

**Forecasting the Dollar/Euro Exchange Rate:
Are International Parities Useful?***

by

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ABSTRACT:

In this paper we assess the empirical relevance of an expectations version of purchasing power parity in forecasting the Dollar/Euro exchange rate. This version is based on the differential of inflation expectations derived from inflation-indexed bonds for the Euro area and the USA.

Using the longest daily data a for both the Dollar/Euro exchange rate and for the inflation expectations, our results suggest that, with few exceptions, our predictors behave significantly better than a random walk in forecasts up to five days, both in terms of prediction errors and in directional forecast.

JEL classification numbers: C53, F31

KEY WORDS: Forecasting, Purchasing Power Parity, Exchange rates

1. INTRODUCTION

The past fifty years have been characterised by increasing internationalisation of economic activity. The relentless advances that have taken place in areas such as transport and communications, together with the progressive liberalisation of international economic relationships, have given rise to unprecedented increases in trade in goods and services as well as in financial assets.

This increase has gone hand in hand with the spectacular development that has been experienced in foreign exchange markets, since the use of different national currencies makes conversions from one to another a necessary aspect of each international transaction. Naturally, this puts what are universally known as “foreign exchange markets” at the forefront as mechanisms of multilateral conversion.

The foreign exchange market is the world’s most important financial market, both due to its daily trade volume as well as its incidence in the behaviour of other markets, both for financial assets and for goods and services. The daily trade volume is, on average, around about a billion dollars, that is, more than 100 times the daily average value of shares traded on Wall Street. This figure is far greater than world-wide commerce during the rest of the year, and its order of magnitude is several times the world’s total gross product.

Due to the extreme importance of foreign exchange markets for international economic activity, it is common to see in the financial market literature attempts to predict exchange rates. This has proven to be a most difficult task, due to the high volatility experienced by exchange markets, as well as the complex data generating process governing its underlying dynamic behaviour [see, for example, Sarno and Taylor (2002)]. Following on from the influential paper by Meese and Rogoff (1983) on the poor predictive capacity of exchange rate determination models compared to a random walk, there has been an immense amount of effort dedicated to analysing the causes of the extreme difficulties experienced when attempting to predict exchange rates, as well as attempts to design alternative procedures that offer improvements in predictions. Recently, Cheung, Chinn and García-Pascual (2002) have evaluated the predictability of a wide variety of models that have been proposed over the past decade, and they conclude that these models are still unable to improve a random walk.

The challenge to improve the predictive capability of a random walk has been magnified by the introduction of the new European currency, which over its short existence has already shown itself to be problematic as far as predictions go. This paper hopes to contribute to the expanse of literature that attempts to explain the

short-run behaviour of the Euro's exchange rate. Given the widely accepted viewpoint in the profession that any analysis based on the fundamental variables that are traditionally thought to be potential determinants of the exchange rate is only likely to be significant for explaining long-run behaviour (European Central Bank, 2002), but will be relatively useless for explaining short-run behaviour, we base our analysis on an interpretation of the Expectations Version of Relative Purchasing Power Parity (EVRPPP) to generate expected short-run variations in the exchange rate.

The paper is organised as follows. In section 2 we present an overview of the theoretical framework used to generate the predictions Section 3 describes the data base used, and offers a statistical evaluation of the predictors. Finally, some concluding remarks are provided in Section 4.

2. INTERNATIONAL PARITIES

As mentioned, in this paper we make use of the EVRPPP, that integrates the parity conditions of both commodity and financial markets. This version, known as the efficient market approach [see Roll (1979)] is based on Fisher's Hypothesis and the assumption of Uncovered Interest Rate Parity.

Fisher's Hypothesis postulates that a country's nominal interest rate should be equal to its real interest rate plus the expected rate of inflation. Therefore:

$$i = r + \pi^e \quad (1a)$$

$$i^* = r^* + \pi^{*e} \quad (1b)$$

where i is the nominal interest rate, r is the real interest rate, π^e is the expected rate of inflation, and an asterisk denotes a foreign variable.

