Post-EMS Exchange Risk Trends:
A Comparative Perspective between Euro, British Pound and Japanese Yen Excess Returns against US Dollar

Yolanda Santana-Jiménez
and
Jorge V. Pérez-Rodríguez
Department of Quantitative Methods
University of Las Palmas de Gran Canaria

Number of words: 7695
Number of diagrams: 5

Authors:

Yolanda Santana-Jiménez
Departamento de Métodos Cuantitativos
Facultad de Ciencias Económicas
Universidad de Las Palmas de Gran Canaria
Campus de Tafira
35017, Las Palmas de G.C.
Spain
e-mail: ysantana@dmc.ulpgc.es
Tlf: 34-928-458644

Jorge V. Pérez-Rodríguez
Departamento de Métodos Cuantitativos
Facultad de Ciencias Económicas
Universidad de Las Palmas de Gran Canaria
Campus de Tafira
35017, Las Palmas de G.C.
Spain
e-mail: jvperez@dmc.ulpgc.es
Tlf: 34-928-458222

Post-EMS Exchange Risk Trends:
A Comparative Perspective between Euro, British Pound and Japanese Yen Excess Returns against US Dollar

Abstract

This paper analyses the evolution of the exchange rate risk of the Deutsch mark/dollar (euro/US dollar from January 1, 1999) by employing the GARCH-M with GED conditional distribution function of the errors. We examine the effect on Germany and, more generally, on the EMU countries of the introduction of the euro, in terms of exchange rate risk with respect to the US dollar. For the purposes of comparison, this study is also performed for the British pound (a currency which does not belong to the EMU, but is in its neighbourhood) and for the Japanese yen against the US dollar. Daily data are used, covering the period from January 1, 1996 to May 26, 2003. A recursive estimation of the models suggested is performed in order to determine the evolution of the risk price coefficient (RPC). The results show that after a period of adaptation following the introduction of the euro, the euro/US dollar risk price decreased. With respect to the euro/US dollar risk premium, there is evidence of a higher risk during 2000.

I. Introduction

The introduction of the euro constituted a major structural change in the international financial system, comparable with the withdrawal of the fixed exchange rate system in 1983. There is a consensus that the European Monetary System (EMS) has succeeded in reducing exchange rate risks for the currencies which participated in the EMS during the whole period (i.e. Deutsch mark, French franc, Danish krone, Dutch guilder, among others), as has been shown in various studies [see Artis and Taylor (1994), Sarno (1997a), Frömmel and Menkhoff (2001)][1]. This success can be explained, among other reasons, by the high degree of credibility enjoyed by many of the currencies participating in the EMS [see, for instance, the works of Svensson (1991), Bertola and Svensson (1993), Malliaropulos (1995), Fernández-Rodríguez et al. (1997) and Ledesma, Navarro, Pérez-Rodríguez and Sosvilla (1999a,b,c and 2000)][2], and which are currently part of the euro zone.

Nevertheless, this significant change of regime has not yet been the object of analysis. The most recent studies of the euro have only analysed its impact on the stock markets [Morana and Beltratti (2002)], the impact of fundamentals on the exchange rate [Closterman and Schnatz (2000), Stein (2001)] and the predictive capacity of non-linear techniques on the US dollar/euro short-term prediction [Andrada, Sosvilla and Fernández (2001)].

---

[1] These studies compared the volatility of the currencies belonging to the EMS with that of others, finding favourable results within the EMS in terms of exchange rate risk reduction.

[2] The degree of credibility was very high, not only because EMS stability was affected, but also because of the real effects derived from the implementation of the economic policies established.

The aim of the present paper is to study the impact of the euro on exchange risks, using the Deutsch mark in the post-EMS period[3]. We compare the Deutsch mark before and after the introduction of the euro with the exchange risk outside the euro zone (UK and Japanese economies) and estimate the daily trends of risk premiums. Our work represents an extension of the studies of Frömmel and Menkhoff (2001) and of De Santis, Gérard and Hillion (2003), although a different methodological approach is employed.

This study adds to the empirical literature of exchange rates that analyses exchange rate risk premium trends[4], considering both pre-EMS and post-EMS periods. We have employed a classical approach to the financial literature, in which the model used could be interpreted as a simplification of the basic International Capital Asset Pricing Model (ICAPM) which considers risk aversion[5]. This model proportionally relates the excess returns and exchange risk for the Deutsch mark (DEM), British pound (BP) and Japanese yen (JY) against the US dollar (USD). We introduce an empirical model with ARCH disturbances and a time-varying mean. The model divides the

---

[3] This currency, like those of the other countries which adopted the euro as a single currency on January 1, 1999, is a virtual currency because it is no longer quoted. The DEM/USD exchange rate is obtained as the result of 1euro/USD times 1.95883 DEM/euro.

[4] The first studies considering exchange risk premiums, such as Solnik (1974), Stultz (1981) and Adler and Dumas (1983), did not obtain conclusive results. However, more recent works, like Dumas and Solnik (1995) and De Santis and Gerard (1998), have found evidence suggesting an exchange rate risk different from zero for the major currencies. De Santis, Gerard and Hillion (2003) analysed the exchange risk for the period 1974-1997 from the perspective of a German investor and suggest that the elimination of EMU risk is likely to be offset at least partially by an increase in non-EMU risk.

[5] See Baillie and Bollerslev (1990) for a more detailed explanation.

predictable component of the excess returns achieved into two parts: the time-varying price of volatility and the time-varying volatility of returns. In order to study these components, we employ two approaches: on the one hand, we compare two periods (before and after introduction of the euro) with the whole period. Thus, we estimate the DEM, BP and JY risk by using GARCH-M type models[6]. Secondly, we use recursive regressions to examine the behaviour of the GARCH-M coefficients over time. In this way, we recursively estimate the parameters of the models, updating the parameters for each period.

In these recursive regressions, the parameters are estimated repeatedly, using larger and larger subsets of the sample data. This procedure is intended to determine whether there was a significant change of regime around January 1, 1999, confirming the existence of time-varying risk premia. Thus, the temporal evolution of the price of volatility can be explained by structural changes in the preferences of the agents, or because the rules which govern expectations change or because of variations derived from the learning process during each trading day.

We use daily data corresponding to each trading day for exchange rates and for three-month interbank interest rates. The sample period is from January 1, 1996 to May 26, 2003 for all currencies. The reasons for studying these particular currencies are based on the following factors: on the one hand, we have investigated the entire history of the EMS with respect to Germany, because this country was a leading participant in

---

[6] The GARCH methodology has been commonly used in the risk analysis of major world currencies (e.g. DEM, BP, USD and JY) by employing alternative approaches, in particular the International Capital Asset Pricing models (ICAPM) [see Domowitz and Hakkio (1985), Baillie and Bollerslev (1990), McCurdy and Morgan (1987, 1988, 1989, 1991, Ayuso and Restoy (1996), Malliaropulos (1997) and Tai (2001)].

the EMS; furthermore, we wished to consider a sample that was large enough to compare a subperiod before the introduction of the euro (January 1, 1999) with another subperiod after that event. Note that since January 1, 1999 the DEM has been a virtual currency, as its dynamics depend directly on the economic factors of all the member countries of the euro zone. Secondly, the American currency is included in this study, as the U.S. economy is the main rival of those of Europe and Japan; moreover, analysis of the relationship between the euro and the USD allows us to determine the strength of the new currency with respect to the American dollar. Thus, we can evaluate European international transaction power at the introduction of the single currency, and whether European economic agents experience a higher or lower exchange risk. Finally, the BP and JY were used against the USD because, although these currencies do not belong to the EMU, the BP is in its neighbourhood and the JY is one of the main world currencies. The differences between these currencies facilitate possibilities of arbitrage for investors between the euro, BP, JY and USD. Furthermore, analysis allows us to consider the importance of the arbitrage between the currencies in question.

