Are **EUR** and **GBP** different words for the same currency?

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**Abstract.** The British Pound (**GBP**) is not part of the Euro (**EUR**) monetary system. In order to find out arguments on whether **GBP** should join the **EUR** or not correlations are calculated between **GBP** and **EUR**, including a reconstructed **EUR** for the time interval from 1993 till June 30, 2000. The distribution of fluctuations of the exchange rates is Gaussian for the central part of the distribution, but has fat tails for the large size fluctuations. Within the **Detrended Fluctuation Analysis** (**DFA**) statistical method the power law behaviour describing the root-mean-square deviation of the exchange rate fluctuations is obtained as a function of time for the time interval of interest. The time-dependent exponent evolution of the exchange rate fluctuations is given. Statistical considerations imply that the **GBP** is already behaving as a true **EUR**.

**Key words.** Econophysics; Detrended fluctuation analysis; Foreign currency exchange rate; Euro; Scaling hypothesis

1 Historical Introduction

Inspired marketing may be needed to get the British to accept the euro [1]. The Prime Minister in early February 2001 said that he would call for a referendum on joining the euro within two years of a Labour party election victory. The British public seems hostile. Between a Mori poll a couple of years ago, and one in November 2000, the no’s climbed from 56% to 71%. The big problem for the euro camp is the emotional argument (abolishing the sterling). It is very difficult to sell advantages through rational arguments. It seems that the people are shouting for a football team, and the business elite wish to surrender sovereignty, since anyway they go for Tuscany for holidays, says Mr. Byrne, chief executive of Weber Shandwick Public Affairs, as quoted by R. Tomkins [1]. To argue in favor of the euro might be a hard task, but it is simply true that the Britons will use the euro, whatever their taste, in 2005, whether they like it or not. Mr. Draper, as quoted by R. Tomkins in Ref. 1 considers that it has to be emphasized that it makes no difference if all pounds turned into euro. It is just another name for money. This paper shows just that from a currency exchange point of view. So what the fuss?

Of course, from a financial and monetary policy, one can wonder what governments should do? In 1961 Mundell [2] asked whether it is advantageous
to relinquish monetary sovereignty in favor of a common currency? For fixed exchange rates, the central banks must intervene on the currency market in order to satisfy the public demand for foreign currency at this exchange rate. As a result, the central banks lose some control of the money supply which adjusts itself to the domestic liquidity. To implement independent national monetary policy by means of so-called open market operations becomes futile: neither the interest rate nor the exchange rate can be affected. A currency union as early as 1960 with fixed exchange rates existed within the so-called Bretton Woods System. International capital movements were highly curtailed, in particular by extensive capital and exchange rate controls. It was noticed that due to high capital mobility in the world economy, such regimes with a temporarily fixed, but adjustable, exchange rate were not robust. Whence several governments have some fear about joining a system like EUR. Often psychological or demagogic arguments are more relevant to the public than real economic ones, - see the case of Denmark. The Blair Government supports the principle of joining the single currency, if that is in the national economic interest but considers not to be ready yet. Can the exchange rates serve as arguments? We have searched for statistical correlations between EUR and GBP currency fluctuations.

Hereby the question is raised on how the GBP has fluctuated with respect to a false EUR, made of an equally weighted linear superposition of the 11 currencies forming EUR, and how GBP/EUR fluctuates since Jan. 01, 1999. Essentially it has been first searched whether the fluctuations did change after the formal introduction of EUR. Next it has been observed whether there is an a posteriori mathematical evidence for fluctuation correlations between GBP, EUR and the still presently national currencies. The considered time interval is Jan.01, 1993 to June 30, 2000 is presented.

The Detrended Fluctuation Analysis (DFA) is used. The α exponent characterizing the power law over the longest possible scaling range pertaining to this study is obtained. Next the local DFA study is performed and the resulting so-called correlation matrix is presented, eliminating the time as a series parameter. The data is summarized through the mean, the variance and the median of the local α exponents. Some financial policy statement and historical considerations arising from our observations serve as conclusions.