Uncovered Interest Rate Parity requires that the nominal interest differential between a domestic currency investment and a foreign currency investment be equal to the expected change in the exchange rate:

$$\sigma^e = i - i^* \quad (2)$$

where σ^e is the expected rate of depreciation.

Since international investors are concerned with real rather than nominal returns on their financial assets, in order to maximise the real returns of their assets, they transfer capital from a low interest rate country to one with a higher real rate.

Thus, in absence of transactions costs, specific asset risks and taxation, this process of arbitrage will result in the real rates of interest over the two countries being equated:

$$r = r^* \quad (3)$$

By subtracting (1b) from (1a), using (2) and (3), and rearranging, we obtain:

$$\sigma^e = \pi^e - \pi^{*e} \quad (4)$$

which is the EVRPPP, in which all of the variables are expressed in expected values instead of in current values. In this way, given economic agents' expectations of the future rates of inflation in both the national and the foreign economies, we can derive a measure of market expectations on the future behaviour of the exchange rate which, compared to the rate actually observed at any given moment, will allow us to calculate the market's expected exchange rate for the following period:

$$S_{t+1}^e = (1 + \sigma^e) S_t \quad (5)$$

where S denotes the exchange rate (expressed as the number of units of local currency that are exchanged for one unit of foreign currency).

Note that this exchange rate prediction generator process is based on market expectations of the future evolution of the inflation rates. In order to make it effective, we need to have proxy variables for the expected rates of inflation in the national and foreign economies.

In this paper, in contrast with the generally accepted approach in the empirical literature in this area which consists of using observed values for inflation rates, or predictions for these rates based on univariate models, we use equivalent (or implicit) inflation rates obtained from the so-called “break-even inflation rate”. This rate measures the difference between index-linked bond yields and the yield from nominal fixed income securities with the same maturity issued by the same institution and in the same currency. In the absence of risk premia, the break-even inflation rate is equal to the expected average inflation rate over the life of the bonds from which it is constructed [see Wrase (1997)].

3. STATISTICAL EVALUATION OF THE PREDICTIONS

The data used in this paper covers the period from September 16th 1998 up to December 31st 2002, and is conditioned by the availability of the variables that are necessary to calculate the equivalent inflation rates. Given that the Euro began to trade on exchange markets only as of January 4th 1999, we have used the synthetic Dollar/Euro series created by the Financial Times for the period between September 16th 1998 and December 31st 1998, and our data set is completed by the daily data on the actual Dollar/Euro series that was observed between January 4th 1999 and December 31st 2002 (1107 observations in all). As far as inflationary expectations go, both for the euro area and for the United States, we calculated the break-even inflation rates using the information provided by ten-year public bond yields. It is worthwhile pointing out that the inflation rates calculated in this way offer the daily expected rates of inflation of the exchange operators, allowing instantaneous processing of all of the information that these operators receive concerning the behaviour of prices in the economies under study.

Even so, it is likely that the bond yields used for our calculations of inflationary expectations include certain premia (notably liquidity premia and risk premia related to inflation uncertainty), and so given the data available we estimated the following equation, which constitutes a testable empirical formulation of expression (4):

$$\sigma_t = \alpha + \beta \pi_t^e - \beta^* \pi_t^{*e} + \varepsilon_t \quad (6)$$

where ε_t is the error term. Even though it could make sense to apply instrumental variables given the joint determination of the variables in the equation, previous experience suggests that gains in consistency are far outweighed by the loss in efficiency in terms of prediction [see, for example, Chinn and Meese (1995)]. Therefore, we rely solely on ordinary least squares.

Equation (6) was estimated recursively, so that at each step of the process the estimations of σ^e for up to five days into the future were generated, conditional only upon the information available at that moment, and so from expression (5) we obtain predictions of the exchange rate for that prediction horizon. Therefore, the process begins with an estimation of equation (6) for the estimation period covering September 16th 1998 to December 31st 1998, thereby generating the predictions up to five days ahead of December 31st 1998. Next, the data for January 4th 1999 is incorporated into the data set, the model is re-estimated, and new predictions are generated for the next five days. This recursive process continues up until the prediction for December 31st 2002 has been generated.