The present paper is organised as follows: Section II describes the model used to analyse the exchange risk trend. Section III contains a descriptive analysis of the variables and the sample. Section IV shows the results of the estimations carried out for the DEM/USD, BP/USD and JY/USD relations. Section V analyses the results of the recursive estimations of the prices of risk. Finally, the conclusions drawn are summarised in section VI.

II. An Empirical Relationship between
Excess Return and Exchange Risk

ARCH-M is a simple model to relate financial return to risk. It was originally

derived by Engle, Liliens and Robbins (1987) and is similar to the single-factor CAPM

model. The model used in the present paper is based on the definition of the risk

premium of each currency considered against the USD. Thus, considering the following

"return-risk" relationship, which connects the excess exchange rate return with, for

example, its conditional standard deviation, we can write

$$er_t^c = \delta\, h_t + \varepsilon_t \tag{1}$$

where er_t^c is the excess exchange rate return of the currency considered with respect to

the USD, and represents the return of a unit of domestic currency invested in a foreign

asset and financed by borrowing a loan at the risk-free domestic interest rate, such that

$$er_t^c = r_t^* + (s_t - s_{t-1}) - r_t$$

where r_t^* and r_t are the foreign and domestic risk-free interest rates, respectively, and

s_t is the logarithm of the spot exchange rate defined in units of domestic currency per

unit of foreign currency. Then, it can be said that er_t^c is the *ex-post* uncovered interest

parity (UIP) deviation, that is, the excess of return of an open position in a foreign

currency. δ is the risk price coefficient (RPC) and can be interpreted as the price that the

investor demands for undertaking a unit of risk; ε_t is a forecast error which is

conditional to the information available up to *t*-1 and which is distributed as $N(0, h_t^2)$, in

which h_t^2 is the heteroskedastic variance conditional to the information in *t*-1.

The proposed specification to characterise the conditional heteroskedastic variance is GARCH(1,1), where h_t^2 is defined as:

$$h_t^2 = \omega + \alpha_1 \varepsilon_{t-1}^2 + \beta \, h_{t-1}^2 \qquad (2)$$

for which the coefficients must satisfy the following restrictions: $\omega > 0, \alpha > 0$ and $\beta > 0$. This model characterises the evolution of the mean and the variance of a time series simultaneously[7]. As regards the behaviour assumed for the conditional distribution of the errors, several alternative distributions are considered, namely the conditional normal distribution, the t-Student density distribution and the generalised exponential distribution, conditional to the available information in t-1. Finally, among the various alternatives for the specification of the distribution function of the errors, we selected the generalised error distribution (GED), as applied by Nelson (1991). GED encompasses the Normal and the t-Student distributions, including not only the Normal distribution as a particular case, but also those ones with thicker and narrower tails than the Normal. The density function GED is

$$f_v\left(\varepsilon_t / \psi_{t-1}\right) = v\left[\lambda 2^{\left(1+\frac{1}{v}\right)} \Gamma\left(\frac{1}{v}\right) h_t\right]^{-1} \exp\left[-\frac{1}{2}\left|\varepsilon_t \lambda^{-1} h_t^{-1}\right|^v\right], \quad \lambda = \left[2^{-\frac{2}{v}} \Gamma\left(\frac{1}{v}\right) \middle/ \Gamma\left(\frac{3}{v}\right)\right]^{\frac{1}{2}}$$

where v is the scale factor. When $v = 2$ the distribution GED for the standardised residuals $z_t = \varepsilon_t / h_t$ tends to the Normal, while if $v < 2$, the density of $z_t = \varepsilon_t / h_t$ is more leptokurtic and has thicker tails than the standard Normal distribution.

---

[7]Alternatively, various models which allow the existence of asymmetries in the conditional volatility have been considered, but the GARCH(1,1)-M specification provides the best results.

The maximum likelihood estimation method is applied, and the logarithmic maximum likelihood function is

$$Log\,L(\theta) = -\frac{1}{2}\sum_{t=1}^{T}\left[\log\left(f_\nu\left(\varepsilon_t/\psi_{t-1}\right)\right)\right]$$

where θ is the vector of parameters and T is the sample size. The optimisation algorithm used is that of Bernt, Hall, Hall and Haussman (hereafter, BHHH).

III. Data

The data used in this study are daily and cover the period from January 1, 1996 to May 26, 2003, since we wished to distinguish the periods before and after the introduction of the euro (EMS and post-EMS periods). The variables studied are the excess exchange rate returns for DEM/USD, BP/USD and JY/USD. These variables are obtained from the following initial variables, where the subscript j refers to Germany if j=1, to Great Britain if j=2, to Japan if j=3 and to USA if j=4; s_{jt} is the exchange rate of the j-th currency with respect to USD, expressed in Neperian logarithm; i_{jt} is the 3-month interbank interest rate, where j=1,2,3,4. From these initial variables, the following variables are generated: r_{jt} is the effective daily interest rate, defined as $r_{jt} = \left(\left(i_{jt}/400\right)+1\right)^{1/90}$, for j=1,2,3,4; er_{jt}^c is the excess exchange rate return, defined as $er_{jt}^c = r_{3,t-1} + s_{jt} - s_{j,t-1} - r_{j,t-1}$ for j=1,2,3. Figure 1 illustrates the evolution of the DEM/USD, BP/USD and JY/USD exchange rates, and their excess returns. DEM, like the currencies of all the countries which adopted the euro as their single currency from

