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Abstract

This paper presents new empirical evidence on the Italian Lira – US $ exchange rate over the recent float. A univariate model as simple as the monetary model of exchange rate (MMER) can outperform a benchmark random walk with drift (RW) in out-of-sample forecasting up until the early 90s. This superiority of the MMER with respect to the RW model vanishes toward the end of 1992 (after the departure of the Italian Lira from the European Monetary System - EMS). These findings are most likely dependent on the presence of market imperfections such as capital control and high inflation in the Italian economy. These results are counterintuitive with respect to the theory of MMER which says that these models can be useful in explaining the behaviour of the exchange rate in the presence of perfectly competitive markets. Results are robust to changes in variables and the sample period.

JEL Codes: F31, F47.
Keywords: Exchange rates, Forecasting.
Fields: International Economics, Econometrics-Time Series.

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1. Introduction

One of the main themes of empirical international economics is the role of macroeconomic models, based on fundamental variables, in explaining the short-term and/or the long-term behaviour of the exchange rate.

The main empirical results from existing literature demonstrate that out-of-sample asset market models do not predict the exchange rate significantly better than a naïve RW model (Meese and Rogoff – MR, 1983a)[1] [2]. In particular, MR (1983a) find that a simple RW model outperforms all structural models in out-of-sample forecasting of the exchange rate for four Western countries[3]. These results are confirmed in Cushman (2000) and Meese (2001). These negative results lead to different reactions among economists such as: a) the use of MMER with time-series and panel-data (see the work of Mark, 1995; Blomberg and Hess, 1997; Mark and Sul, 2001)[4]; b) the use of large macroeconometric models (see Gandolfo et al., 1990, 1992)[5]; c) the use of non-linear models (see Balke and Fomby, 1997; Kilian and Taylor, 2003). Since the literature on these studies is so vast it is not our intention to provide here a summary of it (for further details refer to Sarno and Taylor (2002) and Franses and van Dijk (2000)).

The theoretical justification for using data on macroeconomic fundamentals to predict exchange rate movements is given by the MMER with flexible (Frenkel-Bilson - FB) and sticky prices (Dornbusch-Frankel - DF).

This paper innovates by presenting new empirical evidence on the Italian Lira – US $ exchange rate during the recent float, comparing the forecasting ability of different exchange rate models (FB, DF and a simple model based on the uncovered interest parity condition) with a benchmark random walk model using out-of-sample predictions. In other words, the

[1] The main reason for the relevance of macroeconomic fundamentals for forecasting exchange rate movements is given by the asset market approach of exchange rate. Under this approach, demand for currencies is determined by purchases and sales of goods as well as assets.

[2] Fitting exchange rates to contemporary observable variables, in sample, is one thing. Forecasting out-of-sample is quite another. A stronger test of the MMER's validity is to determine how well they perform out-of-sample compared to an alternative, such as the naïve RW with drift.

[3] Since the work of Meese and Rogoff (1983a) the focus of the attention of the literature on the determination of the exchange rate has changed from in-sample estimation to out-of-sample forecasting.

[4] Mark (1995) and Chinn and Meese (1995) proved the usefulness of monetary models in predicting the nominal exchange rate in the long-term; Blomberg and Hess (1997) demonstrated that monetary models augmented with political variables out-perform the random walk model in the short-term forecasting ability of the nominal exchange rate; Mark and Sul (2001) reported positive short-term results for a panel of countries.

[5] Gandolfo, Padoan and Paladino (1990) abandon the idea of using traditional single equation structural models of exchange rate, favouring instead the use of economy-wide macro-econometric models, and found positive results for the Italian lira versus the US dollar nominal exchange rate

ability of each competing model to generate out-of-sample forecasts at one- to twelve-month horizons for the Italian lira – US dollar exchange rate is assessed. The parameters of each model are estimated for every forecast period by the rolling regressions method using the most up-to-date information available at the time of a given forecast.
Results indicate:

(i) pre- 1992, the MMER is a good predictor of the Italian Lira – US $ exchange rate in out-of-sample forecasting. In particular, in out-of-sample forecasting, MMERs significantly outperform the benchmark RW model up a to twelve-months horizon. We suggest that these findings can be interpreted in light of the presence of controls on capital movements in Italy until the early 90s[6].

(ii) post- 1992, the MMER ceases to be a good predictor of the exchange rate. This contradicts the MMER framework, which says that it should perform better in perfectly competitive markets. The MR (1983a) negative results hold for Italy (just after the departure of the Lira from the EMS in 1992).

