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Exchange rate volatility in the EMS before and after the fall

by

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Abstract

In this paper we present the results of applying an alternative indicator of volatility, based on the literature on deterministic chaos, to six EMS currencies, using daily data for the January 1974-September 1994 period.

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1. Introduction

Computing the degree of volatility is a usual way of assessing the performance of exchange rate systems. In fact, the uncertainty related to exchange-rate volatility has been deemed as having pernicious effects on the working of the whole economic system.

Time series volatility is frequently measured by means of the conditional variance of its unexpected component, which is assumed to follow an ARCH (Engle, 1982) or GARCH (Bollerslev, 1986) process [see Bollerslev, Chou and Kroner (1992) for a survey].

The now popular target-zone models (Krugman, 1991) assess exchange rate volatility in an indirect way, by studying the credibility of the bands. If the agents believe that the probability of a realignment is high, this would signal a lack of credibility on the side of the fluctuation bands, which would increase exchange-rate variability as fundamentals would reach the (upper or lower) limits of the band (Bertola and Caballero, 1992). This is the approach followed, among others, by Chen and Giovannini (1992), Svensson (1993) or Rose and Svensson (1994).

On the other hand, the concept of volatility associated with the unpredictability of a series can be also derived from the literature on deterministic chaos. So, Bajo-Rubio, Fernández-Rodríguez and Sosvilla-Rivero (1992a,b) propose an indicator of global volatility based on the inverse of the maximum Lyapunov characteristic exponent.

The aim of this paper is to extend this analysis, by presenting an alternative indicator of volatility, now local instead of global, also based on the literature on forecasting in chaotic systems. This indicator is then applied to six currencies participating in the exchange rate mechanism (ERM) of the European Monetary System (EMS), using daily exchange-rate data vis-à-vis the German mark, and covering the period from January 1st 1974 to September 20th 1994. Our results will allow us to compare exchange rate volatility before and after the crisis experienced by the EMS at the end of 1992 and the beginning of 1993.

The proposed indicator of local volatility is presented in section 2, while the empirical results are shown in section 3. Some concluding remarks are offered in section 4.

2. An alternative indicator of volatility

The Takens (1981) embedding theorem establishes that, given a time series X_t ($t=1, 2, \dots, T$), in a M -dimensional phase space, the M -histories

$$X_t^M = (X_t, X_{t-1}, X_{t-2}, \dots, X_{t-M+1}), \quad t=M, M+1, M+2, \dots \quad (1)$$

can, for a big enough M (called the "embedding dimension"), mimic the data generation process. The proximity of two M -histories in the phase space $\mathbb{R}^M$ allow us to talk of "occurring analogues" in the time series X_t .

In this way, we could consider an individualized indicator of volatility associated to each observation of the time series. This local (daily) volatility indicator would be related with the unanticipated volatility of each observation, which in turn would be associated with the degree of unpredictability of the observation considered (based on the information contained in the previous observations), and would be evaluated in terms of the forecasting errors obtained from some forecasting procedure.

In order to generate short-run forecasts, we will make use of some non-parametric techniques of prediction by occurring analogues (or nearest neighborhood), proposed by Farmer and Sidorowich (1987), and previously applied in Bajo-Rubio, Fernández-Rodríguez and Sosvilla-Rivero (1992a,b). To this end, we will pay special attention to the last available M -history for the time series X_t :

$$X_N^M = (X_N, X_{N-1}, X_{N-2}, \dots, X_{N-M+1}), \quad (2)$$

and construct a local predictor by comparing it with the k M -histories

$$X_{j_1}^M, X_{j_2}^M, X_{j_3}^M, \dots, X_{j_k}^M \quad (3)$$

more similar to X_N^M . The future short-term evolution of the time series will be then obtained from some extrapolation method using the occurring analogues found in the past.