9

January 1, 1999, is a virtual currency because it is no longer quoted. The DEM/USD exchange rate is obtained as the result of 1euro/USD times 1.95883 DEM/euro.
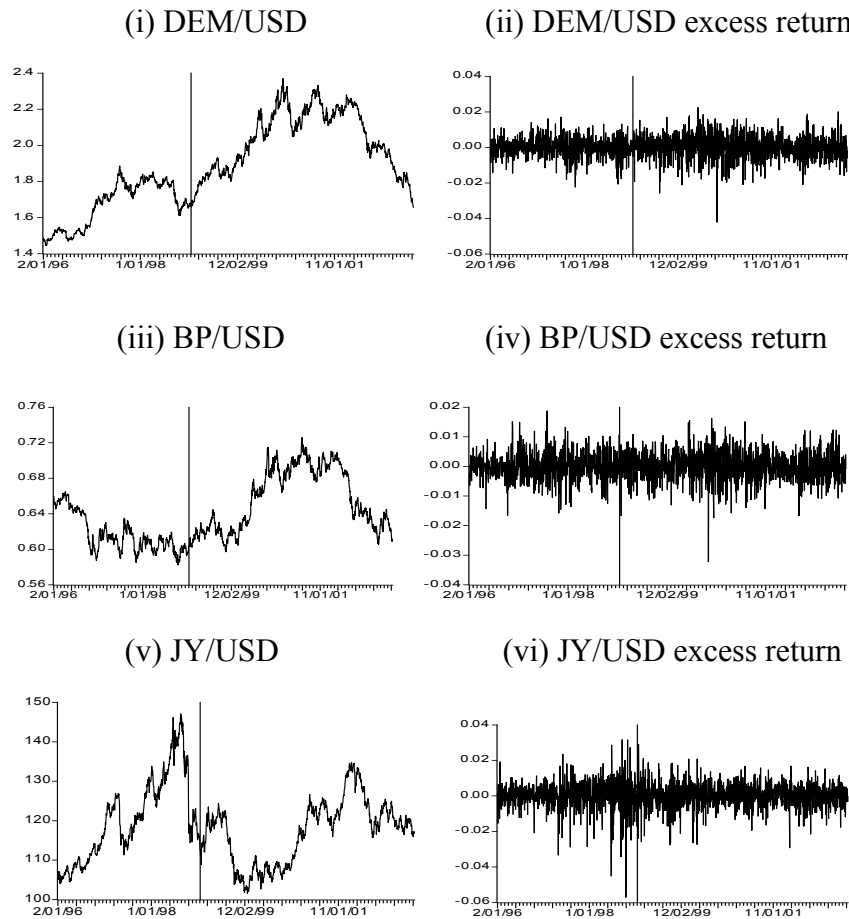
Table 1. Summary statistics for excess returns against USD (annualised)

	Deutsch mark			British pound			Japanese yen		
	Mean	St.Dev.	Pearson	Mean	St. Dev.	Pearson	Mean	St. Dev.	Pearson
Full Sample	0.0195	1.641	83.994	-0.0074	1.230	-165.9	0.0167	1.896	113.28
Before euro	0.0524	1.392	26.58	-0.0214	1.1659	-54.4	0.029	2.126	71.192
After euro	-0.002	1.792	-633.51	0.00214	1.2984	604.39	0.0077	17.231	2237.0

A currency's volatility over time tells us something about its credibility. Table 1 shows that the mean excess returns of the DEM and the JY decreased slightly during the period in question, while the standard deviations of the three excess-of-return values increased significantly, as can be seen from the results of the Pearson coefficient (Pearson).

The period considered in this study features two well-differentiated stages: firstly, 1996-2000 was characterised by a remarkable increase in GDP among most major world economies (except Japan), headed by the USA, followed by the euro zone countries and Great Britain. Japan, however, has had a very different behaviour since the early nineties, characterised by a stagnant economy with an additional problem of deflation, which has persisted to date. The second stage is characterised by a generalised recession, due to the end of the expansive cycle from 2000. Furthermore, the increasing political tension originated by terrorist attacks against the USA on September 11, 2001 and the subsequent conflicts in Afghanistan and Iraq contributed to accelerating this recession.

Figure 1. Time path for exchange rates and their excess returns against USD

(i) DEM/USD

(ii) DEM/USD excess return

(iii) BP/USD

(iv) BP/USD excess return

(v) JY/USD

(vi) JY/USD excess return

Note. Vertical lines denote the introduction of the euro: 1-1-1999

Thus, during 2001, a financial crisis strongly affected the USA and extended all over the world. Nevertheless, the USA possesses a great capacity to overcome recessions, as shown by the sharp recovery experienced just a year later.

With respect to the evolution of exchange rates, the introduction of the euro on 1 January 1999 started with a severe depreciation of this currency, and also of the BP, against the USD. However, both exchange rates had stabilised by the end of 2000 and

this stability continued during 2001; the USD began to depreciate against these currencies in 2002.

The JY, on the other hand, behaved in a different way: after two decades of appreciation against the USD, it underwent a phase of depreciation from 1995 to 1998. Since then, the evolution of this exchange rate has not followed a clear trend, fluctuating around its mean.

Table 2. Unit root tests for excess returns

	ADF(p=4)		PP(l=6)	
	Intercept	Trend	Intercept	Trend
er_{1t}^{c}	-20.13	-20.327	-45.46	-45.61
er_{2t}^{c}	-19.38	-19.38	-43.349	-43.34
er_{3t}^{c}	-19.612	-19.625	-42.718	-42.719
1%	-3.438	-3.970	-3.438	-3.970
5%	-2.864	-3.415	-2.864	-3.415

Note. Critical values of ADF and PP tests obtained from MacKinnon (1991). The number of lags p selected is 4, while the truncation point l is obtained from the expression $l = floor\left[(T/100)^{1/4}\right]$, where *floor* is the smallest integer.

Finally, as regards the characteristics of the series of excess returns of the currencies analysed, these series can be considered stationary (see Table 2, which shows the results of the models with constant, and constant and trend, from the Augmented Dickey and Fuller test and the Phillips and Perron test for the null hypothesis of non-stationarity). According to Table 3, the series of excess returns do not possess significant autocorrelation structures, although they do show the existence of ARCH effects and non-Normality.

Table 3. Autocorrelation and ARCH tests for excess returns

	Panel A: Excess retuns									
	LBQ(1)	**LBQ(5)**	**LBQ(10)**	**LBQ(20)**	**SK**	**K**	**JB**	**ARCH1**	**ARCH5**	**ARCH10**
er_{1t}^c	2.2622 [0.133]	5.543 [0.353]	7.075 [0.718]	19.635 [0.481]	-0.38	4.651	267.93^c [0.0]	6.378^b [0.011]	9.763^c [0.0]	6.492^c [0.0]
er_{2t}^c	0.33 [0.565]	3.905 [0.563]	7.11 [0.715]	20.155 [0.448]	-0.2	4.808	276^c [0.0]	7.65^c [0.005]	3.69^c [0.0024]	4.41^c [0.0]
er_{3t}^c	1.471 [0.22]	7.72 [0.17]	17.83^a [0.058]	32.278^b [0.04]	-0.81	8.28	2463^c [0.0]	154.77^c [0.0]	34.75^c [0.0]	22.9^c [0.0]
	Panel B: Squared excess retuns									
	LBQ$_2$(1)	**LBQ$_2$(5)**	**LBQ$_2$(10)**	**LBQ$_2$(20)**	**AS$_2$**	**K$_2$**	**JB$_2$**			
er_{1t}^c	6.3758^b [0.012]	59.56^c [0.0]	92.44^c [0.0]	157.14^c [0.0]	8.449	157.2	1938^c [0.0]			
er_{2t}^c	7.649^c [0.006]	21.862^c [0.001]	61.291^c [0.0]	85.51^c [0.0]	8.959	172.9	2349^c [0.0]			
er_{3t}^c	143.26^c [0.0]	217.69^c [0.0]	324.28^c [0.0]	422.2^c [0.0]	10.52	180.4	2569^c [0.0]			

Note. LBQ(1),LBQ(5), LBQ(10) and LBQ(20) are Ljung-Box statistics from residuals. SK, K and JB are skewness and kurtosis coefficients, and Jarque-Bera normality test, respectively. An analysis of the squared residuals is also performed, the characteristics being given by subscript 2. ARCH(1), ARCH(5) and ARCH(10) denote the statistics corresponding to the Lagrange multiplier test ARCH, which tests the existence of ARCH specification with 1, 5 and 10 lags, respectively. The values in brackets denote significance levels where a=10%, b=5% and c=1%.

