EUI WORKING PAPERS IN ECONOMICS

EUI Working Paper ECO No. 95/3

Risk-related Asymmetries in Foreign Exchange Markets

GIAMPIERO M. GALLO
and
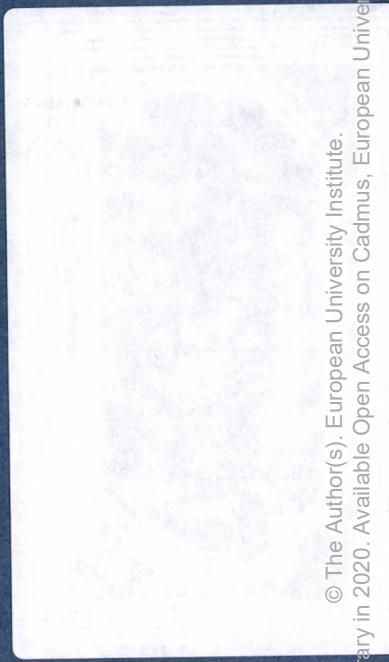BARBARA PACINI

European University Institute, Florence

EUROPEAN UNIVERSITY INSTITUTE, FLORENCE

ECONOMICS DEPARTMENT

EUI Working Paper **ECO** No. 95/3

**Risk-related Asymmetries in
Foreign Exchange Markets**

GIAMPIERO M. GALLO
and
BARBARA PACINI

BADIA FIESOLANA, SAN DOMENICO (FI)

Risk–related Asymmetries in Foreign Exchange Markets [*]

Giampiero M. Gallo

Economics Department – EUI
and
Dipartimento Statistico
Università di Firenze
GALLOG @ DATACOMM.IUE.IT

Barbara Pacini

Dipartimento Statistico
Università di Firenze
Viale Morgagni, 59
I-50134 Firenze, Italy
PACINI @ STAT.DS.UNIFI.IT

December 1994

Abstract

We consider a new nonparametric evaluation of the time–varying risk–related term in the relationship between spot and forward rates, suggesting it as an instrument for an estimator which is compared to others present in the literature. The nature of the time–varying term is discussed, focussing on possible asymmetries in the perception of risk for different currencies in a number of market situations approximated by standard trading strategies. The issue of the strong appreciation and subsequent depreciation of the US dollar in the 1980s is addressed. The results confirm the existence of asymmetries in the size and magnitude of risk–related effects in exchange rate determination.

1 Introduction

In the literature on foreign exchange markets, the reader is customarily briefed on the the largely documented untenability of the hypothesis which asserts that the forward rate is an unbiased predictor of the future spot rate. In this paper we seek to investigate the nature of the time–varying risk–related term often inserted in the spot–forward relationship, in its possible links to market inefficiencies, bounded rationality, or non-linearities as reasons for the breakdown of the unbiasedness hypothesis. We will concentrate in particular on the suggestions to evaluate this risk–related term linking it to the conditional variance, exploiting some of the recent developments in nonparametric and semiparametric estimation [1].

One suggestion advanced in evaluating the presence of this risk–related term in the spot–forward relationship has been to consider an ARCH-M framework where the autoregressive conditional variance term enters as its proxy in the mean equation. Such a parameterization of the conditional variance may turn out to be restrictive in that it imposes specific assumptions about how the information available can be processed to provide a measure of risk. In fact, the empirical evidence provided by Domowitz and Hakkio (1985) with monthly data and by Baillie and Bollerslev (1990) with weekly data has shown the weakness of a parametric approach to the evaluation of risk–premium effects in a spot–forward rates relationship and signals the need to explore other routes. As noted by Froot and Thaler (1990), this approach belongs to the class of statistical models of risk which are not derived from an asset pricing theory where time–varying risk is related to intertemporal

---

[1]Although the presence of stochastic heteroskedasticity is largely documented in the exchange rate analysis, it is not clear whether conditional heteroskedasticity is a structural characteristic of the data generating process, or, rather, is an effect of an incorrect linear specification of the conditional mean function. A different stream of research suggests to seek for nonlinearities in the mean equation with nonlinear and chaotic models. Nonparametric estimates of the conditional mean equation are proposed in Diebold and Nason (1990), Hsieh (1993) and Mizrach (1993).

optimization and attitude towards risk. Nevertheless, its adoption is usually justified on the grounds that risk is related to uncertainty, and the latter to volatility. In our case, a measure of volatility in the market, conditional on an information set and derived from weekly data without imposing a specific parameterization, is used to reflect the prevailing level of uncertainty, given the recent experience on the markets. The outcome is a flexible nonlinear moving average where previous surprises relative to the spot–forward relationship are processed nonlinearly.

We prefer to discuss the presence of a conditional volatility term in the mean equation by referring to it as a risk–related term rather than as a risk–premium for essentially two reasons: the theoretical foundations of a model with a risk–premium fade away when its testable implications need to be derived (cf. Hansen and Hodrick, 1983); second, as shown by Backus and Gregory (1993), a monotonic, increasing relationship between conditional variance and risk–premium cannot be derived in general. The presence of a large number of heterogeneous agents is reflected at times by disparate (but evolving) beliefs concerning the prevailing trends on the markets and might qualify the time–varying nature of this uncertainty, still interpretable as risk–related. The forecastability of returns in periods of low volatility documented by LeBaron (1993a) can then be interpreted as the result of a (temporary) convergence of beliefs about the behavior of the exchange rate, although the small size of the returns and the presence of transaction costs make profitability negligible.

Moreover, the pure risk–premium argument would not explain the market behavior such as the one allowing for periods of strong appreciations and sharp depreciations of the US$ in the 1980s, as noted also by Froot and Thaler (1990). Also, since the behavior of the exchange rates mirrors reputation as regards stability and credibility of monetary and fiscal policies, a working hypothesis is that agents hold different attitudes toward observed periods of relative strength and weakness of a currency. For currencies such as the Italian Lira, for example, for which progressive devaluations vis–à–vis the major currencies in the 70s and the 80s have been the rule rather than the exception, some agents might maintain expectations about a future depreciation even when the signals coming

2

from interest rate differentials would suggest otherwise. An interest rate differential of about 2% between Eurodeposit rates on the Italian Lira and the Deutsche Mark was the norm when the behavior of the Lira in the ERM of the European Monetary System was fairly stable and was not accompanied by any expectation of specific Lira movements. At other times higher differentials were seen as a sign of distress for the Lira, in the presence of expectations of a depreciation. High differentials do not imply necessarily an impending depreciation: in fact, such a situation was observed between the DM and the US$ in the early 1990s, but the former long maintained a position of relative strength when compared to the latter.

The reputation accompanying each currency is related to many economic and political elements under consideration by the markets, among which are the anti–inflationary stances taken by monetary authorities. These elements vary across countries and time, so that it is of interest to investigate the impact of the risk–related term on the exchange rate movements in an attempt to isolate asymmetry of behavior in some specific market situations. Here we will adopt three common trading rules (cf. Le Baron, 1993b) which provide signals of action, in an effort to sift through the different attitudes held by market operators towards a given currency as reflected in "buy" or "sell" actions on the market. To avoid confusion, the trading rules are not examined here for their profitability or to show possible market inefficiencies, but as indicators of situations which the market may not interpret univocally. The movements in the conditional variance (risk-related term) will then have different effects on exchange rate movements if asymmetry is present. In fact, if symmetry in the reactions were to be assumed, we would observe a sheer reversal of signs in the coefficient of the risk–related term. Otherwise, we should interpret the evidence as a sign of the presence of a "reputation" or "prejudice" effect attached to the currency which filters the signals coming from the market. As a further step, we will examine the episodes of strong appreciation and depreciation of the US$ in the 1980s for which the traditional risk premium argument fails to provide convincing explanations. Note that in our analysis the only economic fundamentals

3

taken into considerations are the interest rate differentials, so that there is no explicit reference to learning about changes in monetary policy as in Lewis (1989). The evolution of beliefs concerning the credibility of the monetary authority's actions is taken to be reflected in the behavior of conditional volatility.

Our approach differs from previous parametric studies not only because of the particular interpretation given to the conditional variance term, and the interpretation given in this context, but also because, relative to Baillie and Bollerslev (1990), we allow the MA coefficients to be freely varying, and we estimate the risk term nonparametrically on a larger sample size of 1077 weeks (from 1973 to 1994)[2]. We differ from previous semiparametric estimations of the spot–forward relationship (Pagan and Ullah, 1988; Pagan and Hong, 1991) in choice of estimator and in provision of a comparison of the three methods.

The paper is organized as follows: after recalling some theoretical issues surrounding the relationship between forward spot markets, the econometric treatment of risk evaluation in the parametric case is presented in Section 3. Section 4 discusses the nonparametric estimation of the risk premium, suggesting an original instrumental variable framework given the error–in–variable problem affecting the use of generated variables for the risk term. A comparison with other methods of choosing the instruments for the estimator at hand (Pagan and Ullah, 1988; Pagan and Hong, 1991) is discussed in Section 5 which leads to the empirical application of the procedures to the bilateral exchange rate of five currencies vis–à–vis the US\$[3].

In Section 6 we address the explicit question of asymmetric expectations when periods are formed relative to three trading rules (LeBaron, 1993b): the first is based on the interest rate differentials, the second on short–term and long–term moving averages, and the third on short–term

---

[2]We avoid altogether the sample selection problem which led Hansen and Hodrick (1983) to exclude the years up to 1976 on the grounds that up to that point the free-float system was still being perfected.

[3]Several studies have highlighted the rejection of a "dollar phenomenon" so that the results would not be dependent on the choice of the *numéraire*.

4

and long–term variances. Further evidence is gained from examining the periods in the 1980s characterized by the largest appreciations and depreciations of the US\$ after the collapse of the Bretton Woods regime.

2 The Spot–Forward Relationship

The cornerstone of the analysis of foreign exchange market efficiency is the theory of interest rate parity, which, in its covered form, conveniently provides a link between spot and forward rates, and interest rate differentials.

$$f_{t,k} - s_t = i^*_{t,k} \tag{1}$$

and in its uncovered version, between spot and expectations about future spot rates and interest rate differential

$$E_t(s_{t+k}) - s_t = i^*_{t,k} \tag{2}$$

where $f_{t,k}$ is the (logarithm) of the forward exchange rate at time t for delivery at time $t + k$; s_t is the (logarithm) of the spot rate at time t expressed as units of foreign currency per unit of domestic currency; E_t is the expected value conditional on the relevant information set at time t,

$$i^*_{t,k} = \log(1 + i^d_{t,k}) - \log(1 + i^f_{t,k}) \approx i^d_{t,k} - i^f_{t,k},$$

$i^d_{t,k}$ is the interest rate on the domestic currency between t and $t+k$; $i^f_{t,k}$ is the interest rate on the foreign currency on the same horizon and on foreign assets perfectly substitutable with domestic ones.

Thus, according to the theory, in the absence of market frictions, transaction costs, capital controls, and so on, when faced with the need of availability of foreign currency k periods into the future one would be indifferent (in *ex ante* expected terms) between holding domestic currency (lucrating domestic interest rates) and purchasing a forward contract or purchasing foreign currency (lucrating foreign interest rates) right away.

