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THE EURO AND THE VOLATILITY OF EXCHANGE RATES

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Abstract

This paper attempts to determine whether or not the introduction of the euro affected the volatility of bilateral exchange rates all over the world. To that end, we examine the exchange rate behaviour for a set of OECD and non-OECD countries during the 1993-2007 period. Two econometric methods are implemented for this purpose: the OLS-based tests to detect multiple structural breaks, as proposed by Bai and Perron (1998, 2003), and several procedures based on Information Criterion together with the so-called sequential procedure suggested by Bai and Perron (2003). Although results suggest evidence of structural breaks in volatility across investigated variables, there is high heterogeneity regarding the located dates. Moreover, the realignments in the Exchange Rate Mechanism seem to play a significant role in the reduction of volatility in some European countries and transition economies.

1. Introduction

Prior to the lunch of the third stage of Economic and Monetary Union (EMU) in 1999, speculation abounded about how much of an international role the single currency would play. Since then, and especially after circulation in 2002, the euro has become a leading financial currency, making substantial gains in some international currency functions.

The euro's share of international debt securities is greater than that of the US dollar, with the single currency accounting for nearly half of the world stock. In addition, the euro has become the second most used reserve currency, accounting for about 26 per cent of world official reserves, and the second most actively traded currency in foreign exchange markets worldwide, accounting for 37 per cent of all transactions in recent years.

As the international status of the single currency has clearly conferred certain benefits on euro-area members, there is not available evidence whether the euro, at a time of dollar volatility, has provided a much-needed anchor for the global economy.

This paper tries to shed some light on this issue by providing empirical evidence on whether or not the introduction of the euro affected the volatility of bilateral exchange rates all over the world. To that end, we examine the exchange rate behaviour for a set of OECD and non-OECD countries during the 1993-2007 period, Two econometric methods are implemented for this purpose: the OLS-based tests to detect multiple structural breaks, as proposed by Bai and Perron (1998, 2003), and several procedures based on Information Criterion together with the so-called sequential procedure suggested by Bai and Perron (2003).

The paper is organised as follows. Section 2 presents the econometric methodology used for testing structural breaks in the exchange rate volatility. Section 3 describes the data set and reports our empirical results. Finally, Section 4 provides some concluding remarks.

2. Econometric Methodology: Testing for Structural Breaks

Recent econometric methodology for detecting structural breaks is based on testing endogenously the presence of structural breaks of an unknown location. In this sense, three main approaches have been developed: the CUSUM-type tests, such as the iterated cumulative sums of squares (ICSS) algorithm by Inclán and Tiao (1994), to test for structural breaks in variance; the OLS-based tests to detect structural breaks in mean or/and variance (Quandt, 1960; Andrews, 1993; Andrews and Ploberger, 1994; Hansen, 1997; Bai and Perron, 1998, 2003); and, finally, the procedures based on Information Criterion (Liu *et al.*, 1997; Bai and Perron, 1998, 2003). This paper uses the two last approaches[1].

[1] We concentrate on the last two approaches given that the ICSS algorithm presents several weaknesses (see, for example, Sansó, Aragó and Carrión, 2004 and Valentinyi-Endrész, 2004).

Bai and Perron (1998, 2003)[2] consider the following multiple linear regression with m breaks (m+1 regimes):

$$\begin{aligned} y_t &= x_t'\beta + z_t'\delta_1 + u_t, \qquad t = 1,...,T_1, \\ y_t &= x_t'\beta + z_t'\delta_2 + u_t, \qquad t = T_1+1,...,T_2, \\ &\vdots \\ y_t &= x_t'\beta + z_t'\delta_{m+1} + u_t, \qquad t = T_m+1,...,T. \end{aligned} \tag{1}$$

In this model, y_t is the observed dependent variable at time t; x_t $(p\times 1)$ and z_t $(q\times 1)$ are vectors of covariates and β and δ_{j} $(j = 1,...,m+1)$ are the vectors of coefficients, respectively. Finally, u_t is the disturbance at time t. The break points $(T_1,...,T_m)$ are unknown. The purpose is to estimate the unknown regression coefficients and the break points using a sample of T observations.

We consider a pure structural change model $(p = 0)$, where all the coefficients are subject to change, from the model in equation (1). In this sense, we specify each series as an AR(1) process and then, to detect multiple structural breaks in variance, we use the absolute value of the fitted residuals of the AR(1) models[3]. For this analysis we specify $z_t = \{1\}$.

To detect multiple structural breaks, we use the following set of tests developed by Bai and Perron (1998, 2003)[4]: the sup F type test, the double maximum tests and the test for ℓ versus $\ell + 1$ breaks.

[2] We are particularly grateful to Bai and Perron for providing us with the GAUSS code for computations.
[3] Similarly, Stock and Watson (2002) use the absolute value of the fitted residuals of a VAR model to analyse changes in variance. Alternatively, Valentinyi-Endrész (2004) use the squared errors from a AR(1)-GARCH(1,1) model to compute changes in variance.
[4] For further analysis see Bai and Perron (1998, 2003).

