Testing exchange rate efficiency: the case of Euro-Dollar

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Abstract

This paper tests the semi-strong efficiency of the euro-dollar currency market by introducing by introducing a simple nested test, based on the "general-to-specific" methodology and meant to include as two specific subcases the Efficient Market Hypothesis in the currency market as well as alternative theories focusing on the hearding behaviour of agents and implying a time dependent process of propagation of information. Our test is introduced by a preliminary analysis containing a test that verifies whether the exchange rate behaves consistently with the notion of rational expectation such as originally defined by Lucas. According to the results of our nested test, the Efficient Market Hypothesis in the euro-dollar currency market is rejected, while the preliminary test yields mixed results, not entirely consistent with the rational expectation assumption.

Keywords: Information and market efficiency, foreign exchange

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1. Introduction

This paper investigates the efficiency of the euro-dollar currency market by introducing a simple nested test, based on the notion of semi-strong efficiency and meant to include as two specific subcases the Efficient Market Hypothesis (henceforth EMH) in the currency market as well as alternative theories focusing on the hearding behaviour of agents. The latter have in common the fact that they predict an empirical behaviour of the fundamentals determining the prediction mistake be characterized by a persistent statistical significance of the lagged variables of the regressors, to the extent that the process of information spreading is time consuming.

Like many efficient market tests, our test employs as a dependent variable a suitable definition of prediction mistake and regress it on a set of relevant fundamental variables. The rationale of our test lies in the fact that any piece of new information driving the investors decisions has to determine some kind of portfolio reallocation (i.e. modification in the demand and supply of the different stocks and securities) which is bound to affect the stock price of the different assets. This means that the intensity of the new information spreading around the market can be captured by the variance in the asset price. In other words, assuming that a certain variance in the stock price is physiological, a higher or a lower variance in the stock index has to be associated to more or less frequent portfolio reallocations, therefore to a higher or lower flow of new information available in the market.

In our case, the underlying theory suggesting what variables have to be regarded as fundamentals is rather strong: the national account definition of Balance of Payments. However, as explained below, the variables included as proxies for capital reallocation and portfolio recomposition are constructed, by definition, “after” the moment when the prediction of the future exchange rate is made by the market. Therefore, a statistically significant contemporaneous value of these proxies for portfolio reallocation would be consistent with the efficient market assumption, since they capture a flow of information not available at the time when the exchange rate predictions are formulated. On the other hand, if these proxies for portfolio reallocation were to be significant in their lagged values (and, of course, if any other lagged variable had to be statistically significant), this would be inconsistent with the efficient market assumption.

In order to include as specific subcases in the same test both the assumption of efficient markets and the case of persistent significance of the lagged variables (and let the data say the last word) we have followed the “general-to specific” methodology (Harvey, 1989, Hendry, 1985, 1988), which consists of starting form a general “unrestricted model” containing both the contemporaneous and the lagged values of the regressors and get to a final “parsimonious” specification of the model (with only the significant lagged and contemporaneous variables) by means of a joint significance specification test that eliminates the redundant variables.

2. Efficient market hypothesis and hearding behaviour

In the assumption of semi-strong efficiency in the currency market it is postulated that the agents use any information available from the fundamentals to formulate their (rational) expectations on the future asset price. This means that any forecast error has to be unpredictable. Hearding behaviour can be associated to a more general analysis of individual and collective learning processes. In literature this is often associated to information asymmetries among agents, decision problems similar among the different agents, informational externalities and payoff externalities. Devenon and Welch (1996) define the hearding behaviour as a pattern of correlated behaviour among individuals. Banerjee (1992) introduces a theory of hearding behaviour based on the assumption of information asymmetries but consistent with a generally accepted notion of agents’ rationality. He shows that some agents while taking their decisions have necessarily to take into account the decisions of other agents, in order to obtain the information they lack. Banerjee shows that a consequence of this behaviour pattern is a possible underestimation of private information, when it is in conflict with the information obtainable from other agents’ actions. However in this context hearding is only a miminal deviation from the classical notion of rationality and is still consistent with an efficient use of all available information in the market, although possibly with some lag, due to the fact that the process of information spreading my be time consuming. Bikhchandani, Hirshleifer and Welch (1992, 1998) analyze hearding as a consequence of actions observability. They introduce a distinction between direct and indirect observability and derive the minimal conditions that determine informational cascades. They also show that small perturbations in the informational sets of the individuals may drastically modify the equilibria, making these informational cascades very fragile. Young (1993), in a framework based on the assumption of bounded rationality, emphasize the role of hearding behaviour in the process of selecting equilibria, while Topol (1991) shows that if one abandons the assumption of perfect structural knowledge of the system where the agents operate and if one assumes that agents calculate the net present value of the assets on the basis of an incomplete information set, the calculation of the asset value by the agents corresponds to a behaviour of bounded rationality. In particular, the asset value is given by the sum of a component associated to the net present value and a component associated to the hearding behaviour. The latter is endogenous and can generates speculative bubbles and fads, dramatically increasing the volatility of the market.

De Grauwe, Dewachter and Embrechts (1993), in a context of bounded rationality show that chaotic dynamics may emerge when the market calculates its expectation of the exchange rate on the basis of a weghited average of the rational expectation prediction and "technical analysis" based on time series observation of the past behaviour of the other agents.

More in general, to the extent that the process of information spreading is time consuming and time dependent (like in the "epidemic models" of information spreading introduced by Shiller 1984 and 1989) hearding behaviour may generate statistical significance and relevance of the lagged values of the fundamentals in explaining agents' behaviour and predicting mistakes. To the extent that information is not instantaneously available and requires time and resources, the agents may rely on values (obtained with high delay) of the relevant variables to implement their forecasts. In this case, with monthly data, even lagged variables (but less lagged than the ones included in the agents' information sets) may have a statistically significant contribution in explaining the prediction mistakes.