The issues of whether the error term $\epsilon_{t,k} = s_{t+k} - f_{t,k}$ has a zero mean (unbiasedness hypothesis), is uncorrelated, or has a constant variance have often surfaced in the literature of the past fifteen years with a

wide array of results according to which currency was under consideration and for what period. In sampling the data at a frequency higher than the interest rate maturity (for example, 30-day contracts with weekly or daily data), an additional complication arises from the operation of matching data on the forward rates with the corresponding future spot rates. This is not only a problem of determining the appropriate timing of the contract (Fama, 1984, for example, incorrectly takes Friday data for both spot and forward rates four weeks apart). Depending on the actual terms of the problem, $\epsilon_{t,k}$ follows either a MA(k) process or a MA($k-1$) (cf. Baillie and Bollerslev, 1990), because of the sampling at a higher frequency than the maturity of the forward contract.

The simple unbiasedness hypothesis is seldom accepted in empirical applications, despite the fact that it is widely recognized by now that its rejection does not imply market inefficiency. In fact, using the Lucas (1982) model of intertemporal asset pricing in a two–country world, it is often shown (e.g. Hodrick and Srivastava, 1984) that uncertainty about the future purchasing power of domestic and foreign monies, and about future marginal utility of the domestic good translate into uncertainty about the intertemporal rate of substitution of domestic currency between t and $t+k$. The presence of a conditional covariance term between this rate of substitution (multiplied by the risk–free return) and the future spot rate is used to support the argument for the existence of a time–varying risk–premium. Stockman (1978) was probably the first to stress the sign changes in the influence of the risk–related factor, with a division of his sample into sub–periods.

Explicit tests of the theory have not been possible because of the various assumptions needed (Hansen and Hodrick, 1983; Domowitz and Hakkio, 1985). The lack of an economic model which can be translated into an empirically testable model is at the basis of the various statistical models of risk where the goal of the analysis becomes one of extracting an economically interpretable signal from $\epsilon_{t,k}$. The latent nature of this term calls for appropriate econometrics (Pagan and Ullah, 1988, Pagan and Hong, 1991). The definition and measurement of risk is the object of the present investigation, where nonparametric measures of risk are

6

taken into account. The empirical interest in the present paper is to compare these alternative measures and, subsequently, to investigate the importance that the risk term has in the relationship of the spot exchange rate to forward rates. As noted by Cumby (1988), for example, the error term contains both the uncertainty in *ex ante* profits relative to an information set and the error–in–variable problem between the unobservable *ex ante* profits and their realized counterparts. Other authors rewrite the assumptions as to lead to the expression

$$s_{t+k} - s_t = RP + (f_{t,k} - s_t) + \epsilon_{t,k},$$

where $RP_{t,k}$ is taken to represent the risk premium of the theory, which is assumed to be linked to the conditional variance in the $\epsilon_{t,k}$. As mentioned previously, a monotonic and increasing relationship between conditional variance and risk–premium has been recently challenged by Backus and Gregory (1993) who show that the convenient insertion of the conditional variance in the mean equation has little theoretical foundation from existing dynamic asset–pricing models, and that the use of the conditional variance as a proxy for risk premium can be justified on the basis of a specific structure of the economy, but is by no means general. With this caution, we will continue to refer to the risk–related term as $RP_{t,k}$. Nevertheless, the interpretation given in the present context maintains a relationship between the evolution of conditional volatility and the evolution of uncertainty on the markets and the perception of risk.

This issue is quite separate from the motivation for a nonparametric treatment of the risk–related term, which mainly stems from the limitations of a linear specification for the mean equation in the ARCH-M model. A nonlinear mapping between the conditional variance and the information set is more likely to be captured in a flexible context (cf. Pagan and Hong, 1991). Moreover, the performance of the ARCH-M model by Domowitz and Hakkio (1985) is somewhat unsatisfactory, failing to assess the importance of the risk–related term, although the endogenous dynamics introduced does present some appealing elements. An explicit parameterization of the risk term introduces uncertainty about the interpretability of the results because of the possible misspecification of the model.

7

The change in the effects of the risk premium and the frequent changes in sign discovered by Stockman (1978) were interpreted as being related to the nature of the stochastic processes ruling the state variables. Adding to that the highly nonlinear nature of the transformations these processes undergo in the intertemporal asset pricing models, the adoption of a nonparametric measure of risk seems to buy a lot of flexibility relative to a parametric specification which is not derived from the theory anyway.

Traditionally, a number of suggestions have been advanced in the literature (mostly without success) in this and other fields where risk plays a relevant role. Moving variances have been proposed by French *et al.* (1987) to model inflation risk; Pagan et al. (1983) derive measures of risk which highlight the relationship between individual and aggregate prices; also, survey data on business expectation were used (Levi and Makin, 1979) to infer a measure of risk. Alternative nonparametric measures of risk–related volatility are suggested by Pagan and Schwert (1990).

From an econometric point of view, the use of proxy variables determines an error–in–variable problem since the proxy variable is correlated with the disturbance. A way to avoid this problem is to parameterize the second moment according to a model of risk determination. Some authors model the conditional variance as a function of some variable z_t, as $\sigma_t^2 = \sigma^2 + z_t'\alpha$, although the choice is neither clear–cut for the set of variables, nor for the linearity of the functional form. Since, as noted, economic theory is not clear as to what relationship the predictable component of market volatility – thus of risk – has to the relevant information set Ψ_t, referring to all publicly available information does not help to determine which variables should be used in the empirical analysis. Below we will adopt an information set limited to the spot and forward rates at one maturity (one month), relying on the results by Hakkio (1981) in assuming that further maturities would not add to the analysis in terms of surprises from other forward premia.

8

3   The Nature of the Risk Premium

As noted before, the possible existence of a time–varying risk premium ensures that the efficiency hypothesis of the speculative markets still holds. Domowitz and Hakkio (1985) were the first to model this time-varying term within an ARCH-M framework (Engle, Lilien and Robins, 1987), obtaining results which point to the time variability of the influence of the risk premium, but fail to isolate clearly its contribution in determining the magnitude of the forecast error. Their model is

$$\frac{S_{t+k} - S_t}{S_t} = RP_{t,k} + \beta_1 \frac{F_{t,k} - S_t}{S_t} + \epsilon_{t+k} \tag{3}$$

$$RP_{t,k} = \beta_0 + \theta h_{t+k}$$

$$\epsilon_{t+k} \mid \Psi_t \sim N(0, h_{t+k})$$

$$h_{t+k} = \alpha_0 + \sum_{i=1}^{p} \alpha_i \epsilon_{t+k-i}^2 + z_t \phi,$$

where Ψ_t is the information set available at time t and z_t is a vector of variables belonging to the information set. In such a model the conditional variance is evolving as a function of its own past and enters the equation for the mean as well. By its own nature, this term is time–varying and lends itself to act as a risk term once the signs of β_0 and θ are determined. In fact, given the structure of the model, we have that

$$
\begin{aligned}
h_{t+k} &= var(\epsilon_{t+k}|\Psi_{t+k-1}) \\
&= var(s_{t+k} - s_t|\Psi_{t+k-1}) + \theta^2 \, var(h_{t+k}|\Psi_{t+k-1}) \\
&\quad + \beta_1^2 \, var(f_{t,k} - s_t|\Psi_{t+k-1}) - 2\theta \, cov(s_{t+k} - s_t, h_{t+k}|\Psi_{t+k-1}) \\
&\quad + 2\beta_1 \, cov(s_{t+k} - s_t, f_{t,k} - s_t|\Psi_{t+k-1}) \\
&\quad + 2\theta\beta_1 \, cov(h_{t+k}, f_{t,k} - s_t|\Psi_{t+k-1})
\end{aligned}
$$

thus stressing the dependence of the risk term on higher order conditional moments of the forecast error, and on conditional variances and covariances of the exchange rate and the forward premium.

The general reference model is then

$$\epsilon_t = u_t \sigma_t, \quad u_t \sim \text{iid} \, (0,1)$$

$$y_t = f(\mathbf{x}_t, \sigma_t^2) + \epsilon_t,$$

where the most commonly used formulation is one in which the functional form $f(\cdot)$ is linear. In particular, let us assume for the moment that, for disturbances following an ARCH(p) process, we have

$$(y_t \mid \mathbf{x}_t, \mathbf{\Psi}_t) \sim N(\mathbf{x}_t'\boldsymbol{\beta} + \sigma_t^2 \delta, \sigma_t^2) \qquad (4)$$

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{p} \alpha_{t-i} \, \epsilon_{t-i}^2$$

$$\epsilon_t = y_t - \mathbf{x}_t'\boldsymbol{\beta} - \sigma_t^2 \delta$$

where the variables of interest and the available information set at time t are defined on the basis of the theoretical framework.

The ARCH-M model, in the formulation by Domowitz and Hakkio, allows for testing some hypotheses about the behavior of the risk premium: in particular, test the hypothesis $\theta = 0$ means to verify the role played by the conditional variance in determining the difference between forward and expected spot rates. Assuming that $\beta_1 = 1$ and ϵ_{t+1} is white noise, then $\beta_0 = 0$ and $\theta = 0$ imply absence of a risk premium; while $\beta_0 \neq 0$ and $\theta \neq 0$ confirm the presence of a time–varying risk term. Note that model (3) implies that the movements in the risk premium can only be introduced through changes in the conditional variance. Moreover, $RP_{t,k}$ can be either positive or negative according to the values of β and θ. The disappointing results of the analysis by Domowitz and Hakkio, which fail to lend support to the relationship between conditional variance and risk premium, have been attributed to the use of monthly data; other authors think that the univariate framework is too restrictive, while in a multivariate framework one could take into consideration not only the conditional variances but also the covariances among the various currencies in the market. Bollerslev (1990) and Baillie and Bollerslev (1990), for example, use a multivariate GARCH model on weekly data, but do not achieve strong results.

10

Pagan and Hong (1991) have proposed to estimate flexible forms for the ARCH-M model, estimated in a nonparametric fashion on monthly data. In what follows we will discuss the instrumental variable procedure and suggest an alternative way to select the instrument for the risk–related term. Our suggestion and the estimators proposed by Pagan and Ullah (1988) and by Pagan and Hong (1991) are then compared using weekly data.

4 Semiparametric IV Estimation: A Suggestion

Recall the general problem at hand:

$$y_t = \mathbf{x}_t'\boldsymbol{\beta} + \sigma_t^2\delta + \epsilon_t, \quad t = 1, ...T. \tag{5}$$

We are interested in the estimation of β and δ; σ_t^2 is unobservable. As previously stressed, in recent years the general tendency has been that of specifying a parametric model for σ_t^2, the most popular choice being an ARCH process. This model can be efficiently estimated by maximum likelihood under correct specification, but the estimator is inconsistent if the functional form of σ_t^2 is misspecified, as σ_t^2 (or a function of it) is a constituent part of the conditional mean of y_t.

