False EUR Exchange Rates vs. DKK, CHF, JPY and USD.
What is a strong currency?

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Abstract. The Euro (EUR) has been a currency introduced by the European Community on Jan. 01, 1999. This implies eleven countries of the European Union which have been found to meet the five requirements of the Maastricht convergence criteria. In order to test EUR behavior and understand various features, we have extrapolated the EUR backwards and therefore have obtained a false euro (FEUR) dating back to 1993. We have derived the exchange rates of the FEUR with respect to several currencies of interest not belonging to the EUR, i.e., Danish Kroner (DKK), Swiss Franc (CHF), Japanese Yen (JPY) and U.S. Dollar (USD). We have first observed the distribution of fluctuations of the exchange rates. Within the Detrended Fluctuation Analysis (DFA) statistical method, we have calculated the power law behavior describing the root-mean-square deviation of these exchange rate fluctuations as a function of time, displaying in particular the JPY exchange rate case. In order to estimate the role of each currency making the EUR and therefore in view of identifying whether some of them mostly influences its behavior, we have compared the time-dependent exponent of the exchange rate fluctuations for EUR with that for the currencies that form the EUR. We have found that the German Mark (DEM) has been leading the fluctuations of EUR/JPY exchange rates, and Portuguese Escudo (PTE) is the farthest away currency from this point of view.

1 Introduction

The Euro (EUR) is a bona fide currency introduced by the European Community on Jan. 01, 1999 in contrast to the XEU which was a theoretical "basket" of currencies. The EUR is superseding national currencies in eleven countries of the European Union which have been found to meet the five requirements of the Maastricht convergence criteria: price stability, fiscal prudence, successful European monetary system membership, and interest-rates convergence in particular. In order to test EUR behavior and understand various features, we have extrapolated the EUR backwards and therefore have obtained a false euro (FEUR) dating back to 1993. We have reconstructed the exchange rates of the FEUR with respect to several currencies of interest not belonging to the EUR, i.e., Danish Kroner (DKK), Swiss Franc (CHF), Japanese Yen (JPY) and U.S. Dollar (USD).
The DKK is a currency for a country belonging to the European Community and outside the EUR system. The CHF is a European currency for a country NOT belonging to the European system. The JPY and USD are both major currencies outside Europe.

The irrevocable conversion rates of the participating countries have been fixed by political agreement based on various considerations and the bilateral market rates of December 31, 1998 [1,2,3]. Using these rates one false Euro (FEUR) can be represented as an unweighted sum of the eleven currencies $C_i$, $i = 1, 11$:

\[
1EUR = \sum_{i=1}^{11} \frac{\gamma_i}{11} C_i
\]

(1)

where $\gamma_i$ are the conversion rates and $C_i$ denote the respective currencies, i.e. Austrian Schilling (ATS), Belgian Franc (BEF), Finnish Markka (FIM), German Mark (DEM), French Franc (FRF), Irish Pound (IEP), Italian Lira (ITL), Luxembourg Franc (LUF), Dutch Guilder (NLG), Portuguese Escudo (PTE), Spanish Peseta (ESP). In order to study correlations in the EUR exchange rates as of now, the EUR existence can be artificially extended backward, i.e., before Jan. 01, 1999. This can be done by applying Eq.(1) to each participating currency for the time interval of the exchange rates which are available before Jan. 01, 99, thereby defining a more or less legal (but false) FEUR before its birth. Nevertheless we drop the letter $F$ in FEUR thereafter.

We are concerned with the behavior of EUR toward currencies which are outside the European Union, since nowadays these are the only exchange rates of interest. These are e.g. Danish Kroner (DKK), Swiss Franc (CHF), Japanese Yen (JPY) and U.S. Dollar (USD). Therefore, we construct a data series of EUR toward e.g. Japanese Yen ($EUR/JPY$) following the artificial rule:

\[
1EUR/JPY = \sum_{i=1}^{11} \frac{\gamma_i}{11} C_i/JPY
\]

(2)

However, the number of data points of the exchange rates for the period starting Jan. 1, 1993 and ending Dec. 31, 1998 is different for these eleven currencies toward DKK, CHF, JPY and USD. This is due to different national and bank holidays when the banks are closed and official exchange rates are not defined in some countries. The number $N$ of data points has been equalized as done in [3], assuming that the exchange rate does not change if there is such a gap (usually a holiday), such that $N = 1985$, spanning the interval time from January 1, 1993 till October 31, 2000.