3. A nested test of Efficient Market Hypthesis vs alternative theories

The very extended literature on currency market efficiency and its applications to the euro-dollar exchange rate has often been concerned with associating a suitable formalization of the EMH with a robust theory justifying the choice of the fundamentals to be included in the regression and the statistical problems of long run co-movement of the regressors (see, for instance Engle and Hamilton, 1990, Liu and Maddala, 1992a, 1992b). In the assumption of semi-strong efficiency in the currency market it is postulated that the agents use any information available from the fundamentals to formulate their (rational) expectations on the future asset price. Obviously, in our case the asset price is given by the euro-dollar exchange rate, and any prediction error has to be random and unpredictable. In our case, the underlying theory saying what variables have to be regarded as fundamentals is simply given by the national account definition of Balance of Payments and by the monetary authorities interventions in the currencu market. Therefore the choices of the fundamentals affecting the prediction mistake in the currency market are based on a definition which is tautologically true. In our test we employ monthly data. This obviously means that the variance of the current account of the balance of payments is bound to be considerably smaller than the variance of the capital movements (mainly determined by the agents' portfolio reallocation, caused by any piece of available new information). and also smaller than the variance of official currency reserves (mainly determined by the interventions of the monetary authorities as well as decisions of the private sector), but it is still taken into account in order to avoid any potential bias.

We consider therefore the following national account definition:

$$BP = CA + FA + \Delta RU$$

Where *BP* is the balance of payments, *CA* the current account and ΔRU the change in official reserves, *FA* the financial account. Since we are testing a theory of information spreading and expectation formation, we needed to use monthly data, so that the fundamental real variables referred to the current account could show some variance (although very limited) and, at the same time, the financial variables affecting portfolio reallocation could be measured at reasonably short intervals. However, given that we are using monthly data, we had to employ the Trade Balance as a proxy for the Current Account, in order to have the exactly the same variable both for the US and the Euro area.

The literature on covered parity interest rates tests is often based on some some kind regression similar to the following one (see for instance Sarno, L., Taylor, 2002, pp. 6-17):

$$s_{t+k} + f_t^{(k)} = \Gamma \ \Psi_t + \ \eta_{t+k}$$

where s_{t+k} is the spot exchange rate at time $f_t^{(k)}$, is the future valued at time *t* for time *t+k*, Ψ_t is a set of variables known to the investors at time *t*, Γ is a matrix of coefficients and, of course η_{t+k} are the regression residuals. Normally the set of regressors Ψ_t would also include a number of lagged prediction errors (see for instance Hansen and Hodrik, 1980), which obviously raises the problem of stationarity of the variable included in the equation. In particular, a significant value of the lagged prediction errors would be, of course, inconsistent with the efficient market hypothesis, Sice some preliminary analyses has shown that the lagged prediction mistakes are completely non significant and since the object of our test is exactly the EMH, we have followed a more conservative strategy and have implemented the test simply on the significance of lagged fundamentals (independent variables).

3.1 A few preliminary comments on the employed variables

The dependent variable of the equation employed for the test, $| s_{(t+1)} - f_t^{(t+1)} |$, in the regression *SF*, is the difference, in absolute value, between the spot exchange rate euro-dollar measured at time *t+1* and the future measured at time *t* for time *t+1*, i.e.the forward exchange rate measured in a given month for the next one. Under the assumption of covered parity, the dependent variable of the test equation is the prediction error of the market. The fundamental variables (regressors) are the following:

- *VARSP* is the monthly variance (i.e. such as measured between time *t* and time *t+1* by using daily data) of the US stock market: we used for this purpose the variance of the S&P 500 index, which represents approximately 75% of the NYSE and Nasdaq capitalization;

- *VAREUROSTOXX* is the monthly variance of the EMU stock markets, by using as a proxy the Dow Jones Eurostoxx TMI, which represents approximately 80% of the aggregate capitalization of the 12 EMU countries;

- *VARBONDUSA* is the variance of the US bond market, by using as a proxy the JMP US bond index, which includes US government bonds with a maturity up to 10 years;

- *VARBONDEMU* is the variance of the euro area bond market. We use as a proxy the JPM EMU bond, similar to the previous one, but composed by government bonds from EMU countries;

- $\Delta TBUS_{t+1,t}/TBUS_t$ is the monthly rate of growth of the US trade balance between time *t+1* and *t*, included as a proxy for the current account of the balance of payments; to simplify the notation this variable in the estimates is simply called $TBUSA_{t+1}$.

- $\Delta TBE_{t+1,t}/TBE_t$ is the monthly rate of growth of the EMU trade balance between time *t+1* and *t*, again included as a proxy for the current account of the balance of payments; to simplify the notation this variable is simply called $TBEMU_{t+1}$ in the estimates;

– $\Delta RUE_{t+1,t}/RUE_t$ the monthly rate of growth of the official reserves of the European Central Bank; to simplify the notations this variable is simply called in the estimates $RUECB_{t+1}$;

- $\Delta RFED_{t+1,t}/RFED_t$ is the monthly rate of growth of the official reserves of the Federal Reserve; to simplify the notations this variable is simply called in the estimates $RUFED_{t+1}$;

