

The Exchange Rate Disconnect Puzzle: A Resolution?

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Abstract

Early empirical studies of exchange rate determinants demonstrated that fundamentals-based monetary models were unable to outperform the benchmark random walk model in out-of-sample forecasts while later papers found evidence in favor of long-run exchange rate predictability. More recent theoretical works have adopted a microeconomic structure; a utility-based new open economy macroeconomic framework and a rational expectations present value model. Some recent empirical work argues that if the models are adjusted for parameter instability, it is a good predictor of nominal exchange rates while others use aggregate idiosyncratic volatility to generate good predictions. This latest research supports the idea that fundamental economic variables are likely to influence exchange rates especially in the long run and further that the emphasis should change to the economic-value or utility based value to assess these macroeconomic models.

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1. Introduction¹

The problem of the determination of exchange rates, while still not completely solved, may be headed towards a cautious resolution. Recent research supporting the relationship between macroeconomic variables and exchange rates has concentrated on: theoretical developments and explanations (Moore and Roche, 2006; Evans and Lyon, 2005a, 2005b; Bacchetta and van Wincoop, 2006; Devereux and Engel, 2002); sophisticated

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¹ The term “exchange rate disconnect puzzle” was coined by Obsteld and Rogoff (2000) to cover the weak short-run relationship between the exchange rate and macroeconomic variables.

econometric techniques along with improved data quality, including firm level data (Rossi, 2005 and 2006; Guo and Savickas, 2005; Dekle, Jeong and Ryoo, 2005; Deckle and Ryoo, 2004; and Fitzgerald, 2004) and on the economic value or utility-based value of assessing the performance of these fundamentals models (Abhyankar, Sarno and Valente, 2005; and earlier West, Edison and Cho, 1993).

As far as the historical evidence on exchange rates is concerned, it is well known that exchange rates have behaved very differently during the last century. Until the early 1970s and with the exception of the two World Wars, most countries maintained a system of fixed exchange rates. The Bretton Woods System was specifically created to prevent the destabilization of foreign exchange rates caused by speculators in the floating exchange rate period during the first and second world wars. Under this system, the member countries established narrow bands pegging the nominal exchange rate between their currency and the US dollar. However, the system failed to stabilize the volatile foreign exchange rates mechanism after the dollar devaluation of 1973 and despite some sporadic intervention, industrialized countries floated their exchange rates after 1973, aiming to increase the degree of flexibility of the exchange rate system.

The breakdown of the Bretton Woods System represented a compelling opportunity for economists and policymakers to test competing exchange rate models to try and explain what determines exchange rates and their variability.² The first generation of empirical tests on exchange rates were directed to assess the validity of models like “the flexible price monetary model” and “the sticky price model”. After the early wave of empirical studies largely supportive of monetary models,³ later results turned out to be negative. Fitting exchange rates to contemporary observable variables, in-sample, is one thing, forecasting out-of-sample is quite another. In the early 1980s two economists shifted the focus of the empirical exchange rate studies from in-sample to out-of-sample forecasting. Meese and Rogoff (1983a) found that a simple random walk model out-performed both the flexible-price (Frenkel) and the sticky-price (Dornbusch) monetary models.

This article provides a selective overview of the theoretical and empirical evidence on the exchange rate disconnect puzzle with a special focus on its main determinants relating to nominal exchange rates and monetary fundamentals and the ability of macroeconomic variables to predict exchange rate movements both in the short-run and in the long-run. Since the real exchange rate is highly correlated to the nominal exchange rate, it also is disconnected to macroeconomic fundamentals (Kilian and Taylor, 2003). The article concludes by arguing that the past debate on fundamentals models has been misdirected and that these models should be evaluated on the basis of their usefulness to an investor and as a means of describing the long-run behavior of the economy.

² Baxter and Stockman (1989) showed that the transition from fixed to floating exchange rates leads to a strong increase in nominal and real exchange rate variability that is not followed by a similar increase in the variability of macroeconomic fundamentals. This implies that monetary models alone cannot explain the high variability of the exchange rates. Flood and Rose (1995) confirm the finding of Baxter and Stockman reporting once again the weak relationship between exchange rates and macroeconomic variables.

³ See Frenkel's (1976) classical study on the German hyperinflation, Bilson (1978), Hodrick (1978), Dornbusch (1979).

This article is divided into the following main sections. Section 2 presents the key theoretical concepts while the monetary models of exchange rates are presented in Section 3. Section 4 focuses on reviewing some of the empirical literature on the exchange rate determination while Section 5 looks at the recent theoretical literature. These studies all analyze the same question - are economic fundamentals useful in explaining exchange rates? The final section sets out the conclusions and suggestions for future research.

2. Market Efficiency and the Random Walk

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 possess two characteristics: (i) rational expectation and (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, and therefore, prices move randomly). To illustrate this more clearly, the concept of a Fair-Game should be considered.

A Fair-Game is a game which is neither in one person's favor nor in their opponent's. This is the essence of a martingale, a stochastic process $[s_t]$ which satisfies the following condition:

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

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:

$$s_t = E [V^* \mid I_t] = E_t V^* \tag{2}$$

It follows that:

$$s_{t+1} = E[V^* \mid I_{t+1}] = E_{t+1} V^* \tag{3}$$

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

$$E_t[E_{t+1}[V^*]] = E_t[V^*] \tag{4}$$

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:

$$E[s_{t+1} - s_t] = E_t[[E_{t+1}[V^*] - E_t[V^*]]] = 0 \tag{5}$$

In other words, realized 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 hypothesis is neither a necessary nor a sufficient condition for rationally determined asset prices (see Lucas, 1978).