The evolution of the false (from Jan. 1, 1993 to Dec. 31, 1998) and the real (from Jan. 1, 1999 to Jun 30, 2000) EUR with respect to the DKK, CHF, JPY, and USD are plotted in Fig. 1. While the EUR/DKK exchange
rate is not much disturbed by the transition to the real EUR, the other currencies, in particular USD and JPY and a little bit less CHF have been much sensitive to the transition.

Fig. 1. Normalized evolution assuming an exchange rate = 1 on Jan. 01, 1999 for EUR/DKK, EUR/CHF, EUR/JPY and EUR/USD

The DFA technique has been often described and is not recalled here. It leads to investigating whether the root-mean-square deviations of the fluctuations of the investigated signal $y(n)$ has a scaling behavior, e.g. if the function $< F^2(\tau) >$ scales with time as

$$\langle \frac{1}{\tau} \sum_{n=k\tau+1}^{(k+1)\tau} [y(n) - z(n)]^2 \rangle \sim \tau^{2\alpha} \quad (3)$$

where $z(n)$ is hereby a linear function fitting at best the data in the $\tau$ interval which is considered. A value $\alpha = 0.5$ corresponds to a signal mimicking a Brownian motion.

Let it be recalled that in [3] it has been shown that the time scale invariance for EUR/CHF, EUR/USD, and EUR/JPY holds from 5 days (one week) to about 300 days (one year) showing Brownian type of correlations. Two different scaling ranges were found for the EUR/DKK: one, from four to 25 days (5 weeks) with a non-Brownian $\alpha = 0.37 \pm 0.01$, and another, after that for up to 300 days (61 weeks) with Brownian-like correlations.

In order to estimate the role of each currency making the EUR and therefore in view of identifying whether some of them mostly influences its behavior, we have first looked at the distribution of exchange rate fluctuations in the interesting time interval defined above. Next the time-dependence of
the $\alpha$ exponent characterizing the scaling law for the exchange rate fluctuation correlations for EUR and that for the 11 currencies that form EUR has been calculated. This evolution has been averaged (i) over the currencies, (ii) over the time interval considered here. The results are compared here to the behavior of the fluctuation correlations for EUR/JPY and DEM/JPY exchange rates. Let it be pointed out that we have also tested elsewhere the DKK, CHF and USD exchange rates with respect to EUR, DEM and the other EUR forming currencies [5].

2 Distribution of the fluctuations and strong currency

It is of interest to observe whether the usual statement that the EUR is nothing else than a generalized DEM holds true. In order to do so we have first compared the distributions of the exchange rate fluctuations for DEM/DKK, DEM/CHF, DEM/JPY, DEM/USD with the distributions of the fluctuations for EUR/DKK, EUR/CHF, EUR/JPY, EUR/USD (Fig. 2). From such a comparison we are led to consider that DEM is dominant in defining the distribution of the fluctuations of EUR exchange rate with respect to DKK, CHF, JPY and USD. For all cases the central part of the distributions can be fitted by a Gaussian distribution while the tails, i.e. the large fluctuations, follow a power law with a slope equal to ca. 2.9 for EUR/CHF and DEM/CHF, 3.2 for the negative and 4.0 for the positive tail of EUR/JPY and DEM/JPY, and 3.2 for the negative and about 4.5 for the positive tail in EUR/USD and DEM/USD.

It is fair to recall that the volatility of exchange rates follows different scaling laws depending on the horizon which is considered [6]. However the correlation coefficient stabilizes at scales one day and higher [7]. Those values might be examined whether they result from the equivalent of trading momentum and price resistance just like in the model of [8] for stock price and price fluctuation distribution. The above asymmetry in the power law for the positive and negative tail might result or not from the limited amount of data.