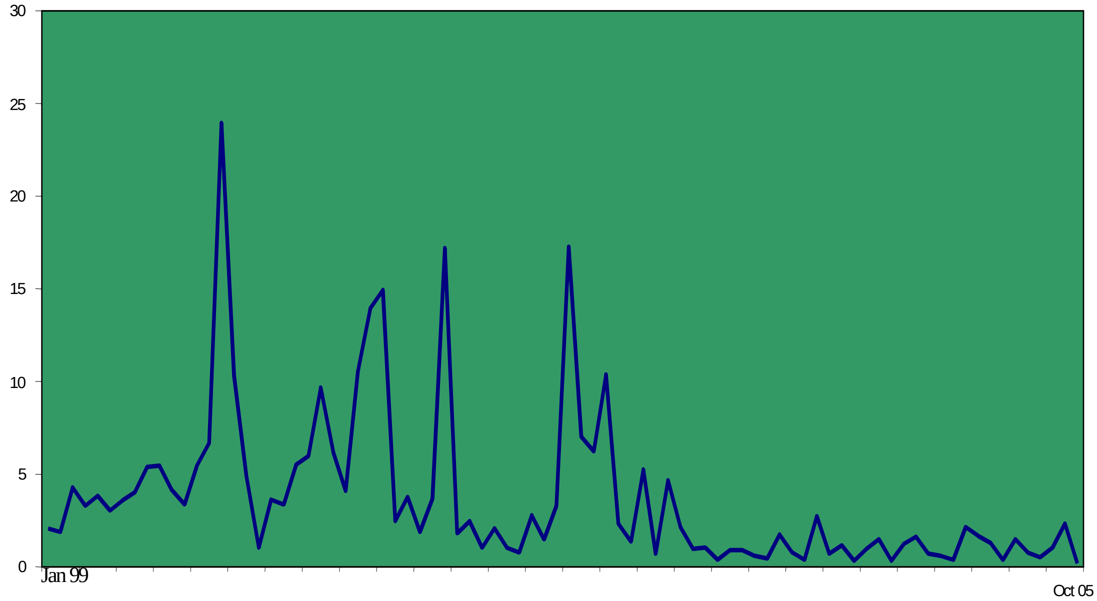
- $CP_{t\ (USA)}/CP_{t\ (EMU)}$ represents the relative price, measured as the ratio between the price level in the US and in the EMU: we employed in this regard the monthly based Consumer Price Index since monthly data for the implicit deflator of GDP were not available for both currencies. and in order to capture any possible inflation affect on the US and EMU trade balances suitable to determine any short run deviation from the Purchasing Parity Power condition. It is true that the PPP is mostly regarded in literature as a long run relationship, but introducing it in our regression corresponds to a conservative attitude, meant to avoid any bias, no matter how small; to simplify the notations this variable is simply called in the estimates CPI_t;

The varances of the two stock market indexes needed to be made comparable and homogeneous, since the two indexes are calculated in different ways: since S&P500

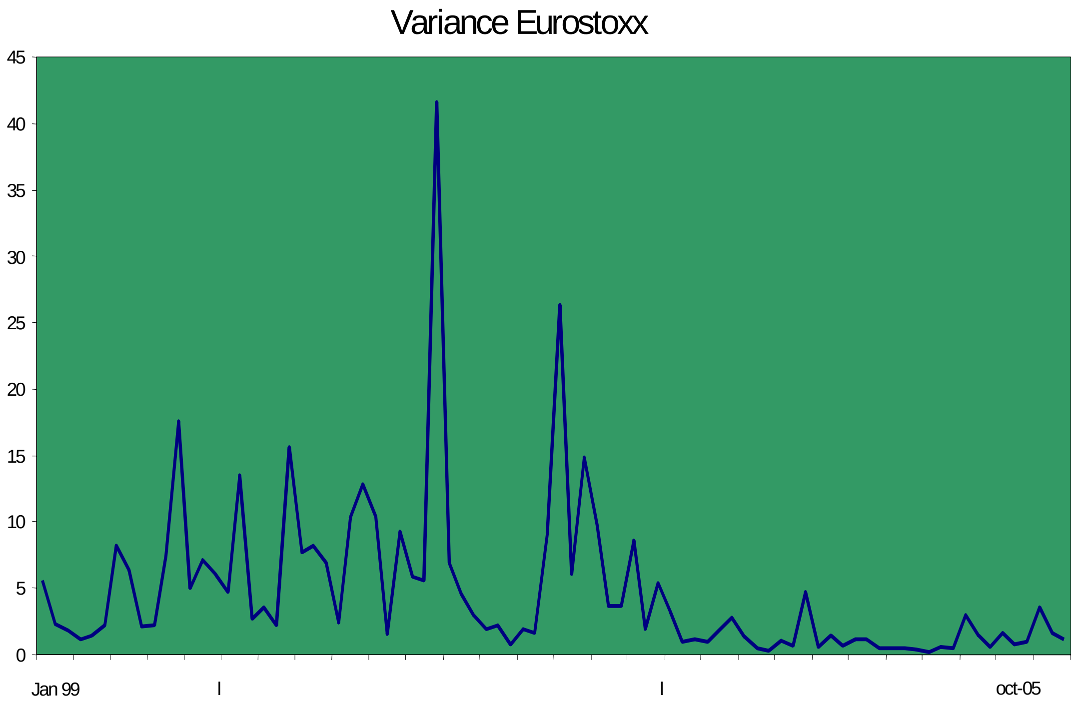
has a different magnitude, they had to be both scaled to a common base set to 100, so that the magnitude of the two variances could be compared.

Any problem of long run co-movement of the variables included in the test is ruled out by the fact that all the above regressors are stationary.

Variance S&P500 - USA



[source: Datastream]