2 Experimental Data

The conversion rates of the EUR participating countries were fixed by political agreement based on the bilateral market rates of December 31, 1998. Using these rates, one Euro (EUR) can be represented as a weighted sum of the eleven currencies $C_i$, $i = 1, 10$:

$$1EUR = \sum_{i=1}^{10} (\delta_{i,2} + 1) \gamma_i \frac{1}{11} C_i$$  \hspace{1cm} (1)
where \( \gamma_i \) are the conversion rates and \( C_i \) denote the respective currencies, i.e. Austrian Schilling (\( ATS, i=1 \)), Belgian Franc (\( BEF, i=2 \)), German Mark (\( DEM, i=3 \)), Spanish Peseta (\( ESP, i=4 \)), Finnish Markka (\( FIM, i=5 \)), French Franc (\( FRF, i=6 \)), Irish Pound (\( IEP, i=7 \)), Italian Lira (\( ITL, i=8 \)), Dutch Guilder (\( NLG, i=9 \)), Portuguese Escudo (\( PTE, i=10 \)). In view of the financial identity of the Luxemburg Franc (\( LUF \)), with the Belgian Franc (\( BEF \)), the latter is weighted by a factor of two, whence the \( \delta \) Kronecker symbol in the above equation. In order to study correlations in the EUR/GBP exchange rate, the EUR existence can be artificially extended backward, i.e., before Jan. 01, 1999 and thereby defining an artificial EUR before its birth.\(^{[6]}\)

A data series of EUR exchange rates with respect to GBP is constructed following the linear superposition rule:

\[
1\text{EUR/GBP} = \sum_{i=1}^{10} (\delta_{i,2} + 1) \frac{\gamma_i}{11} (C_i/GBP)
\]  
(2)

Since the number of data points of the exchange rates for the period starting Jan. 1, 1993 and ending Dec. 31, 1998 is different for the eleven currencies, due to different national and bank holidays a linear interpolation has been used for the days when the banks are closed and official exchange rates are not defined in some countries. The number \( N \) of data points as equalized is \( N = 1902 \), spanning the time interval from January 1, 1993 till June 30, 2000.\(^{[6]}\)

The normalized and true EUR/GBP exchange rates so reconstructed are given in Fig. 1(a-b). For normalization purpose of the exchange rate Oct. 2, 1996 has been chosen as a typical day, i.e. are given in Table 1.

### Table 1. Indicative values, for normalization purposes of GBP exchange rate on Oct 2, 1996, e.g. 1 GBP \( \simeq 16.87 \) ATS. Numerical values of DFA-\( \alpha \) exponent for EUR-forming currency exchange rates. The scaling time interval is ca. one year. Values of the exponent of the power-law of tail of the distribution of fluctuations for EUR-forming currency exchange rates.

| \( C_i \) | ATS | BEF | DEM | ESP | FIM | FRF | IEP | ITL | NLG | PTE | EUR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ExR | 16.87 | 49.38 | 2.39 | 76 | 201.59 | 7.15 | 87 | 8.12 | 243.61 | 1.22 | 34 |
| \( \alpha \) | 0.47 | 0.47 | 0.50 | 0.51 | 0.46 | 0.47 | 0.41 | 0.40 | 0.49 | 0.45 | 0.46 |
| \( \pm 0.02 \) | \( \pm 0.02 \) | \( \pm 0.02 \) | \( \pm 0.02 \) | \( \pm 0.02 \) | \( \pm 0.02 \) | \( \pm 0.03 \) | \( \pm 0.02 \) | \( \pm 0.02 \) | \( \pm 0.02 \) | \( \pm 0.02 \) |
| \( \mu \) | 4.10 | 3.30 | 3.85 | 3.67 | 3.98 | 3.98 | 4.65 | 3.30 | 3.98 | 3.56 | 4.02 |

\(^{[1]}\) This last day was chosen for the studies in order to remain coherent and avoid a possible spurious effect arising from the Greek Drachma (\( GRD \)), introduced as a supplementary currency in EUR on June 19, 2000.
It is known that ExR like EUR/CHF and EUR/DKK are pretty stable across the transition to the EUR. However it seems that the ExR with respect to GBP has been much sensitive to the transition, with a noticeable decay of the EUR value after Jan. 01, 1999. See the 1995 bump of ITL, and dips at the end of 1993 for ATS, BEF, DEM and NLG ExR with respect to GBP, the rate evolution being rough. The ESP, FIM, and ITL seem currencies following weakly the ExR majority (and the ExR statistical mean) evolution.