Pagan and Ullah (1988) considered issues related to the estimation of a linear model containing a risk term as a regressor. They questioned the form of the mapping between risk terms and information set available to agents and suggested the use of an instrumental variable estimator. As σ_t^2 is unobservable, assume another variable ϕ_t exists, such that $E(\phi_t \mid \boldsymbol{\Psi}_t) = \sigma_t^2$. In the ARCH-M model such a variable is given by the series of squared innovations ϵ_t^2. Instead of ϵ_t^2, some residuals $\hat{\epsilon}_t^2$ may be used, without affecting the asymptotic properties of the estimator (Pagan and Ullah, 1988). By substitution we arrive at

$$y_t = \mathbf{x}_t'\boldsymbol{\beta} + \phi_t\delta + \delta(\sigma_t^2 - \phi_t) + \epsilon_t \tag{6}$$

$$y_t = \mathbf{z}_t'\boldsymbol{\theta} + u_t, \quad u_t = \delta(\sigma_t^2 - \phi_t) + \epsilon_t \tag{7}$$

11

where $E(\mathbf{x}_t \epsilon_t) = 0$, $E(\phi_t \epsilon_t) = 0$, $E(\phi_t u_t) \neq 0$ and $E(\mathbf{z}_t u_t) \neq 0$, so that the OLS estimation of model (7) is inconsistent. Pagan and Ullah show that, in the case of stationary time series, consistent and asymptotically normal estimates can be obtained via nonparametric estimation of the instruments (proposition 5, pag. 94).

Efficiency improvements are related to the choice of the instruments. The definition of the instruments plays an important role in the instrumental variable estimation of a parametric model. BNL2SLS (Best Nonlinear Two-Stage Least Squares) and BNL3SLS (Best Nonlinear Three-Stage Least Squares), proposed by Amemiya (1974, 1977), rely on the choice of optimal instruments minimizing the asymptotic covariance matrix of the estimates. Computational problems, due to the presence of nonlinear functions or unknown conditional distributions of the endogenous variables, led to the development of semiparametric instrumental variable estimation methods.

Recent results suggest the potential use of nonparametric regression techniques to estimate the conditional expectation of the endogenous variables, which appears in the Amemiya optimal instruments formulation. In Newey (1990) two different kinds of nonparametric regression estimators are proposed. The first one is based on a local approximation of the conditional expectation, using the Nearest Neighbor method; the second relies on global approximation criteria using series expansion techniques.

Robinson (1991) proved that the optimal instruments can be estimated using a (not necessarily random) sampling without replacement from the empirical distribution of the residuals of a preliminary consistent estimation. Therefore it seems worthwhile to rely on a semiparametric specification of models containing risk terms (the ARCH-M model in this particular case) to allow for a flexible form in modelling the risk premium. Since

$$E\left(\mathbf{u}(\mathbf{z}_t, \boldsymbol{\theta}) \mid \boldsymbol{\Psi}_t\right) = \mathbf{0},$$

where $\mathbf{u}$ is the residual vector from (7), there will be a function of the

12

information set $\mathbf{g}(\boldsymbol{\Psi}_t)$ such that

$$E\left(\mathbf{u}(\mathbf{z}_t, \boldsymbol{\theta})\mathbf{g}(\boldsymbol{\Psi}_t)\right) = 0.$$

An optimal choice of instruments is given by

$$\mathbf{g}(\boldsymbol{\Psi}_t) = (\hat{\boldsymbol{\Omega}}_t)^{-1}\hat{\mathbf{Q}}_t,$$

where

$$\mathbf{Q_t} = \mathbf{E}(\frac{\partial\mathbf{u}(\mathbf{z_t}, \boldsymbol{\theta})}{\partial\boldsymbol{\theta}} \mid \boldsymbol{\Psi_t})$$

$$\boldsymbol{\Omega_t} = \mathbf{E}\left((\mathbf{u}(\mathbf{z_t}, \boldsymbol{\theta}))(\mathbf{u}(\mathbf{z_t}, \boldsymbol{\theta}))' \mid \boldsymbol{\Psi_t}\right).$$

Both these conditional expectations can be estimated in a nonparametric way. In particular, instead of the Nearest Neighbor method suggested by Newey, we prefer the Kernel method, using the Nadaraya-Watson Kernel regression estimator in the leave-one-out version. This kind of regression estimator is based on a linear combination of the response variable with coefficients depending on a differentiable kernel function and a bandwidth parameter. Robinson (1983) proved consistency and asymptotic normality of such an estimator in a time series context, under weak conditions, which are likely to be satisfied in our case [4]. Comparable results are not yet available for the Nearest Neighbor method.

Let us consider now the specific heteroskedastic regression model, which contains a risk term among the regressors:

$$s_{t+k} - s_t = RP_{t,k} + \beta_1(f_{t,k} - s_t) + \epsilon_{t+k} + \sum_{j=1}^{k-1} \gamma_j \epsilon_{t+k-j} \qquad (8)$$

---

[4]With the help of higher order kernels (Bartlett, 1963) and the device to trim out small density estimates, under suitable regularity conditions a reasonable conjecture is that

$$T^{-\frac{1}{2}}(\tilde{\boldsymbol{\theta}} - \boldsymbol{\theta}) \overset{a}{\sim} N(\mathbf{0}, \boldsymbol{\Phi}^{-1})$$

$$\tilde{\boldsymbol{\theta}} = \bar{\boldsymbol{\theta}} - (\sum_t \dot{\mathbf{z}}_t \mathbf{z}_t')^{-1} \sum_t \dot{\mathbf{z}}_t \dot{\mathbf{u}}_t$$

where $\bar{\boldsymbol{\theta}}$ is a preliminary consistent estimate of $\boldsymbol{\theta}$, $\dot{\mathbf{z}}_t$ is the nonparametric regression of $\mathbf{z}_t$ on the information set, the $\dot{\mathbf{u}}_t$ are the residuals of that regression, and $\boldsymbol{\Phi}^{-1}$ achieves the semiparametric efficiency bound (Chamberlain, 1987).

$$RP_{t,k} = \beta_0 + \theta\sigma^2_{t+k}$$

$$\sigma^2_t = Var[\epsilon_t \mid \Psi_{t-1}] = g(\epsilon_{t-1}, \epsilon_{t-2}, \ldots, \epsilon_{t-p}).$$

The conditional variance, σ^2_t, is a measure of the predictable component of market volatility, and is used to approximate the time–varying risk term.

Note that, upon substitution of the various terms in (8), the right–hand side contains, besides the forward premium, the time $t + k$ disturbance, a linear function of the past disturbances, and a nonlinear function of the past disturbances, with only the latter entering the risk term. Independently of the overlapping observations problem (where the linear MA term appears explicitly), the interpretation of the conditional variance as reflecting the level of uncertainty on the markets shows that in this model the past forecast errors exert their effects in a nonlinear way. Thus the model could be interpreted as a nonlinear MA model. Its specific form is left unspecified in our case to allow for the consideration of the various ways in which the relevant information is processed to forecast market volatility.

Following the semiparametric approach suggested in Pagan and Ullah (1988), an observed (or consistently estimated) series can be used instead of σ^2_t. It turns out that

$$s_{t+k} - s_t = \beta_0 + \theta\sigma^2_{t+k} + \beta_1(f_{t,k} - s_t) + \epsilon_{t+k} + \sum_{j=1}^{k-1}\gamma_j\epsilon_{t+k-j} \qquad (9)$$

becomes

$$s_{t+k} - s_t = \beta_0 + \theta\epsilon^2_{t+k} + \beta_1(f_{t,k} - s_t) + u_{t+k} + \sum_{j=1}^{k-1}\gamma_j\epsilon_{t+1-j}$$

$$u_{t+k} = \theta(\sigma^2_{t+k} - \epsilon^2_{t+k}) + \epsilon_{t+k}$$

where the error term and the new regressor are correlated. The instrumental variable estimation procedure is implemented here using three types of nonparametric instruments:

14

1. the estimated conditional variance is obtained as a nonparametric regression function of $\hat{\epsilon}_t^2$, given $\hat{\epsilon}_{t-1}, \hat{\epsilon}_{t-2}, \ldots, \hat{\epsilon}_{t-k+1}$, where $\hat{\epsilon}_t$ are the consistent residuals of a preliminary OLS parametric regression and $\hat{\epsilon}_t^2$ are used as ϕ_t;

2. the conditional expectation of $y_t = (s_{t+k} - s_t) - (f_{t,k} - s_t)$ given $\Psi_{t-1} = \{y_{t-1}, y_{t-2}, \ldots, y_{t-k+1}\}$ is computed, the square nonparametric residuals are then used as ϕ_t and the conditional variance is obtained as $E(y_t^2 \mid \Psi_{t-1}) - (E(y_t \mid \Psi_{t-1}))^2$. This way of proceeding corresponds to imposing $\beta_1 = 1$ in the model of risk determination, as in Pagan and Ullah (1988);

3. without imposing $\beta_1 = 1$, the same procedure as in 2 is carried out, calculating the nonparametric conditional expectation of $(s_{t+k} - s_t)$ given its lagged values and $(f_{t,k} - s_t)$ (Pagan and Hong, 1991).

5 A Comparison among Estimators

The purpose of this section is to evaluate the importance that the risk term has in the spot–forward relationship, and to outline the differences in the various nonparametric estimation methods, deferring to the following section the issues related to the possible asymmetries of risk–related effects.

We have considered weekly spot and 30-day forward rates from June 1973 to February 1994 relative to five currencies the French Franc (FF), the Italian Lira (ItL), the Japanese Yen (JY), the British Pound (BP) and the Deutsche Mark (DM), all against the US Dollar. The data are 12 noon bid (spot) and ask (forward) prices[5] from the New York Foreign Exchange Market for a total of 1077 observations. We have decided to use the definition of foreign currency over US\$ for all currencies (there including the BP for comparison's sake).

---

[5] Alan Kirman has pointed out to us that these quotes, although widely used, are not necessarily equilibrium prices and might entail a higher measured volatility of returns than the actual ones on the markets.

© The Author(s). European University Institute. Available Open Access on Cadmus, European University Institute Research Repository. Digitised version produced by the EUI Library in 2020.

As customary, the forward rates taken on Tuesday refer to the spot rates four weeks and two days later on Thursday (referred to as f_t and s_{t+k}). An MA(4) term is inserted in the conditional mean equation, but, contrary to Baillie and Bollerslev (1990), we do not impose the values found under the hypothesis that the (continuous time) data generating process for the spot rate is a Brownian motion[6]. In what follows, the order of the ARCH process is assumed equal to four throughout.

In Table 1 the results of a preliminary maximum likelihood estimation in the absence of a risk term are reported to be used as a benchmark to show the departure from the efficiency hypothesis. Note that some of the coefficients on the forward term are not significant, and that the joint hypothesis $\beta_0 = 0$ and $\beta_1 = 1$ can be rejected. The diagnostics on autocorrelation and ARCH confirm earlier findings on the model's inadequacy.

The subsequent tables (2–4) are devoted to the presentation of the results of instrumental variable estimation using the different methods of estimating σ_t^2, previously outlined. The coefficient of the risk term can be interpreted as reflecting the marginal impact of volatility on the currency, or the degree of the prevailing marginal risk aversion towards the currency: if positive, an increase in volatility would push towards an appreciation of the US\$, if negative, the opposite would apply.