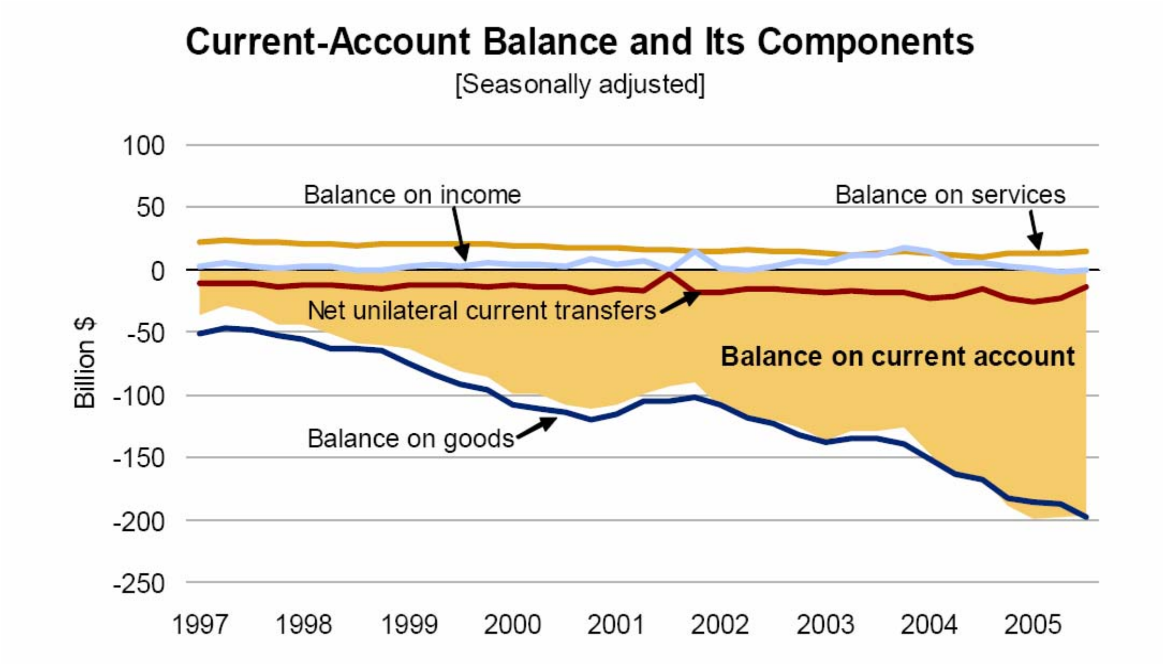


The correlation between the two indexes variances is rather high (about 68%), and the variance peak of September 2001 in the European markets, not found in the US market, is essentially due to the fact that the European Markets (see the graph below) remained open on september 11 2001, differently from the US markets.

The change in the private sector net foreign position is obviously affected by the portfolio adjustments of the private investors receiving new information. This means that, provided that a certain amount of portfolio adjustment is physiological and is captured by a certain level of variance, an increase in the stock market variance normally reflect changes in the intensity of new information that determines, in its turn, the choices of private portfolio reallocations. While any change in this variance, as well as in the other asset variances included in the regression from time *t* to time *t+1* cannot possibly be included in the future exchange rate formulated at time t for time *t+1*, any significant lagged value of this variance is inconsistent with any notion of market efficiency because it simply means that a piece of information known to the market *before* time *t* can improve the prediction mistake. On the other hand the efficient market assumption suggests that the portfolio reallocation performed between time *t* and time *t+1* plays a relevant role in unpredictable mistakes and might be strongly correlated with the prediction mistake for the exchange rate at time *t*, such as predicted at time *t*.

The Current Account of the Balance of Payments is in general relatively stable in the short run and has been included in our analysis in order to avoid any possible bias (even of relatively small magnitude) in the estimates.

Since the Current Account data are not published monthly by the BEA (Bureau of Economic Analisys), we had to employ as a proxy the Trade Balance. This might be better understood by looking at the following graphic.



[source:Bureau of Economic Anlysis]

As we can see, the Current Account of the US Balance of Payments increases with the deficit: According to the IMF estimates it should reach 6% of the US GDP in 2006, and this is mainly due to the "commodities". This reason probably justifies the emphasis on the trade balance by BEA and the reason why only monthly statistics are available for the trade balance and not for the current account. In the EMU the deficit/surplus of the current accounts is only about 1% of the EMU GDP, according to the ECB data.

A normalization to a common basis and magnitude has also been implemented for the variances of the bond markets, which, anyway, turned out to be extremely slow.

Obviously, data for the EMU official reserves are only available from the year 2000. For this reason our estimates consider the time period from January 2000 until October 2005, i.e. 70 observations. Only the official reserves in foreign currencies have been included, since the reserves in gold only show extremely small changes, and, at times, almost no changes at all.

The rate of variation of the net official reserves also contains the monetary policy measures decided by the authorities an the currency markets.

Furthermore, the monthly variance of the bond market reflects, on the one hand the authorities' open market operations aiming at the domestic economy, on the other hand, the private sector holdings of risk-free assets, which is also part of a more general portfolio allocation choice. In Keynesian terms, this could be affected by "liquidity preference" decisions, while, according to the theories that postulate investors' mimicking or imitative behaviour or other theories emphasizing the const and time-consuming, the holdings of more liquid and risk-free assets might be the consequence of the need to re-evaluate and calculate the optimal portfolio after an innovation shock.

3.2 Test implementation

The implementation of the test is based on the "general-to-specific" (Hendry 1985, Harvey, 1988, 1989) methodology, starting from a general unrestricted specification containing four lags, since simulation studies already consolidated in the literature of the 1980's have shown that this seems to be an appropriate dynamic structure to start with in order to capture the dynamic properties of the models.

Preliminary regressions have shown that the lagged dependent variables are totally non significant (which amount to saying that the past prediction mistakes do not improve the present prediction mistakes), therefore, in the specification of the general unrestricted model they have been omitted, in order to run the estimates and tests with a higher and more reliable degree of freedom. This also corresponds to a more conservative test strategy, since the object of the test is the EMH and in this way we are excluding variables whose statistical significance would contradict the EMH.

The final "restricted" specification is obtained by imposing zero-restrictions in the "general unrestricted model" and by testing them with variable deletion tests.

The theoretical equation, in levels, specified according to the above mentioned *general-to-specific* methodology is the following:

$$| s_{(t+1)} - f_t^{(t+1)} | = const + \sum_{i=0}^{4} \alpha_i VARSP_{t-i} + \sum_{i=0}^{4} \beta_i VAREUROSTOXX_{t-i} + \sum_{i=0}^{4} \phi_i VARBONDUSA_{t-i} +$$

$$+ \sum_{i=0}^{4} \varphi_i VARBONDEMU_{t-i} + \sum_{i=0}^{4} \gamma_i [\Delta TBUS_{(t+1,t)} / TBUS_t]_{t-i} + \sum_{i=0}^{4} \eta_i [\Delta TBE_{(t+1,t)} / TBE_t]_{t-i} +$$

$$+ \sum_{i=0}^{4} \psi_i [\Delta RUE_{(t+1,t)} / RUE_t]_{t-i} + \sum_{i=0}^{4} \lambda_i [\Delta RFED_{(t+1,t)} / RFED_t]_{t-i} +$$

$$+ \sum_{i=0}^{4} \mu_i [CP_{t(USA)} / CP_{t(EMU)}]_{t-i} + \varepsilon_t$$

(2

While the variables *VARSP*, *VAREUROSTOXX*, *VARBONDUSA* and *VARBONDEMU* reflect, as we said, the portfolio reallocations between time t and time t+1, therefore, since they could not be predicted at time t, they must be significant if the Efficient Market Hypothesis is true, all the other variables, as well as any lagged value of the regressors cannot be significant under the Efficient Market Hypothesis. On the other hand, they are significant if any of the alternative theories true. The software employed for the estimates is E-views, version 5.0.

