mean	0.00093286

Table 5. Pound-Dollar Rate: Goodness-of-Fit Tests for Normal Distribution of the Hurst Exponents over Time Calculated by R/S Analysis

Test	Statistic		p Value	
Kolmogorov-Smirnov	D	0.0706557	Pr > D	<0.010
Cramer-von Mises	W-Sq	10.6360354	Pr > W-Sq	<0.005
Anderson-Darling	A-Sq	63.7222424	Pr > A-Sq	<0.005

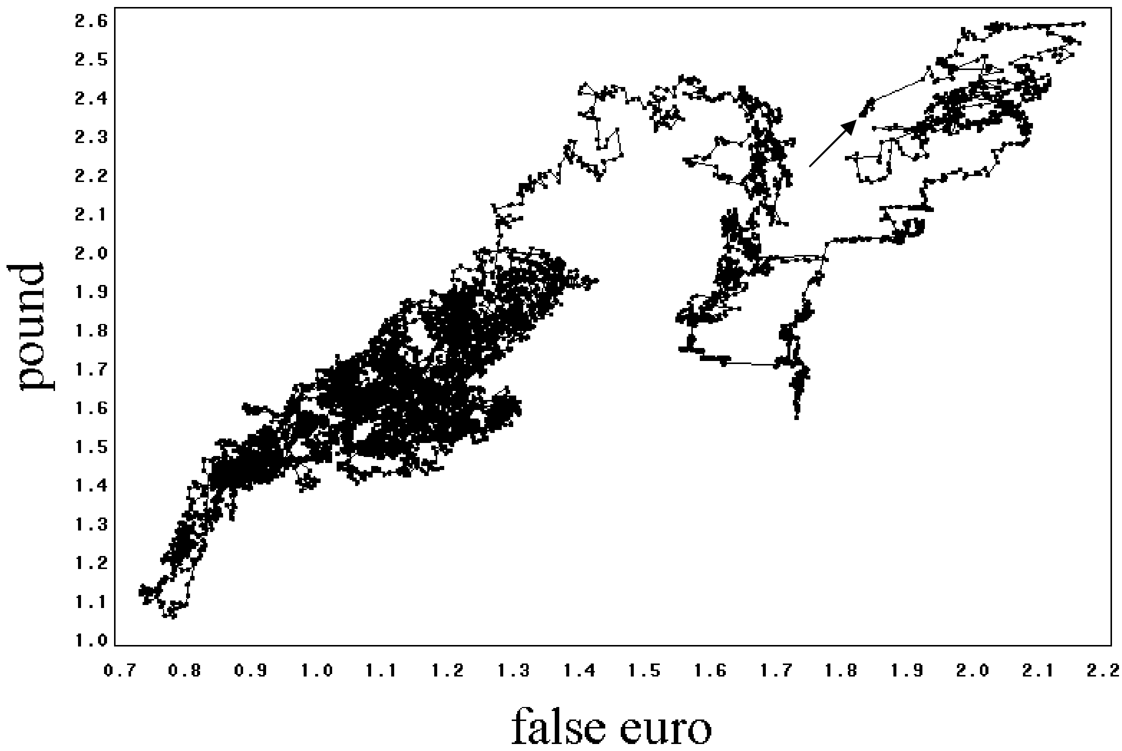


Figure 1. Pound-dollar and false euro-dollar correlation. The arrow indicates the starting point at 2 January 1973, and the continuous line tracks consecutive points.