The robustness of these results is assessed by introducing forward-looking variables (expected inflation and survey data on production expectation) into these models and by changing the sample period. Results appear to be robust to these changes[7].

This paper is organized as follows: section 2 describes the methodology used to compare different models; section 3 describes the competing exchange rate models that need to be tested out-of-sample; the sub-section 3.1 derives the benchmark RW with drift; section 4 of the paper provides a preliminary data analysis; section 5 contains the out-of-sample results; the issue of robustness is addressed in section 6 and the conclusion follows in section 7.

2. Methodology

This section presents the methodology used below to assess the forecasting ability of MMERs against that of a benchmark model.

The out-of-sample forecasts are obtained by using recursive estimation methodology. The data is partitioned in such a way that the proposed models are first estimated using data from January 1974 to December 1984. The estimated coefficients are then used to construct the

[6] The controls on the capital movements in Italy and their implications are discussed extensively in Berardi, Dalmazzo e Marini (1996); Pozzolo (1999) and Ciocca (2000).

[7] Gandolfo et al. (1990) also found, using a different dataset and a multiple-equation model "MARK V", that the benchmark RW model can be out-performed in out-of-sample forecasting by a wide-macro-econometric model for the Italian lira – US dollar exchange rate. Gandolfo et al. (1990), however, stressed that single equation monetary models were not useful in predicting exchange rate movements.

one-step-ahead forecast of the bilateral exchange rate for the country considered in this paper. The regressions are then re-estimated with one more observation, using data from 1974:1 to 1985:1, to obtain the forecast for 1985:1. The process is then continued in this recursive manner until the last forecast (1988:12) is constructed. The process is then repeated for the 2-, 3-, 4-, 5-, 6- and 12-months-ahead prediction error. This recursive methodology produces a vector of 48 forecast errors for the 1-month-ahead prediction error, another of 47 for the 2-months-ahead prediction error, and so on until the 12 months-ahead prediction error is constructed. Each vector is then used to calculate the Root Mean Squared Error (henceforth RMSE), which is a standard measure for assessing competing models in out-of-sample forecasts:

$$\mathrm{RMSE} = \left\{ \sum_{s=0}^{Nk-1} [F(t+s+k) - A(t+s+k)]^2 / Nk \right\} \qquad (2.1)$$

where k = 1, 2, 3, 4, 5, 6, 12 denotes the forecast step, N_k the total number of forecasts in the projection period for which the actual value A(t) is known and F(t) the forecast value. Forecasting begins in period t (see MR, 1983a).

3. The model

The aim of this paper is to report new empirical results on the Italian lira - US dollar exchange rate over the recent float showing that a simple univariate-linear model, which includes macroeconomic fundamentals, is able to outperform a benchmark RW with drift in predicting the exchange rate. For this purpose, two versions of the monetary model were selected. The first is the flexible-price monetary model, originally introduced by Frenkel (1976) and Bilson (1978). The second is the Dornbusch-Frankel monetary model with sticky prices. A third model, based on the uncovered interest parity condition, is also considered. All models are assessed against a benchmark RW with drift. Consider the following specification:

$$s_t = a_0 + a_1(m-m^*)_t + a_2(y-y^*)_t + a_3(i-i^*)_t + a_4(\pi-\pi^*)_t + u_t \qquad (3.1)$$

All variables are in log and to conform with the empirical literature on exchange rates the dependent variable is considered in log first difference. Jensen's inequality problem is avoided by comparing predictors on the basis of their ability to predict the logarithm of the exchange rate. In other words, because of Jensen's inequality, the best predictor of the level of the Italian lira – US dollar exchange rate might not be the best predictor