The estimates for the general unrestricted model are shown in TABLE 2 in the Appendix.

From some preliminary regressions, the lagged dependent variables turned out to be non significant. This is not surprising, since their significance would simply imply that the past prediction mistakes would provide some relevant information to forecast the future prediction mistakes, which violates any notion of market efficiency. Since the purpose of our tests are exactly to verify the notion of semi-strong market efficiency, and in order to have sufficiently high degrees of freedom for the tests, we thought that a good conservative strategy could be to exclude from the general unrestricted model the lagged dependent variable, representing the past prediction mistakes. We believe, in this case, that such a methodological choice is strongly supported by theoretical reasons.

As usual in financial markets high volatility variables, the level of joint significance of the regressors is not very high: they are only significant at the level of confidence of 80%. This is due to the high number of regressors (therefore low degree of freedom) and to the presence of non significant regressors in the general unrestriceted model. As usual, the level of significance turns out to be much higher once the redundant variables are eliminated with the specification tests.

The first step of our market efficiency test consists of a battery of specification tests, starting by eliminating all variable (including the constant intercept) that are not significant at the level of confidence of 95%. This is shown in TABLE 3 in the Appendix. The constant intercept has not been included among the variables subject to the variable deletion test, but it has been included instead among the regressors, since it can be interpreted as a persistent risk premium associated to expectations of future devaluation (revaluation) of a currency, and this cannot be ruled out a priori. As shown in TABLE 3 in the appendix, all the redundant variable included in the test are non significant. The "restricted model", i.e. the model re-estimated with only the significant variables, according to the "*general-to specific*" approach, shows that all the variables that were individually significant with a level of confidence of at least 95% in the general unrestricted model are highly significant: VAREUROSTOXX(-4), VARBONDEMU(-2) and CPI(-2) with a level of confidence above 95%. RUFED(-1), which contains –as we said – the information about the official reserves of the FED and its ability to intervene in the currency market, is significant at the level of confidence of 93% . This first result is nconsistent with any EMH.

TABLE 4 contains a "counterfactual" test: a variable deletion test has been performed for the joint significance of the variables that appear to be individually significant in the general unrestricted model has been tested. As expected, they are highly significant (with a level of confidence above 99%), while the general model estimated without them loses any significance.

The same test strategy of tables 3-4 has been implemented to run a variable deletion test in the general unrestricted model for the regressors that are not significant at least with a level of confidence of 90% (TABLE 5 in the appendix.). Then another "counterfactual test" to run a variable deletion test for the variables that are significant with a level of confidence of at least 90% (TABLE 6 in the appendix.). As expected, the redundant variables are not significant, while the regressors that were significant with a level of confidence of at least 90% are jointly significant with a level of confidence above 99%, although the interest rate on the US treasury bonds (TBUSA) and the 4-periods lagged value of the official reserves of the ECB (RUECB(-4)) are not significant. This result again contradicts the EMH.

Finally, the last step of our test consist of performing a variable deletion test of the contemporaneous variances of assets included in the regression, whose significance would be consistent with the EMH. This is shown in TABLE 7 in the appendix.

The regression of Table 7 show that VARSP (the variance of the US stock market index), VAREUSTOXX (the EUROSTOXX index variance), VARBONDUS (the variance of the US bond market), VARBONDEMU (the variance of a representative European bond market), that are expected to capture the speed of portfolio reallocation, i.e. the inflow of new information available in the market are not significant, while the regression with all the remaining variables of the general unrestricted model increases its significance, since the regressors turn out to be jointly significant with a level of confidence of 90%.

We can conclude then that our test reject the EMH, while it shows results that appear to be consistent with the models and literature on the hearding behaviour.

4.Concluding remarks

In this paper we have introduced a nested test to verify, through the "*general-to-specific*" methodology the efficiency of the Euro-Dollar currency market, by using monthly data obtained from DATASTREAM.

The test is based on the National Account definition of Current Account of the Balance of Payments and introduces therefore as fundamentals the variables that capture the behaviour of the main items of the Current Account identity. In particular, as an element to discriminate between the EMH and the theories and literature focused on the hearding behaviour it has been pointed out and assumed that the unexpected news (i.e. the only ones that might account for the prediction mistake according to the EMH) are bound to determine a change in the intensity of portfolio reallocations (captured by the variance of the stock and bond market in the US and in Europe) while, as usual, the hearding behaviour implies a persistent significance of the lagged variables employed in the regressions. The results of our test turn out to be inconsistent with the EMH and consistent with the hearding behaviour theories.