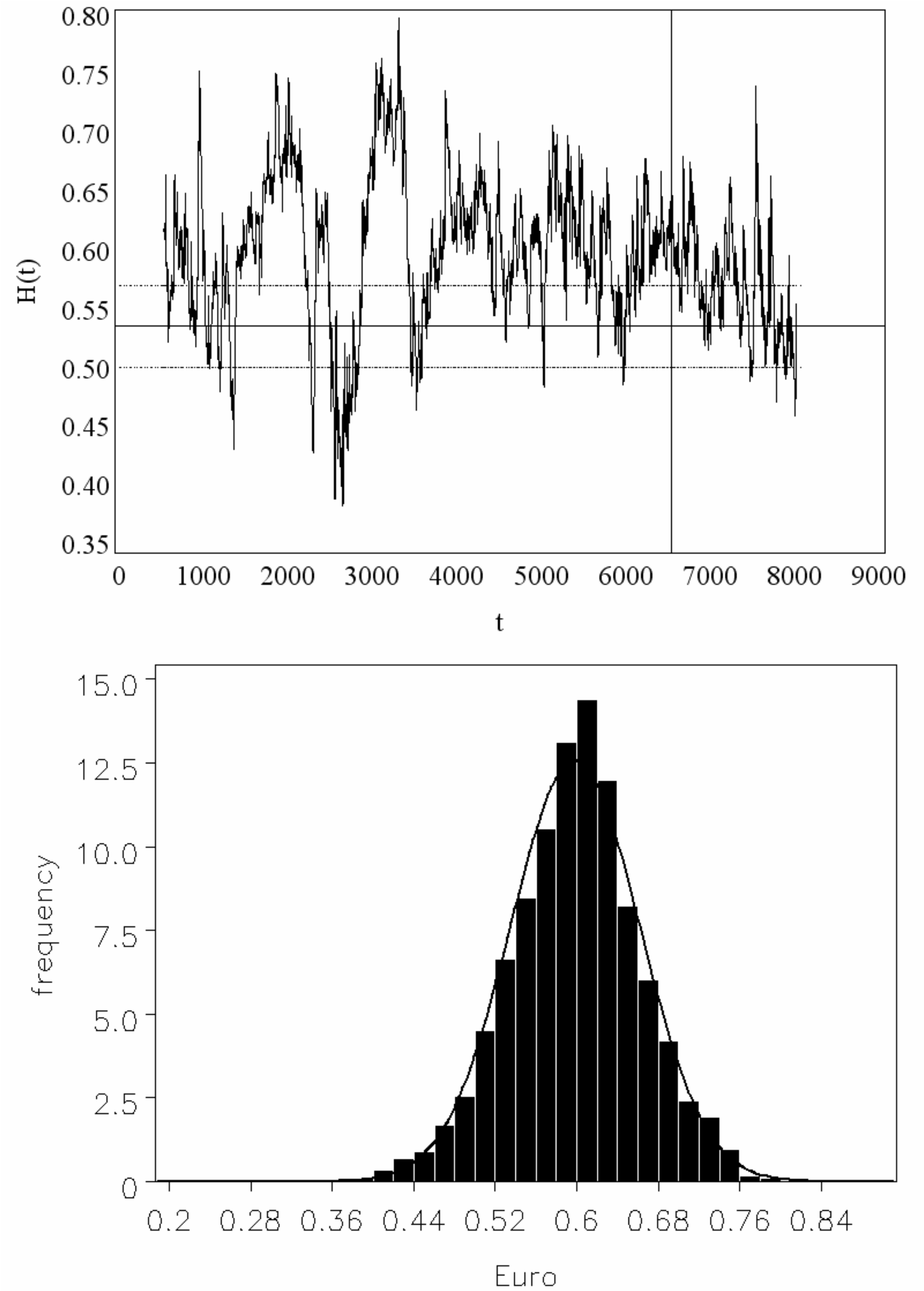
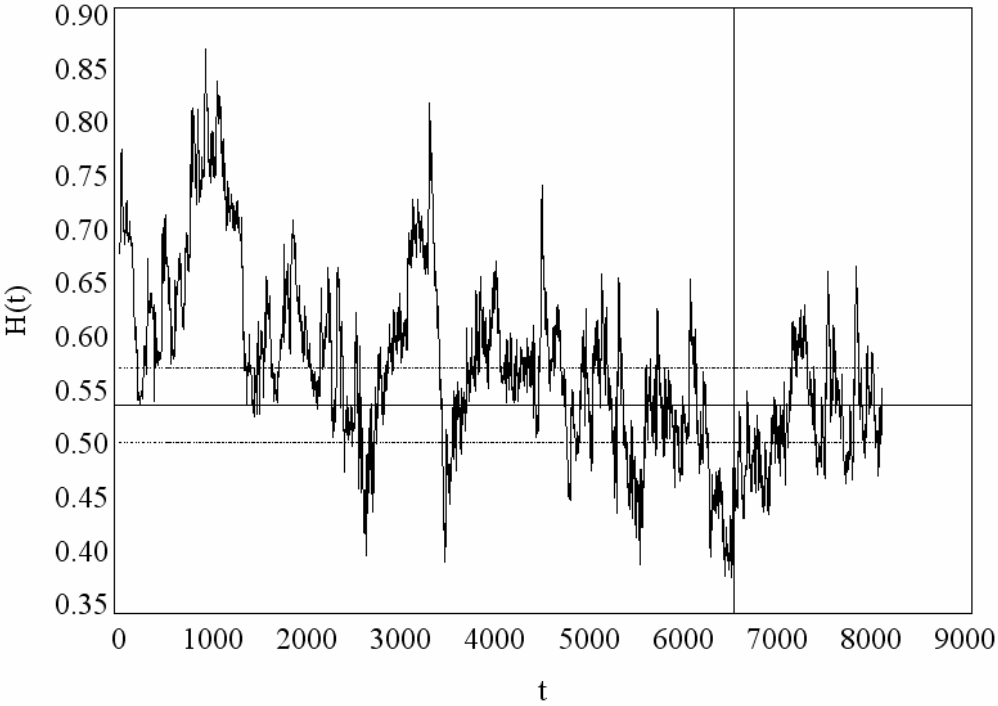