The use of the five day horizon for predictions is justified by the fact that certain authors have evaluated the predictability of exchange rate models under different predictive scenarios, without ever having consistently improved upon a random walk [see, for example, Cheung, Chinn and García-Pascual (2002)] .

In order to formally test the predictability of market expectations on the future behaviour of the exchange rates generated from the difference between break-even inflation rates, we use the test statistic proposed by Diebold and Mariano (1995). Let Z_{1t}^f and Z_{2t}^f denote alternative predictors of a given variable Z_t , let e_{1t} and e_{2t} denote the corresponding prediction errors ($Z_{1t}^f - Z_t$ and $Z_{2t}^f - Z_t$, respectively), and let $d_t = (e_{1t})^2 - (e_{2t})^2$ denote the loss differential, then the Diebold and Mariano (DM) test involves a test of the hypothesis that the mean loss differential $\bar{d}$ is zero with an appropriate correction for serial correlation in the series d_t :

$$DM = \frac{\bar{d}}{\sqrt{\frac{2\pi \hat{f}_d(0)}{T}}}, \quad (7)$$

where $\hat{f}_d(0)$ is a consistent estimate of the spectral density of the loss function at zero frequency, and T is the number of predictions, where the asymptotic distribution of DM is $N(0,1)$. Thus, a significant and positive (negative) value for DM indicates a significant difference between the prediction errors generated by the two predictors, indicating that the most accurate predictor is Z_{2t}^f (Z_{1t}^f).

For the case of predictions generated for more than one period into the future, which is the case at hand, Harvey, Leybourne and Newbold (1998) propose a modified Diebold and Mariano test statistic that is defined by the following expression:

$$DM^* = T^{-1/2} [T+1-2h+T^{-1}h(h-1)]^{1/2} DM \quad (8)$$

where h is the number of predictions made into the future. Harvey, Leybourne and Newbold (1998) also suggest that one should use the critical values provided by the t_{n-1} distribution, where n is the number of observations in the prediction period.

Given that the behaviour of the Dollar/Euro exchange rate has not been very homogeneous over the period of analysis, we have examined the predictability not only for each natural year of the sample, but also for each of the different sub-periods of upward or downward trends that were registered. In particular, we have taken into consideration five sub-periods of appreciation (January 1st to July 12th 1999, October 18th 1999 to October 26th 2000, January 8th to July 5th 2001,

September 14th 2001 to January 31st 2002, and July 17th to October 30th 2002), and five others of depreciation (July 13th to October 15th 1999, October 27th 2000 to January 5th 2001, July 6th to September 13th 2001, February 1st to July 16th 2002, and October 31st to December 31st 2002).

Table 1 shows the results of the modified Diebold and Mariano test for each of the periods and sub-periods that were examined, as well as for the different prediction horizons. As can be seen in Panel A of the table, with the exception of the predictions for a one day horizon during the years 1999 and 2002, we always reject the null hypothesis of equality in the loss functions when we compare the predictive capacity of a random walk against the predictor based on expectations of variations in the exchange rate derived from the equivalent inflation rates. Since, in these cases, the statistic takes positive values, the conclusion is that our predictions are significantly better than those obtained from a random walk. Regarding the result of the one day horizon prediction during 1999, the value of the statistic suggests that our predictions are marginally worse than a random walk, although it is not statistically significant. This behaviour could be related with the small size of the sample that we have used to generate the expectations of the variation in the exchange rate, implying that we have not been able to fully exploit the informational content of the equivalent inflation rate series.