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APPENDIX

TABLE 2: GENERAL UNRESTRICTED MODEL

Dependent Variable: SF
Method: Least Squares

Sample(adjusted): 5 70
Included observations: 66 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.260475	0.867435	-0.300282	0.7671
VARSP	0.001498	0.002185	0.685386	0.5010
VARSP(-1)	0.000130	0.002708	0.048105	0.9621
VARSP(-2)	0.000949	0.001513	0.627413	0.5375
VARSP(-3)	-0.000131	0.001349	-0.097410	0.9234
VARSP(-4)	0.001209	0.001191	1.014931	0.3223
VAREUROSTOXX	-0.000885	0.001506	-0.587779	0.5633
VAREUROSTOXX(-1)	0.000540	0.001295	0.416614	0.6814
VAREUROSTOXX(-2)	-0.001226	0.000786	-1.561032	0.1342
VAREUROSTOXX(-3)	-0.000470	0.000817	-0.575122	0.5716
VAREUROSTOXX(-4)	-0.001930	0.000827	-2.334594	0.0301
VARBONDUS	-0.025049	0.028650	-0.874317	0.3923
VARBONDUS(-1)	0.013427	0.025312	0.530474	0.6016
VARBONDUS(-2)	0.008473	0.027798	0.304804	0.7637
VARBONDUS(-3)	0.007154	0.026515	0.269816	0.7901
VARBONDUS(-4)	0.020403	0.034164	0.597193	0.5571
VARBONDEMU	0.005035	0.007064	0.712715	0.4843
VARBONDEMU(-1)	-0.004313	0.005247	-0.821932	0.4208
VARBONDEMU(-2)	0.014093	0.005664	2.488404	0.0218
VARBONDEMU(-3)	-0.004878	0.004753	-1.026284	0.3170
VARBONDEMU(-4)	-0.007675	0.005797	-1.324013	0.2004
TBUSA	-0.074532	0.043275	-1.722285	0.1004
TBUSA(-1)	-0.086398	0.053189	-1.624350	0.1200
TBUSA(-2)	-0.021578	0.043045	-0.501292	0.6216
TBUSA(-3)	-0.031376	0.045998	-0.682124	0.5030
TBUSA(-4)	-0.026161	0.039753	-0.658073	0.5180
TBEMU	-0.000451	0.000693	-0.650429	0.5228
TBEMU(-1)	-0.000695	0.000529	-1.314510	0.2036
TBEMU(-2)	0.000713	0.000489	1.457911	0.1604
TBEMU(-3)	5.17E-05	0.000541	0.095523	0.9249
TBEMU(-4)	-0.000595	0.000755	-0.788367	0.4397
RUFED	0.296636	0.200270	1.481177	0.1541
RUFED(-1)	0.388528	0.188083	2.065730	0.0521
RUFED(-2)	-0.239293	0.211492	-1.131453	0.2712
RUFED(-3)	-0.068644	0.202442	-0.339082	0.7381
RUFED(-4)	-0.068741	0.161465	-0.425730	0.6749
RUECB	0.055230	0.111609	0.494850	0.6261
RUECB(-1)	0.139367	0.108062	1.289700	0.2119
RUECB(-2)	-0.031644	0.094763	-0.333926	0.7419
RUECB(-3)	-0.002163	0.100580	-0.021507	0.9831
RUECB(-4)	0.169346	0.095621	1.771013	0.0918
CPI	-0.976403	0.899214	-1.085840	0.2905
CPI(-1)	-0.649603	1.068729	-0.607828	0.5501
CPI(-2)	2.937800	1.099064	2.673001	0.0146
CPI(-3)	-1.332460	1.058612	-1.258686	0.2226
CPI(-4)	0.281409	1.056096	0.266461	0.7926

R-squared	0.766421	Mean dependent var	0.024743
Adjusted R-squared	0.240869	S.D. dependent var	0.018624

S.E. of regression	0.016227	Akaike info criterion	-5.204311
Sum squared resid	0.005266	Schwarz criterion	-3.678188
Log likelihood	217.7422	F-statistic	1.458316
Durbin-Watson stat	2.396079	Prob(F-statistic)	0.181371

TABLE 3: VARIABLE DELETION TEST

Redundant Variables: VARSP VARSP(-1) VARSP(-2) VARSP(-3) VARSP(-4) VAREUROSTOXX VAREUROSTOXX(-1) VAREUROSTOXX(-2) VAREUROSTOXX(-3) VARBONDUS VARBONDUS(-1) VARBONDUS(-2) VARBONDUS(-3) VARBONDUS(-4) VARBONDEMU VARBONDEMU(-1) VARBONDEMU(-3) VARBONDEMU(-4) TBUSA TBUSA(-1) TBUSA(-2) TBUSA(-3) TBUSA(-4) TBEMU TBEMU(-1) TBEMU(-2) TBEMU(-3) TBEMU(-4) RUFED RUFED(-2) RUFED(-3) RUFED(-4) RUECB RUECB(-1) RUECB(-2) RUECB(-3) RUECB(-4) CPI CPI(-1) CPI(-3) CPI(-4)

F-statistic	1.012932	Probability	0.504583
Log likelihood ratio	74.17054	Probability	0.001155

Test Equation:
Dependent Variable: SF
Method: Least Squares

Sample: 5 70
Included observations: 66

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.910351	0.366486	-2.484000	0.0158
VAREUROSTOXX(-4)	-0.000944	0.000360	-2.625271	0.0109
VARBONDEMU(-2)	0.013830	0.003411	4.054181	0.0001
RUFED(-1)	0.167384	0.089179	1.876951	0.0653
CPI(-2)	0.832813	0.327111	2.545965	0.0134

R-squared	0.281392	Mean dependent var	0.024743
Adjusted R-squared	0.234270	S.D. dependent var	0.018624
S.E. of regression	0.016297	Akaike info criterion	-5.322939
Sum squared resid	0.016201	Schwarz criterion	-5.157056
Log likelihood	180.6570	F-statistic	5.971591
Durbin-Watson stat	2.113490	Prob(F-statistic)	0.000402

TABLE 4

Counterfactual test: elimination of the variable that are significant with the level of confidence of 95%

Redundant Variables: VAREUROSTOXX(-4) VARBONDEMU(-2) RUFED(-1) CPI(-2)

F-statistic	4.723566	Probability	0.007572
Log likelihood ratio	43.89756	Probability	0.000000