In order to establish occurring analogues to X_N^M , we have looked for a certain number k of points $X_{j_i}^M$ in the phase space that maximize the serial correlation with X_N^M :

$$\rho(X_{j_i}^M, X_N^M) \quad j=M, M+1, \dots, N-M \quad (4)$$

Once we have these occurring analogues, we forecast the future evolution of X_N^M making use of linear autoregressive predictors with time varying coefficients:

$$\hat{X}_{N+1} = a_0(N) X_N + a_1(N) X_{N-1} + \dots + a_{M-1}(N) X_{N-M+1} + a_M(N) \quad (5)$$

being the coefficients locally estimated from a least square regression of the future evolution of the k occurring analogues chosen

$$X_{J_1+1}^M, \dots, X_{J_k+1}^M \quad (6)$$

on the current values of those M -histories

$$X_{J_1}^M, \dots, X_{J_k}^M \quad (7)$$

In this way, we define an alternative indicator of local volatility (unpredictability) for the observation X_{N+1} :

$$V(X_{N+1}) = \frac{|X_{N+1} - \hat{X}_{N+1}|}{\sigma_N} \quad (8)$$

i. e., the (absolute value of the) forecast error weighted by the standard deviation of the original series for $X_1, X_2, \dots, X_N$ (σ_N). A value of $V(X_{N+1})$ greater than one would signal an excess of volatility (in the sense of unpredictability).

3. Empirical results

The above developed volatility indicator has been applied to six EMS currencies experiencing different evolutions during the EMS crisis: two of them "temporary" leaving the ERM (Italian lira and Pound sterling), two other forced to devalue (Spanish peseta and Portuguese escudo), and the remaining two not devaluing (French franc and Dutch guilder). Our sample period runs from January 1st 1974 through September 20th 1994 (around 5110 observations), covering in particular the EMS period, the monetary turmoil after the summer of 1992, and the new episode initiated with the broadening of the fluctuation bands to $\pm 15\%$ in August 1993.

Our exchange rate data are measured in logarithm and, given the presence of a unit root in the series, they were first differenced in order to obtain stationary series. In addition, the embedding dimension M and the numbers of closest points k in the phase space $\mathbb{R}^M$ were chosen according to Casdagli's (1991) algorithm, obtaining in our case an embedding dimension $M=6$ and a number of closest points $k=180$.

Figures 1 through 6 show our volatility indicator evaluated for the six abovementioned currencies. The period shown in the figures runs from the last realignment in the EMS before the monetary turmoil (January 12th 1987) for the currencies of the three founding members considered here (Dutch guilder, French franc and Italian lira), and from the joining date for the other three (June 19th 1989 for the Spanish peseta, October 8th 1990 for the Pound sterling and April 9th 1992 for the Portuguese escudo).

As can be seen, until September 1992 our indicators for the Dutch guilder, the French franc and the Italian lira suggest, in general, a low degree of exchange-rate volatility, the only exception being the episode of high financial turbulence registered after the stock market crash of 1987. These results would be in line with those previously reported by Rose and Svensson (1994), who interpreted them as evidence in favour of the credibility of the exchange-rate commitment.

Regarding the Spanish peseta and the Pound sterling, the degree of exchange-rate volatility after joining the EMS would have been also low, but higher than in the previous cases (specially for the Pound sterling). However, some instability episodes would have occurred at the end of 1989, August 1990, June 1991 and April 1992 for the former; and the end of 1990, August 1991 and April 1992 for the latter. Notice that the short time period available for the Portuguese escudo prevents us to draw any significant conclusion.

A different picture emerges after September 1992, when the volatility indicators of all the currencies considered experienced an impressive upward jump as a consequence of the turbulences registered in the currency market, coinciding with the increasing uncertainty about the future of monetary union in Europe. As a result, the Pound sterling and the Italian lira suspended their participation in the ERM, the Spanish peseta and the Portuguese escudo experienced several devaluations, and the French franc suffered heavy speculative pressures. Following almost a year of unprecedented turmoil in the history of the EMS, the fluctuation bands of the ERM were broadened to $\pm 15\%$ on August 2nd 1993 (except for the Dutch guilder, which remained with the narrow bands of $\pm 2.25\%$).

As can be seen in Figures 3 and 5, the currencies that abandoned the ERM would have registered a much higher volatility since September 1992, especially in the case of the Italian lira. On the other hand, Figures 1, 2, 4 and 6 show that the broadening of the bands would have led to a decrease in volatility to levels comparable to those prevailing before the crisis. Similar results have been recently found by Ayuso, Pérez-Jurado and Restoy (1994) who measure volatility using an estimate of the conditional variance, corrected for the possible lack of credibility of the exchange rate commitment.