In the absence of a detailed analysis of the small sample properties of the three estimators, we can only rely on the economic interpretation of the results for the various currencies. In fact, Method (1) detects the presence of a significant effect of the risk term for all currencies, whereas the other two methods produce more mixed results, with a change reversal for the French Franc and the Deutsche Mark and non–significant effects for the French Franc and the Italian Lira for Method (3). Method (2) produces the highest (in absolute value) coefficients both for the forward premium and the risk term, while Method (3) produces results comprised between the two.

---

[6]In fact, the empirical evidence (not shown but available upon request) suggests that the values for the MA coefficients are quite far from the values implied by the Baillie and Bollerslev model.

16

Table 1: Estimation with unrestricted MA(4)

Exch. Rate	Constant $\times 10^3$	$f_{t,k} - s_t$	R^2	AC (12)	HS	ARCH (4)
FF/$	0.6981	0.3466	0.77	106.9	0.6	37.5
	(5.4220)	(0.0293)				
ItL/$	3.2135	0.2970	0.82	136.2	9.5	71.6
	(0.6145)	(0.0551)				
JY/$	-4.2055	0.0894	0.83	56.1	1.7	43.3
	(0.4130)	(0.0470)				
BP/$	2.4703	0.0234	0.80	19.5	14.8	27.9
	(0.4992)	(0.0502)				
DM/$	-1.0471	0.4234	0.75	151.4	1.4	50.8
	(0.5520)	(0.0606)				

AC (12): Ljung-Box Test for autocorrelation (χ^2_{12})
HS: White Test for heteroskedasticity, χ^2_l, $l = \frac{k(k+1)}{2}$ (k number of regressors)
ARCH (4): Test for ARCH (4) effect (χ^2_4)

Table 2: IV MA(4). Instruments chosen according to our method.

Exch. Rate	Constant $\times 10^3$	$f_{t,k} - s_t$	$\hat{\epsilon}_t^2$
FF/$	3.8603	0.3228	2.5532
	(0.8308)	(0.0566)	(0.4888)
ItL/$	-1.7363	0.4118	3.6192
	(0.7604)	(0.0521)	(0.3588)
JY/$	1.7736	0.4163	-4.8256
	(0.7256)	(0.0568)	(0.4004)
BP/$	-4.2734	0.3710	5.2676
	(1.6649)	(0.0761)	(1.1232)
DM/$	0.5945	0.2945	-1.2584
	(0.7720)	(0.0541)	(0.4524)

Table 3: IV MA(4). Instruments chosen according to Pagan and Ullah (1988).

Exch. Rate	Constant $\times 10^3$	$f_{t,k} - s_t$	$\hat{\epsilon}_t^2$
FF/$	2.8940	0.4750	-5.5120
	(1.5299)	(0.0672)	(2.7040)
ItL/$	-1.8841	04642	8.6116
	(1.1298)	(0.0628)	(1.8824)
JY/$	0.1277	0.4740	-11.2840
	(1.9886)	(0.0692)	(4.7892)
BP/$	-2.2013	0.3618	7.0252
	(0.9758)	(0.0643)	(1.4040)
DM/$	-6.8065	0.4632	12.8700
	(3.2817)	(0.0765)	(6.5624)

Table 4: IV MA(4). Instruments chosen according to Pagan and Hong (1991).

Exch. Rate	Constant $\times 10^3$	$f_{t,k} - s_t$	$\hat{\epsilon}_t^2$
FF/$	1.4540	0.1084	-0.1508
	(1.0011)	(0.0497)	(1.1232)
ItL/$	3.5500	0.1405	0.8372
	(0.7981)	(0.0483)	(0.8060)
JY/$	-0.2120	0.4863	-6.6404
	(1.6049)	(0.0630)	(2.4336)
BP/$	-1.6873	0.3045	4.3940
	(1.4067)	(0.0633)	(1.4612)
DM/$	-5.3237	0.3926	5.8396
	(1.9147)	(0.0684)	(2.3764)

The analysis was repeated by adding a term $(f_{t,k} - s_t)^2$ in order to check for possible nonlinear effects captured by the squared forward

18

premium. The only currencies for which the addition was relevant were the French Franc, for Pagan and Ullah's method, and the British Pound, for our method. The changes in the other coefficients were not such as to change the sign of the risk term, or the significance of the estimates.

The impact of volatility as captured by the measured risk term shows that there is an alternance of positive and negative values, as discussed by Stockman (1978) and Domowitz and Hakkio (1984). In fact, the French Franc, the Yen, and the Mark have a positive constant and a negative slope coefficient, while the Lira and the Pound show reversed signs. The range within which the risk–related term varies shows different values for the various currencies, stressing how differently the various currencies are affected by time–varying volatility. In fact, on the basis of our estimates, the same three currencies that have a negative slope coefficient on the risk term exhibit a moderate positive impact (0.17% for the Yen, 0.38% for the Franc, and 0.59% for the DM), and a wider range on the negative side (−1.74% for the DM, −4.30% for the Franc, and −8.47% for the Yen). The two "weaker" currencies are the Lira (ranging from −0.17% to 13.26%) and the Pound (ranging from −0.42% to 16.86%), for which the impact of volatility on the positive side reached quite strong levels in the direction of their depreciation vis–à–vis the US$ dollar.

The question we turn to now is whether it is possible to discern more recognizable patterns in the behavior of the risk term using a classification of regimes under which the agents' reactions can be expected to be different.

6 Asymmetries in Risk Effects

As noted in Section 2, if interest parity theory were to hold, market operators should be indifferent between purchasing a forward contract or foreign currency right away. However, it is often remarked that a common rule when one facing a need for currency at a future date, for example (cf. Froot and Thaler, 1990), is to invest the money where

19

the interest rate is higher. This, as other trading rules examined below, seems to provide a profitable outcome (cf. LeBaron, 1993a and 1993b), in apparent contradiction to present theory.

Technical analysis is receiving increasing attention in the academic literature, as the focus shifts from a representative individual to hetero-geneity of beliefs in the market, and seeks illumination of the practical functioning of markets. The results reported by Taylor and Allen (1992), for example, show that there is a high proportion of traders relying on technical analysis to determine their position on the market. The main focus of recent research is the expectation formation process and the possibility of expectational errors, or of fads as the results of mutual in-fluence by participants in the markets (Lehmann, 1990; Kirman, 1993). In particular, the signals hitting the markets require interpretation and translation into actions which, in turn, will affect the exchange rate move-ments.

As noted before, the risk–premium argument for reconciling the un-tenability of the unbiasedness hypothesis relies on inflation expectations, as the term derived from the Lucas model involves expectations on rela-tive real returns as contributing to the asset price. Higher interest rates may mean expectations of higher inflation and, hence, of a loss of pur-chasing power, but may also reflect the result of a strong anti–inflationary stance by the monetary authority. The strength and weakness of the US$ during the early 1980s occurred in a situation of constantly higher US$ interest rates and thus a switch in expectation formation must have not surfaced in the forward premium. In this respect, the uncertainty is actu-ally about future monetary policy and the way the monetary authorities will react to nominal or real shocks. In fact, Lewis (1989) assumes that it takes time to learn about the direction of monetary policy and shows that it would be possible to reduce the gross misprediction of the dol-lar's strength and weakness based on the forward premium alone. But in Lewis's analysis there is no switching off of the learning parameter which is in contrast with the once-and-for-all nature of the change in monetary policy by US authorities.

In our model the only fundamentals considered are the interest

rate differentials, and so what enters the information set is the filtered outcome of the combined effect of interventions (which build reputation) and of expectations (which reflect that reputation). However, given our heterogeneous world view, we assume that, in forming expectations, traders influence one another through their interactions. The clustering of volatility observed in the exchange rate returns can be interpreted as the outcome of contrasting beliefs since the $RP_{t,k}$ term is measured as a constant corresponding to the smallest level of volatility plus a time–varying portion which measures the effect of an increase in one percentage point of volatility on exchange rate movements. If disparate beliefs are present among agents, their effects may be exerted differently according to the specific situation on the market.

Clearly, the question is more complex than the mere assessment of the presence or absence of a risk–premium term in the spot–forward relationship, and this is so not only due to the difficulties of interpreting the time–varying term as the risk premium in theoretical models. The empirical interest in the present analysis is, rather, focussed on the presence of uncertainty and on the perception of risk, and hence to the (possibly nonlinear) effects that risk has on exchange rate determination. In order to extract these effects, we characterize various market situations on the basis of signals referred to by technical analysts as "buy", "sell", or "hold the position" and which give rise to actions, when meshed with the agents' perceptions of the market trends. The various trading rules need not provide the same signal, as we will also see from the empirical results: in fact, these (at times contradictory) signals received by the agents have to be accompanied by a process of further information gathering where reputation about strength and weakness of a given currency plays also a role.

Another way of justifying the importance of a currency's reputation derives from analysis of the impact that the conditional volatility has in correspondence to a "buy" or "sell" signal. If this perception were irrelevant, the risk–related term would have the same impact irrespective of the nature of the signal.

To perform this evaluation we apply the previous analysis defining

various regimes in accordance to three trading rules [7]:

1. The first rule selects Regime 1 when the foreign interest rate is higher than the numéraire (in our case the US\$). It provides a "buy" signal for the higher interest rate currency. Neglecting, for simplicity's sake, the rare instances when the interest rate differential is exactly zero, expression (9) is modified as:

$$s_{t+k} - s_t = \beta_0 + \beta_0^1 D_{1t} + \theta \sigma_{t+k}^2 + \theta^1 \sigma_{t+k}^2 D_{1t}$$
$$+ \beta_1 (f_{t,k} - s_t) + \beta_1^1 (f_{t,k} - s_t) D_{1t}$$

plus the MA error term. $D_{1t} = 1$ characterizes the periods when $i_t^* > 0$, i.e., domestic rates are higher than the US\$. Under the null hypothesis of symmetry, of course, $\beta_0^1 = \theta^1 = \beta_1^1 = 0$. Also, if there is a mere switch of sign, but the effect stays the same, we should have that $2\theta + \theta^1 = 0$.

2. The second rule is based on the comparison between short– and long–term moving averages of exchange rates, s_t, and selects as belonging to Regime 1 the periods characterized by a short–term moving average that is higher than that found in the long–term. Usually the short–term contains just the observation itself and the long–term is chosen here to contain 10 observations. Its occurrence is interpreted as an unusual depreciation of the currency relative to the US\$ and hence as a buy signal for the US\$. Also in this case the regimes are considered as mutually exclusive. The same interpretation for the coefficients follows.