3 Correlations of the fluctuations and strong currency

As done elsewhere [9], in order to probe the existence of locally correlated and decorrelated sequences, we have constructed an observation box, i.e. a 515 days ($\approx$ 2 years) wide window probe placed at the beginning of the data, calculated $\alpha$ for the data in that box, 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 for the $N - 515$ last days. The JPY exchange rate case results only are illustrated in this report. The time dependent $\alpha$ exponent for EUR/JPY and that for each of the 11 currency (which form the EUR) exchange rates toward
JPY have been computed. Together with the EUR/JPY result, some of the
time dependent $\alpha$-exponents, i.e. for ATS/JPY, DEM/JPY, ITL/JPY,
PTE/JPY are shown in Fig. 3 as the most representative ones of various
behaviors. Notice, the similarity between EUR/JPY and DEM/JPY, a
maximum in 1998 but a rather flat behavior for ATS/JPY, a very irregular
behavior for ITL/JPY, and an increase in $\alpha$ around 1998 for PTE/JPY.
The other cases, i.e. BEF/JPY, FIM/JPY, FRF/JPY, IEP/JPY, and
NLG/JPY are similar to ATS/JPY and DEM/JPY cases. While the dif-
fences in the $\alpha$-behavior after Jan. 1, 1999 are almost undistinguishable,
the time dependent $\alpha$-exponents before that day exhibit nevertheless
different correlated fluctuations depending on the currency. We stress that $\alpha$
for EUR/JPY most closely resembles the DEM/JPY before and after Jan. 01,
99, they are almost identical already since mid 1996.

Notice that the $\alpha$-exponent for EUR/JPY and those $\alpha$-values of the
other currency exchange rates are not strictly equal to each other even after
Jan. 1, 1999 because the fit window used for calculating $\alpha$ includes days prior
Fig. 3. The evolution of the local value of $\alpha$ estimated with the DFA method for a window of size 2 years (solid line) for (a) EUR, (b) ATS, (c) DEM, (d) ITL, (e) PTE with respect to JPY. Dotted lines mark one standard deviation in the $\alpha$ estimate. Dashed horizontal lines indicate a 0.02 threshold relative to the uncorrelated fluctuations of a Brownian motion signal, $\alpha = 0.5$.

to Jan. 1, 1999. A strict identity should only occur on Jan. 1, 2001, i.e. after two years (515 days) from EUR strict birth. Yet, the values are already very close to each other (less than 1%) before such a date.

Looking for more diversified answers to our question on whether e.g. DEM truly controls the market, we have constructed a graphical correlation matrix of the time-dependent $\alpha$ exponent for the various exchange rates of interest. In Fig. 4(a–j), the correlation matrix is displayed for the time
Fig. 4. Structural correlation diagram of the DFA - $\alpha$ exponent for the exchange rate EUR/JPY and the DFA - $\alpha$ exponent for the exchange rate with respect to JPY of the 11 currencies forming one EUR; (BEF=LUF)
interval between Jan. 1, 1993 and Jan. 1, 1999 for $\alpha_{EUR/JPY}$ vs. $\alpha_{C_i/JPY}$, where $C_i$ stands for the 11 currencies that form the EUR; ($BEF=LUF$). As described elsewhere, e.g. in [10], such a diagram can be divided into sectors through a horizontal, a vertical and perpendicular diagonal lines crossing at $(0.5,0.5)$. If the correlation is strong the cloud of points should fall along the slope = 1 line. This is clearly the case of the relationship between $\alpha_{EUR/JPY}$ and $\alpha_{DEM/JPY}$, while the largest spread is readily seen for $\alpha_{EUR/JPY}$ vs. $\alpha_{PTE/JPY}$.

In order to assess additional features of the time dependent $\alpha$-exponents of the exchange rate fluctuation correlations we have time averaged $\alpha$ for the EUR exchange rate with respect to JPY, and for each of the 11 eleven currencies which form EUR, over the time interval [Jan. 1, 1993 - Jan. 1, 1999]. We present the results of $\alpha_{mean}$, $\alpha_{median}$, $\alpha_{mean}/\alpha_{median}$ and the standard deviation $\sigma(\alpha)$ in Table I. The time evolution of such quantities is given in Figs. 5(a–d), where $\alpha_{mean} - \alpha_{median}$ rather than $\alpha_{mean}/\alpha_{median}$ is displayed for readability.