The excess returns of the DEM/USD, BP/USD and JY/USD present a weak structure in the regular part, since the null hypothesis of non autocorrelation of the LBQ(k) tests can not be rejected (except LBQ(20) for the JY/USD, which nevertheless, can not be rejected at 1% of significance level). On the other hand, the null hypothesis of non autocorrelation of the squared residuals is always rejected, which is evidence of conditional volatility. Moreover, the ARCH(p) test rejects the null hypothesis of absence of ARCH effects in the three currencies. Furthermore, the series are leptokurtic and show a certain skewness towards the left. Therefore, the use of ARCH processes is justified.

IV. Before and after Euro Risk Premium Estimates

The objective of the ERM, that of reducing exchange rate risks for the participating currencies, was achieved. In the present section, we perform a simple econometric analysis of the behaviour of the new currency, the euro, after its introduction. For this purpose, we study a model of the recent history of the DEM in the EMS and compare it with that of the BP and JY in the same period.

Model (1) implies that the risk price (δ) is constant; heteroskedastic conditional variance, therefore, was modelled by using the excess of return. DEM/USD, BP/USD and JY/USD were considered according to the GARCH-M specification described in Section II.

We now comment on each currency, considering the results given in Table 4 (panels A, B and C), which summarises the main characteristics of the joint estimation of models (1) and (2) by maximum likelihood assuming GED distribution for the errors. Every currency is estimated for the EMS and post-EMS period (whole period), and also for the subperiods before and after the introduction of the euro (EMS and post-EMS, respectively).

Table 4. Maximum likelihood estimations for model (1) and (2) under GED error distribution

	Parameters						*Misspecification tests*					
								ε_t			z_t	
	δ	ω	α_1	β_1	ν	F	K	LBQ (20)	LBQ$_2$ (20)	K	LBQ (20)	LBQ$_2$ (20)
Panel A: Deutsch mark												
EMS and post-EMS	0.034[a] [0.10]	2E-6[c] [4E-5]	0.101[c] [3E-7]	0.827[c] [0.0]	1.39[c,c] [0.0] [0.0]*	1.9 [0.12]	4.6	19.59 [0.48]	154.6[c] [0.0]	4.4	11.79 [0.92]	25.39 [0.18]
EMS period	0.0694[b] [0.033]	6E-6[c] [6E-4]	0.155[c] [0.002]	0.613[c] [0.0]	1.336[c] [0.0]	2.6[b] [0.05]						
Post-EMS	0.0144 [0.61]	1E-5[c] [0.0]	0.075[b] [0.03]	0.628[c] [0.0]	1.47[c] [0.0]	2[a] [0.065]						
Panel B: British pound												
EMS and post-EMS	0.039 [0.83]	1E-5[c] [0.004]	0.142[c] [3E-7]	0.313 [0.83]	1.32[c,c] [0.0] [0.0]*	1..33 [0.26]	4.8	20.13 [0.44]	85.74[c] [0.002]	4.7	17.441 [0.62]	42.77[c] [0.002]
EMS period	-0.057 [0.73]	9E-6[c] [0.001]	0.321[c] [0.001]	0.249 [0.16]	1.22[c] [0.0]	2.41[a] [0.06]						
Post-EMS	0.54 [0.13]	2E-5[c] [0.001]	0.062 [0.21]	-0.006 [0.98]	1.38[c] [0.0]	0.429 [0.73]						
Panel C: Japanese yen												
EMS and post-EMS	0.053[c] [0.006]	4E-6[c] [9E-6]	0.099[c] [0.0]	0.81[c] [0.0]	1.2[c,c] [0.0] [0.0]*	16.47[c] [0.0]	8.3	32.21[b] [0.04]	428[c] [0.0]	5.5	19.759 [0.47]	10.73 [0.953]
EMS period	0.096[c] [0.0002]	7E-6[c] [0.001]	0.2[c] [7E-5]	0.69[c] [0.0]	1.03[c] [0.0]	25.6[c] [0.0]						
Post-EMS	0.017 [0.51]	4E-5[c] [1.5E-5]	0.05[a] [0.089]	-0.007 [0.97]	1.33[c] [0.0]	2.57[b] [0.05]						

Note. Levels of significance appear in brackets, with a, b and c referring to the level of significance: a=10%, b=5% and c=1%. The asterisk denotes the *p*-value under the null hypothesis that ν =2 against the alternative that ν < 2. F is the Engle and Ng(1993) test based on the distinction between negative and positive shocks. LBQ(20) and LBQ$_2$(20) are the statistics of the Ljung-Box test on the standardized and the squared standardized residuals, respectively.

IV.1. Deutsch Mark against US Dollar

In the case of DEM/USD (Table 4, panel A), and for the estimation of the whole period, the estimated coefficients are significant at 5%, except the RPC, which is significant at 10%. On the other hand, the variance is stationary (i.e. $\alpha_1 + \beta_1 < 1$), and the model is properly specified, since the Engle and Ng test (F-test) does not reject the null hypothesis at 5%, the standardised residuals (z_t) have a lower excess of kurtosis

(K) than the original residuals (ε_t), and moreover, do not show structure according to the Ljung-Box test (LBQ and LBQ$_2$). Finally, in order to decide which logarithm likelihood function properly represents the model, we evaluated the null hypothesis ν =2, against the alternative $\nu < 2$ in the GED model, finding that the hypothesis of normality is rejected. In summary, the proposed model is properly specified.
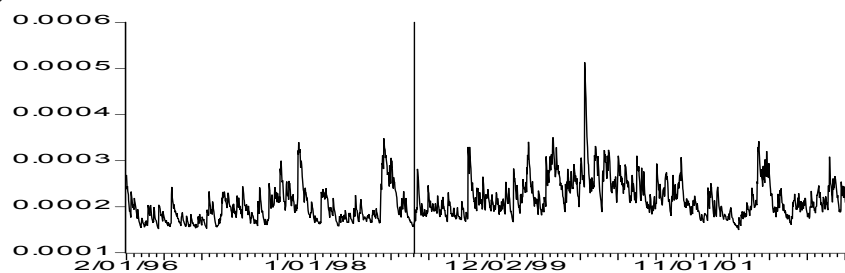
As regards the interpretation of the parameters of interest, the RPC (δ) is positive and statistically significant at 10%, which implies that there exists a significant risk premium if we allow this level of significance. Analysis by subperiods shows that the RPC decreased after the introduction of the euro; it was significant before 1999, but not after this date. Therefore, there exists evidence of a reduction in the RPC of DEM/USD after the introduction of the euro. Therefore, the risk price accepted by an investor in the euro zone who seeks to invest in US dollars has decreased. A similar conclusion was obtained by Frömmel and Menkhoff (2001), although this result contradicts that of De Santis, Gérard and Hillion (2003), who found that the exchange risk of a German investor against the US and Japanese currencies increased during the period 1974-1997.