Test Equation:
Dependent Variable: SF
Method: Least Squares

Sample: 5 70
Included observations: 66

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.613573	1.045409	0.586921	0.5627
VARSP	0.004349	0.002574	1.689535	0.1041
VARSP(-1)	-0.001416	0.003155	-0.448681	0.6577
VARSP(-2)	0.001872	0.001903	0.983605	0.3351
VARSP(-3)	-0.000468	0.001636	-0.285970	0.7774
VARSP(-4)	-0.000126	0.001180	-0.106662	0.9159
VAREUROSTOXX	-0.002941	0.001734	-1.695801	0.1029
VAREUROSTOXX(-1)	0.000591	0.001514	0.390396	0.6997
VAREUROSTOXX(-2)	-0.001380	0.000978	-1.411242	0.1710
VAREUROSTOXX(-3)	-0.000753	0.001020	-0.738606	0.4673
VARBONDUS	0.008557	0.034342	0.249166	0.8054
VARBONDUS(-1)	0.042853	0.028919	1.481844	0.1514
VARBONDUS(-2)	0.002151	0.031187	0.068957	0.9456
VARBONDUS(-3)	-0.014794	0.031959	-0.462910	0.6476
VARBONDUS(-4)	0.043196	0.039373	1.097099	0.2835
VARBONDEMU	0.000322	0.008586	0.037518	0.9704
VARBONDEMU(-1)	-0.005012	0.006652	-0.753465	0.4585
VARBONDEMU(-3)	-0.003783	0.005883	-0.642996	0.5263
VARBONDEMU(-4)	-0.013373	0.006850	-1.952435	0.0626
TBUSA	-0.045774	0.051458	-0.889542	0.3825
TBUSA(-1)	-0.067563	0.058608	-1.152804	0.2603
TBUSA(-2)	0.054399	0.044614	1.219329	0.2346
TBUSA(-3)	-0.035798	0.055752	-0.642084	0.5269
TBUSA(-4)	-0.014684	0.045190	-0.324934	0.7480
TBEMU	-0.000601	0.000825	-0.729224	0.4729
TBEMU(-1)	-0.000228	0.000633	-0.359392	0.7224
TBEMU(-2)	0.000698	0.000615	1.133885	0.2680
TBEMU(-3)	4.50E-05	0.000660	0.068157	0.9462
TBEMU(-4)	0.000426	0.000901	0.472779	0.6406
RUFED	0.313436	0.240297	1.304372	0.2045
RUFED(-2)	-0.210578	0.243816	-0.863675	0.3963
RUFED(-3)	0.059232	0.240722	0.246060	0.8077
RUFED(-4)	-0.088125	0.180217	-0.488994	0.6293
RUECB	0.177740	0.118044	1.505713	0.1452
RUECB(-1)	0.072197	0.106322	0.679044	0.5036
RUECB(-2)	0.001666	0.108655	0.015333	0.9879
RUECB(-3)	0.095171	0.114491	0.831252	0.4140
RUECB(-4)	0.168637	0.110227	1.529909	0.1391

CPI	-1.662538	1.107737	-1.500842	0.1464
CPI(-1)	1.037411	1.087874	0.953613	0.3498
CPI(-3)	0.087067	1.155984	0.075319	0.9406
CPI(-4)	0.018329	1.316989	0.013917	0.9890

R-squared	0.545756	Mean dependent var	0.024743
Adjusted R-squared	-0.230244	S.D. dependent var	0.018624
S.E. of regression	0.020657	Akaike info criterion	-4.660408
Sum squared resid	0.010241	Schwarz criterion	-3.266992
Log likelihood	195.7935	F-statistic	0.703294
Durbin-Watson stat	2.247995	Prob(F-statistic)	0.842566

TABLE 5: VARIABLE DELETION TEST

Redundant Variables: VARSP VARSP(-1) VARSP(-2) VARSP(-3) VARSP(-4) VAREUROSTOXX VAREUROSTOXX(-1) VAREUROSTOXX(-2) VAREUROSTOXX(-3) VARBONDUS VARBONDUS(-1) VARBONDUS(-2) VARBONDUS(-3) VARBONDUS(-4) VARBONDEMU VARBONDEMU(-1) VARBONDEMU(-3) VARBONDEMU(-4) TBUSA(-1) TBUSA(-2) TBUSA(-3) TBUSA(-4) TBEMU TBEMU(-1) TBEMU(-2) TBEMU(-3) TBEMU(-4) RUFED RUFED(-2) RUFED(-3) RUFED(-4) RUECB RUECB(-1) RUECB(-2) RUECB(-3) CPI CPI(-1) CPI(-3) CPI(-4)

F-statistic	1.037953	Probability	0.478960
Log likelihood ratio	73.03449	Probability	0.000777

Test Equation:
Dependent Variable: SF
Method: Least Squares

Sample: 5 70
Included observations: 66

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.916554	0.371975	-2.464020	0.0167
VAREUROSTOXX(-4)	-0.000924	0.000363	-2.543088	0.0136
VARBONDEMU(-2)	0.014261	0.003496	4.079492	0.0001
TBUSA	-0.001411	0.018257	-0.077309	0.9386
RUFED(-1)	0.170569	0.090033	1.894509	0.0631
RUECB(-4)	0.043827	0.044887	0.976375	0.3329
CPI(-2)	0.838215	0.332013	2.524648	0.0143

R-squared	0.293656	Mean dependent var	0.024743
Adjusted R-squared	0.221824	S.D. dependent var	0.018624
S.E. of regression	0.016429	Akaike info criterion	-5.279546
Sum squared resid	0.015925	Schwarz criterion	-5.047309
Log likelihood	181.2250	F-statistic	4.088112
Durbin-Watson stat	2.111469	Prob(F-statistic)	0.001704

TABLE 6

Redundant Variables: VAREUROSTOXX(-4) VARBONDEMU(-2) TBUSA RUFED(-1) RUECB(-4) CPI(-2)

F-statistic	3.877984	Probability	0.009922
Log likelihood ratio	50.93081	Probability	0.000000