of the US dollar – Italian lira exchange rate. s_t, is the difference of the spot exchange rate defined as Italian lira per one US dollar, y_t, is the output level, i_t, is the short- term interest rate, π_t is the consumer price index and u_t is a random error. An asterisk next to a variable indicates foreign values. Equation (3.1) makes the assumption that domestic and foreign variables affect the exchange rate with coefficients of equal but of opposite sign. The flexible-price monetary model of exchange rates (henceforth Model 2) is readily obtained from equation (3.1) by restricting a_1 to be unity, $a_2<0$, $a_3>0$ and $a_4=0$. The sticky-price monetary model (Model 1) is obtained by imposing the following restrictions: $a_1=1$, $a_2<0$, $a_3<0$ and $a_4>0$. The main difference between the flexible- and sticky-price monetary models is that the DF model allows for short-term deviation from purchasing power parity in the goods market. Our proposed model, based on the uncovered interest parity condition (henceforth Model 3), uses the following restrictions: $a_1=a_2=a_4=0$ and $a_3\neq0$. Lastly, as a benchmark model, a RW model with drift (this is explained below), based on the restrictions $a_1=a_2=a_3=a_4=0$ is used (Model 4). The reason for incorporating the interest rate differential in the model (Model 3) is based on the idea that the adjustment of interest rates influences the movements in the exchange rates. So, for instance, by raising the domestic interest rate, the foreign exchange value of the domestic currency unit could be strengthened. On the other hand, by reducing the domestic interest rate the domestic currency could depreciate. From the above equation it is possible to see that an increase in the domestic money supply, relative to the foreign money supply, depreciates the domestic currency. An increase in the domestic output increases the value of the domestic currency (through PPP). All variables are dated as if they were known ex-ante.

3.1 Derivation of the Random Walk with drift

Numerous empirical studies of international financial markets have focused on market efficiency. In an efficient speculative market, prices should fully reflect information available to market participants and it should be impossible for a trader to earn excess returns on speculation. Foreign exchange market participants show two elements: (i) rational expectation; (ii) risk neutrality. The efficient market hypothesis in the presence of risk neutrality implies that the gain from holding one currency rather than another must be compensated for by the opportunity cost of holding investments in this currency rather than the other. Black (1971) defined a perfect market for a stock as one in which both people endowed with publicly available information and those with private information are unable to make profits from speculation (because prices adjust very quickly

as the information becomes available, therefore, prices move randomly). To illustrate this more clearly, we should consider the concept of a Fair-Game. A Fair-Game is a game which is neither in your favour nor in that of your opponent. This is the essence of a martingale, a stochastic process $[s_t]$ which satisfies the following condition:

$$E[s_{t+1}-s_t \mid s_t, s_{t-1}]=0 \tag{3.2}$$

Suppose that the variable s_t can be written as the rational expectation of some "fundamental value" V*, conditional on all available information at time t "I_t ". Formally:

$$s_t = E[V^*|I_t] = E_tV^* \tag{3.3}$$

It follows that:

$$s_{t+1} = E[V^*|I_{t+1}] = E_{t+1}V^* \tag{3.4}$$

Since $I_t \subseteq I_{t+1}$, thus:

$$E_t[E_{t+1}[V^*]] = E_t[V^*] \tag{3.5}$$

all the information in I_t is also in I_{t+1}, but I_{t+1} is superior because it contains extra information. By the Law of Iterated Expectation:

$$E[s_{t+1}-s_t] = E_t[[E_{t+1}[V^*] - E_t[V^*]]=0 \tag{3.6}$$

In other words, realised price changes are unforecastable given the information in the set I_t. If s_t is the spot price of one country's money in terms of another at time t, then the martingale hypothesis states that the change in the spot price exchange rate is zero when conditioned on the exchange rate's entire history. In a forecasting context, the martingale hypothesis implies that the best (here best = minimal mean-squared error) forecast of tomorrow's exchange rate is simply today's exchange rate. Until recently the martingale hypothesis was considered to be a necessary condition for an efficient asset market. The more efficient the market, the more random the sequence of price changes generated by the market. Unfortunately the martingale hypotheses do not account for "risk" in any way, which is indeed one of the most important concepts in modern financial economics (trade-off risk-return). Specifically, if the change in the spot exchange rate is positive, it may be the reward necessary to attract

investors to hold that currency and its associated risk. Thus implying that the martingale hypotheses is neither a necessary nor a sufficient condition for rationally determined asset prices [see Lucas(1978)].

To overcome the aforementioned problem, tests on the efficiency market hypothesis are carried out on a stronger version of the martingale model; one which assumes identically and independently distributed increments. This model, known also as "random walk with drift", is given by the following expression: $s_t = c + s_{t-1} + e_t$ where c is the expected change in the exchange rate or drift.

4. Description of data

This section examines the sample moments of the variables considered in the paper. The first and the second moment of all variables used in the paper are reported. The raw data is monthly and is taken from DataStream. The full sample covers the period from January 1974 to November 1998. Variables are selected according to the asset market approach of exchange rates. The spot exchange rate, presented in Italian lira per one US dollar, is used as the exchange rate, the index of industrial production as a measure of output, the monetary aggregate m_t as a measure of money supply, the money market interest rate as a measure of the short-term nominal interest rate and the consumer price index is used to calculate a measure of inflation. In this paper Italy represents the domestic country while the US represents the foreign country. Foreign variables are denoted with an asterisk. Table 1 provides the mean and standard deviation of all variables considered in this paper. Each column reports the variable name, the mean and the standard deviation over the full sample.