4. Concluding remarks

In this paper we have proposed a volatility indicator based on the literature on deterministic chaos which has been used to assess the volatility of the EMS currencies before and after the monetary turmoil at the end of 1992 and the beginning of 1993.

Starting from low levels of volatility for all the currencies considered, after the EMS crisis started in September 1992 our volatility indicators experienced a spectacular increase in all cases. Only once the ERM fluctuation bands were broadened in August 1993, the volatility indicators have tended to levels more comparable to those prevailing before the crisis, in the cases of those currencies remaining in the ERM. On the contrary, those currencies leaving the ERM discipline have registered an unambiguous increase in volatility from September 1992 onwards, especially in the case of the Italian lira.

Our results broadly tend to support Rose and Svensson's (1994) in the sense of having detected a sudden increase in volatility from September 1992 on. However, it seems dubious to interpret these results in terms of an unexpected loss of ERM credibility (Branson, 1994). The lack of credibility can actually have speeded up the events, but the higher volatility after September 1992 might be rooted in the fragility of a fixed exchange rate system in a world of very high international capital mobility, which has become evident with the problems associated with German unification and the effects of self-fulfilling speculative attacks (Eichengreen and Wyplosz, 1993). Finally, this fragility casts additional doubts on the feasibility of the strategy chosen for monetary union in Europe, since an immediate monetary reform might be a better choice (De Grauwe, 1994).

References

- Ayuso, J., M. Pérez-Jurado and F. Restoy (1994): "¿Se ha incrementado el riesgo cambiario en el S. M. E. tras la ampliación de las bandas?", Documento de Trabajo No. 9419, Banco de España, Madrid.
- Bajo-Rubio, O., F. Fernández-Rodríguez and S. Sosvilla-Rivero (1992a): "Chaotic behaviour in exchange-rate series: First results for the peseta-US dollar case", Economics Letters Vol. 39, pp. 207-211.
- Bajo-Rubio, O., F. Fernández-Rodríguez and S. Sosvilla-Rivero (1992b): "Volatilidad y predecibilidad en las series del tipo de cambio peseta-dólar: Un enfoque basado en el caos determinista", Revista Española de Economía, Monográfico Mercados Financieros Españoles, pp. 91-109.
- Bertola, G. and R. Caballero (1992): "Target zones and realignments", American Economic Review Vol. 82, pp. 520-536.
- Bollerslev, T. (1986): "Generalized autoregressive conditional heteroskedasticity", Journal of Econometrics Vol. 31, pp. 307-327.
- Bollerslev, T., R. Chou, and K. Kroner (1992): "ARCH modeling in finance. A review of the theory and the empirical evidence", Journal of Econometrics Vol. 52, pp. 5-59.
- Branson, W. (1994): "Comments to European exchange rate credibility before the fall, by A. Rose and L. Svensson", European Economic Review Vol. 38, pp. 1217-1220.
- Casdagli, M. (1991): "Nonlinear forecasting, chaos and statistics", Working Paper N° 91-05-022, Santa Fe Institute, New Mexico.
- Chen, Z. and A. Giovannini (1992): "Estimating expected exchange rates under target zones", Working Paper No. 3955, National Bureau of Economic Research, Cambridge, MA.
- De Grauwe, P. (1994): "Towards European Monetary Union without the EMS", Economic Policy Vol. 18, pp. 149-185.

Eichengreen, B. and C. Wyplosz (1993): "The unstable EMS", Brookings Papers on Economic Activity Vol. 1, pp. 51-143.

Engle, R. (1982): "Autoregressive conditional heteroscedasticity with estimates of the variance of UK inflation", Econometrica Vol. 50, pp. 987-1007.

Farmer, D. and J. Sidorowich, J. (1987): "Predicting chaotic time series", Physical Review Letters Vol. 59, pp. 845-848.

Krugman, P. (1991): "Target zones and exchange rate dynamics", Quarterly Journal of Economics Vol. 106, pp. 669-682.