We consider the sup F type test of no structural breaks $(m = 0)$ versus the alternative hypothesis that there are $m = k$ breaks. Let $(T_1, \ldots, T_k)$ be a partition such that $T_i = [T\lambda_i]$ $(i = 1, \ldots k)$. Let R be the matrix such that $(R\delta)' = (\delta_1' - \delta_2', \ldots \delta_k' - \delta_{k+1}')$. Define

$$F_T^*(\lambda_1, \ldots \lambda_k; q) = \frac{1}{T}\left(\frac{T - (k+1)q - p}{kq}\right)\hat{\delta}' R' \left(R\hat{V}(\hat{\delta})R'\right)^{-1} R\hat{\delta} \tag{2}$$

where $\hat{V}(\hat{\delta})$ is an estimate of the variance covariance matrix of $\hat{\delta}$ that is robust to serial correlation and heteroskedasticity. The statistic F_T^* is the conventional F-statistic for testing $\delta_1 = \ldots = \delta_{k+1}$ against $\delta_i \neq \delta_{i+1}$ for some i given the partition $(T_1, \ldots, T_k)$. The *supF* type test is defined as

$$sup\, F_T^*(k; q) = \sup_{(\lambda_1, \ldots \lambda_k) \in \Lambda_\epsilon} F_T^*(\lambda_1, \ldots, \lambda_k; q) \tag{3}$$

A simpler version of this statistic uses the estimates of the break dates obtained from the global minimization of the sum of squared residuals. If we denote these estimates by $\hat{\lambda}_i = \hat{T}_i / T$ for *i=1,...k*, the test will then be

$$sup\, F_T(k; q) = F_T(\hat{\lambda}_1, \ldots, \hat{\lambda}_k; q)$$

The null hypothesis of the double maximum tests, *UD*max and *WD*max, is no structural breaks against an unknown number of breaks given some upper bound M. The first is an equal weighted version defined by

$$UDmaxF_T^*(M;q) = \max_{1\leq m\leq M} \sup_{(\lambda_1,\ldots\lambda_m)\in\Lambda_\in} F_T^*(\lambda_1,\ldots\lambda_m;q) \tag{4}$$

We use the asymptotically equivalent version is

$$UDmaxF_T(M;q) = \max_{1\leq m\leq M} F_T(\hat{\lambda}_1,\ldots\hat{\lambda}_m;q)$$

where $\hat{\lambda}_j = \hat{T}_j / T$ for *j=1,...m* are the estimates of the break points obtained using the global minimization of the sum of squared residuals.

The second applies weights to the individuals tests such that the marginal p-values are equal across values of *m*. This version is denoted

$$WD\max F_T^*(M;q) = \max_{1\leq m\leq M} \frac{c(q,\alpha,1)}{c(q,\alpha,m)} \sup_{(\lambda_1,\ldots\lambda_m)\in\Lambda_\in} F_T^*(\lambda_1,\ldots\lambda_m;q) \tag{5}$$

We use the asymptotically equivalent version

$$WDmaxF_T(M;q) = \max_{1\leq m\leq M} \frac{c(q,\alpha,1)}{c(q,\alpha,m)} F_T(\hat{\lambda}_1,\ldots\hat{\lambda}_m;q)$$

Finally, we use the test for ℓ versus $\ell+1$ breaks, the labelled sup $F_T(\ell+1/\ell)$ test. The method involves the application of the $(\ell+1)$ test of the null hypothesis of no structural change versus the alternative hypothesis of a single change. The test is applied to each segment containing the observations $\hat{T}_{i-1}$ to $\hat{T}_i$ $i=1,\ldots,(\ell+1)$.

To run these tests it is necessary to decide the minimum distance between two consecutive breaks, *h*, that it, is obtain as the integer part of a trimming parameter, ε, multiplied by the number of observations *T* (we use $\varepsilon = 0.15$ and allow up to 5 breaks for the full sample analysis, and $\varepsilon = 0.20$ and up to 3 breaks for the sub-period analysis).

To select the dimension of the models, following the suggestions by Bai and Perron (2003), we consider the Bayesian Information Criterion (BIC) developed by Yao (1988), and a modified Schwarz' criterion –the LWZ criterion- proposed by Liu, Wu and Zidek (1994). In addition, we follow the method suggested by Bai and Perron (1998) based on the sequential application of the sup $F_T(\ell + 1/\ell)$ test, the sequential procedure (SP). This method begins by estimating a model with a small number of breaks thought to be necessary. Parameter-constancy tests are then performed for each sub-period, adding a break to a sub-period associated with a rejection with the test sup $F_T(\ell + 1/\ell)$. This process is repeated by increasing ℓ sequentially until the test sup $F_T(\ell + 1/\ell)$ fails to reject the null hypothesis of no additional structural breaks.

3. Data and Empirical Results

3.1. Data

We use daily data of nominal exchange rates against the Euro from 4/01/1993 to 8/05/2007[5] taking from Reuters' EcoWin Pro for a large number of countries: Austria, Australia, Belgium, Bulgaria, Canada, Switzerland, Cyprus, Denmark, Czech Republic,

[5] This period differs between series depending on data availability.

Spain, Finland, France, United Kingdom, Hong Kong, Hungary, Ireland, Iceland, Italy, Japan, Korea, Luxemburg, Malta, New Zealand, Portugal, Romania, Russia, Swiss, Slovenia, Slovakia, Turkey, United States and South Africa.

In our empirical analysis, we have considered the following sub-samples of countries:

- Group of Seven: Canada, Germany, France, United Kingdom, Italy, Japan and United States of America.
- European countries: Austria, Belgium, Switzerland, Cyprus, Denmark, Spain, Ireland, Luxembourg, Malta, Norway, Portugal, Sweden and Turkey.
- Transition economies: Bulgaria, Czech Republic, Hungary, Poland, Romania, Russia, Slovenia and Slovakia.
- Other countries: Australia, Hong Kong, Iceland, Korea, New Zealand and South Africa.