When analysing the risk premium, the value of which is obtained as the product of the RPC and the conditional standard deviation, note that volatility increased during 2000, which implies that investing in US dollars during this period became more risky. This is due to the fact that the expansive cycle in the USA was ending; the USD was overvalued and the currency was expected to depreciate. Moreover, the American economy suffered from structural problems, such as high levels of public deficit, which could affect investors' confidence.

In summary, while Frömmel and Menkhoff (2001) found a negative trend for DEM/USD during the period 1979-1998, and De Santis, Gérard and Hillion (2003)

found an increased level of risk, we cannot confirm a clear trend during the period 1996-2003 from our estimation of the risk premium. Nevertheless, we did observe stages of higher volatility, as occurred during 2000, and can affirm that the RPC decreased after the introduction of the euro.

Figure 2. Evolution of the risk premium for the excess return of the DEM/USD, assuming that RPC is constant

From the above results we may conclude the following: although there exist arguments in favour of the stability of the euro[8], its volatility increased, at least during 2000. Such a higher volatility can be explained by various factors: in the first place, after 1999 there were mistaken expectations of growth in the euro zone while, in fact, the USA experienced a higher growth rate. This had a negative effect on the European currency, starting a phase of depreciation and instability against the dollar. In the second place, March 1999 marked the onset of a continuous rise in the price of oil (which affects the euro, since Europe depends on this raw material), causing inflationary pressures all over

---

[8] For example, it is logical that the euro should be more stable than the mean of its components, since a large economic area has less necessity than an individual country to make strategic use of monetary policy to stabilise its economy. A large area would be less worried about its exchange rate because its production is less dependent on it. Thus, large economic units should enjoy more stable exchange rates than small ones.

17

the world. In consequence, central banks were forced to adopt stricter monetary policies, and both the Federal Reserve and the European Central Bank increased official interest rates several times.

The euro underwent severe depreciation from its introduction. This fact was so worrying that in late September 2000, various central banks, including the USA Federal Reserve and the Bank of Japan, agreed to buy euros, thus contributing to a transitory recovery of the euro/USD exchange rate. In this sense, although the European Central Bank does not have an explicit rule requiring the stability of exchange rates, it is prepared to intervene in critical situations. A further crucial factor is the high level of European investment in the American economy. The existence of a huge European financial market has allowed significant flotations of assets which have later been invested in foreign companies. Although this fact is, in principle, a positive factor that balances the traditional asymmetry between American investor flows towards Europe and European investments in the USA, it does imply an initial depreciation of the euro against the USD. Finally, we should take into account that the introduction of a new currency generates great uncertainty in the markets; thus, it is reasonable to consider that the mere introduction of the euro is reason enough to justify an increased risk in the European area against the USD. Therefore, during this brief period, the European agents suffered a higher degree of risk and their international negotiation power was reduced by the depreciation of the euro against the USD.

After 2001, the evolution of the euro experienced a radical change, with a generalised depreciation of the USD occurring from this date. According to the monetary authorities, this might have been caused by the slow growth of the American economy during this period, together with increasing worries in the markets about the

U.S. current account deficit, its high and persistent public deficit, increasing political tensions and uncertainty concerning future economic growth.
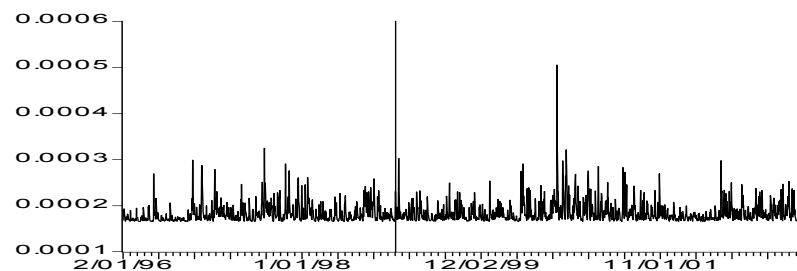
IV.2. British Pound against US Dollar

The BP's participation in the ERM was short-lived (1990-1992). During this period, the fact of being tied to the German mark (the system's "anchor currency") and the process of interest rate convergence forced the UK to follow a particular monetary policy. We do not believe the BP can be considered an external benchmark, as it was in the ERM for two years. After 1998, the BP continued to appreciate against DEM and then against the euro from 1 January 1999. This appreciation of the BP against the euro was due mainly to the entrance of significant volumes of capital from abroad.

The UK and European cycles have, in fact, gradually converged, which seems natural given that the euro-zone countries form the UK's main market (54% of its exports, against 13% in the case of the USA). The appreciation of the BP against the euro should be understood in conjunction with the USD's concomitant appreciation against the euro. It seems that the strength of the BP reflected the weakness of the euro (which was undervalued against the USD), while the BP/USD relationship remained more stable.

The BP was included in our analysis in order to determine whether the euro has affected this currency in terms of risk. Models (1) and (2) were considered, and the estimated results are shown in Table 4, panel B. Difficulties arose in finding an adequate model for the BP, although various specifications were tried. The specification tests of the model estimated show evidence of conditional volatility, although this was not captured

by the model, since we found significant autocorrelation in the standardised squared residuals. In general, the RPC is not significant, neither with the whole sample, nor before or after the introduction of the euro, and so it may not be appropriate to extract conclusions from this analysis, since we consider that it is more reasonable to argue that the proposed specification is inadequate than to postulate a zero risk premium of the BP. Table 4 shows that the RPC was negative before the introduction of the euro, and subsequently positive, with an increasing value of the t-Student statistic. From these results, we see there exists a certain positive trend in the evolution of the RPC, although such an interpretation should be made cautiously. Other recent papers analysing the BP risk [Benati (2002) and Panigirtzoglou (2000)] have also found the sign of the risk premium to change. Benati (2002) found that the BP risk premium with respect to the USD, using the Duffie-Kan affine multifactor model, is variable in sign during the period 1982-2000. Panigirtzoglou (2000) estimated the BP risk against the euro, and concluded that it has decreased since 1996 and has been negative since the introduction of the euro. Figure 3 illustrates the evolution of the estimated BP/USD risk premium.

Figure 3. Evolution of the risk premium for the excess return of the BP/USD, assuming that RPC is constant
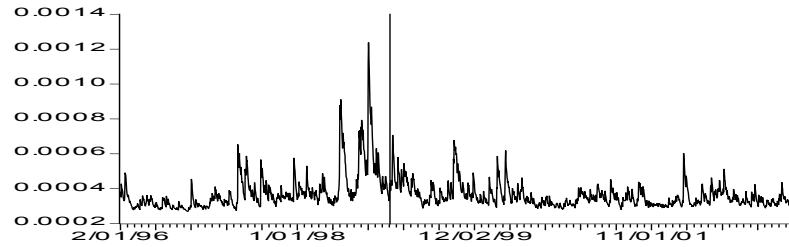

20

IV.3. Japanese Yen against US Dollar

Analysis of the JY risk with respect to the USD (see Table 4, panel C) reveals evidence of a significant risk premium. This result coincides qualitatively with those of He, Ng and Wu (1996), De Santis and Gérard (1998) and Tai (2001), who, working within the framework of an unconditional multi-factor asset pricing model, provided evidence that this exchange risk is priced. However, previous works which are also in the framework of a multifactor ICAPM, such as Hamao (1988) and Brown and Otsuki (1990) concluded that the Japanese RPC with respect to the USD was not significant.