3. The third rule is based on short– and long–term moving variances of the exchange rate returns defined in our case as

$$MVS_t = \frac{1}{10} \sum_{j=0}^{9} (s_{t-j} - s_{t-j-1})^2,$$

---

[7]For all rules, a band of neutrality can be built implying stronger signals before they are considered as impetus to action. Also, other existing trading rules can be applied or others may be devised based on whether the exchange rate is above or below the PPP level or on current account levels.

respectively,

$$MVL_t = \frac{1}{100} \sum_{j=0}^{99} (s_{t-j} - s_{t-j-1})^2$$

Action is called for when $MVS_t < (1 + \alpha)MVL_t$, i.e., the short–term volatility is lower than the long–term one. Regime 1 is characterized by periods when the previous return was positive (hence appreciation of the US$), and Regime 2 by periods when the previous return was negative. In this case, as in the following one, we will have a base period assumed as neutral, and the two regimes:

$$
\begin{aligned}
s_{t+k} - s_t = {} & \beta_0 + \beta_0^1 D_{1t} + \beta_0^2 D_{2t} \\
& + \theta \sigma_{t+k}^2 + \theta^1 \sigma_{t+k}^2 D_{1t} + \theta^2 \sigma_{t+k}^2 D_{2t} \\
& + \beta_1(f_{t,k} - s_t) + \beta_1^1(f_{t,k} - s_t)D_{1t} + \beta_1^2(f_{t,k} - s_t)D_{1t}
\end{aligned}
$$

plus the MA error term. $D_{1t} = 1$ characterizes Regime 1 and $D_{2t} = 1$ characterizes Regime 2.

4. Finally, we investigate the episodes of strong appreciation and depreciation of the US$ in the 1980s. We select Regime 1 as being characterized by a strong Dollar (July 1980–July 1981 and November 1981–January 1985, following the analysis by Baillie and McMahon, 1989, p.20) and Regime 2 by a weak dollar (August to October 1981 and February to August 1985). The behavior of the markets in those periods is seen as being at odds with the risk–premium argument (as noted by Froot and Thaler, 1990), in that the appreciation periods, being accompanied by an interest rate differential favoring the Dollar, would characterize this currency as risky, and would characterize it as safe during depreciation. If the asymmetry argument is valid, the risk term should affect appreciation differently than it does depreciation. It is also of interest to verify whether conditional volatility worked in the direction of accelerating the appreciation or depreciation (fad argument).

Finally, let us summarize the characteristics of each period in Table 5 where we report the definitions for ease of reference.

Table 5: Summary of trading rules and regimes.

Trading Rule	Regime
Interest Rate Differential (i_t^*)	Regime 1 Domestic interest rate higher than foreign
	Regime 2 Domestic interest rate lower than foreign
Moving Average (MA)	Regime 1 Short term MA higher than long term
	Regime 2 Short term MA lower than long term
Moving Variance (MV)	Neutral Short term MV higher than long term
	Regime 1 Short term MV lower than long term and previous excess return positive
	Regime 2 Short term MV lower than long term and previous excess return negative
Dollar Episodes (US$)	Regime 1 Strong US Dollar: $7/80 - 7/81$ and $11/81 - 1/85$
	Regime 2 Weak US Dollar: $8/81 - 10/81$ and $2/85 - 8/85$

7 The Empirical Evidence

In order to characterize the regimes defined in the previous section, it is instructive to examine a few descriptive statistics which justify their characterization as market situations giving rise to asymmetries in behavior [8]. However, note that these results should not be read as evidence

---

[8]To make sure that there was no serious overlap of information in each regime we computed the correlations across regimes (not reported here for the sake of brevity), the highest being between the moving average rule and the moving variance one for all currencies (around 0.5 in modulus), while most of the others are below 0.2 in modulus.

either in favor or against any rule's profitability.

Tables 6 to 9 contain the results for the exchange rate returns by regime. For the first rule, in particular, the descriptive statistics by regime are not very different from one another, implying an expectation of irrelevance of this regime for the characterization of the behavior of the risk–related term. Asymmetries in the behavior of the returns by regime are more noticeable for the moving average and moving variance regimes, and even more so (by definition) for the US$ episodes.

Furthermore, the tables report the correlation between the forward premium and the conditional volatility term which are very low across currencies and regimes.

Finally, the last three rows show that the number of periods spent in each regime is high enough to provide quite a large sample to each sub-period. The row labeled "Switching" indicates the number of times there was a passage from one regime to another. Apart from the four changes for the US$ episodes, the other regimes experience quite a remarkable number of passages, this being amplified in the case of the interest rate differential regime.

The main empirical results derive from the estimation of the spot–forward relationship, including in the analysis appropriate dummies corresponding to the regimes. Tables 10 to 14 contain the estimated coefficients with the appropriate standard errors. We omit the results for the MA coefficients as they are of no interest in this context, despite their being highly significant. Since a differentiation of the coefficient on the forward premium across regimes turned out to be not significant, the reported estimates are obtained restricting the coefficient on the forward premium to be the same.

The results for overall significance of the discrimination across regimes on the risk term show that the interest rate differential rule is uninteresting. In fact, only the French Franc exhibits a slope different from zero in Regime (1) while all the other currencies would see the two regimes as not distinguishable from one another. This is not surprising given the high number of switches from one regime to another (which

25

would imply changing position and incurring into transaction costs), and the fact that, as previously noted, an interest rate differential of a certain sign can be consistent with both an appreciation and a depreciation of the foreign currency. The other three regimes are significant on the basis of a joint test on the coefficients.

According to the results (examined by currency), the sign reversal in the measure of the impact of the conditional volatility on the exchange rate returns is by no means preserved. For example, for the French Franc in Regime 1 it has a purely positive impact of the MA and MV rules and of the US$ episodes, and a purely negative one for the MA in Regime 2. Also, the size of the impact changes remarkably. For the Italian Lira the maximum impact of the volatility in the so–called neutral period of the MV rule increases to 15.41% (from 13.26% derived from Table 2) but the minimum goes from -0.17% to -31.3% in Regime 2. Similar occurrences appear for the other currencies as well and will be pointed out below when the regimes will be analysed in greater detail. In general we can rule out symmetry when we observe a significance of the regime coefficients, but, most importantly, when the sum of the two regime coefficients is significantly different from zero implying that the same conditional volatility would have a different impact on the foreign exchange returns.

The coefficient on the forward premium changes considerably relative to the constrained counterpart under the absence of regimes (Table 2). In fact, it decreases (to the point of being negative, although insignificant for the Yen) under rule MA, and it increases for the US$ episodes, with more mixed behavior under rule MV.

The comparative analysis by rule is best illustrated by depicting graphically the joint range of impact of the risk–related term on the foreign exchange returns, where each axis corresponds to a regime. This analysis ignores the neutral period for the MV rule and the US$ episodes, and clearly there is no temporal correspondence between the minima and the maxima in each regime. Also the usual word of caution applies regarding the unequal scale between axes in some pictures.

Table 6: Interest Rate Differential Rule: Descriptive Statistics.

Exch.Rate Returns	FF	ItL	JY	BP	DM
Mean (1) ×100	0.0810	0.4311	-0.7000	0.1310	-0.3766
Mean (2) ×100	0.3707	0.9133	-0.1971	0.4769	0.0514
Overall ×100	0.1727	0.4977	-0.4215	0.2497	-0.1382
Std (1) ×100	3.5049	3.4096	3.4320	3.3413	3.5135
Std (2) ×100	3.6954	4.0054	3.5385	4.0118	3.7025
Overall ×100	3.5643	3.5334	3.4959	3.5847	3.6197
Min (1)	-0.1009	-0.1015	-0.1222	-0.1597	-0.0997
Min (2)	-0.1243	-0.1028	-0.1314	-0.1806	-0.1234
Overall	-0.1243	-0.1028	-0.1314	-0.1806	-0.1234
Max (1)	0.1352	0.1804	0.1081	0.1265	0.1361
Max (2)	0.1109	0.1923	0.1084	0.1560	0.1097
Overall	0.1352	0.1923	0.1084	0.1560	0.1361
Correlations					
$(f_{t,k} - s_t), \hat{\sigma}_t^2$ (1)	0.0743	0.4171	0.0157	0.1735	-0.0216
$(f_{t,k} - s_t), \hat{\sigma}_t^2$ (2)	0.0321	0.2674	0.0905	-0.0126	-0.0520
Overall	-0.0401	-0.1114	0.0914	-0.0037	0.0098
Weeks in regime (1)	722	815	460	712	463
Weeks in regime (2)	345	212	596	359	602
Switching	411	322	438	431	479

Table 7: Moving Average Rule: Descriptive Statistics.

Exch.Rate Returns	FF	ItL	JY	BP	DM
Mean (1) ×100	2.4027	2.5746	1.8312	2.4731	2.3462
Mean (2) ×100	-2.2979	-1.9624	-2.6254	-2.6120	-2.5191
Overall ×100	0.1727	0.4977	-0.4215	0.2497	-0.1382
Std (1) ×100	2.7821	2.9519	2.3594	2.8035	2.7095
Std (2) ×100	2.5494	2.4260	3.0131	2.6757	2.6381
Overall ×100	3.5643	3.5334	3.4959	3.5847	3.6197
Min (1)	-0.0498	-0.0565	-0.0641	-0.0802	-0.0635
Min (2)	-0.1243	-0.1028	-0.1314	-0.1806	-0.1234
Overall	-0.1243	-0.1028	-0.1314	-0.1806	-0.1234
Max (1)	0.1352	0.1923	0.1084	0.1560	0.1361
Max (2)	0.0603	0.1089	0.0605	0.0833	0.0451
Overall	0.1352	0.1923	0.1084	0.1560	0.1361
Correlations					
$(f_{t,k} - s_t), \hat{\sigma}_t^2$ (1)	-0.0451	-0.0504	-0.1949	-0.1609	-0.2461
$(f_{t,k} - s_t), \hat{\sigma}_t^2$ (2)	0.2700	0.3519	0.1489	0.3286	0.1426
Overall	-0.0401	-0.1114	0.0914	-0.0037	0.0098
Weeks in regime (1)	555	581	525	549	517
Weeks in regime (2)	509	483	539	515	547
Switching	159	157	166	173	149

Table 8: Moving Variance Rule: Descriptive Statistics.

Exch.Rate Returns	FF	ItL	JY	BP	DM
Mean (1) ×100	0.8657	0.9612	0.9852	1.0118	0.7999
Mean (2) ×100	-0.8749	-0.6939	-1.0162	-0.9826	-1.0258
Overall ×100	0.1727	0.4977	-0.4215	0.2497	-0.1382
Std (1) ×100	1.6909	1.7270	1.8331	1.8357	1.6973
Std (2) ×100	1.8853	1.8291	1.9737	1.8858	1.9020
Overall ×100	3.5643	3.5334	3.4959	3.5847	3.6197
Min (1)	-0.0498	-0.0565	-0.0641	-0.0802	-0.0635
Min (2)	-0.1243	-0.1028	-0.1314	-0.1806	-0.1234
Overall	-0.1243	-0.1028	-0.1314	-0.1806	-0.1234
Max (1)	0.1352	0.1923	0.1084	0.1560	0.1361
Max (2)	0.0603	0.1089	0.0605	0.0833	0.0451
Overall	0.1352	0.1923	0.1084	0.1560	0.1361
Correlations					
$(f_{t,k} - s_t), \hat{\sigma}_t^2$ (1)	0.2343	0.2259	-0.2735	0.2797	-0.2596
$(f_{t,k} - s_t), \hat{\sigma}_t^2$ (2)	0.3723	0.3100	-0.0281	0.0711	0.1261
Overall	-0.0401	-0.1114	0.0914	-0.0037	0.0098
Weeks in regime (1)	304	286	358	300	292
Weeks in regime (2)	299	329	291	348	303
Switching	133	127	137	129	124

Table 9: Dollar Episodes Rule: Descriptive Statistics.