3 Distribution of the fluctuations

The distributions of the exchange rate fluctuations for EUR/GBP are shown in Fig. 2(a) for the time interval of interest. Each distribution central part, i.e. the smallest fluctuations, is close to a Gaussian. The tails of the distributions, i.e. the large fluctuations, strictly depart from the normal distribution. Such tails usually have a slope markedly different from $-2$. These so-called fat tails are found to follow a power-law distribution with a slope of order of 4.0 for EUR/GBP. The distribution of fluctuations in exchange rates for each 11 currency of interest is shown in Fig. 2(b-k). The characteristic power-law exponent of the tail of the distributions for each $C_i/GBP$ is given in Table 1.
The distribution for DEM, FRF, FIM, NLG, and ATS are close to that of the EUR, but that for BEF, IEP and ITL is wide. The FRF large rate fluctuations are similar to those of the GBP.

4 Correlations between fluctuations in GBP exchange rates

The DFA technique[1] leads to investigate whether the root-mean-square deviations of the fluctuations of an investigated signal $y(n)$ have a scaling behaviour, i.e. whether the DFA function
\[ < F^2(\tau) > = \frac{1}{\tau} \sum_{n=k\tau+1}^{(k+1)\tau} [y(n) - z(n)]^2 \sim \tau^{2\alpha} \]  

scales with time; \( z(n) \) is a linear (trend) function fitting at best the data in the \( \tau \)-wide interval which is considered. A value \( \alpha = 0.5 \) corresponds to a signal mimicking a Brownian motion.

A log-log display of the DFA function leading to a measure of \( \alpha \) for the 11 exchange rates of interest is found in the inset of Fig. 3. The \( \alpha \)-exponent values for each national currency are summarized in Table 1. The time scale invariance holds from 5 days (one week) to about 250 days (ca. 52 weeks or one banking year) showing a Brownian-like type of correlations.

![Fig. 3. Time dependence of the DFA local \( \alpha \)-exponent for EUR and each currency (which forms the EUR) exchange rate with respect to GBP. The \( \alpha \)-values are artificially multiplied by two and then displaced along the vertical axis in order to make the fluctuations noticeable. Insert: Log-log plot of the DFA function showing how to obtain the \( \alpha \) exponent for the 11 exchange rates of interest for EUR/GBP.](image)

In all cases, notice that the value of \( \alpha \) for the EUR ExR falls very close to the Brownian motion value, a result indicating in particular the good sense of creating and using the EUR, thus guarding against speculations like those having existed on national european currencies.

In order to probe the existence of locally correlated and decorrelated sequences, an observation box, i.e. a 514 days (two years) wide window probe is placed at the beginning of the data, calculated \( \alpha \) for the data in that box,
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moved this box by one day toward the right along the signal sequence, calculated \( \alpha \) in that box, a.s.o. up to the \( N \)-th day of the available data. A local, time dependent \( \alpha \) exponent is thus found.

The time dependent \( \alpha \)-exponent for EUR/GBP ExR are shown in Fig. 3, where \( \alpha \) is determined from the best fit over the central, from 11 to 67 days (i.e., from 2 to 13 weeks) box/interval maintained to be constant for any day on the examined time evolution.

The evolution of fluctuation correlations in the currency ExR are very well seen. Notice how different the EUR/GBP ExR behaves with respect to ITL/GBP. Interestingly the \( \alpha \)-exponents for ESP, DEM and FRF are very close to the EUR-\( \alpha \)-exponent behaviour over the whole period, indicating the “control” of such currencies over the nine others. Notice the special behaviour of a country currency quite tied to the UK, i.e. the behaviour of IEP-\( \alpha \)-exponent is markedly different from the other EUR partners.

In Fig. 4 the time evolution of the statistical mean, median and standard deviation of the \( \alpha \) exponents for the currencies forming the EUR, are compared to that of the EUR in the ExR to GBP. Since the media is sometimes a better representation of the main behaviour of a system, it is of interest to consider the ratio between \( \alpha_{\text{mean}} \) and \( \alpha_{\text{median}} \), i.e. the upper curve in Fig. 4. The mean/median ratio has large fluctuations before 1996, but clearly tends to 1 thereafter; except for some 1999 spring period, the ratio is now a constant.