![Fig. 5](image-url)
Several remarks follow from the correlations shown with the structural diagrams and the relations between the $\alpha_{\text{mean}}$ and $\alpha_{\text{median}}$. While the structural diagrams for ATS, PTE, and ITL with respect to EUR show weak or no correlation at all, the $\alpha_{\text{mean}}$ is equal within the error bars to the $\alpha_{\text{median}}$ for PTE and ATS but $\alpha_{\text{mean}}$ and $\alpha_{\text{median}}$ are markedly different from each other for ITL. On the other hand, $\alpha_{\text{mean}}$ is not equal to $\alpha_{\text{median}}$ for DEM but the structural diagram shows very strong correlations between the time dependent $\alpha$-exponents. It is clear that the leading currencies from the point of view of the exchange rate fluctuations were DEM, and to a lesser extent BEF, FRF, IEP, and NLG while PTE is far away from the main stream, i.e. $\alpha \simeq 0.45$. We stress the quite small and quite large values of $\sigma(\alpha)$ for ATS and ITL respectively, both having the largest $\alpha_{\text{mean}}/\alpha_{\text{median}}$ ratio, both greater than unity in fact, indicating e.g. specific national bank financial policies.

Let it be pointed out that $\alpha_{\text{mean}}$ follows $\alpha_{\text{EUR/JPY}}$ while $\alpha_{\text{median}}$ follows the fluctuations of $\alpha_{\text{DEM/JPY}}$.

### Table 1

Averaged values for the time interval [Jan. 1, 1993 ; Jan. 1, 1999] of the time dependent $\alpha$-exponents of the exchange rate with respect to the Japanese Yen (JPY) for EUR and those 11 currencies forming the EUR on Jan. 01, 99.

| Currency | $\alpha_{\text{mean}}$ | $\alpha_{\text{median}}$ | $\alpha_{\text{mean}}/\alpha_{\text{median}}$ | $\sigma(\alpha)$ |
|----------|-------------------------|---------------------------|-----------------------------------------------|-----------------|
| EUR      | 0.5541                  | 0.5565                    | 0.9956                                        | 0.0441          |
| ATS      | 0.4994                  | 0.4971                    | 1.0046                                        | 0.0355          |
| BEF      | 0.5264                  | 0.5284                    | 0.9961                                        | 0.0357          |
| DEM      | 0.5389                  | 0.5408                    | 0.9966                                        | 0.0361          |
| ESP      | 0.5076                  | 0.5062                    | 1.0028                                        | 0.0398          |
| FIM      | 0.5096                  | 0.5136                    | 0.9922                                        | 0.0388          |
| FRF      | 0.5366                  | 0.5408                    | 0.9923                                        | 0.0325          |
| IEP      | 0.5282                  | 0.5339                    | 0.9893                                        | 0.0395          |
| ITL      | 0.5348                  | 0.5174                    | 1.0337                                        | 0.0763          |
| LUF      | 0.5264                  | 0.5284                    | 0.9961                                        | 0.0357          |
| NLG      | 0.5168                  | 0.5200                    | 0.9937                                        | 0.0364          |
| PTE      | 0.4483                  | 0.4440                    | 1.0097                                        | 0.0534          |

### 4 Conclusion

We have thus studied a few aspects of the EUR exchange rates from the point of view of the fluctuations of the EUR and the 11 currencies forming
the $EUR$. We have examined here the exchange rates toward $DKK$, $CHF$, $JPY$ and $USD$. The central part of the distribution of the fluctuations can be fitted by a Gaussian, while the distribution of the large fluctuations follows a power law. We have observed that the $DEM$ is the strongest currency that has dominated the correlations of the fluctuations in $EUR$ exchange rates with respect to $JPY$, while $PTE$ was the most extreme one in the other direction.

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