TABLE 1

Sample moments: 1974(1)-(11)1998

	s	y	π	m	i	y*	π*	m*	i*
mean	1285	85	8.1	262	12.9	80	4.6	676	7.7
variance	387	11	4.8	124	3.9	15	2.7	304	3.3

Notes: The variables in the table are defined as follows: s is the Italian lira – US dollar nominal exchange rate; y is output; π is the rate of inflation; m is the money supply and i is the short-term interest rate.

The main empirical regularity of this exchange rate is as follows: First, the Italian interest rates and inflation rates were on average almost twice those of the US rates. Second, the volatility of the Italian interest rates and inflation rates was greater than that of the foreign rates.

5. Empirical results: out-of-sample forecasts

The empirical analysis in this section focuses on the out-of sample estimation. The preliminary data analysis is started first by looking at the cross-correlations between the series and then by choosing their optimal lag length for the estimation according to the Akaike information criteria. Then Model 1, Model 2 and Model 3 are assessed in an out-of-sample estimation for the Italian lira – US dollar bilateral exchange rate against a RW with drift. The main result of this section is that the MMER has a lower RMSE than the RW up to twelve-months ahead. This result is robust across different models and for different sample periods.

The out-of-sample forecast results are displayed in Table 2 which is organized in the following way: the forecasting horizon, which goes from 1 to 12 months, is contained in the first column of the table, the second column reports the RMSE results of the DF model, the third column reports the RMSE results of the FB model, the fourth column reports the RMSE results of the model based on the interest rate differential and the fifth column reports the RMSE results of the benchmark RW model.

The issue of data mining is then addressed by repeating the experiment over a different sample period (1986:7-1990:6) to account for the fact that the above results could be dependent upon a particular sample period used in the estimation. Results are shown in the bottom quadrant of Table 2 The out-of-sample results for the bilateral exchange rates confirm our hypothesis, for the Italian lira – US dollar nominal exchange rate, that the simple MMERs have a lower RMSE than the benchmark RW. As can be seen from Table 2, during the period 1984:12 – 1988:12 all models outperform the RW significantly for up to a year. Repeating the experiment over the period 1986:6 – 1990:6 it is found, however, that Models (1)-(3) lose some of their advantage over the RW in predicting the exchange rate movements.

The out-of-sample forecasts based on the RMSE results confirm the previous finding, for the Italian lira – US dollar nominal exchange rate during the recent float, that the MMERs outperform the RW. These results are consistent and robust across different sample periods.

TABLE 2

RMSE from out-of-sample-forecast

Nominal exchange rate Lira /$ - Sample: 1984(12)-(12)1988				
	Model 1	Model 2	Model 3	R W
Horizon				
1	0.0251*	0.0250*	0.0265**	0.0297
2	0.0286***	0.0261***	0.0302*	0.0311
3	0.0293***	0.0287***	0.0307	0.0311
4	0.0298***	0.0290***	0.0311***	0.0313
5	0.0289*	0.0283***	0.0299**	0.0302
6	0.0293**	0.0285***	0.0303**	0.0305
12	0.0283**	0.0275**	0.0290**	0.0292
Nominal exchange rate Lira /$ - Sample: 1986(6)-(12)1990				
	Model 1	Model 2	Model 3	R W
Horizon				
1	0.0224*	0.0226*	0.0232	0.0255
2	0.0242*	0.0244*	0.0255	0.0255
3	0.0238	0.0241	0.0248**	0.0249
4	0.0241	0.0244**	0.0251	0.0251
5	0.0242	0.0246	0.0252	0.0252
6	0.0245	0.0248	0.0255	0.0255
12	0.0247	0.0251	0.0255	0.0253

Notes:
Model 1, beside the dependent variable, includes also a constant and lags of the differentials between domestic and foreign short-term interest rate, domestic and foreign money supply, domestic and foreign output and domestic and foreign inflation. Model 2 is simply defined as Model 1 less the inflation differential. Model 3 besides the dependent variable, includes also a constant and lags of the differential between domestic and foreign short-term interest rates. The time horizon is reported in the first column, columns 2, 3, and 4 report the RMSE results of Models (1) – (3) and compare their significance level with the RMSE of the benchmark Random Walk Model. The asterisk beside the RMSE indicates the significance level of the Sign test, which is applied to the vector of each forecast error according to the formula S= S - 0.5T/sqrt(0.25T). S, which is asymptotically distributed with a standard normal N(0,1), represents the number of positive forecast errors and T the sample size (T=48 for the 1-step-ahead forecast and T=37 for the 12-step-ahead) [see Diebold and Mariano (1995)]. As pointed out by Diebold and Mariano (1995), the use of the F-test to compare the forecast errors series would be of little use here because the conditions required to obtain its distribution are too restrictive.
*different from random walk at a 10% significance level.
**different from random walk at a 5% significance level.
***different from random walk at a 1% significance level.