5 Intercorrelations between fluctuations

A graphical correlation matrix of the time-dependent \( \alpha \) exponent has been constructed for the various exchange rates of interest. In Fig. 5, \( \alpha_{C_i/GBP} \) vs. \( \alpha_{EUR/GBP} \) are shown for all \( i \) values. This so-called correlation matrix is displayed for the time interval hereby considered, i.e. from Jan. 01, 1995 till Dec. 31, 1998.

If the correlation is strong the cloud of points should fall along the slope = +1 line. It appears that the about equally strong correlations exist between the EUR/GBP and the DEM/GBP, EUR/GBP and FRF/GBP, EUR/GBP and BEF/GBP, EUR/GBP and NLG/GBP. Such a behaviour is related to the fact that DEM and FRF are the currencies of the leading economic countries, while BEF and NLG are tightly related to both. Note that the structural diagrams for ITL/GBP, IEP/GBP, and ESP/GBP with respect to EUR/GBP show weak or no correlation at all.

2 The interval is so chosen because the latter has to be reduced on one hand at the lower end due to the size of the testing window box, and at the upper end by the fact that after Jan. 01, 1999 the 11 currencies are not independent any more since their conversion rates are fixed within the EUR.
Fig. 4. Time evolution of the mean, median and standard deviation of the $\alpha$ exponents for the currencies forming the EUR, compared to that of EUR ExR with respect to GBP and the $\alpha_{\text{mean}}/\alpha_{\text{median}}$ ratio. The $\alpha_{\text{mean}}$ and $\sigma(\alpha)$ curves are not displaced. The $\alpha_{\text{median}}$ curve is displaced by -0.25. The $\alpha_{\text{EUR/GBP}}$ curve is displaced by +0.25. Horizontal dashed lines mark Brownian motion 0.5 level for each $\alpha$-data.

6 Conclusion

A few aspects of the EUR and its constitutive currencies exchange rates have been studied from the point of view of the fluctuations of the exchange rates toward GBP.

In examining various reconstructed exchange rates for the currencies forming the EUR before Jan. 01, 1999 it has been searched whether correlations would confirm historical and financial viewpoints and so called standard knowledge. The fluctuation distribution density as examined confirms that the foreign exchange markets do not follow Gaussian distributions. The distribution of the fluctuations is close to a Gaussian one only for small fluctuations, with power-law distribution for large fluctuations. The correlation between fluctuations were close to Brownian, and the more so after the EUR was introduced. There is no doubt that speculators have not found and do not find some way to gamble on the EUR/GBP exchange rates, since the DFA-$\alpha$ exponent is close to 0.5. It has been noticed that the introduction of the EUR tends to smoothen the fluctuations and their correlations, as well gather together in a main stream most of the European currencies, forming the EUR.
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Fig. 5. Graphical representation of the so-called correlation matrix elements for the time interval Jan. 01, 1995 till Dec. 31, 1999 for the various local $\alpha_{C_i/GBP}$ vs. $\alpha_{EUR/GBP}$ exponents, where $C_i$ are the ten EUR currencies of interest ($i=1,10$).
It is clear that the leading currencies from the point of view of the exchange rate fluctuations are DEM and FRF, with ITL far away from the main stream. The mean and median $\alpha$ evolution for EUR/GBP follows closely the mean and median $\alpha$ exponents for the currencies in the EUR. This is in favor of the conjecture that the GBP has already been part of the EUR system even before Jan 1, 1999.

Thus will the EUR be a gain for Britons or not? The answer is: not more than now, on a statistical sense, since (i) GBP is already a EUR currency according to the behaviour of local $\alpha$; (ii) the $\alpha_{\text{mean}}/\alpha_{\text{median}}$ ratio is close to unity; (3) correlation matrix elements are close to unity as well.

What will be the future of GBP? It will surely depend on the future of EUR, and explanations, not counting hard statistical facts. According to a Referendum Street program, broadcasted on Sunday Feb. 18, 2001 residents of a North London borough, opposed euro entry by 65% before hearing arguments; over the week-end, hearing both side arguments, they were in favour by 58%. Pro-euro had appealed to economic arguments, while the anti-euro side stressed the loss of sovereignty and the existence of a European super state. Our study shows that GBP is already part of EUR.

Acknowledgements

This paper arises from a question raised by P. Richmond (Trinity College, Dublin, and Norwich Union) at Applications of Physics to Financial Analysis (APFA2), Lige, Belgium, July 2000.[11]

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