Table 1: Modified Diebold- Mariano Predictability Test
(random walk versus EVRPPP)

A) Results by years					
	1 day	2 days	3 days	4 days	5 days
1999	-0,8534	5,6482***	5,5756***	6,5671***	6,1087***
2000	1,9841*	7,1426***	6,2084***	6,2377***	6,4065***
2001	3,3870***	5,1967***	6,5999***	6,3690***	6,2048***
2002	-0,5254	5,3594***	6,2182***	6,4094***	6,0095***
B) Results by appreciation and depreciation sub-periods					
	1 day	2 days	3 days	4 days	5 days
01/01/99-12/07/99	-0,1727	4,7968***	4,2333***	4,4913***	4,8014***
13/07/99-15/10/99	-0,4526	2,4651**	2,6603***	3,3276***	2,9940***
18/10/99-26/10/00	0,9797	6,9204***	5,9648***	6,0762***	6,4818***
27/10/00-05/01/01	-0,0262	3,3727***	3,0366***	3,0739***	2,7984***
08/01/01-05/07/01	1,9619*	3,3592***	4,5929***	4,0286***	4,0162***
06/07/01-13/09/01	1,2286	2,3423**	2,6912***	2,9677***	2,2951***
14/09/01-31/01/02	1,9291	4,1405***	4,1930***	4,1523***	4,5641***
01/02/02-16/07/02	0,2968	3,0057***	4,1777***	3,2389***	2,7738***
17/07/02-30/10/02	-1,2653	2,4688**	2,9730***	3,3795***	3,4653***
31/10/02-31/12/02	1,3668	2,5349**	3,3391***	3,4223***	3,6138***

Note: *, ** and *** denote, respectively, significance at the 10%, 5% and 1% levels.

As far as the behaviour of our predictors over the different sub-periods of appreciation and depreciation are concerned, in Panel B of Table 1 we show that our predictors are always significantly better than those derived from a random walk for prediction horizons greater than one day. Only the depreciation sub-period between January 8th and July 5th 2001 registers a statistically significant value for predictions for a one day horizon, although at 10%.

As Boothe and Glassman (1987) observe, a further test of forecasting performance relative to the forecasts of a random walk is the accuracy in the direction of movements in the dollar/euro exchange rate. This is because getting the right sign in the prediction matters in markets with low transaction costs, like foreign exchange markets. Therefore, we calculated the correct percentage appreciations and depreciations, the results of which are presented in Table 2. As can be seen there, with the exception of the depreciation sub-period from July 6th to September 13th 2001 and the appreciation sub-period from July 17th to October 30th 2002, for all prediction horizons our predictors offer a value that is greater than 50%, which indicates an improvement over the random walk in terms of directional prediction.

Table 2: Directional forecast
(total number of appreciations and depreciations correctly predicted by EVRPPP)

A) Results by years					
	1 day	2 days	3 days	4 days	5 days
1999	54,41	54,02	54,02	54,02	54,41
2000	56,76	56,76	56,76	56,76	56,76
2001	51,16	51,16	51,16	51,16	51,16
2002	51,56	50,78	51,95	51,56	51,17
B) Results by appreciation and depreciation sub-periods					
	1 day	2 days	3 days	4 days	5 days
01/01/99-12/07/99	54,74	53,28	52,55	53,28	53,28
13/07/99-15/10/99	55,07	55,07	55,07	55,07	55,07
18/10/99-26/10/00	54,65	55,02	55,39	55,02	55,39
27/10/00-05/01/01	65,31	65,31	65,31	65,31	65,31
08/01/01-05/07/01	52,34	52,34	52,34	52,34	52,34
06/07/01-13/09/01	48,00	48,00	48,00	48,00	48,00
14/09/01-31/01/02	52,04	52,04	52,04	52,04	52,04
01/02/02-16/07/02	50,00	50,00	50,00	50,00	50,00
17/07/02-30/10/02	48,68	44,74	48,68	47,37	46,05
31/10/02-31/12/02	57,14	59,52	59,52	59,52	59,52

Note: In bold print, percentages greater than or equal to 50%.