Test Equation:
Dependent Variable: SF
Method: Least Squares

Sample: 5 70
Included observations: 66

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.217213	0.899465	-0.241492	0.8111
VARSP	0.003462	0.002538	1.364259	0.1842
VARSP(-1)	-0.001700	0.003140	-0.541496	0.5928
VARSP(-2)	0.001515	0.001914	0.791772	0.4357
VARSP(-3)	-0.000913	0.001608	-0.568021	0.5749
VARSP(-4)	0.000380	0.001146	0.332069	0.7425
VAREUROSTOXX	-0.002366	0.001719	-1.376291	0.1805
VAREUROSTOXX(-1)	0.000592	0.001506	0.392904	0.6976
VAREUROSTOXX(-2)	-0.001122	0.000978	-1.147216	0.2617
VAREUROSTOXX(-3)	-0.000159	0.000964	-0.165103	0.8701
VARBONDUS	0.000316	0.033839	0.009336	0.9926
VARBONDUS(-1)	0.025411	0.027017	0.940554	0.3556
VARBONDUS(-2)	-0.009342	0.030763	-0.303694	0.7638
VARBONDUS(-3)	0.004768	0.029545	0.161387	0.8730
VARBONDUS(-4)	0.033196	0.038820	0.855139	0.4003
VARBONDEMU	0.002068	0.008626	0.239792	0.8124
VARBONDEMU(-1)	-0.004283	0.006564	-0.652457	0.5198
VARBONDEMU(-3)	-0.002687	0.005897	-0.455612	0.6525
VARBONDEMU(-4)	-0.009566	0.006391	-1.496789	0.1465
TBUSA(-1)	-0.023585	0.046450	-0.507757	0.6159
TBUSA(-2)	0.057361	0.044885	1.277959	0.2126
TBUSA(-3)	-0.043308	0.053778	-0.805297	0.4280
TBUSA(-4)	0.002639	0.044013	0.059961	0.9526
TBEMU	-0.000311	0.000800	-0.388413	0.7009
TBEMU(-1)	-7.82E-05	0.000635	-0.123195	0.9029
TBEMU(-2)	0.000241	0.000541	0.445409	0.6597
TBEMU(-3)	-0.000129	0.000656	-0.196705	0.8456
TBEMU(-4)	0.000448	0.000912	0.491470	0.6272
RUFED	0.309206	0.239503	1.291032	0.2081
RUFED(-2)	-0.083983	0.231946	-0.362078	0.7202
RUFED(-3)	-0.000909	0.233715	-0.003889	0.9969
RUFED(-4)	-0.181210	0.160532	-1.128804	0.2693
RUECB	0.100809	0.108727	0.927180	0.3624
RUECB(-1)	-0.028043	0.088105	-0.318289	0.7528
RUECB(-2)	-0.002339	0.110024	-0.021260	0.9832
RUECB(-3)	0.010476	0.103574	0.101144	0.9202
CPI	-1.281644	1.097137	-1.168172	0.2533
CPI(-1)	0.611915	1.051011	0.582215	0.5654
CPI(-3)	0.895795	1.038928	0.862230	0.3964
CPI(-4)	-0.006402	1.314748	-0.004870	0.9962

R-squared	0.494677	Mean dependent var	0.024743
Adjusted R-squared	-0.263308	S.D. dependent var	0.018624
S.E. of regression	0.020933	Akaike info criterion	-4.614450
Sum squared resid	0.011393	Schwarz criterion	-3.287386
Log likelihood	192.2768	F-statistic	0.652621
Durbin-Watson stat	2.272005	Prob(F-statistic)	0.888597

TABLE 7

Redundant Variables: VARSP VAREUROSTOXX VARBONDUS VARBONDEMU

F-statistic	0.612565	Probability	0.658456
Log likelihood ratio	7.627620	Probability	0.106212

Test Equation:
Dependent Variable: SF
Method: Least Squares

Sample: 5 70
Included observations: 66

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.174695	0.764479	-0.228515	0.8212
VARSP(-1)	0.000897	0.001981	0.452993	0.6546
VARSP(-2)	0.000420	0.001147	0.365819	0.7177
VARSP(-3)	0.000202	0.001188	0.169770	0.8666
VARSP(-4)	0.001072	0.001107	0.967851	0.3428
VAREUROSTOXX(-1)	0.000118	0.000983	0.120265	0.9053
VAREUROSTOXX(-2)	-0.000958	0.000686	-1.396147	0.1755
VAREUROSTOXX(-3)	-0.000468	0.000780	-0.600093	0.5541
VAREUROSTOXX(-4)	-0.002040	0.000710	-2.874218	0.0084
VARBONDUS(-1)	0.008673	0.022571	0.384277	0.7042
VARBONDUS(-2)	0.006772	0.023725	0.285425	0.7778
VARBONDUS(-3)	0.005306	0.023798	0.222967	0.8254
VARBONDUS(-4)	0.017246	0.021602	0.798343	0.4325
VARBONDEMU(-1)	-0.004056	0.004924	-0.823722	0.4182
VARBONDEMU(-2)	0.014315	0.005121	2.795368	0.0100
VARBONDEMU(-3)	-0.006169	0.004504	-1.369829	0.1834
VARBONDEMU(-4)	-0.005290	0.004829	-1.095513	0.2842
TBUSA	-0.069996	0.040522	-1.727335	0.0970
TBUSA(-1)	-0.072755	0.049580	-1.467426	0.1552
TBUSA(-2)	-0.032440	0.038675	-0.838779	0.4099
TBUSA(-3)	-0.023494	0.042380	-0.554364	0.5845
TBUSA(-4)	-0.018733	0.037748	-0.496248	0.6242
TBEMU	-0.000433	0.000655	-0.660946	0.5149
TBEMU(-1)	-0.000721	0.000495	-1.456030	0.1583
TBEMU(-2)	0.000642	0.000445	1.442598	0.1621
TBEMU(-3)	0.000169	0.000487	0.348223	0.7307
TBEMU(-4)	-0.000790	0.000385	-2.051845	0.0512
RUFED	0.159545	0.141737	1.125635	0.2715

RUFED(-1)	0.330352	0.176277	1.874051	0.0731
RUFED(-2)	-0.286272	0.185124	-1.546375	0.1351
RUFED(-3)	-0.090920	0.184408	-0.493037	0.6265
RUFED(-4)	-0.066288	0.145206	-0.456511	0.6521
RUECB	0.027474	0.094665	0.290222	0.7741
RUECB(-1)	0.122142	0.097600	1.251451	0.2228
RUECB(-2)	-0.052129	0.079972	-0.651844	0.5207
RUECB(-3)	-0.020282	0.089739	-0.226017	0.8231
RUECB(-4)	0.163607	0.087436	1.871164	0.0736
CPI	-1.039358	0.846493	-1.227840	0.2314
CPI(-1)	-0.880799	0.996842	-0.883589	0.3857
CPI(-2)	3.176499	0.986427	3.220208	0.0037
CPI(-3)	-1.502009	0.982253	-1.529147	0.1393
CPI(-4)	0.430033	0.988827	0.434892	0.6675

R-squared	0.737805	Mean dependent var	0.024743
Adjusted R-squared	0.289888	S.D. dependent var	0.018624
S.E. of regression	0.015694	Akaike info criterion	-5.209953
Sum squared resid	0.005911	Schwarz criterion	-3.816536
Log likelihood	213.9284	F-statistic	1.647191
Durbin-Watson stat	2.473382	Prob(F-statistic)	0.097570