In our study, we found that, considering the whole sample, not only the RPC, but also the other coefficients in the model were significant, all of them verifying the sign restrictions. The specification tests satisfy the hypotheses, thus confirming the adequacy of the model selected. In estimating the two subperiods, we found that the RPC was higher and significant before the introduction of the euro, but not significant after this date. According to these results, during the period 1995-1998, which was characterised by a phase in which the USD appreciated against the JY (after many years of appreciation of the JY), the price demanded by Japanese investors for investing in USD deposits was higher than after 1999. Since then, JY/USD has fluctuated without a clear trend. The South East Asian crisis in 1997 hit Japan hard, as 90% of its exports go to Asia, and many bankruptcies were caused in this country. This helps explain the higher RPC estimated before 1999. Finally, the estimated risk premium (see Figure 4) showed higher volatility during 1998 (probably due to the effects of the Asian crisis on Japan), becoming more stable after this date.

Figure 4. Evolution of the risk premium for the excess return of the JY/USD, assuming that RPC is constant

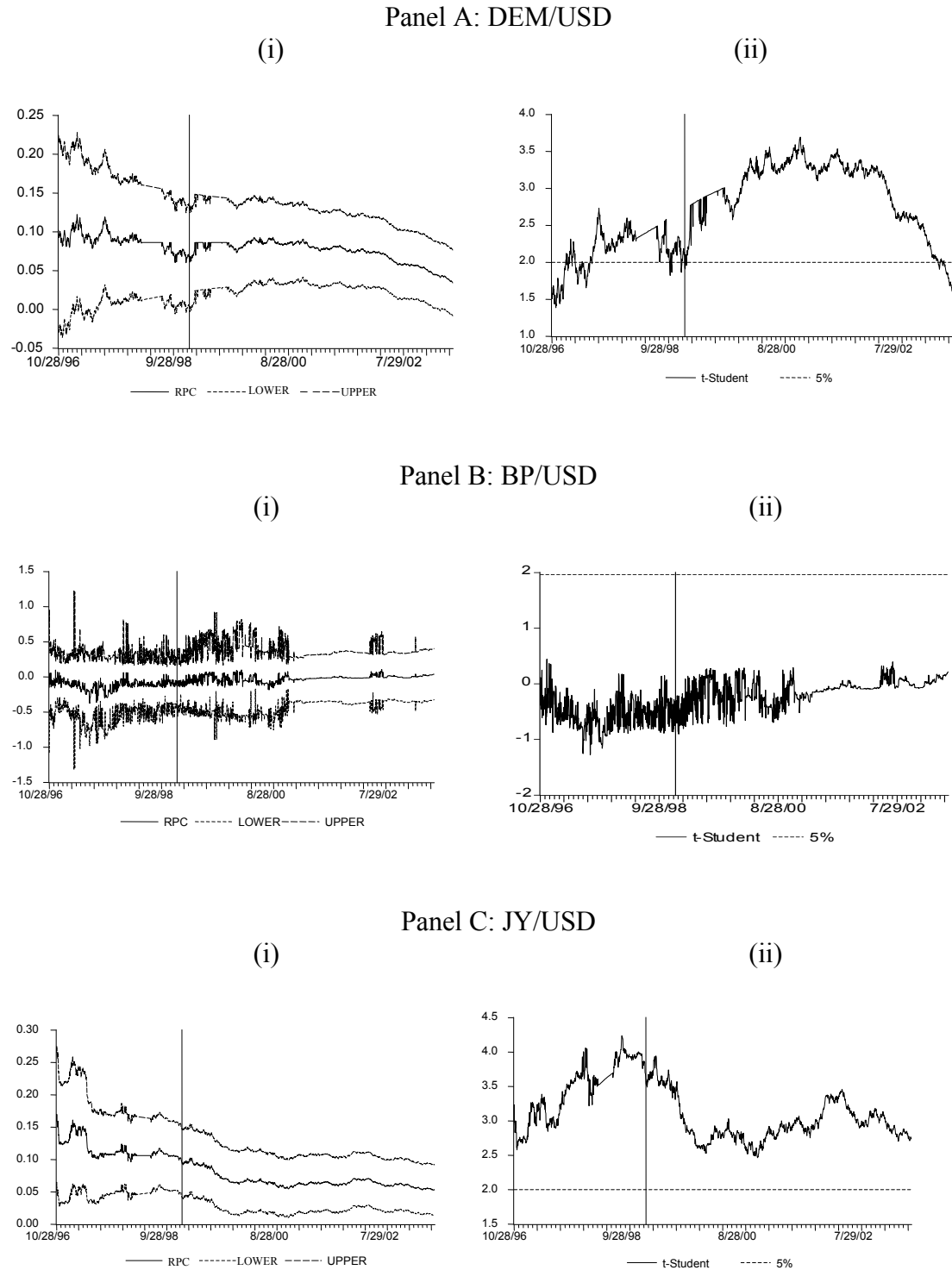## V. Risk Price Estimation for each Trading Day

The major aim of this work is to study the RPC trend in the currencies considered, a question which allows us to determine the stability or instability of the exchange risk after the introduction of the euro, since we consider an increase in the RPC to imply a higher risk premium. Therefore, in this section we examine whether the RPC varies during each trading day, that is, if there is evidence of the temporal instability of this coefficient. For this purpose, we follow a recursive procedure which updates the estimations of the parameters for every period. The recursive estimation is based on re-estimations of both the RPC and the conditional volatility, adding an additional observation in the framework of maximum likelihood. The recursive method applied comprises a recursive adaptation of the method proposed by Engle (1982); this hypothesis is considered acceptable, since the sample maximum likelihood is also a way of learning. The recursive estimations use the initial values of the parameters obtained in the last recursive estimation for the ith iteration of the algorithm. The procedure is as follows: the general expression of the model estimated is

22

$er_r^c = \delta_r h_r + \varepsilon_r$, $r = 215, 216, ..., 1931$, and if the conditional volatility is a GARCH(1,1), then its expression is $h_r^2 = \omega + \alpha \varepsilon_{r-1}^2 + \beta h_{r-1}^2$, $r = 215, ..., 1931$. The initial sample size is 215 observations[9]. Thus, the first sample estimated contains information for the period from January 1, 1996 to October 25, 1996 (r=215). The second sample refers to the period between January 1, 1996 and October 26, 1996 (r=216), and so on. The total number of estimations obtained is 1716, corresponding to the period from October 25, 1996 to May 25, 2003. The algorithm used for the recursive estimations is that of Bernt, Hall, Hall and Haussman, from which the estimations of the parameters of interest have been obtained (δ, ω, α_1, β_1, and v), considering the GARCH(1,1)-M model for each currency. The individual tests of the parameters and the specification tests were also obtained recursively.