Exch.Rate Returns	FF	ItL	JY	BP	DM
Mean (1) ×100	1.9427	1.9031	0.2896	1.5181	1.4104
Mean (2) ×100	-1.1877	-0.4273	-0.3072	-1.6854	-1.5471
Overall ×100	0.1727	0.4977	-0.4215	0.2497	-0.1382
Std (1) ×100	3.4476	2.9291	3.4100	2.9581	3.2507
Std (2) ×100	4.8044	4.2255	2.6290	5.8355	4.9917
Overall ×100	3.5643	3.5334	3.4959	3.5847	3.6197
Min (1)	-0.0692	-0.0663	-0.1314	-0.0638	-0.0754
Min (2)	-0.1243	-0.1028	-0.0495	-0.1806	-0.1234
Overall	-0.1243	-0.1028	-0.1314	-0.1806	-0.1234
Max (1)	0.1260	0.0988	0.0798	0.0985	0.1055
Max (2)	0.0758	0.0854	0.0596	0.0616	0.0774
Overall	0.1352	0.1923	0.1084	0.1560	0.1361
Correlations					
$(f_{t,k} - s_t), \hat{\sigma}_t^2$ (1)	0.1009	0.2093	-0.1830	-0.2071	-0.2555
$(f_{t,k} - s_t), \hat{\sigma}_t^2$ (2)	0.2461	0.2589	-0.2638	0.3513	-0.0035
Overall	-0.0401	-0.1114	0.0914	-0.0037	0.0098
Weeks in regime (1)	227				
Weeks in regime (2)	38				
Switching	4				

Each box corresponds to a different currency, with the sides repre-

senting the range between the minimum and the maximum impact of the conditional volatility. Ruling out symmetry on the basis of the analysis of the coefficients implies that the constants (minimum impact) and the slopes (marginal impact) are different across regimes. In practice, the analysis must be complemented by the inspection of the various situations, once the actual values of the conditional volatility are considered. In fact, it would be possible that the higher coefficients (in absolute value) are associated with lower values of conditional volatility, thus re-equilibrating the overall effect.

We start by commenting on Figure 1 where the interest rate differential rule is reported. Recall that for this rule regime coefficients do not achieve statistical significance. In fact, the picture shows a clustering of the various currencies around the origin, with different shapes and sizes, the smallest corresponding to the French Franc the largest to the Pound.

More interestingly, Figure 2 corresponding to the MA rule shows that the currencies all belong to the second quadrant, i.e., there is a positive impact of volatility (i.e., towards depreciation of the foreign currency) when the signals relate to selling the currency and buying Dollars (short–term MA above long–term MA) and a negative impact of volatility for the other regime. Note, however, that the impact of the volatility is not symmetric, the clearest case in point being the Pound for which the volatility impact in Regime 2 is just a fraction of the impact in Regime 1. Note how similar the impacts are for the Yen and the Pound in Regime 1 and how different they are in Regime 2. However, the ranges of impacts for the Franc and the Mark are fairly similar in the two regimes, while for the Italian Lira the appreciating impact of the volatility in Regime 2 is much higher (in absolute value) than the depreciating one in Regime 1.

The MV rule exhibits (Figure 3) a similar range of outcomes, in that also in this case all currencies belong to the second quadrant, with minuscule sign reversals for the Franc and the Mark (Regime 1) and the Lira (Regime 2). The striking feature of the results is the wide response range across currencies. The Lira and the Pound have the largest effects in the two regimes, although the largest impact is had for different

regimes. The impact for the Franc is small in Regime 1 due to an insignificant slope coefficient, but it is quite high for Regime 2. We interpret this as if in periods of low volatility (characterizing the MV rule) the signals leading to Regime 1 (previous forward excess return greater than 0, that is, a surprise depreciation) were received less clearly (hence the smaller impact had) than in Regime 2.

To some extent, a different picture arises in the case of the US$ episodes (Figure 4) with a smaller impact of the risk–term on the Dollar appreciation than it has on the Dollar depreciation. The British Pound is the only currency for which the impact in both regimes does not exhibit any sign reversal. Three currencies, the Franc, the Mark and the Lira do not have a sign reversal in Regime 1, the conditional volatility having an impact towards their depreciation, so that a hike in conditional volatility had a strengthening effect for the Dollar. For these three currencies, the behavior in Regime 2 exhibits a sign reversal (very tiny for the DM), but while for the former two the main impact is on the direction of Dollar depreciation, for the Lira in the second regime the observed depreciation seems to be countered by a volatility effect. Finally, for the Yen neither slope coefficient for either regime is significant and only one constant term is. The visual impression, however, is towards a countertendency in Regime 1 and no effects in Regime 2.

Table 10: French Franc/US$: Analysis by Regimes.

Model with constrained $(f_{t,k} - s_t)$				
	i_t^*	MA	MV	US$
Constant ×10³	4.8140 (1.5250)	-0.7203 (1.1384)	3.6193 (1.6753)	-1.3106 (1.0868)
Dummy (1) ×10³	-2.9969 (1.9594) ◊	5.8383 (1.5255) ◊	2.2104 (3.0209)	15.7167 (2.0827) ◊
Dummy (2) ×10³			2.5710 (2.8750)	22.1605 (4.8997)
$(f_{t,k} - s_t)$	0.1942 (0.0761)	0.1759 (0.0481)	0.4423 (0.0752)	0.4223 (0.0606)
Risk Term	-0.7067 (0.8561)	-13.0732 (0.6903)	-0.6893 (0.7277)	-1.6265 (0.7420)
Risk Term (1)	3.5971 (1.0129) ◊	22.1599 (0.8422) ◊	0.3892 (3.1237) ◊	2.3443 (1.1225) ◊
Risk Term (2)			-15.9962 (2.5787) ♡	-12.0145 (1.7391) ♡
Fraction spent in (1)	0.6729	0.5216	0.2833	0.2116
Fraction spent in (2)	0.3215	0.4784	0.2782	0.0354
Switching	411	159	133	4

♡ Two regime coefficients significantly different from each other at 5% sig. level.
◊ Sum of two regime coefficients significantly different from zero at 5% sig. level.

Table 11: Italian Lira/US$: Analysis by Regimes.

Model with constrained $(f_{t,k} - s_t)$				
	i_t^*	MA	MV	US$
Constant ×10³	-2.8174 (1.4612)	-2.9156 (1.2354)	1.0012 (1.5071)	-3.2648 (0.8685)
Dummy (1) ×10³	2.3620 (1.9025) ◊	8.7736 (1.6130)	1.1478 (2.5759) ◊	11.7518 (1.8471)
Dummy (2) ×10³			5.3625 (2.2358)	-18.2512 (4.8127) ♡
$(f_{t,k} - s_t)$	0.3824 (0.0690)	0.3407 (0.0536)	0.3750 (0.0628)	0.4703 (0.0545)
Risk Term	3.8312 (0.6431)	-11.4842 (0.8369)	1.7138 (0.5205)	2.7071 (0.4110)
Risk Term (1)	-0.9276 (0.7707) ◊	19.4250 (0.9378) ◊	5.8428 (2.1581) ◊	0.8616 (1.1228) ◊
Risk Term (2)			-18.0806 (2.1968) ♡	4.8914 (2.2405)
Fraction spent in (1)	0.7596	0.5461	0.2669	0.2116
Fraction spent in (2)	0.1976	0.4539	0.3069	0.0354
Switching	322	157	127	4

♡ Two regime coefficients significantly different from each other at 5% sig. level.
◊ Sum of two regime coefficients significantly different from zero at 5% sig. level.

**Table 12: Japanese Yen/US$: Analysis by Regimes.**

	Model with constrained $(f_{t,k} - s_t)$			
	i_t^*	MA	MV	US$
Constant $\times 10^3$	1.1057 (1.0855)	-1.9504 (0.9756)	2.3773 (1.4568)	0.6066 (0.8444)
Dummy (1) $\times 10^3$	1.9905 ◊ (1.7819)	1.3849 (1.5635)	-0.9250 (2.2816)	7.9458 (1.7869)
Dummy (2) $\times 10^3$			-1.8855 (2.3542)	-8.6739 ♡ (5.4221)
$(f_{t,k} - s_t)$	0.3987 (0.0789)	-0.0615 (0.0501)	0.3255 (0.0731)	0.4370 (0.0585)
Risk Term	-4.4426 (0.5038)	-11.5259 (0.3949)	-6.7304 (0.5585)	-4.8622 (0.0.4569)
Risk Term (1)	-1.2349 ◊ (0.8406)	26.0993 ◊ (0.9721)	13.8318 ◊ (2.1276)	-1.2319 (1.0318)
Risk Term (2)			-4.5727 ♡ (1.4772)	9.5956 (6.9488)
Fraction spent in (1)	0.4287	0.4934	0.3336	0.2116
Fraction spent in (2)	0.5555	0.5066	0.2710	0.0354
Switching	438	166	137	4

♡ Two regime coefficients significantly different from each other at 5% sig. level.
◊ Sum of two regime coefficients significantly different from zero at 5% sig. level.

Table 13: British Pound/US$: Analysis by Regimes.

	Model with constrained $(f_{t,k} - s_t)$			
	i_t^*	MA	MV	US$
Constant $\times 10^3$	-3.8009 (2.4331)	-7.7332 (2.3716)	-5.4812 (3.8470)	-4.1439 (1.1263)
Dummy (1) $\times 10^3$	-1.0064 ◊ (3.5002)	6.9898 ◊ (2.6424)	6.3644 (5.2258)	9.9097 (2.7804)
Dummy (2) $\times 10^3$			3.0099 (4.5187)	-5.1279 (29.8834)
$(f_{t,k} - s_t)$	0.2901 (0.1026)	0.3353 (0.0636)	0.4859 (0.0812)	0.4231 (0.0606)
Risk Term	4.0510 (1.2921)	0.4342 (1.8605)	4.5824 (1.6714)	2.8926 (0.7222)
Risk Term (1)	2.5244 ◊ (2.2382)	7.4856 ◊ (1.9600)	2.4530 (3.9958)	3.6922 (2.2660)
Risk Term (2)			-11.5195 ♡ (3.4154)	-5.8555 (8.3885)
Fraction spent in (1)	0.6636	0.5160	0.2792	0.2116
Fraction spent in (2)	0.3346	0.4840	0.3244	0.0354
Switching	431	173	129	4

♡ Two regime coefficients significantly different from each other at 5% sig. level.
◊ Sum of two regime coefficients significantly different from zero at 5% sig. level.

Table 14: Deutsche Mark/US$: Analysis by Regimes.