6. Robustness

The issue of robustness is explored along a number of dimensions. Firstly, the Italian and US measures of inflation are replaced with those of expected inflation. Secondly, to provide a more stringent robustness test, the sample period for the out-of-sample estimation is changed and a measure of expected output from survey data is used instead of the Italian and US measures of output used earlier.

6.1. Expected inflation

Table 3 reports the out-of-sample results once the measure of expected inflation is included in place of inflation. Expected inflation introduces a forward-looking element in the analysis.

TABLE 3

RMSE from out-of-sample-forecast

Nominal exchange rate Lira /$ - Sample: 1984(12)-(12)1988			
	Model 1	Model 2	R W
Horizon			
1	0.0264***	0.0276***	0.0297
2	0.0323	0.0322	0.0311
3	0.0335	0.0327	0.0311
4	0.0342	0.0331	0.0313
5	0.0324	0.0309	0.0302
6	0.0326	0.0311	0.0305
12	0.0304	0.0291	0.0292
Nominal exchange rate Lira /$ - Sample: 1986(6)-(12)1990				
	Model 1	Model 2	Model 3	R W
Horizon				
1	0.0226***	0.0231*	0.0255	
2	0.0241***	0.0248***	0.0255	
3	0.0238	0.0239	0.0249	
4	0.0239***	0.0241***	0.0251	
5	0.0242***	0.0244***	0.0252	
6	0.0244***	0.0246***	0.0255	
12	0.0250	0.0248	0.0253	

Notes:
To introduce a forward-looking element in the analysis, in Model 1 the Italian – US expected inflation differential replaces the inflation differential. Model 1, besides the dependent variable, also includes a constant and lags of the differentials between domestic and foreign short-term interest rates, domestic and foreign money supply, domestic and foreign output and domestic and foreign expected inflation. Model 2, besides the dependent variable, includes a constant and lags of the differential between domestic and foreign expected inflation. The time horizon is reported in the first column, columns 2, 3, and 4 report the RMSE results of Model (1) – (2) and compare their significance level with the RMSE of the benchmark Random Walk Model. The asterisk beside the RMSE indicates the significance level of the Sign test, which is applied to the vector of each forecast error according to the formula S= S - 0.5T/sqrt(0.25T). S, which is asymptotically distributed with a standard normal N(0,1), represents the number of positive forecast errors and T the sample size (T=48 for the 1-step-ahead forecast and T=37 for the 12-step-ahead) [see Diebold and Mariano (1995)]. As pointed out by Diebold and Mariano (1995), the use of the F-test to compare the forecast errors series would be of little use here because the conditions required to obtain its distribution are too restrictive.
*different from random walk at a 10% significance level.
**different from random walk at a 5% significance level.
***different from random walk at a 1% significance level.

As before, the out-sample-forecasting exercise is carried out on two different sample periods (1984:12-1988:12; 1986:7-1990:6). The results from the first sample period (1984:12-1988:12) show that Models 1 and 2

both significantly outperform the RW with drift at one-month-ahead. Those from the second (1986:7-1990:6) report a striking superiority of fundamentals based models over the RW (Model 1 and Model 2 outperform the RW up to six-months-ahead)[8].

6.2 Expected output

A more stringent robustness test is: 1) to change the sample period considered for the –out-of-sample forecasting exercise and 2) to introduce a forward-looking element in the analysis the place of the output. This forward-looking element is represented by "production expectation for Italy" and is taken from the European Commission Business Survey. The European Community business survey is carried out in Italy by the ISAE (Istituto Studi e Analisi Economica, previously ISCO) following national institution on the basis of the Commission's harmonized questionnaires. The EU survey is not designed to yield exact quantitative forecasts but takes the form of a trend survey in which respondents may choose from 3 categories of responses. During the last ten days of each month around 20,000 firms (all in the EU) are contacted by national institutions (such as the ISCO) and asked to respond to a set of questions, including "Production expectations for the month ahead: up, unchanged, down?". The majority of replies are received by the first week of the month to which the questionnaires refer[9]. Results are then published during the first week of the following month. The survey data may thus be interpreted as an assessment of the movement of the respective national production. Despite the existence of other income variables such as GNP, GDP and the Index of Industrial Production, the advantage of this study is that the time required for data collection and release is very short. In the foregoing robustness analysis the variable representing production expectation for the month ahead is converted from a qualitative to a quantitative measure in the following way:

- measure 1 = $(\text{Up} + \text{Unchanged}/2)_{t-1}$;
- measure 2 = $(\text{Up} - \text{Down})_{t-1}$;
- measure 3 = $(\text{Up} + \text{Unchanged}/2)_{t-2}$

[8] MacDonald and Marsh, (1997) present evidence to support the proposition that fundamentals based models have clear ability to forecast at horizons as short as two months ahead; Mark and Soul (2001) find that monetary fundamentals have a small but statistically significant level of predictability for the exchange rate.

[9] The only exceptions are Italy and Germany, where the questionnaires are issued around the $15^{th} - 20^{th}$ of the month preceding that to which the result are attributed. In both cases, however, most of the completed questionnaires are received during the first 10 days of the month to which the results are attributed.

The results from the out-sample-forecasting exercise are reported in Table 4. These results are based on the following sample period (1988:7-1992:6). The first column indicates the forecasting horizon, the following two columns report the RMSE results using the first measure of output expectation (and are contrasted with those of the benchmark RW with drift) and the remaining columns show the RMSE results obtained using the other two measures of production expectation as explained above.

The results shows that Models 1 and 2 both significantly outperform the RW with drift at two-months-ahead. Furthermore, these results are not dependent on the measure of expected output used.

The robustness of the results confirms our previous finding that for the Italian lira – US dollar nominal exchange rate the MMERs outperform the RW.

TABLE 4

RMSE from out-of-sample-forecast

Nominal exchange rate Lira /$ - Sample: 1988(7)-(6)1992

	Model 1 (using measure 1)	Model 2	R W	Model 1 (using measure 2)	Model 2	R W	Model 1 (using measure 3)	Model 2	R W
Horizon									
1	0.02517***	0.02474***	0.02721	0.02529***	0.02484***	0.02721	0.02528***	0.02492***	0.02721
2	0.02658*	0.02552***	0.02685	0.02667*	0.02563***	0.02685	0.02672**	0.02950	0.02685
3	0.02639	0.02590	0.02701	0.02651	0.02604*	0.02701	0.02656	0.02635	0.02701
4	0.02698	0.02661	0.02728	0.02708	0.02675	0.02728	0.02712	0.02702	0.02728
5	0.02691	0.02671	0.0272	0.02704	0.02688	0.0272	0.02709	0.02715	0.0272
6	0.02632	0.02627	0.02652	0.02648	0.02648	0.02652	0.02655	0.02676	0.02652
12	0.02701	0.02708	0.02762	0.02712	0.02727	0.02762	0.02710	0.02741	0.02762

Notes:

To introduce a forward-looking element in the analysis, in Model 1 the Italian – US expected output differential replaces the output differential. The three measures used in the table are the following: measure 1 = $(\text{Up} + \text{Unchanged}/2)_{t-1}$; measure 2 = $(\text{Up} - \text{Down})_{t-1}$; measure 3 = $(\text{Up} + \text{Unchanged}/2)_{t-2}$. Model 1, besides the dependent variable, includes a constant and lags of the differentials between domestic and foreign short term interest rate, domestic and foreign money supply, domestic and foreign inflation and domestic and foreign expected output. Model 2, besides the dependent variable, includes a constant and lags of the differential between domestic and foreign expected output. The time horizon is reported in the first column, columns 2, 3, and 4 report the RMSE results of Model (1) – (2) and compare their significance level with the RMSE of the benchmark Random Walk Model. The asterisk beside the RMSE indicates the significance level of the Sign test, which is applied to the vector of each forecast error according to the formula S= S - 0.5T/sqrt(0.25T). S, which is asymptotically distributed with a standard normal N(0,1), represents the number of positive forecast errors and T the sample size (T=48 for the 1-step-ahead forecast and T=37 for the 12-step-ahead) [see Diebold and Mariano (1995)]. As pointed out by Diebold and Mariano (1995), the use of the F-test to compare the forecast errors series would be of little use here because the conditions required to obtain its distribution are too restrictive.