The results of the recursive estimation of the RPC and the recursive value of the t-Student statistic, which allows us to value the individual significance of the RPC, are illustrated in Figure 5. More concretely, in this figure two types of graphs are shown for every currency:

---

[9] The choice of the number of observations in the first sample is arbitrary. Nevertheless, the selected size is sufficient to avoid a lack of precision in the estimation of the models used when the sample size is small.

Figure 5. RPC and *t*-Student calculated from the DEM, BP and JY against the USD for the period 28-10-1996 to 26-5-2003. GARCH(1,1)-M estimation with GED distribution error.

Panel A: DEM/USD

(i)   (ii)

Panel B: BP/USD

(i)   (ii)

Panel C: JY/USD

(i)   (ii)

Note. Vertical lines denote the introduction of the euro: 1-1-1999

24

In this figure, the three graphs (i) contain the evolution of the RPCs with the upper and lower confidence intervals for the DEM/USD, BP/USD and JY/USD, respectively. On the other hand, graphs (ii) show the evolution of the t-Student statistics and their critical values at 5%. From these results the following conclusions can be drawn:

a) The evolution of the RPC of the DEM/USD shows a clearly different behaviour between the two subperiods analysed. Before the euro, the RPC decreased (31.89%) and showed high volatility; after the introduction of the euro, there was an increasing trend during 1999 (38.1%), followed by a stable phase during 2000 and by a sharp decline from 2001 (96.5%), while the volatility of the series gradually diminished. During 1996, the RPC was not statistically significant. From this date, the null hypothesis that the RPC is zero is rejected, until 2003, when the RPC was no longer significant. This hypothesis in favour of the reduction of the RPC of the DEM/USD is supported not only by Frömmel and Menkhoff (2001), but also by Capiello, Castrén and Jääskelä (2003), who used a version of the ICAPM model and estimated the RPC for an European agent who invests in USD, working with a sample period from 1987 to 2001. These authors found that the RPC volatility decreased with convergence towards the EU, a process that started in 1996. In our work, we find a more detailed explanation of the evolution of the RPC. Certainly, convergence towards the EU reduced the price demanded for assuming the risk of investing in USD until 1998. Nevertheless, the increase in the RPC during 1999 is associated with the strong depreciation of the euro against the USD during this period. Many studies have tried to identify factors explaining the depreciation of the euro, with no conclusive results being obtained. As discussed in the previous section, a frequently-cited argument is the large transfer of capital from Europe

to the USA that took place during 1999 and 2000, financing the acquisition of foreign companies, in addition to the increase in the price of oil from 1999 and the fact that the introduction of a new currency in itself generates uncertainty.

From 2000, a new process of appreciation of the euro against the USD began, coinciding with a decreasing trend of the RPC. There is no strong evidence that geopolitical tensions have affected the price of risk.

b) The results obtained in the recursive estimation of the BP/USD are not satisfactory. This was also the case in the previous estimations considering the whole sample and the subperiods before and after the introduction of the euro. The recursively-estimated RPC was not significant in any of the versions of the model and had a negative sign during most of the period. Nevertheless, the risk premium and the RPC were not significant for the BP/USD. From this result, we conclude that the introduction of the euro did not significantly affect the British currency.

c) The RPC obtained recursively for the JY/USD reflects the behaviour observed in the estimation of the subperiods before and after the introduction of the euro. A detailed analysis of the evolution of this coefficient reflects the relation between the RPC and the evolution of the exchange rate. During the phase of appreciation of the USD from 1995 to 1998, the RPC increased during periods of strong appreciation (e.g. at the end of 1996). This relationship "USD appreciation-RPC rise" is not exact, as in other stages (1997-1998) the RPC remained stable. In the subsequent phase of depreciation of the USD (second half of 1998 and 1999), the RPC decreased, while during the last stage of fluctuation of the JY, with no clearly-defined trend visible, the RPC was stable. In summary, the Japanese risk premium was significant during the whole period analysed, although tending to decrease. Furthermore, this reduction began considerably before the

entrance of the euro; thus, it does not seem that the evolution of the Japanese risk premium had anything to do with the introduction of the euro.

VI. Conclusions

The aim of this study is to analyse the effects of the introduction of the euro on the DEM exchange rate with respect to the USD. The latter was selected as the reference currency because the USA is the main rival of the European economy, and because the DEM represented the face-value denomination of the euro after January 1, 1999, this analysis enables us to study the strength or weakness of the EMS central currency against the USD by means of exchange risk analysis. The BP/USD and JY/USD exchange rates were also studied for the sake of comparison.

The results obtained reveal evidence of an increased DEM risk premium with respect to the USD after the introduction of the euro. This risk premium is obtained as the product of the RPC and the conditional standard deviation. While the conditional volatility has shown higher values since 1999 (mainly during 2000), the DEM/USD RPC decreased after the introduction of the euro, with the result that an agent from the EMU area demanded a lower price for investing in the American exchange market after that date.

If we compare the evolution of the euro/USD risk with the BP/USD and JY/USD risks, we observe, on the one hand, that there is no significant BP/USD risk premium and, on the other hand, that the JY/USD risk premium follows a different behaviour from that of the DEM/USD, being higher during 1998, and decreasing after 1999. As

regards the JY/USD RPC, this also decreased after 1999, but the reasons underlying the evolution of the RPC and the risk premia of the two currencies are different, due to the diverse commercial links between Japan and the USA and between the EU and the USA. Furthermore, the economic circumstances that characterised Japan and the USA during the period analysed varied considerably.

References

Andrada, J., Sosvilla, S. and Fernández, F. (2001) "Predicción del tipo de cambio dólar/euro: un enfoque no lineal". Presented at the Internacional Conference "Forecasting Financial Markets", London 2002.

Artis, M.J. and Taylor, M.P. (1994) "The Stabilizing Effect of the ERM on Exchange Rates and Interest Rates: Some Nonparametric Tests". *IMF Staff Papers* No. 41, pp. 123-148.

Ayuso, J., Dolado, J. and Sosvilla-Rivero, S. (1992) "¿Es el tipo forward un predictor insesgado del tipo spot futuro? El caso del tipo de cambio peseta/dólar reconsiderado". *Revista Española de Economía*, Monograph "Mercados Financieros Españoles", pp. 111-134.

Baillie R. T.and Bollerslev, T. (1990) "A Multivariate Generalized ARCH Approach to Modeling Risk Premia in Forward Foreign Exchange Rate Markets" *Journal of International Money and Finance,* No. 9, pp. 309-324.

Benati, L. (2002) "Affine Term Structure Models for the Foreign Exchange Risk Premium". *Manuscript*, Bank of England.

Bertola, G. and Svensson, L. (1993) "Stochastic Devaluation Risk and the Empirical Fit of Target-Zone Models", *Review of Economics Studies*, No. 60, pp. 689-712.

Bollerslev, T. (1987) "A Conditional Heteroskedatic Time Series Model for Speculative Prices and Rates of Return". *Review of Economics and Statistics*, No. 69, pp. 542-547.