Rose, A. and L. Svensson (1994): "European exchange rate credibility before the fall", European Economic Review Vol. 38, pp. 1185-1216.

Svensson, L. (1993): "Assessing target zone credibility: Mean reversion and devaluation expectations in the ERM, 1979-1992", European Economic Review Vol. 37, pp. 763-793.

Takens, F. (1981): "Detecting strange attractors in turbulence", in D. Rand and L. Young, (eds.), Dynamical systems and turbulence, Berlin: Springer-Verlag, pp. 366-381.

- Eichengreen, B. and C. Wyplosz (1993): "The unstable EMS", Brookings Papers on Economic Activity Vol. 1, pp. 51-143.
- Engle, R. (1982): "Autoregressive conditional heteroscedasticity with estimates of the variance of UK inflation", Econometrica Vol. 50, pp. 987-1007.
- Farmer, D. and J. Sidorowich, J. (1987): "Predicting chaotic time series", Physical Review Letters Vol. 59, pp. 845-848.
- Krugman, P. (1991): "Target zones and exchange rate dynamics", Quarterly Journal of Economics Vol. 106, pp. 669-682.
- Rose, A. and L. Svensson (1994): "European exchange rate credibility before the fall", European Economic Review Vol. 38, pp. 1185-1216.
- Svensson, L. (1993): "Assessing target zone credibility: Mean reversion and devaluation expectations in the ERM, 1979-1992", European Economic Review Vol. 37, pp. 763-793.
- Takens, F. (1981): "Detecting strange attractors in turbulence", in D. Rand and L. Young, (eds.), Dynamical systems and turbulence, Berlin: Springer-Verlag pp. 366-381.