*different from random walk at a 10% significance level.

**different from random walk at a 5% significance level.

***different from random walk at a 1% significance level.

6.3 A further robustness check

The aim of this section is to assess whether our hypothesis is correct: that monetary models, with both flexible and sticky prices, outperform the random walk model in out-of-sample forecasts before, but not after, 1992 – when the Italian lira departed from the EMS and most of the legal restrictions to capital movements were eased.

In order to do this, the experiments carried out in section 6.2 were repeated using a sample of data that went beyond 1992.

Results from the out-sample-forecasting exercise are reported in Table 5. The Table can be read as before (section 6.2), the only difference being that the results are now carried out on the following sample period (1992:1-1994:6).

The results, in sharp contrast with all previous findings, show that both Model 1 and Model 2 no longer outperform the benchmark RW, thus implying that fundamentals are unable to predict exchange rate movements.

TABLE 5

RMSE from out-of-sample-forecast

Nominal exchange rate Lira /$ - Sample: 1992(1)-(6)1994

	Model 1 (using measure 1)	Model 2	R W	Model 1 (using measure 2)	Model 2	R W	Model 1 (using measure 3)	Model 2	R W
Horizon									
1	0.02929*	0.03035	0.03333	0.02939	0.03037	0.03333	0.02932*	0.03030	0.03333
2	0.03373	0.03952	0.03366	0.03374	0.03939	0.03366	0.03375	0.03927	0.03366
3	0.03393	0.04199	0.03385	0.03392	0.04186	0.03385	0.03393	0.04168	0.03385
4	0.03244	0.04169	0.03244	0.03239	0.04155	0.03244	0.03241	0.04132	0.03244
5	0.03187	0.04150	0.03204	0.03181	0.04136	0.03204	0.03183	0.04109	0.03204
6	0.03212	0.04158	0.03236	0.03206	0.04143	0.03236	0.03208	0.04115	0.03236
12	0.03275	0.04320	0.03319	0.03265	0.04302	0.03319	0.03267	0.04268	0.03319

Notes:

To introduce a forward-looking element in the analysis, in Model 1 the Italian – US expected output differential replaces the output differential. The three measures used in the table are the following: measure 1 = $(Up + Unchanged/2)_{t-1}$; measure 2 = $(Up - Down)_{t-1}$; measure 3 = $(Up + Unchanged/2)_{t-2}$.. Model 1, besides the dependent variable, includes a constant and lags of the differentials between domestic and foreign short term interest rate, domestic and foreign money supply, domestic and foreign inflation and domestic and foreign expected output. Model 2, besides the dependent variable, includes a constant and lags of the differential between domestic and foreign expected output. The time horizon is reported in the first column, columns 2, 3, and 4 report the RMSE results of Models (1) – (2) and compare their significance level with the RMSE of the benchmark Random Walk Model. The asterisk beside the RMSE indicates the significance level of the Sign test, which is applied to the vector of each forecast error according to the formula S= S - 0.5T/sqrt(0.25T). S, which is asymptotically distributed with a standard normal N(0,1), represents the number of positive forecast errors and T the sample size (T=48 for the 1-step-ahead forecast and T=37 for the 12-step-ahead) [see Diebold and Mariano (1995)]. As pointed out by Diebold and Mariano (1995), the use of the F-test to compare the forecast errors series would be of little use here because the conditions required to obtain its distribution are too restrictive.

*different from random walk at a 10% significance level.

**different from random walk at a 5% significance level.

***different from random walk at a 1% significance level.

In particular we argue that, after the early 90s, fundamentals-based macroeconomic models are unable to beat the naïve RW in predicting the Italian lira – US dollar exchange rate using out-of-sample forecasting. We explain these findings in light of the departure of the Italian lira from the European Monetary System (EMS) and the subsequent easing of controls on capital movements in Italy.

7. Conclusion

The aim of this paper has been to report new empirical results on the Italian lira – US dollar exchange rate during the recent float. A simple MMER is able to outperform the benchmark RW model in out-of-sample forecasts. To achieve the proposed goal, after a brief description of the data, three alternative version of the monetary model are presented and tested. The first is a simplified version of the sticky-price monetary model. The second is a simplified version of the flexible-price monetary model. The third is based on the interest rate differential. The performance of these models has been assessed against a RW with drift. Results indicates that the MMERs outperform the RW in predicting the Italian lira – US dollar rate of exchange at one-to-twelve months' horizons until the early 90s. The superiority of the MMER with respect to the RW model vanishes toward the end of 1992 (after the departure of the Italian Lira from the European Monetary System - EMS). These findings are most likely dependent on the presence of market imperfections such as capital control and high inflation in the Italian economy. These findings appear to be robust across models of different specifications and over different sample periods.