Figures 1(a) to 1 (d) plot the first log differences of the daily exchange rate of the euro against the currencies of each group of countries we have considered in our empirical analysis. A simple look at these figures show the differences in the exchange rate volatility before and after 1999 or 2002 for most of the currencies

[Insert Figures 1(a) to 1(d) here]

3.2. Empirical Results

The results are displayed in Tables 1 to 4, offering four sets of information. In the first place, we present in Columns 2 to 6 the numerical results of the statistics we have described in Section 2. In the second place, we show in Column 7 the number of breaks selecting by the SP. In the third place, we present in Columns 8 to 12 the estimated final model and, finally, in the last columns, the dates of the breaks are reported.

Let us now discuss the results obtained for the different groups of countries examined in this paper. Regarding the bilateral nominal exchange rate with the currencies of the group of most industrialized nations (Table 1), results show, on one hand, that there are two out of the seven currencies with two structural breaks in variance, two out of seven currencies with three breaks in variance, and, finally, four currency out of seven with four breaks in variance. Therefore, our results suggest the existence of at least two breaks in the volatility in the exchange rate of the euro against the currencies G-7 currencies. The break point, as identified, varies from currency to currency in general. Recall that these breaks are searched endogenously from the data and our procedure does not rely on pre-test information to determine them, thereby avoiding the possible problem of “data mining”. The breaks detected in November and December 1993 in the Deutchemark and the French Frank could be related to the completion of the single market that marked the start of stage one of EMU, while the break identified in 1996 for the Italian Lira coincides with the its re-entry in the Exchange Rate Mechanism (ERM) of the European Monetary System after four years of floating. Furthermore, other breaks are associated to episodes starting with global turmoil, such as the spillover during 1995 from the Mexican financial crisis, the East Asian financial crisis in July 1997, the collapse of Long Term Capital Management (LTCM) and the Russian bond default in August and September 1998 or the terrorist attacks in September 2001. Regarding the 2003 break detected in the US Dollar, it is probably associated with the substantial uncertainty surrounding the onset of war in Iraq.

[Table 1, here]

As for the volatility of the exchange rate of the euro vis-à-vis the currencies of the European countries, results in Table 2 also suggest the existence of at least two break points. The breaks detected in November and December 1993 in the Austrian Schilling and the Portuguese Escudo, as well as the break identified in January 1994 in the Spanish Peseta could be linked to the start of stage one of EMU, while the breaks found in the first months of 1999 in the Cyprus Pound, the Danish Krone and the Norwegian Krone could be related with the third stage of EMU. There are also breaks in 1998 that could be associated with the formal evaluation of Member States to join the euro. Regarding the New Turkish Lira, the breaks detected in 2001 and 2003 could be justified by the Turkish Stock Market Crash and the Iraqi war, respectively.

[Table 2, here]

When examining the volatility of the exchange rate of the euro against the currencies of our sample of transition economies (Table 3), we find the presence of at least one break point. The break detected for the Czech Koruna, the Hungarian Forint, the Polish Zloty, the Slovenian Tolar and the Slovak Koruna roughly coincide with episodes of implicit bands in their exchange rates vis-à-vis the euro detected in Ledesma-Rodríguez *et al.* (2009), that these authors interpret as an attempt by the National Central Banks to borrow European Central Bank's anti-inflation reputation. Furthermore, for the Slovenian Tolar and the Slovak Koruna, the volatility decreased after formally joining the ERM-II linking them to the euro. Regarding the Bulgarian Lev, the Romanian Lei and the Russian Ruble, there is evidence of break in volatility around August 1998 associated with the Russian financial crisis.

[Table 3, here]

Finally, the results for the volatility of the exchange rate of the euro vis-à-vis the currencies of our group of other countries (Table 4) indicate the existence of at least two break points. The break detected in 1997 is associated once more with unprecedented currency and financial market turmoil in a number of Asian countries. Regarding the breaks identified in 2000 and 2001, they could be related increased uncertainty regarding the relative growth prospects in the major economic areas, while the breaks in 2002 were the consequences of increasing geopolitical tensions.

[Table 4, here]

4. Concluding Remarks

The purpose of our paper has been to contribute to the debate on the possible stabilising effect of the euro on the volatility of the exchange rate worldwide. To that end, we have examined the instability in terms of multiple structural breaks in the variance in the time series of thirty two currencies compromising the Group of Seven, European countries, transition economies and Non-European countries. In particular, we have presented the results of applying alternative two procedures: the OLS-based tests to detect multiple structural breaks, proposed by Bai and Perron (1998, 2003) and several procedures based on Information Criterion joint with the so called sequential procedure suggested by Bai and Perron (2003). In these procedures, the volatility breaks are searched endogenously without using a priori information.

The main results are as follows. First, we found some evidence of structural breaks in volatility across investigated variables. Secondly, there is high heterogeneity between series regarding the dates in which the break points are located, although major economic events in the underlying economies seem to provide reasonable explanations for them. Finally, the realignments in the ERM seem to play a significant role in the reduction of volatility in some European countries and transition economies.

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References

Andrews, D. (1993) Test for parameter instability and structural change with Unknown change point, *Econometrica*, **61**, 821-856.