Figure 1. Volatility of the Dutch guilder

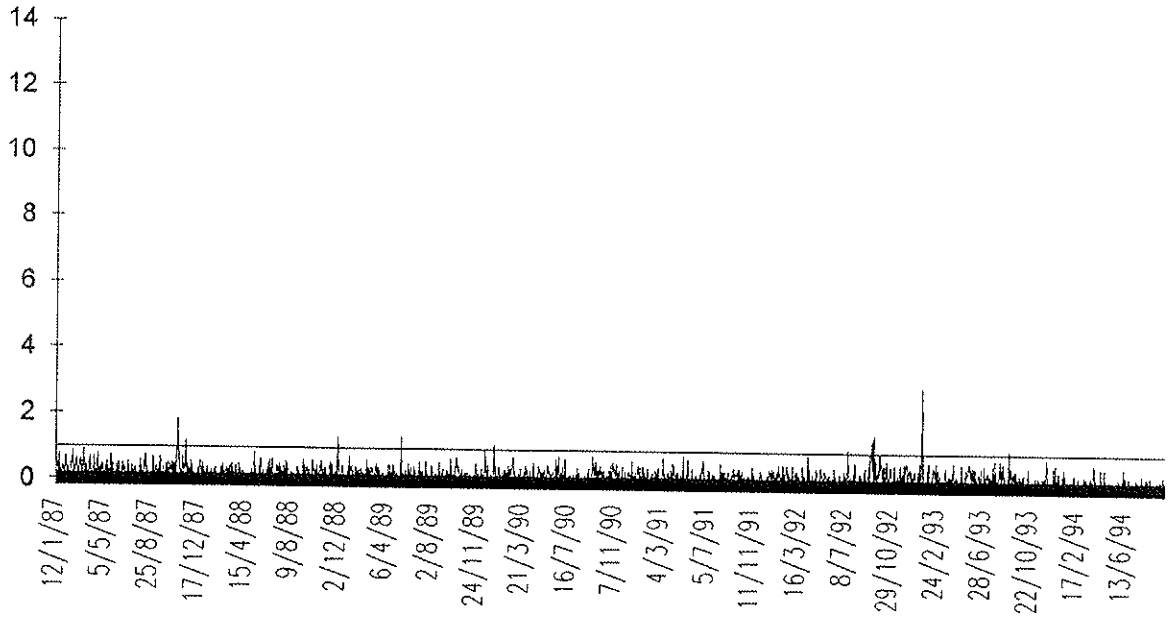


Figure 2. Volatility of the French franc

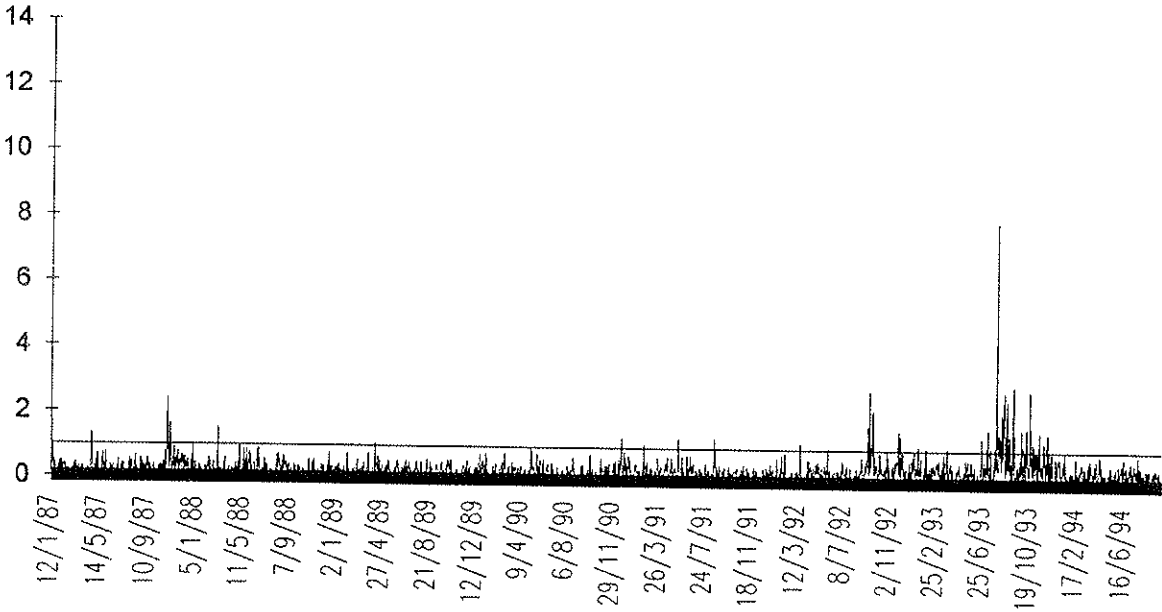