Model with constrained $(f_{t,k} - s_t)$				
	i_t^*	MA	MV	US$
Constant ×10³	1.2900 (1.1535)	-4.2945 (0.9914)	7.0817 (1.5231)	-8.0131 (0.9370)
Dummy (1) ×10³	-1.2173 (1.9060)	6.9466 (1.4533)	-9.9169 ◊ (2.6262)	21.6155 ◊ (2.5550)
Dummy (2) ×10³			-8.5539 ♡ (2.4080)	10.8443 ♡ (4.5133)
$(f_{t,k} - s_t)$	0.3363 (0.0781)	0.3348 (0.0492)	0.3408 (0.0652)	0.4525 (0.0607)
Risk Term	-1.4016 (0.5789)	-9.0723 (0.5740)	-3.2556 (0.6508)	3.0610 (0.5594)
Risk Term (1)	0.1101 ◊ (0.9323)	19.0692 (0.7760)	12.0268 ◊ (2.7309)	-2.5731 ◊ (1.7647)
Risk Term (2)			-4.3846 ♡ (1.7185)	-10.6168 ♡ (1.3843)
Fraction spent in (1)	0.4315	0.4859	0.2720	0.2116
Fraction spent in (2)	0.5610	0.5141	0.2823	0.0354
Switching	479	149	124	4

♡   Two regime coefficients significantly different from each other at 5% sig. level.
◊   Sum of two regime coefficients significantly different from zero at 5% sig. level.
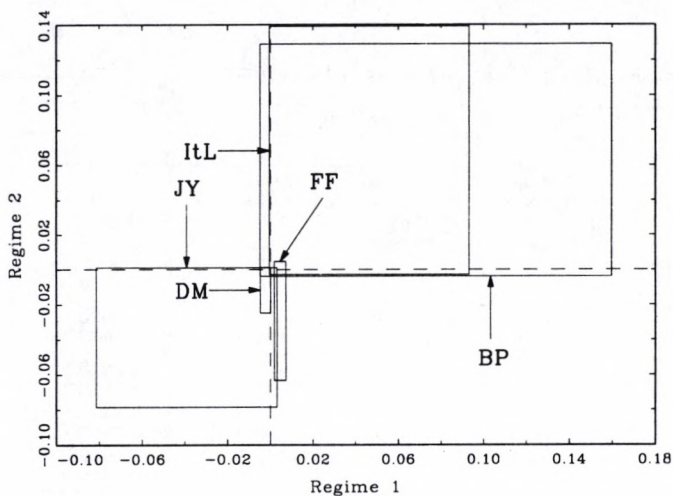
Figure 1: Risk Impact on Exchange Rate Returns. Interest Rate Differential Rule.
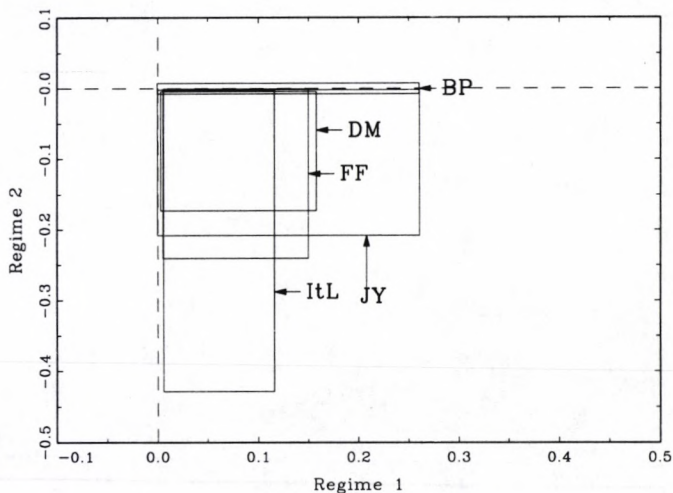
Figure 2: Risk Impact on Exchange Rate Returns. Moving Average Rule.

34
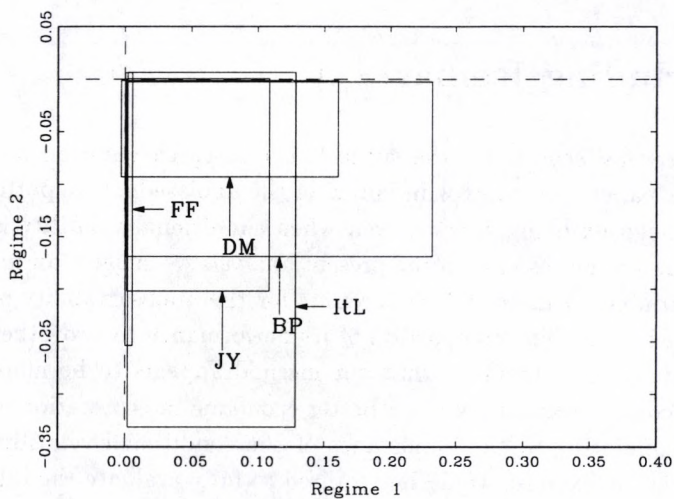
Figure 3: Risk Impact on Exchange Rate Returns. Moving Variance Rule.
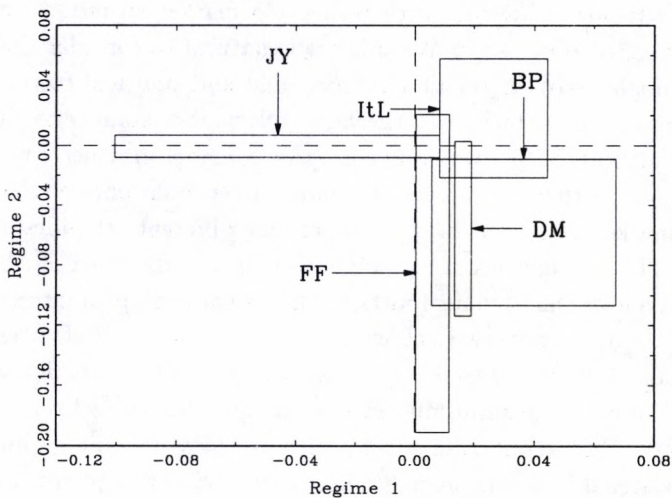
Figure 4: Risk Impact on Exchange Rate Returns. US$ Episodes.

35

8 Concluding Remarks

In line with several studies on the subject, the research question addressed in this paper aims to explain failure of the unbiasedness hypothesis in the foreign exchange market even when conditional volatility is inserted among the regressors. In the present analysis we suggest an instrumental variable estimator which accounts for the unobservability of the risk–related term. The comparison of its performance to two other semiparametric estimators shows that our method appears to be more stable across countries and provides a better economic interpretation of the outcomes, pointing to the importance of the conditional volatility term. A simulation exercise would be required to fully evaluate the different properties of each method.

A more substantial question was asked as to whether the information set that is customarily used for testing the relevance of a risk–related term should be supplemented by elements which could highlight the different attitudes of agents with respect to market situations, or their different signal processing. We think it is natural to consider that asymmetries might exist in relation to economic and political factors, such as the reputation attached to the anti–inflationary stances of the monetary authorities. While we do not propose a model in which reputation emerges in its effects on foreign exchange determination, we select a number of market situations likely to determine different attitudes on the markets. These situations are characterized as signals based on the observed behavior of the exchange rates in their relationship to interest rate differentials, moving averages of levels, or moving variances of excess returns. Signals of "buy" or "sell" from each rule may be contradictory and may not be received uniformly on the markets due to a disparity of expectations. The reputation effect which we have in mind would then filter the signal in a non–homogeneous way, giving rise to clusters of volatility. The analysis of the behavior of the risk–related term on foreign exchange returns then mirrors this disparity in translating the signals into action.

The results show that in the case of the interest rate differential rule

there is no significant change in the impact of the risk term with respect to regimes. This is not surprising given the coexistence of consistently positive (or negative) differentials and expectations of appreciation or depreciation of a currency. Although there is no difference between the regimes, the overall effect shows a sign reversal implying the existence of a threshold beyond which a higher volatility produces an inversion of tendency. This inversion of tendency is absent for the moving average rule where there is a certain homogeneity of behavior in accordance to the definition of the regimes, but quite a difference in the measured impact across currencies. A more differentiated behavior of the risk–related term arises in the moving variance rule with the impact varying across regimes and across currencies. Finally, the interpretation that we provide to the impact of this risk–related term is in line with the "fad" explanation of the strength and weakness of the US$ during the 1980s, although more so for episodes of weakness than of strength.

Even if the unbiasedness hypothesis is still rejected, the evidence is in favor of the relevance of a risk–related term which behaves asymmetrically according to various situations on the markets. The analysis performed here used the US$ as numéraire. Although previous studies have excluded the dependence of the results on such a choice, further insights on the nature of the risk–related term can be gained by applying the same methodology to the Exchange Rate Mechanism in the EMS using the DM as a reference, to investigate the evolution and the impact of the risk term relative to the position of the exchange rate in the band.

References

Amemiya T. (1974), The Nonlinear Two-Stage Least-Squares Estimator, *Journal of Econometrics*, 2, 105-110.

————- (1977), The Maximum Likelihood and the Nonlinear Three-Stage Least-Squares Estimator in the General Nonlinear Simultaneous Equation Model, *Econometrica*, 45, 955-968.

Backus D.K. and A.W.Gregory, Theoretical Relations between Risk Premiums and Conditional Variances, *Journal of Business and Economic Statistics*, 11, 177–185.

Baillie R.T. and T. Bollerslev (1990), A Multivariate Generalized ARCH Approach to Modelling Risk Premia in Forward Foreign Exchange Rate Markets, *Journal of International Money and Finance*.

———— and P. McMahon (1989), *The Foreign Exchange Market. Theory and Econometric Evidence*, Cambridge University Press.

Bartlett M.S. (1963), Statistical Estimation of Density Functions, *Sankya*, Series A, 25, 145-154.

Bollerslev T. (1986), Generalized Autoregressive Conditional Heteroskedasticity, *Journal of Econometrics*, 31, 307-327.

————- (1990), Modelling the Coherence in Short-Run Nominal Exchange Rates: a Multivariate Generalized ARCH Model, *Review of Economics and Statistics*, 72, 498-505.

————-, R.Y. Chou, and K.F. Kroner (1992), ARCH Modeling in Finance, *Journal of Econometrics*, 52, 5-59.

————-, and R. Hodrick (1992), Financial Market Efficiency Tests, *Working Paper* n. 4108, National Bureau of Economic Research.

Chamberlain G. (1987), Asymptotic Efficiency in Estimation with Conditional Moment Restrictions, *Journal of Econometrics*, 34, 305-334.

Clark P.K. (1973), A Subordinated Stochastic Process Model with Finite Variance for Speculative Prices, *Econometrica*, 41, 135-155.

Cumby R.E. (1988), Is it Risk?, *Journal of Monetary Economics*, 22, 279-299.

————-, and M. Obstfeld (1981), Exchange Rate Expectations and Nominal Interest Differentials: a Test of the Fisher Hypothesis, *Journal of Finance*, 36, 697-704.

Delgado M. (1992), Computing Nonparametric Functional Estimates in Semiparametric Problems, *Working Paper* 92-17, Universidad Carlos III de Madrid, Madrid.

Diebold F.X. (1986), Modeling Persistence in Conditional Variances: A Comment, *Econometric Reviews*, 5, 51-56.

————-, and J.A. Nason (1990), Nonparametric Exchange Rate Prediction, *Journal of International Economics*, 28, 333-347.

Domowitz I., and C.S. Hakkio (1985), Conditional Variance and the Risk Premium in the Foreign Exchange Market, *Journal of International Economics*, 19, 47-66.

Engle R. F. (1982), Autoregressive Conditional Heteroskedasticity with Estimates of the Variance of U.K. Inflation, *Econometrica*, 50, 987-1008.