Andrews, D. and Ploberger, W. (1994) Optimal tests when a nuisance parameter is present only under the alternative, *Econometrica*, **62**, 1383-1414.

Bai, J. and Perron, P. (1998) Estimating and testing linear models with multiple structural changes, *Econometrica*, **66**, 47-78.

Bai, J. and Perron, P. (2003) Computation and analysis of multiple structural change models, *Journal of Applied Econometrics*, **18**, 1-22.

Hansen, B. E. (1997) Approximate asymptotic p values for structural-change tests, *Journal of Business and Economic Statistics*, **15**, 60-67.

Inclán, C. and Tiao, G. (1994) Use of cumulative sums of squares for retrospective detection of changes of variance, *Journal of the American Statistical Association*, **424**, 913-923.

Liu, J.S., Wu, S., and Zidek, J.V. (1997) On segmented multivariate regressions, *Statistica Sinica*, **7**, 497-525.

Quandt, R.E. (1960) Tests of the hypothesis that a linear regression system obeys two separate regimes, *Journal of American Statistical Association*, **55**, 324-330.

Ledesma-Rodríguez, F., Pérez-Rodríguez, J. and Sosvilla-Rivero, S. (2009) Implicit exchange regimes in Central and Eastern Europe: A first exploration, *International Economics and Economic Policy*, **6**, 179–206.

Sansó, A., Aragó, V., and Carrión, J. L. (2004) Testing for changes in the unconditional variance of financial time series, *Revista de Economía Financiera*, **4**, 32-53.

Stock, J.H. and Watson, M.W. (2002) Has the business cycle changed and why?, *NBER Macroeconomics Annual*, **17**, 159–218.

Valentinyi-Endrész, M. (2004) Structural breaks and financial risk management, MNB Working Paper 11.

Table 1. Multiple Structural Breaks in Volatility: Nominal Exchange Rates Against Euro, G-7 Countries

Specifications: $z_t = \{1\}$ $q = 1$ $p = 0$ $\varepsilon = 0.15$ $m = 5$

	Tests[a]					NB[a]	Final Model: Parameter Estimates					Dates			
	$SupF_T(1)$	$SupF_T(2/1)$	$SupF_T(3/2)$	$SupF_T(4/3)$	$SupF_T(5/4)$	SP[b]	$\hat{\delta}_1$	$\hat{\delta}_2$	$\hat{\delta}_3$	$\hat{\delta}_4$	$\hat{\delta}_5$	$\hat{T}_1$	$\hat{T}_2$	$\hat{T}_3$	$\hat{T}_4$
CAD[c] 4/01/1993-8/05/2007	71.94*	14.82*	18.73*	14.82*	-	4	0.008 (0.0002)	0.006 (0.0002)	0.008 (0.0002)	0.006 (0.0002)	0.005 (0.0002)	31/10/1995	17/08/1998	22/11/2001	24/09/2004
DEM 4/11/1993-31/12/1998	32.25*	16.63*	14.41*	12.60*	-	4	0.003 (0.0002)	0.002 (0.0001)	0.004 (0.0001)	0.002 (0.0001)	0.001. (0.0002)	6/12/1993	21/02/1995	28/02/1996	20/01/1998
FRF 4/01/1993-31/12/1998	8.77**	36.19*	19.94*	-	-	3	0.011 (0.0006)	0.006 (0.0005)	0.013 (0.0005)	0.008 (0.0004)	-	26/11/1993	6/03/1995	7/06/1996	-
GBP 4/01/1993-8/05/2007	104.38*	34.42*	-	-	-	2	0.082	0.0023	0.001	-	-	10/10/2001	24/12/2004	-	-
ITL 4/11/1993-31/12/1998	48.83*	41.24*	16.38*	-	-	3	4.98 (0.355)	11.68 (0.456)	6.91 (0.346)	5.47 (0.346)	-	11/04/1994	19/01/1995	24/10/1996	-
JPY 4/01/1993-8/05/2007	79.49*	114.29*	25.47*	10.33*	-	3	0.577 (0.017)	0.891 (0.018)	0.592 (0.019)	0.509 (0.023)	-	12/05/1997	4/06/2001	25/11/2004	-
USD 4/01/1993-8/05/2007	13.85*	25.99*	-	-	-	2	0.0056 (0.0001)	0.0045 (0.00009)	0.0053 (0.0001)	-	-	26/09/1995	14/03/2003	-	-

Notes.

a. $SupF_T(1)$ is the sup F type test of no structural breaks versus the alternative hypothesis that there are m=1 breaks. The $SupF_T(\ell+1/\ell)$ are the sup F type tests for ℓ versus $\ell+1$ breaks.

*, **, *** indicate significance at 1%, 5% and 10%, respectively. NB: number of breaks.

b. SP: sequential procedure by Bai and Perron (1998, 2003).

c. CAD: Canada, Dollar; DEM: Germany, Mark; FRF: France, Frank; GBP: United Kingdom, Pound; ITL: Italy, Lira; JPY: Japan, Yen; USD: United States, Dollar.