Figure 2. False euro-dollar rate: Hurst exponents over time calculated by R/S analysis. The horizontal lines are the upper and lower 95 percent confidence bounds under the null hypothesis that the time series follows and independent and purely random Gaussian process (Couillard and Davison's (2005) significance test).



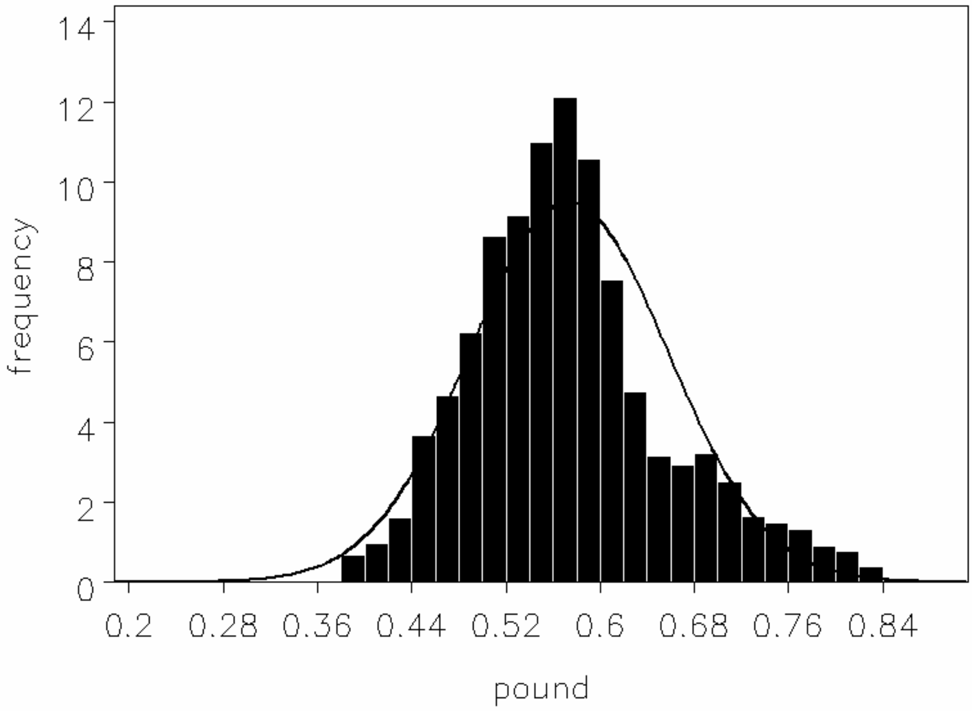


Figure 3. Pound-dollar rate: Hurst exponents over time calculated by R/S analysis. The horizontal lines are the upper and lower 95 percent confidence bounds under the null hypothesis that the time series follows and independent and purely random Gaussian process (Couillard and Davison's (2005) significance test).