Bibliography

Berardi, A., Dalmazzo, A. and G. Marini, (1996) "Regolamentazione di flussi di capitale e volatilità del tasso di cambio. Risultati preliminari sull'esperienza italiana" *Rivista di Politica Economica,* Anno LXXXVI, Serie III pp. 119-137.

Black, F. (1971) "Toward a Fully Automated Stock Exchange", *Financial Analysts Journal*, July-August, 29-44.

Blomberg, S. B. and G. Hess, "Politics and Exchange Rate Forecasts", *Journal of International Economics*, 43, 189-205, 1998.

Campbell, J., Low, A. and C. Mackinlay, The Econometrics of Financial Markets, Princeton University Press, 1997.

Ciocca, P., "La nuova finanza in Italia. Una difficile metamorfosi (1980-2000)", Bollati Boringhieri, Torino 2000.

Diebold, F. X. and R. Mariano, (1995) "Comparing Predictive Accuracy", *Journal of Business and Economic Statistics*, 13, 253-63.

Fama, E. (1970) "Efficient Capital Markets: A Review of Theory and Empirical Work", *Journal of Finance*, 25, 383-417.

Frankel, Jeffrey A., and A. K. Rose, "Empirical Research on Nominal Exchange Rates", Handbook of International Economics, vol. III, Edited by G. Grossman and K. Rogoff, Elsevier Science B. V.,1995.

Frankel, Jeffrey A., "On exchange rates", Cambridge, MA: MITT Press, 1993.

Froot, K. A., "Using Survey Data to Test Standard Propositions Regarding exchange Rate Expectations", published in Frankel, MIT press, 1993.

Gandolfo, G., "International Economics II: International Finance and Open-Economy Macro-Economics", Berlin: Springer-Verlag, 1998.

Gandolfo, G., Padoan C.P. and G. Paladino (1990) "Structural Models Vs Random Walk: The Case of the Lira/$ Exchange Rate", *Eastern Economic Journal*, Vol. XVI, 101-123.

Gandolfo, G., Padoan C.P. and De Arcangelis, G. "The Theory of Exchange Rate Determination, and Exchange Rate Forecasting", CIDEI working paper N.1, June 1991.

Kilian, Lutz (1999) "Exchange Rates and Monetary Fundamentals: What Do We Learn from Long-Horizon Regressions?" *Journal of Applied Econometrics*, 14(5), pp. 491-510.

Levich, R. (1985) "Empirical Studies of Exchange Rates: Price behavior, Rate Determination and Market Efficiency", Handbook of International Economics, vol. II, Edited by R. Jones and P. Kenen, Elsevier Science B. V.

MacDonald, R. (1998a), Floating Exchange Rates: Theories and Evidence, London: Unwin-Hyman.

Mark, N.C., "Exchange Rates and Fundamentals; Evidence on Long-Horizon
Predictability", *American Economic Review*, 85, 201-218, 1995.

Mark N.C. and D. Sul (2001) "Nominal Exchange Rates and Monetary Fundamentals: Evidence from a Small Post-Bretton Woods Panel." *Journal of International Economics*, February, 53(1), pp. 29-52,

Meese, R. (1990) "Currency Fluctuations in the Post-Bretton Woods Era", *Journal of Economic Perspectives*, 4, 117-134.

Meese, R. and K. Rogoff (1983b), "The Out-of-.Sample Failure of Empirical Exchange Rate Models: Sampling Error or Misspecification?" in J.A. Frenkel (ed.) Exchange Rates and International Macroeconomics, Chicago: Chicago University Press and National Bureau of Economic Research pp. 67-105.

Meese, R. and K., Rogoff (1983a) "Empirical Exchange Rate Models of the Seventies: Do They Fit Out of Sample", *Journal of International Economics*, 14(2), pp. 3-24.

Obstfeld, M. and K. Rogoff, "The Six Major Puzzles in International Macroeconomics: Is There a Common Cause?", NBER, Macroeconomics Annual, 2000.

Taylor, M. P. (1995), "The Economics of the Exchange Rates", *Journal of Economic Literature*, 33, 12-47.

Sarno, L., and M. P. Taylor, *The Economics of Exchange Rates*. Cambridge and New York: Cambridge University Press, 2002.

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