Table 2. Multiple Structural Breaks in Volatility: Nominal Exchange Rates Against Euro, European Countries

Specifications: $z_t = \{1\}$ $q = 1$ $p = 0$ $\varepsilon = 0.15$ $m = 5$

	Tests[a]					NB[a]	Final Model: Parameter Estimates					Dates			
	$SupF_T(1)$	$SupF_T(2/1)$	$SupF_T(3/2)$	$SupF_T(4/3)$	$SupF_T(5/4)$	SP[b]	$\hat{\delta}_1$	$\hat{\delta}_2$	$\hat{\delta}_3$	$\hat{\delta}_4$	$\hat{\delta}_5$	$\hat{T}_1$	$\hat{T}_2$	$\hat{T}_3$	$\hat{T}_4$
ATS 4/01/1993-31/12/1998	333.21*	27.93*	11.41**	11.41***	-	3	0.075 (0.002)	0.052 (0.0017)	0.021 (0.0017)	0.016 (0.002)	-	30/11/1993	4/12/1995	26/01/1998	-
BEF 4/01/1993-31/12/1998	34.51*	11.19**	-	-	-	2	0.081 (0.003)	0.059 (0.004)	0.042 (0.005)	-	-	25/03/1996	26/01/1998	-	-
CHF 4/01/1993-8/05/2007	262.75*	8.59*	-	-	-	1	0.004 (0.00007)	0.002 (0.00006)	-	-	-	5/02/1999	-	-	-
CYP 14/11/1996-8/05/2007	302.69*	497.28*	-	-	-	2	0.001 (0.0001)	0.003 (0.00006)	0.0012 (0.00009)	-	-	25/11/1998	15/07/2004	-	-
DKK 4/01/1993-8/05/2007	432*	251.15*	36.30*	25.73*	-	4	0.013 (0.0003)	0.009 (0.0004)	0.006 (0.0004)	0.002 (0.0004)	0.001 (0.0003)	5/06/1996	17/01/1999	17/04/2001	24/07/2003
ESP 4/01/1993-31/12/1998	39.62*	26.09*	17.84*	17.84*	-	4	0.511 (0.026)	0.372 (0.022)	0.263 (0.022)	0.608 (0.027)	0.433 (0.029)	27/01/1994	24/07/1995	23/01/1997	4/02/1998
IEP 4/01/1993-31/12/1998	119.09*	14.10-	-	-	-	2	0.001 (0.0001)	0.002 (0.00008)	0.001 (0.0001)	-	-	10/02/1995	23/12/1997	-	-
LUF 14/11/1996-8/05/2007	12.05*	26.97*	-	-	-	2	0.0069 (0.005)	0.035 (0.007)	0.1029 (0.010)	-	-	4/01/1998	31/08/1998	-	-
MTL 21/08/1998-8/05/2007	99.73*	54.51*	34.93*	-	-	3	0.002 (0.00007)	0.0016 (0.00007)	0.00011 (0.00006)	0.0008 (0.00005)	-	28/04/2000	7/12/2001	23/03/2004	-
NOK 4/01/1993-8/05/2007	277.37*	27.28*	22.14*	14.78**	-	4	0.013 (0.0006)	0.030 (0.0009)	0.020 (0.0006)	0.026 (0.0009)	0.021 (0.0009)	9/01/1997	29/03/1999	9/01/2003	3/03/2005
PTE 4/01/1993-31/12/1998	97.50*	29.28*	-	-	-	2	0.560 (0.030)	0.311 (0.020)	0.639 (0.017)	-	-	27/12/1993	6/02/1996	-	-
SEK 4/01/1993-8/05/2007	271.16*	36.83*	10.59***	-	-	3	0.038 (0.0009)	0.027 (0.001)	0.031 (0.0008)	0.019 (0.0007)	-	13/12/1995	24/08/1998	23/10/2002	-
TRY 4/01/1993-8/05/2007	26.47*	207.06*	205.40*	205.40*	-	4	0.271 (0.221)	0.269 (0.282)	0.265 (0.257)	4.379 (0.282)	0.116 (0.209)	1/07/1996	25/08/1998	3/04/2001	29/05/2003

Notes.

a. $SupF_T(1)$ is the sup F type test of no structural breaks versus the alternative hypothesis that there are m=1 breaks. The $SupF_T(\ell+1/\ell)$ are the sup F type tests for ℓ versus $\ell+1$ breaks.

*, **, *** indicate significance at 1%, 5% and 10%, respectively. NB: number of breaks.

b. SP: sequential procedure by Bai and Perron (1998, 2003).

c. ATS: Austria, Schilling; BEF: Belgium, Franc; CHF: Switzerland, Franc; CYP: Cyprus, Pounds; DKK: Denmark, Kroner, ESP: Spain, Peseta; IEP: Ireland, Pound; LUF: Luxembourg, Franc; MTL: Malta, Lira; NOK: Norway, Kroner; PTE: Portugal, Escudo; SEK: Sweden, Kronor; TRY: Turkey, New Lira.