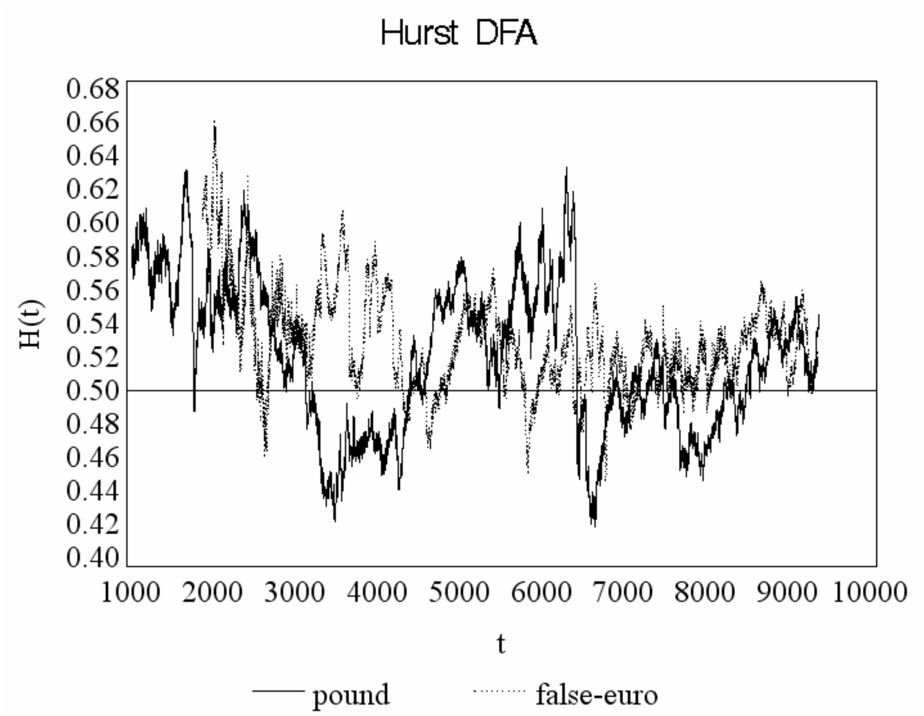


Figure 4. Time-varying Hurst exponents calculated by DFA (cubic polynomial) for the sliding window size of four years (1008 data points)

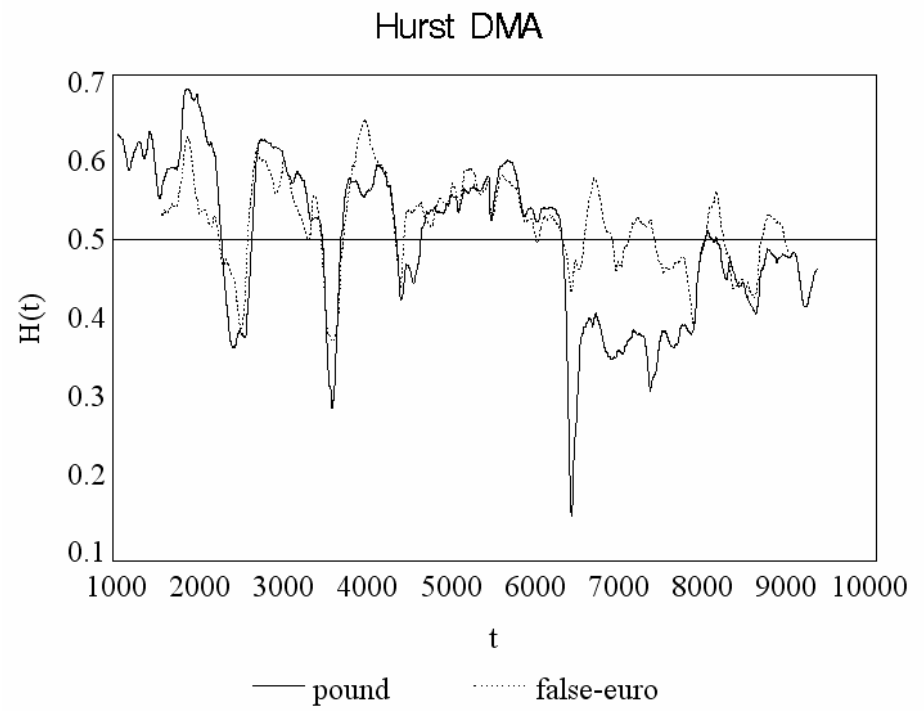


Figure 5. Time-varying Hurst exponents calculated by DMA for the sliding window size of four years (1008 data points)