Brown, S.J. and Otsuki, T (1990) "Macroeconomic factors and the Japanese Equity Markets". E.J. Elton and M.J. Gruber, eds. New York, NY: Harper & Row.

Capiello, L., Castrén, O. and Jääskelä, J. (2003) "Measuring the Euro Exchange Rate Risk Premium: the Conditional International CAPM Approach", European Financial Management Association, http://www.efmaefm.org/confpart2003.html (accessed December 5, 2003).

Castro, F. and Novales, A. (1997) "The Joint Dynamic of Spot and Forward Exchange Rates". *Documento de Trabajo*, ICAE, No. 9706.

Closterman, J.and Schnatz, B. (2000) "The determinants of the euro-dollar exchange rate: synthetic fundamentals and a non-existing currency", in Konjunkturpolitic/Applied Economics Quarterly, Vol. 46, No.3, pp. 274-302.

De Santis, G., Gérard, B. and Hillion, P. (2003) "The relevance of currency risk in the EMU". *Journal of Economics and Business*, No. 55, pp. 427-462.

Domowitz, I. and Hakkio, C. (1985) "Conditional Variance and the Risk Premium in the Foreign Exchange Market". *Journal of International Economics*, No. 19, pp. 47-66.

Dumas, B, and Solnik, B. (1995) "The world price of foreign exchange risk". *Journal of Finance*, No. 50, pp. 445-479.

Engle, R.F. (1982) "Autoregressive Conditional Heteroskedasticity with Estimates of Variance of U.K. Inflation". *Econometrica*, No. 50, pp. 987-1007.

Engle, R.F. and Ng, V. (1993) "Measuring and Testing the Impact of News on Volatility". *Journal of Finance,* No. 48, pp. 1749-1778.

Fama, E.F. (1984) "Forward and Spot Exchange Rates", *Journal of Monetary Economics*, No. 14, pp. 319-38.

Fernández, F., Sosvilla, S. and García, D. (1997) "Using Nearest-Neighbour Predictors to Forecast the Spanish Stock Market". *Investigaciones Económicas,* No. 21, pp. 75-91.

L.P. (1982 Frömmel, M and Menkhoff, L. (2001) "Risk Reduction in the EMS? Evidence from Trends in Exchange Rate Properties". *Journal of Common Market Studies*, Vol. 39, No. 2, pp. 285-306.

Hamo, Y (1988) "An Empirical Examination of the Arbitrage Pricing Theory". *Japan and the World Economy*, No. 1, pp. 45-62.

Hansen,) "Large Sample Properties of Generalized Method of Moments Estimators". *Econometrica*, No. 50, pp. 1029-1054.

He, J. , Ng, L. and Wu, X. (1996) "Foreign Exchange Exposure, Risk and the Japanese Stock Market". *Working Paper*, City Univ. of Hong Kong.

Hsieh, D. A. (1989) "Modeling Heteroskedasticity in Daily Foreign-Exchange Rates 1974-1983". *Journal of Business and Economic Statistics,* No. 7, pp. 307-17.

Krugman, P. (1991) "Target Zones and Exchange Rate Dynamics".*Quarterly Journal of Economics,* No.106, pp. 669-82.

Ledesma, F., Navarro, M. Pérez Rodríguez, J. and Sosvilla, S. (1999a) "A Study of the Credibility of the Spanish Peseta". *Estudios de Economía Aplicada*, No. 11, pp. 85-100.

Ledesma, F., Navarro, M., Pérez-Rodríguez, J. and Sosvilla-Rivero, S. (1999b) "Una aproximación a la credibilidad de la peseta en el Sistema Monetario Europeo". *Moneda y Crédito*, No. 209, pp. 195-230.

Ledesma, F., Navarro, M., Pérez-Rodríguez, J. and Sosvilla-Rivero, S. (1999c) "Una aproximación a la Credibilidad del Escudo en el Sistema Monetario Europeo". *Economia*, Janeiro-Maio-Outubro, No.23, pp. 69-95.

Ledesma, F., Navarro, M., Pérez-Rodríguez, J. and Sosvilla-Rivero, S. (2000) "On the Credibility of the Irish Pound in the ERM". *The Economic and Social Review*, Vol. 31, No.2, pp. 151-172.

MacKinnon, J.G. (1991) "Critical Values for Cointegration Tests", in R.F.Engle and C.W.J. Granger (eds.), *Long-run Economic Relationships. Readings in Cointegration*, Oxford University Press, Oxford, pp. 267-287.

Malliaropulos, D. (1995) "Conditional Volatility of Exchange Rates and Risk Premia in the EMS". *Applied Economics,* No. 27, pp. 117-123.

Malliaropulos, D. (1997) "A Multivariate GARCH Model of Risk Premia in Foreign Exchange Markets". *Economic Modelling*, No. 14, pp. 61-79.

McCurdy, T.H. and Morgan I. G. (1987) "Tests of the Martingale Hypothesis for Foreign Currency Futures with Time Varying Volatility". *International Journal of Forecasting,* No. 3, pp. 131-148.

McCurdy, T.H. and Morgan I. G. (1988) "Testing the Martingale Hypothesis in Deutsche Mark Futures with Models Specifying the Form of Heteroskedasticity". *Journal of Applied Econometrics*, No. 3, pp. 187-202.

McCurdy, T.H. and Morgan I. G. (1989) "Evidence of Risk Premia in Foreign Currency Futures Markets". Queens University, Department of Economics, Mimeo.

McCurdy, T.H. and Morgan I. G. (1991) "Tests for a Systematic Risk Component in Deviations from Uncovered Interest Rate Parity". *Review of Economic Studies*, No. 58, pp. 587-602.

Nelson D.B. (1991) "Conditional Heteroskedasticity in Asset Returns: A New Approach". *Econometrica*, No. 59, pp. 347-370.

Pagan, A.R. and Schwert, G.W. (1990) "Alternative Models for Conditional Stock Volatility". *Journal of Econometrics*, No. 45, pp. 267-290.

Panigirtzoglou, N. (2000) "Implied Foreign Exchange Risk Premia". *Manuscript,* Bank of England.

Sarno, L. (1997) "Exchange Rate and Interest Rate Volatility in the European Monetary System: Some Further Results". *Applied Financial Economics,* No. 7, pp.255-63.

Sentana, E. (1995) "Quadratic ARCH Models". *Review of Economic Studies*, No. 62, pp. 639-661.

Solnik, B. (1974) "The international pricing of risk: an empirical investigation of the world capital market structure", *Journal of Finance*, No. 29, pp. 365-378.

Stein, J. (2001) "The equilibrium value of the euro/$US exchange rate: an evaluation of research", CESifo Working Paper No. 545, Munich.

Svensson, L. (1991) "The Term Structure of Interest Rate Differentials in a Target Zone", *Journal of Economics Perspectives,* Vol. 6, No. 4, pp. 119-44.

Tai, C. (2001) "A Multivariate GARCH in Mean Approach to Testing Uncovered Interest Parity Evidence from Asia-Pacific Foreign Exchange Markets", *The Quarterly Review of Economics and Finance*, No. 41, pp. 441-460.