Table 3. Multiple Structural Breaks in Volatility: Nominal Exchange Rates Against Euro, Transition Economies

Specifications: $z_t = \{1\}$ $q=1$ $p=0$ $\varepsilon = 0.15$ $m=5$															
Tests[a]						**NB a**	**Final Model: Parameter Estimates**					**Dates**			
	$SupF_T(1)$	$SupF_T(2/1)$	$SupF_T(3/2)$	$SupF_T(4/3)$	$SupF_T(5/4)$	SP[b]	$\hat{\delta}_1$	$\hat{\delta}_2$	$\hat{\delta}_3$	$\hat{\delta}_4$	$\hat{\delta}_5$	$\hat{T}_1$	$\hat{T}_2$	$\hat{T}_3$	$\hat{T}_4$
BGN 14/11/1996-8/05/2007	19.17*	393.12*	11.18*	15.77*	-	4	23.85 (1.392)	9.809 (1.387)	13.90 (1.230)	9.950 (0.992)	4.012 (1.167)	2/06/1998	30/12/1999	21/12/2001	14/01/2005
CZK[c] 8/08/1996-8/05/2007	164.55*	49.77*	-	-	-	2	0.161 (0.004)	0.096 (0.004)	0.068 (0.005)	-	-	14/11/2000	9/06/2000	-	-
HUF 16/11/1995-8/05/2007	36.32*	12.38*	18.16*	18.38*	-	2	0.650 (0.038)	0.794 (0.038)	0.918 (0.022)	-	-	12/03/1998	9/06/2000	-	-
PLN 16/11/1995-8/05/2007	170.24*	53.26*	52.10*	-	-	3	0.01 (0.0008)	0.023 (0.0005)	0.019 (0.0006)	0.014 (0.0009)	-	25/09/1997	21/12/2001	7/06/2005	-
RON 14/11/1996-8/05/2007	12.29*	218.49*	218.07*	33.60*	-	3	1.280 (0.168)	0.206 (0.154)	0.288 (0.236)	0.119 (0.204)	-	13/12/1999	8/08/2003	28/02/2005	-
RUB 16/11/1995-8/05/2007	555.68*	129.03*	218.03	-	-	3	0.034 (0.011)	0.504 (00013)	0.171 (0.008)	0.087 (0.013)	-	23/07/1998	9/06/2000	8/03/2005	-
SIT 2//09/2003-29/12/2006	27.06**	-	-	-	-	1	0.2331 (0.013)	0.135 (0.020)	-	-	-	29/12/2005	-	-	-
SKK 14/11/1996-8/05/2007	144.44*	45.76*	13.92*	12.50*	-	4	0.136 (0.007)	0.234 (0.007)	0.106 (0.007)	0.074 (0.007)	0.094 (0.007)	28/09/1998	29/12/2000	30/12/2002	2/02/2005

Notes.

a. $SupF_T(1)$ is the sup F type test of no structural breaks versus the alternative hypothesis that there are m=1 breaks. The $SupF_T(\ell+1/\ell)$ are the sup F type tests for ℓ versus $\ell+1$ breaks.

*, **, *** indicate significance at 1%, 5% and 10%, respectively. NB: number of breaks.

b. SP: sequential procedure by Bai and Perron (1998, 2003).

c. BGN: Bulgaria, Leva; CZK: Czech Republic, Koruny; HUF: Hungary, Forint; PLN: Poland, Zlotys; RON: Romania, New Lei; RUB: Russia, Rubbles; SIT: Slovenia, Tolars; SKK: Slovakia, Koruny;

Table 4. Multiple Structural Breaks in Volatility: Nominal Exchange Rates Against Euro, Other Countries

Specifications: $z_t = \{1\}$ $q = 1$ $p = 0$ $\varepsilon = 0.15$ $m = 5$

	Tests[a]					NB[a]	Final Model: Parameter Estimates					Dates			
	$SupF_T(1)$	$SupF_T(2/1)$	$SupF_T(3/2)$	$SupF_T(4/3)$	$SupF_T(5/4)$	SP[b]	$\hat{\delta}_1$	$\hat{\delta}_2$	$\hat{\delta}_3$	$\hat{\delta}_4$	$\hat{\delta}_5$	$\hat{T}_1$	$\hat{T}_2$	$\hat{T}_3$	$\hat{T}_4$
AUD 4/01/1993-8/05/2007	183.68*	38.14*	-	-	-	2	0.009 (0.0001)	0.007 (0.0003)	0.005 (0.0003)	-	-	20/02/2002	16/09/2004	-	-
HKD 4/01/1993-8/05/2007	12.83*	25.11*	10.23**	-	-	3	0.043 (0.001)	0.032 (0.001)	0.036 (0.0009)	0.041 (0.001)	-	26/10/1995	28/08/1998	13/03/2003	-
ISK 16/11/1995-8/05/2007	159.48*	32.08*	37.35*	11.31***	-	4	0.278 (0.015)	0.232 (0.011)	0.449 (0.016)	0.303 (0.012)	0.513 (0.016)	6/10/1997	2/03/2001	19/11/2002	29/07/2005
KRW 4/01/1993-8/05/2007	162.50*	53.267*	93.77*	13.46*	-	4	4.009 (0.612)	17.86 (0.616)	6.976 (0.526)	8.253 (0.605)	-	15/10/1997	14/12/1999	20/11/2002	10/02/2005
NZD 4/01/1993-8/05/2007	73.80*	75.85*	37.33	18.58*	-	4	0.011 (0.0003)	0.008 (0.0003)	0.014 (0.0003)	0.012 (0.0003)	0.008 (0.0002)	7/06/1995	8/12/1997	1/05/2000	6/09/2002
ZAR 16/11/1995-8/05/2007	210.61*	140.39*	144.27*	-	-	3	0.025 (0.002)	0.047 (0.002)	0.090 (0.002)	0.055 (0.001)	-	27/05/1998	10/08/2001	23/12/2003	-

Notes.

a. $SupF_T(1)$ is the sup F type test of no structural breaks versus the alternative hypothesis that there are m=1 breaks. The $SupF_T(\ell+1/\ell)$ are the sup F type tests for ℓ versus $\ell+1$ breaks.