Figure 3. Volatility of the Italian lira

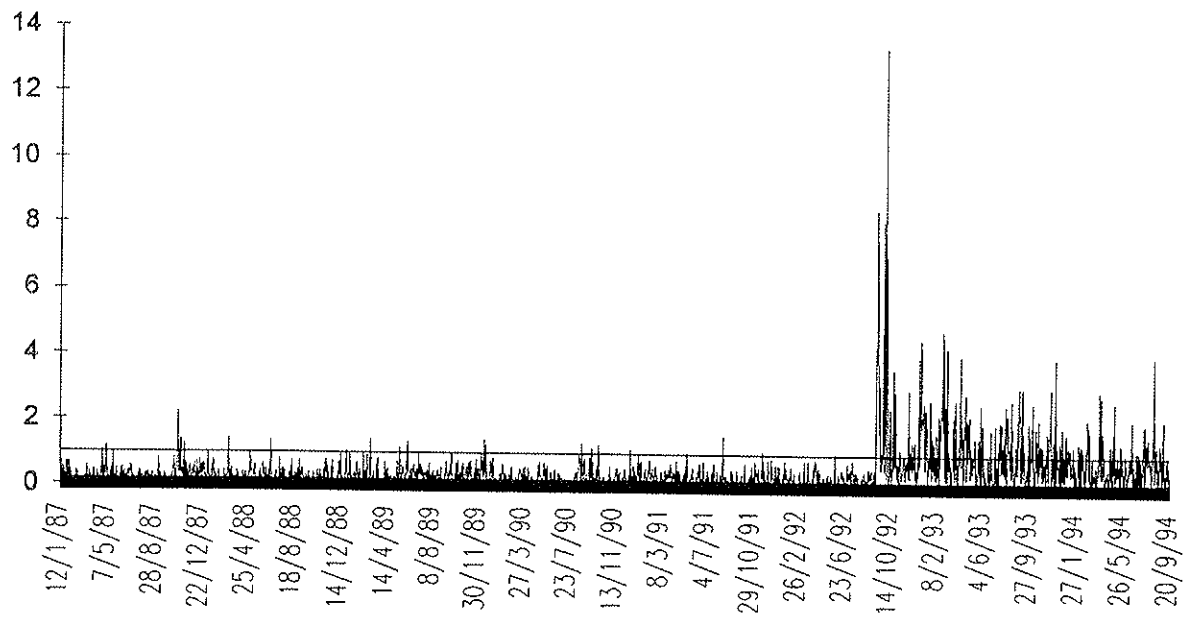


Figure 4. Volatility of the Spanish peseta

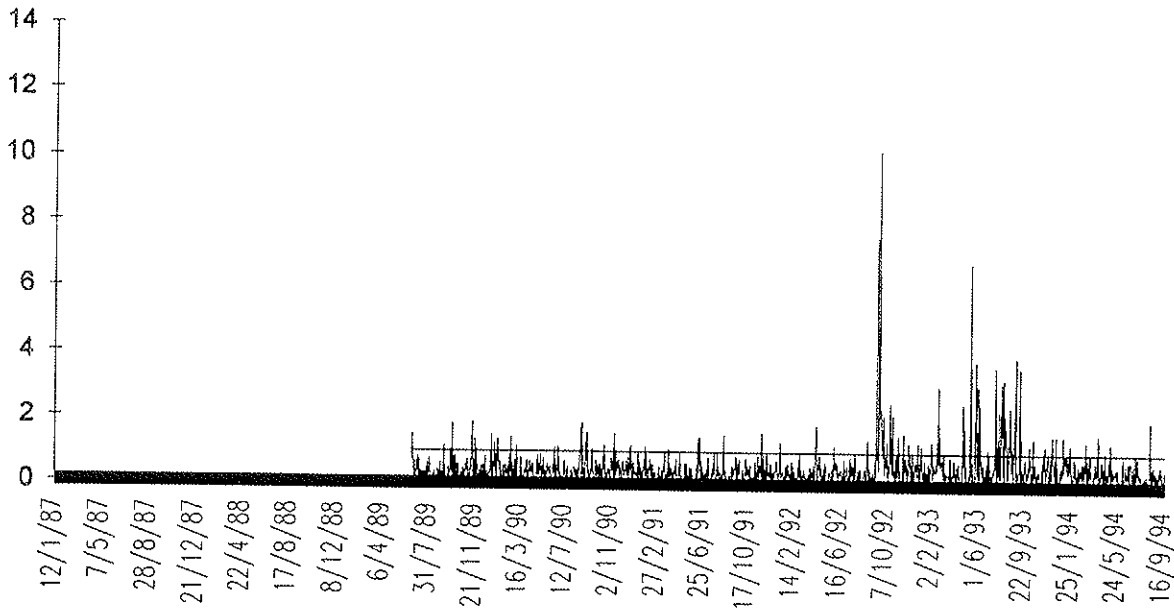


Figure 5. Volatility of the Pound sterling