————-, D.M. Lilien, and R.P. Robins (1987), Estimating Time–Varying Risk Premia in the Term Structure: the ARCH-M Model, *Econometrica*, 55, 391-407.

French, K. R., G.V. Schwert, and R.F. Stambaugh (1987), Expected Stock Return and Volatility, *Journal of Financial Economics*, 19, 3-29.

Froot K.A. and R.H. Thaler (1990), Anomalies: Foreign Exchange, *Journal of Economic Perspectives*, 4, 179-192.

Gallant R., D. Hsieh, G. Tauchen (1991), On Fitting a Recalcitrant Series: the Pound/Dollar Exchange Rate 1974-1983, in W. Barnett, J. Powell and G. Tauchen (eds.), *Semiparametric and Nonparametric Methods in Econometrics and Statistics*, Cambridge: Cambridge University Press.

Grauer F.L.A., R.H. Litzenberger, and R.E. Stehle (1976), Sharing Rules and Equilibrium in an International Trade Capital Market under Uncertainty, *Journal of Financial Economics*, 4, 233-56.

Hansen, L.P., and R.J. Hodrick (1983), Risk Averse Speculation in the Forward Foreign Exchange Markets: An Econometric Analysis of Linear Models, in J.A.Frenkel (ed.), *Exchange Rates and International Macroeconomics*, Chicago: University of Chicago Press.

Hodrick R., and S. Srivastava (1984), An Investigation of Risk and Return in Forward Foreign Exchange, *Journal of International Money and Finance*, 3, 5-30.

Hsieh D.A. (1993), Using Nonlinear Methods to Search for Risk Premia in Currency Futures, *Journal of International Economics*, 35, 113-132.

Kirman A. (1993), Ants, Rationality and Recruitment, *Quarterly Journal of Economics*, 108, 137-156.

LeBaron B. (1993a), Forecast Improvements Using a Volatility Index, in M.H. Pesaran and S.M. Potter (eds.) *Nonlinear Dynamics, Chaos and Econometrics*, New York: J.Wiley.

————- (1993b), Practical Comparisons of Foreign Exchange Forecasts, *Neural Network World*, 6, 770-790.

Lehmann B. (1990), Fads, Martingales and Market Efficiency, *Quarterly Journal of Economics*, 105, 1-28.

Lewis K.K. (1989), Changing Beliefs and Systematic Rational Forecast Errors with Evidence from Foreign Exchange, *American Economic Review*, 79, 621-636.

Levi M., and J. Makin (1979), Fisher, Phillips, Friedman and the Measured Impact of Inflation on Interest, *Journal of Finance*, 34, 35-52.

Lucas R. (1982), Interest Rates and Currency Prices in a Two–Country World, *Journal of Monetary Economics*, 10, 335-360.

Mizrach B. (1993), Multivariate Nearest–Neighbor Forecast of EMS Exchange Rates, in M. Pesaran e S. Potter (eds.) *Nonlinear Dynamics, Chaos and Econometrics*, New York: John Wiley.

Newey W.K. (1990), Efficient Instrumental Variables Estimation of Nonlinear Models, *Econometrica*, 58, 4, 809-837.

Pagan A.R. (1984), Econometric Issues in the Analysis of Regressions with Generated Regressors, *International Economic Review*, 25, 1.

———-, A. Hall, and P. Trivedi (1983), Assessing the Variability of Inflation, *Review of Economic Studies*, 50, 585-596.

———-, and Y.S. Hong (1991), Nonparametric Estimation and the Risk Premium, in W. Barnett, J. Powell and G. Tauchen (eds.) *Semiparametric and Nonparametric Methods in Econometrics and Statistics*, Cambridge: Cambridge University Press.

———-, and G.W. Schwert (1990), Alternative Models for Conditional Stock Volatility, *Journal of Econometrics*, 45, 267-290.

———-, and A. Ullah (1988), The Econometric Analysis of Models with Risk Terms, *Journal of Applied Econometrics*, 3, 87-105.

Robinson P.M. (1983), Nonparametric Estimators for Time Series, *Journal of Time Series Analysis*, 4, 3, 185-207.

————- (1991), Best Nonlinear Three–Stage Least Squares Estimation of Certain Econometric Models, *Econometrica*, 59, 3, 755-786.

Stockman A.C. (1978), Risk, Information and Forward Exchange Rates, in J.A. Frenkel and H.G. Johnson (eds.), *The Economics of Exchange Rates*, Reading: Addison-Wesley, 159-78.

Taylor M.P., and H. Allen (1992), The Use of Technical Analysis in the Foreign Exchange Market, *Journal of International Money and Finance*, 11, 304-314.

EUI
WORKING
PAPERS

EUI Working Papers are published and distributed by the
European University Institute, Florence

Copies can be obtained free of charge
– depending on the availability of stocks – from:

The Publications Officer
European University Institute
Badia Fiesolana
I-50016 San Domenico di Fiesole (FI)
Italy

Please use order form overleaf

Publications of the European University Institute

Department of Economics Working Paper Series

To   Department of Economics **WP**
European University Institute
Badia Fiesolana
I-50016 San Domenico di Fiesole (FI)
E-mail: publish@datacomm.iue.it
Italy

From   Name . . . .

            Address. . . . .

            . . . .

            . . . .

            . . . .

            . . . .

                         (Please print)

❏ Please enter/confirm my name on EUI Economics Dept. Mailing List
❏ Please send me a complete list of EUI Working Papers
❏ Please send me a complete list of EUI book publications
❏ Please send me the EUI brochure Academic Year 1995/96

Please send me the following EUI **ECO** Working Paper(s):

No, Author   . . . .
Title: . . . .
No, Author   . . . .
Title: . . . .
No, Author   . . . .
Title: . . . .
No, Author   . . . .
Title: . . . .

Date . . . .   Signature . . . .

Working Papers of the Department of Economics
Published since 1993

ECO No. 93/21
Stephen MARTIN/Louis PHLIPS
Product Differentiation, Market Structure
and Exchange Rate Passthrough

ECO No 93/22
F. CANOVA/M. FINN/A. R. PAGAN
Evaluating a Real Business Cycle Model

ECO No 93/23
Fabio CANOVA
Statistical Inference in Calibrated Models

ECO No 93/24
Gilles TEYSSIÈRE
Matching Processes in the Labour Market
in Marseilles. An Econometric Study

ECO No 93/25
Fabio CANOVA
Sources and Propagation of International
Business Cycles: Common Shocks or
Transmission?

ECO No. 93/26
Marco BECHT/Carlos RAMÍREZ
Financial Capitalism in Pre-World War I
Germany: The Role of the Universal
Banks in the Financing of German
Mining Companies 1906-1912

ECO No. 93/27
Isabelle MARET
Two Parametric Models of Demand,
Structure of Market Demand from
Heterogeneity

ECO No. 93/28
Stephen MARTIN
Vertical Product Differentiation, Intra-
industry Trade, and Infant Industry
Protection

ECO No. 93/29
J. Humberto LOPEZ
Testing for Unit Roots with the k-th
Autocorrelation Coefficient

ECO No. 93/30
Paola VALBONESI
Modelling Interactions Between State and
Private Sector in a "Previously" Centrally
Planned Economy

ECO No. 93/31
Enrique ALBEROLA ILA/J. Humberto
LOPEZ/Vicente ORTS RIOS
An Application of the Kalman Filter to
the Spanish Experience in a Target Zone
(1989-92)

ECO No. 93/32
Fabio CANOVA/Morten O. RAVN
International Consumption Risk Sharing

ECO No. 93/33
Morten Overgaard RAVN
International Business Cycles: How
much can Standard Theory Account for?

ECO No. 93/34
Agustín MARAVALL
Unobserved Components in Economic
Time Series *

ECO No. 93/35
Sheila MARNIE/John
MICKLEWRIGHT
"Poverty in Pre-Reform Uzbekistan:
What do Official Data Really Reveal?"

ECO No. 93/36
Torben HOLVAD/Jens Leth
HOUGAARD
Measuring Technical Input Efficiency for
Similar Production Units:
80 Danish Hospitals

ECO No. 93/37
Grayham E. MIZON
A Simple Message for Autocorrelation
Correctors: DON'T

ECO No. 93/38
Barbara BOEHNLEIN
The Impact of Product Differentiation on
Collusive Equilibria and Multimarket
Contact

ECO No. 93/39
H. Peter MØLLGAARD
Bargaining and Efficiency in a
Speculative Forward Market

✳✳✳

*out of print

ECO No. 94/22
Isabelle MARET
Heterogeneity and Dynamics of
Temporary Equilibria: Short-Run Versus
Long-Run Stability

ECO No. 94/23
Nikolaos GEORGANTZIS
Short-Run and Long-Run Cournot
Equilibria in Multiproduct Industries

ECO No. 94/24
Alexander SCHRADER
Vertical Mergers and Market Foreclosure:
Comment

ECO No. 94/25
Jeroen HINLOOPEN
Subsidising Cooperative and Non-
Cooperative R&D in Duopoly with
Spillovers

ECO No. 94/26
Debora DI GIOACCHINO
The Evolution of Cooperation:
Robustness to Mistakes and Mutation

ECO No. 94/27
Kristina KOSTIAL
The Role of the Signal-Noise Ratio in
Cointegrated Systems

ECO No. 94/28
Agustín MARAVALL/Víctor GÓMEZ
Program SEATS "Signal Extraction in
ARIMA Time Series" - Instructions for
the User

ECO No. 94/29
Luigi ERMINI
A Discrete-Time Consumption-CAP
Model under Durability of Goods, Habit
Formation and Temporal Aggregation

ECO No. 94/30
Debora DI GIOACCHINO
Learning to Drink Beer by Mistake

ECO No. 94/31
Víctor GÓMEZ/Agustín MARAVALL
Program TRAMO "Time Series
Regression with ARIMA Noise, Missing
Observations, and Outliers" -
Instructions for the User

ECO No. 94/32
Ákos VALENTINYI
How Financial Development and
Inflation may Affect Growth

ECO No. 94/33
Stephen MARTIN
European Community Food Processing
Industries

ECO No. 94/34
Agustín MARAVALL/Christophe
PLANAS
Estimation Error and the Specification of
Unobserved Component Models

ECO No. 94/35
Robbin HERRING
The "Divergent Beliefs" Hypothesis and
the "Contract Zone" in Final Offer
Arbitration

ECO No. 94/36
Robbin HERRING
Hiring Quality Labour

ECO No. 94/37
Angel J. UBIDE
Is there Consumption Risk Sharing in the
EEC?

ECO No. 94/38
Berthold HERRENDORF
Credible Purchases of Credibility
Through Exchange Rate Pegging:
An Optimal Taxation Framework

ECO No. 94/39
Enrique ALBEROLA ILA
How Long Can a Honeymoon Last?
Institutional and Fundamental Beliefs in
the Collapse of a Target Zone

ECO No. 94/40
Robert WALDMANN
Inequality, Economic Growth and the
Debt Crisis

ECO No. 94/41
John MICKLEWRIGHT/
Gyula NAGY
Flows to and from Insured
Unemployment in Hungary