*, **, *** indicate significance at 1%, 5% and 10%, respectively. NB: number of breaks.

b. SP: sequential procedure by Bai and Perron (1998, 2003).

c. AUD: Australia, Dollar; HKD: Hong Kong, Dollar; ISK: Iceland, Kronur; KRW: Korea, Won; NZD: New Zealand, Dollar; ZAR: South Africa, Rand.

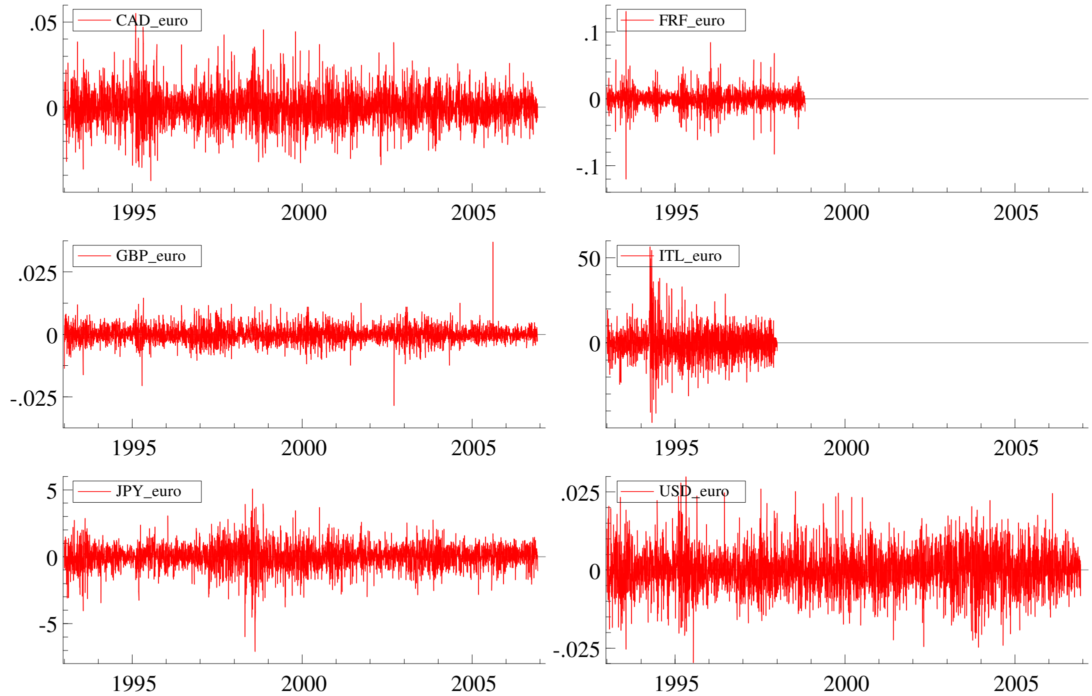

Figure 1 (a). Daily rate of change of nominal exchange rates against euro, G-7 countries.

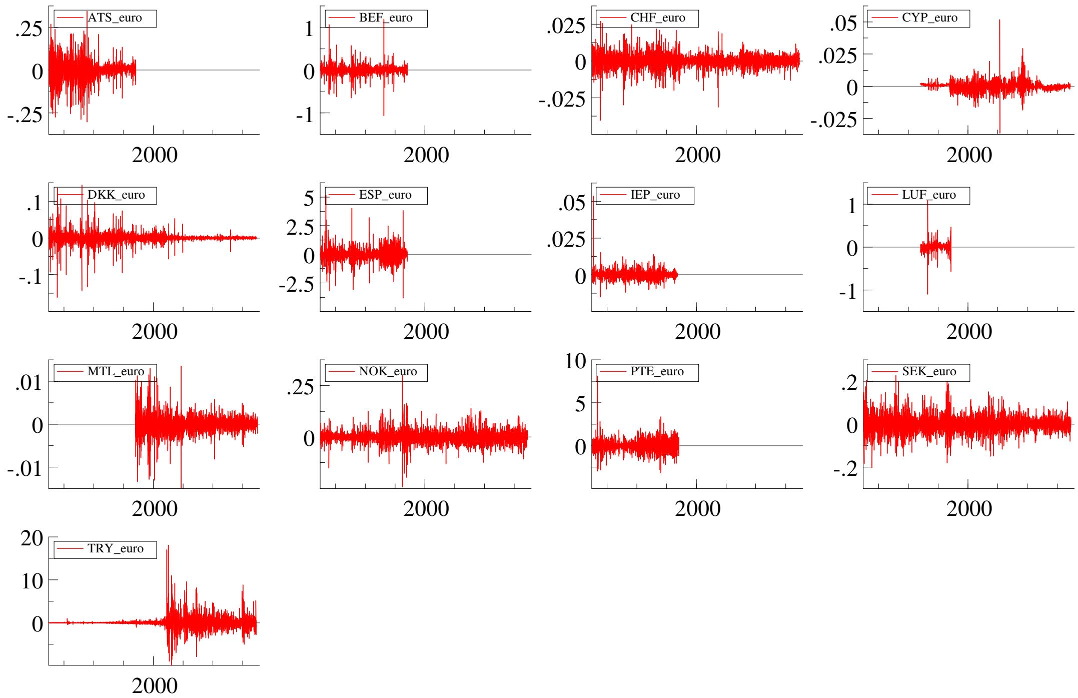

Figure 1 (b). Daily rate of change of nominal exchange rates against euro, European countries.