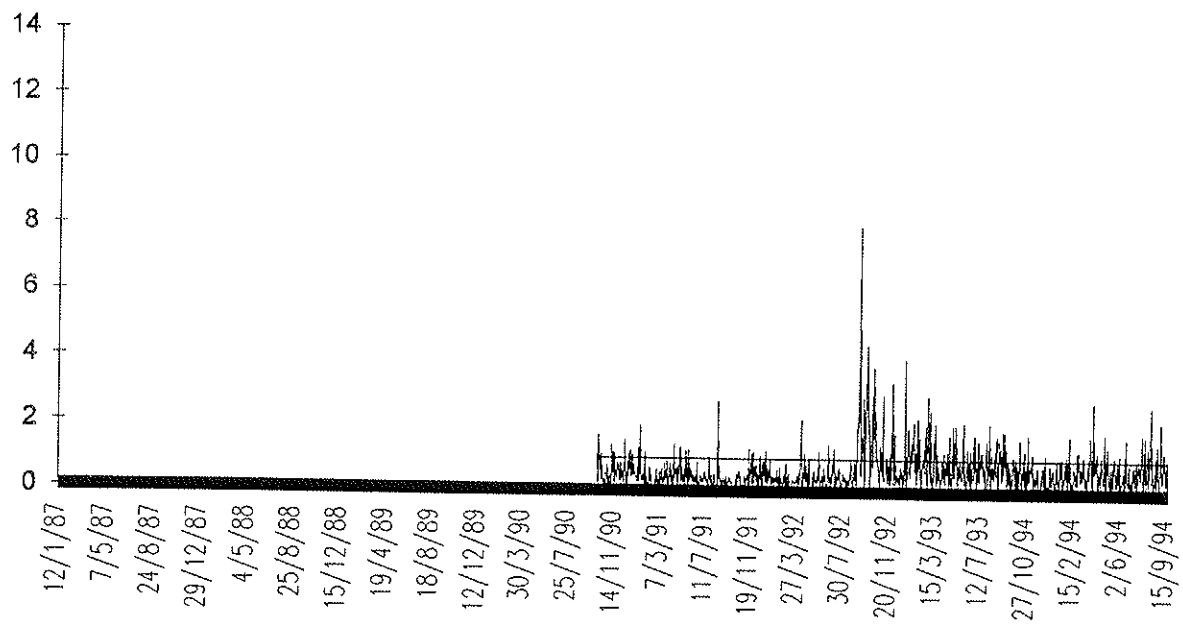
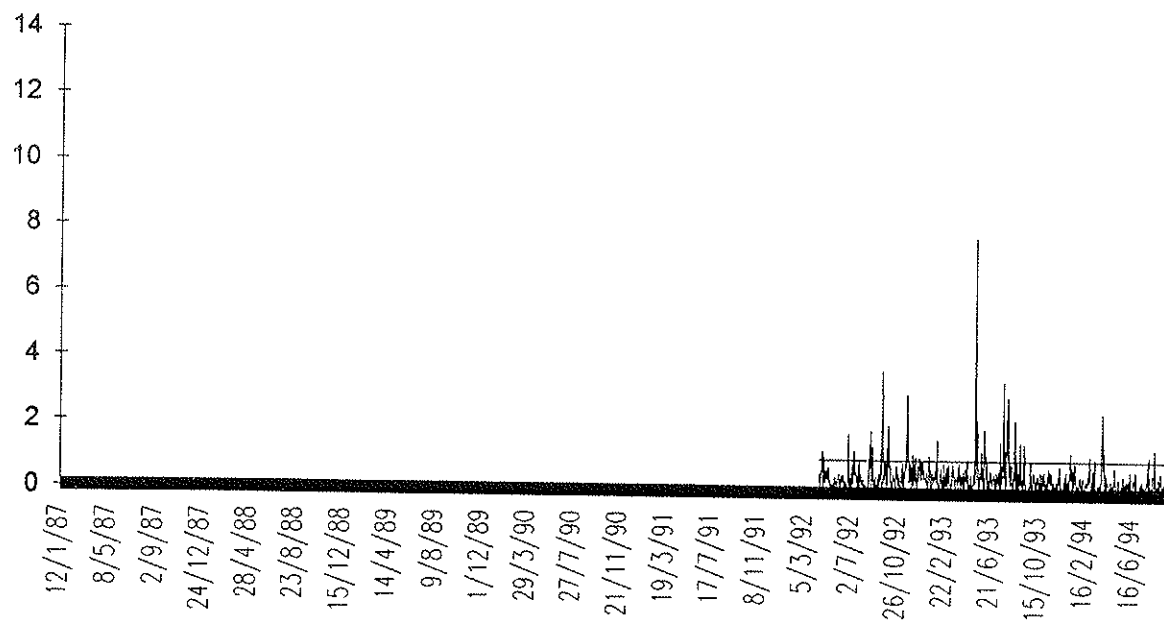


Figure 6. Volatility of the Portuguese escudo



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