Finally, we examined if the forecast errors made when we correctly forecast the movement in the exchange rate (appreciations or depreciations) are higher or not than those made when we failed in predicting the right sign of this variation in the exchange rate.. To that end, we have computed the ratio of the root mean square error (RMSE) from our predictors when the predicted movement in the exchange rate coincides with the appreciation/depreciation actually observed to the RMSE from our predictors when the directional forecast is the opposite of that observed:

$$DFR = \frac{\sqrt{\frac{1}{N} \sum (\Delta S^{cp} - \Delta S)^2}}{\sqrt{\frac{1}{N} \sum (\Delta S^{wp} - \Delta S)^2}}$$

where ΔS^{cp} (ΔS^{wp}) denotes the correctly (incorrectly) forecast variations in the exchange rate and ΔS is the variation in the exchange rate actually observed. As can be seen in Table 3, we always obtain values less than one, suggesting that the forecast errors made when successfully identifying exchange-rate movements are lower than those made when we failed in the directional forecast. This result strengthens the values presented in Table 2. The directional forecast is intended to measure how many times we correctly followed the actual movements of the observed exchange-rate series. Not only are they almost all correctly captured by our predictions, but also, as this last test shows, this is done in a more accurate manner than when we incorrectly forecast the real variations in the exchange rate.

Table 3: Root mean square error ratio
(correctly versus incorrectly predicted exchange-rate movements)

A) Results by years					
	1 day	2 days	3 days	4 days	5 days
1999	0,5557	0,5574	0,5565	0,5570	0,5544
2000	0,5859	0,5857	0,5859	0,5859	0,5858
2001	0,5137	0,5135	0,5135	0,5135	0,5134
2002	0,4637	0,4590	0,4660	0,4652	0,4742
B) Results by appreciation and depreciation sub-periods					
	1 day	2 days	3 days	4 days	5 days
01/01/99-12/07/99	0,5870	0,6009	0,6061	0,5982	0,6025
13/07/99-15/10/99	0,5002	0,4983	0,4999	0,4996	0,4986
18/10/99-26/10/00	0,5945	0,5896	0,5855	0,5899	0,5855
27/10/00-05/01/01	0,5303	0,5299	0,5297	0,5303	0,5304
08/01/01-05/07/01	0,4666	0,4664	0,4665	0,4664	0,4664
06/07/01-13/09/01	0,5880	0,5876	0,5877	0,5877	0,5875
14/09/01-31/01/02	0,5902	0,5902	0,5900	0,5900	0,5898
01/02/02-16/07/02	0,4373	0,4375	0,4374	0,4373	0,4373
17/07/02-30/10/02	0,4353	0,4278	0,4417	0,4409	0,4678
31/10/02-31/12/02	0,4280	0,4314	0,4245	0,4292	0,4291

Note: In bold print, values less than one.

4. CONCLUDING REMARKS

In this paper we have attempted to contribute to the wide and active research programme on predictability in financial markets. In particular, we have evaluated the empirical relevance of an expectations version of Purchasing Power Parity for the Dollar/Euro exchange rate. The PPP model used is based on the difference between equivalent inflation rates, an approximation to expected inflation in financial markets, for the United States and the euro area as a whole.

Using the longest available series of daily data on the Dollar/Euro exchange rate and on the break-even inflation rates, we have obtained the result that, aside from a limited set of exceptions, our predictors are significantly better than the random walk model for forecasting at horizons up to five days, both when considering the exchange rate prediction error as well as when considering the sign of the rate of change. Therefore, the empirical evidence presented here contrasts with the accumulation of previous results, in the sense that we have identified fundamental variables that play a significant role as potential determinants of the short run behaviour of exchange rates.

A natural extension to the analysis presented in this paper would be the use of our predictors for generating technical trading rules in exchange markets, evaluating their returns against the traditional rules of moving averages that have been widely used by the operators in these markets [see Fernández Rodríguez, Sosvilla Rivero and Andrada Félix (2003)]. Given the relatively favourable results that we have obtained here, we are optimistic that such an extension would be quite fruitful.

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