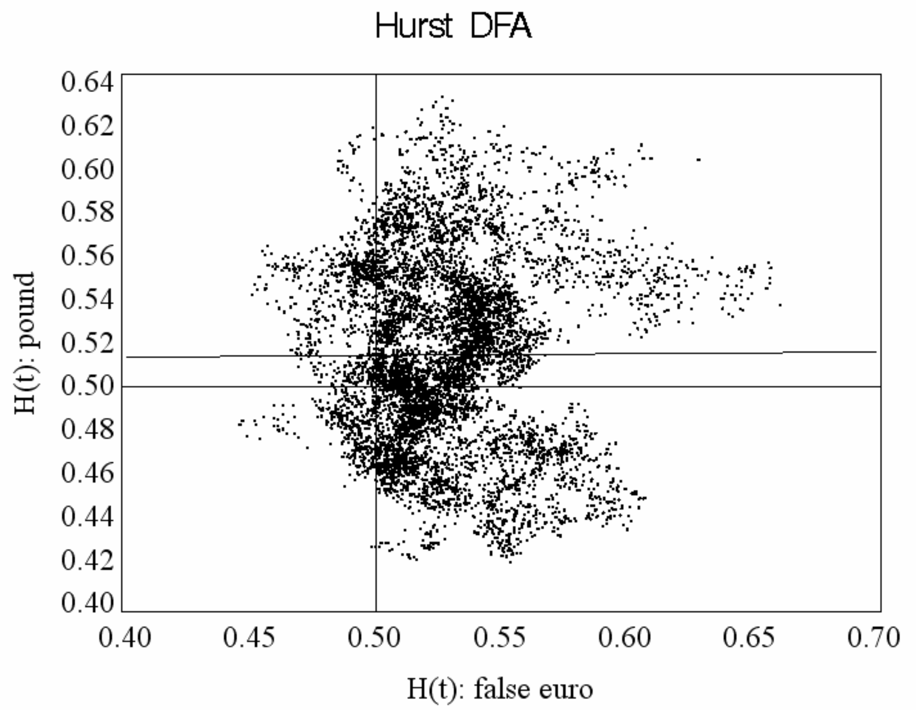


Figure 6. Small correlation: dispersion between the pound and false euro using the time-varying Hurst calculated by DFA (Figure 4). The linear trend is $H_{pound}(t) = 0.51 + 0.009\ H_{false-euro}(t)$

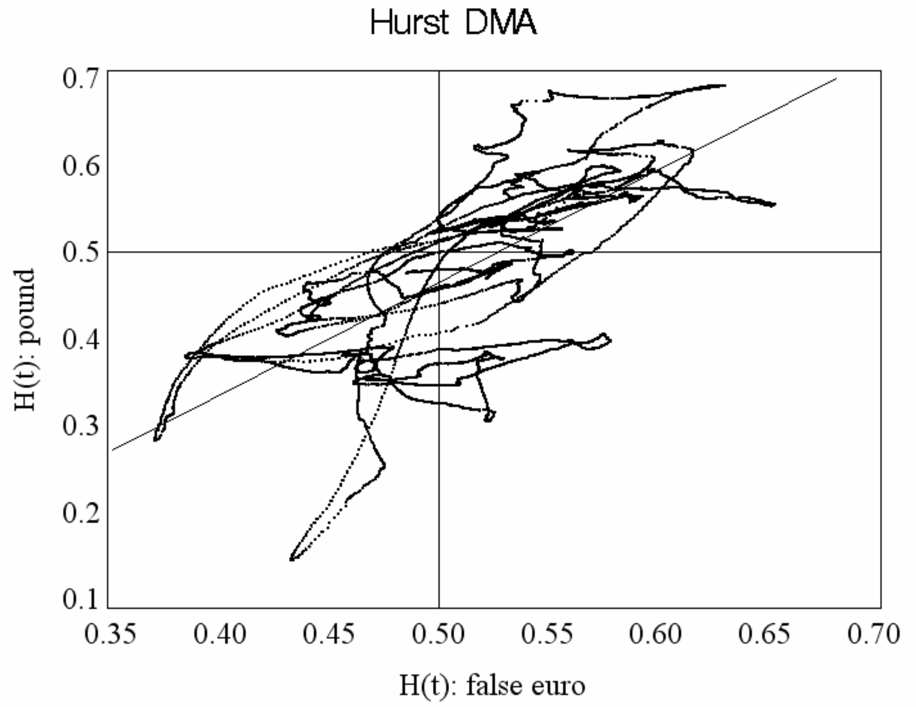


Figure 7. Strong correlation: dispersion between the pound and false euro using the time-varying Hurst exponents calculated by DMA (Figure 5). The linear trend is $H_{pound}(t) = -0.18 + 1.3\ H_{false-euro}(t)$

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