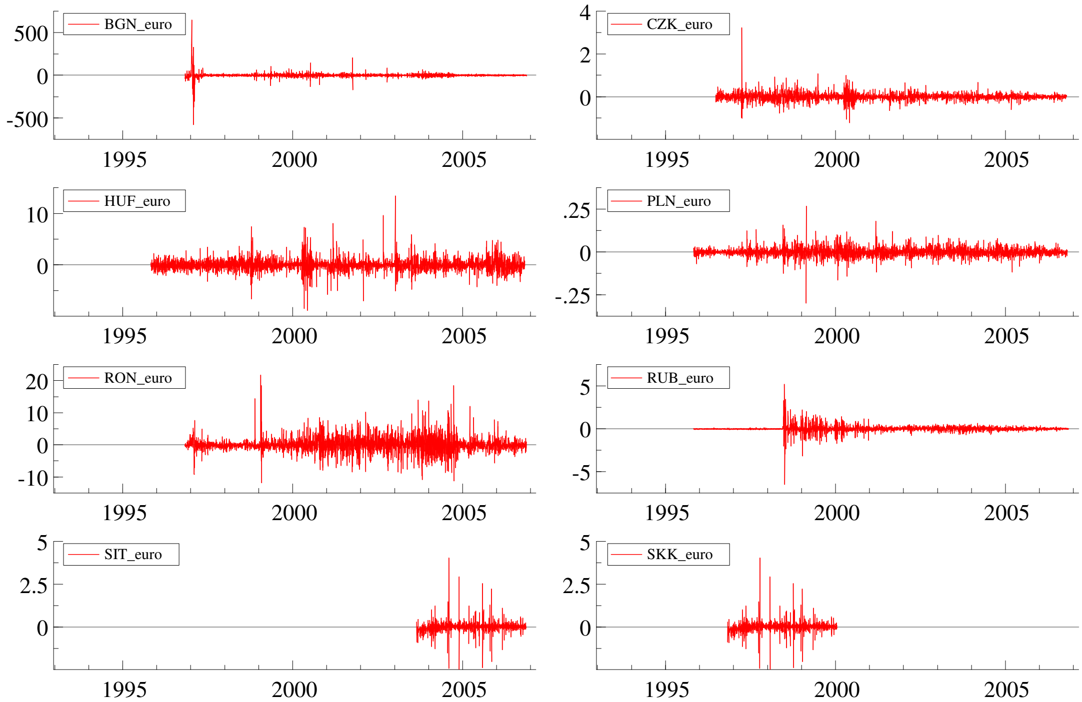

Figure 1 (c). Daily rate of change of nominal exchange rates against euro, transition economies. countries.

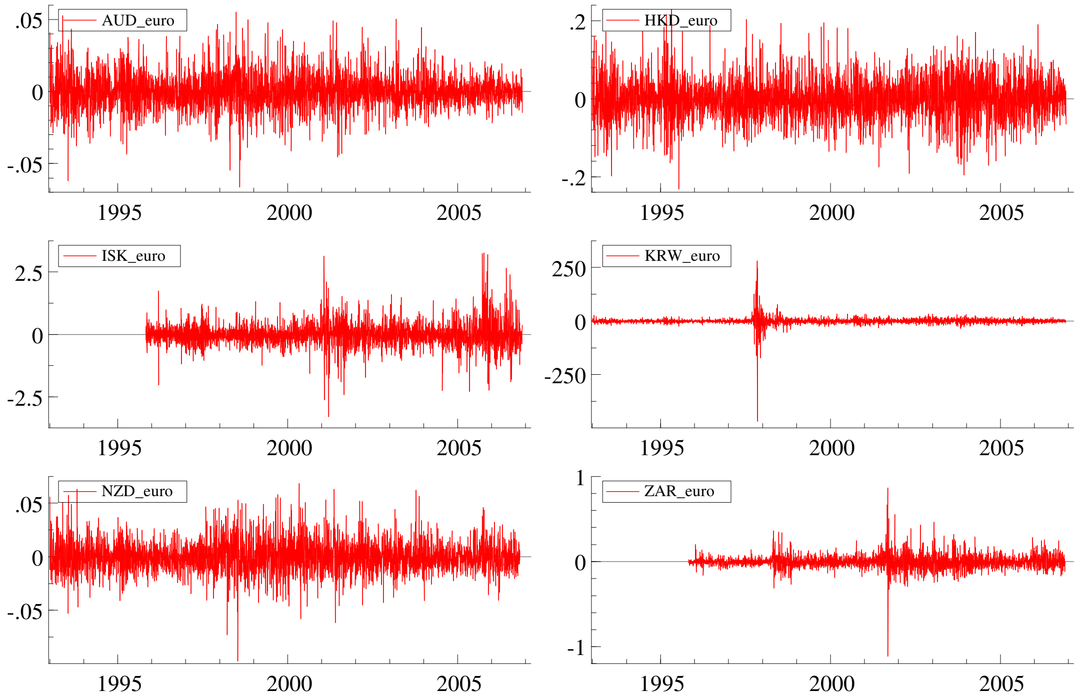

Figure 1 (d). Daily rate of change of nominal exchange rates against euro, other countries.