To overcome the above problem, tests on the efficiency market hypothesis were 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.

3. The Monetary Model

The two most important types of monetary models are the flexible-price and the sticky price model.⁴

The former relies on the assumption of flexible prices. This implies that changes in the nominal interest rate reflect changes in the expected inflation rate. The second relies on the assumption of sticky prices. This implies that changes in the nominal interest rate reflect changes in the tightness of monetary policy.

The first theory is a realistic description when the variation in the inflation differential is large, as in the German hyperinflation of the 1920s to which Frenkel's first theory was applied. The second theory is a realistic description when the variation in the inflation differential is small, as in the Canadian float against the US in the 1950s, the case to which Mundell (1963) refers.

3.1 The Flexible-Price Monetary Model

The flexible-price monetary model of exchange rates is based on three main assumptions: first, money market equilibrium, second, purchasing power parity and third, uncovered interest parity (UIP).

Money market equilibrium is achieved by assuming perfect substitutability of domestic and foreign assets. The exchange rate adjustments allow demand and supply to reach equilibrium in the foreign exchange market.

⁴ See Frankel (1993) and Sarno and Taylor (2002).

$$m_t = p_t + \alpha y_t - \beta i_t + \varepsilon_t \tag{6a}$$

$$m_t^* = p_t^* + \alpha^* y_t^* - \beta^* i_t^* + \varepsilon_t^* \tag{6b}$$

where m_t , p_t and y_t are the logs at time t of the domestic stock of money, the price level and real output. The nominal interest rate is denoted by i_t ; ε_t represents a shock to money demand; α and β are two structural parameters. Note that asterisks denote foreign variables.

Purchasing power parity (PPP) shows how national price levels are linked to the nominal exchange rate. This is taken to imply that all prices, including wage rates, are perfectly flexible, thereby establishing automatic full employment of resources ($P^* = SP$, or $S = P^* / P$). Taking logs and including a disturbance v_t , it follows that:

$$(p - p^*)_t = s_t + v_t \tag{7}$$

where s_t is the nominal bilateral exchange rate defined as the unit price of domestic currency in terms of foreign currency.

The UIP condition relates domestic and foreign nominal interest rates to the change in the nominal exchange rates. To account for the fact that agents might demand a higher rate of return for holding foreign assets, this condition includes a risk premium.

$$E_t[s_{t+1} - s_t] = (i - i^*)_t - \rho_t \tag{8}$$

This modified assumption of UIP states that the expected exchange rate change is equal to the interest rate differential between home and domestic currency less an adjustment for a risk premium, ρ_t . Using equations (6a) to (7) and solving for the nominal exchange rate, assuming that $\alpha = \alpha^*$ and $\beta = \beta^*$, and combining the resulting equation with (8) yields:

$$s_t = (m_t - m^*)_t - \alpha(y_t - y^*)_t + \beta E_t[s_{t+1} - s_t] - (\varepsilon_t - \varepsilon_t^*) - v_t + \rho_t \tag{9}$$

which is similar to the basic flexible monetary model equation derived by Mussa (1976).

One strand of the early theoretical literature on monetary models departed from the simple flexible price model to include a maximizing representative agent subject to budget constraints and cash-in-advance utility constraints. Stockman (1980), for instance, develops an equilibrium model to determine exchange rates and prices of goods, where changes in the relative prices of goods are due to supply or demand shifts inducing changes in the exchange rates and deviations from purchasing power parity. Lucas (1982) solves the maximization problem of a representative agent subject to budget constraints and cash-in-advance constraints and builds a two-country general equilibrium model of exchange rates with perfect competition. Both the Stockman and the Lucas models differ from the one presented above because they introduce the distinction between tradable and non-tradable goods and / or agents with heterogeneous preferences with respect to domestic and foreign goods.

3.2 The Sticky Price Monetary Model

Dornbusch (1976) built a monetary model with sticky prices, which concluded that the short-term exchange rate might overshoot its long-term level. To see this, it is necessary to rewrite equations (6a) and (8). To simplify things, i_t^* is assumed to be constant, the error term is dropped from (6a) and the risk premium correction from (8):

$$m_t = p_t + \alpha y_t - \beta i_t \quad (6a)$$

$$E_t[s_{t+1} - s_t] = (i - i^*)_t \quad (8)$$

The sticky price monetary model departs from the assumption of continuous purchasing power parity to include price rigidity in the goods market. In other words, the equation $s_t = (p - p^*)_t$ does not need to hold continuously. Dornbusch (1976) aggregates all domestic output as a single composite good and assumes that the domestic aggregate demand, y_t^d , is an increasing function of the domestic real exchange rate $q = s + p^* - p$.

$$y_t^d = \underline{y} + \delta(s_t + p^* - p_t - q), \quad \delta > 0 \quad (10)$$

where underscored variables denote the equilibrium level of those variables and δ is a parameter. So, for instance, \underline{y} is the natural or equilibrium output level. To simplify things, it is assumed that \underline{y} , q and p^* are constant. Equation (10) implies that, *ceteris paribus*, an increase in the foreign price level shifts the world demand toward domestically produced goods.

Dornbusch (1976) justifies this adjustment process by assuming that the domestic country has a monopoly power over tradable goods, which have greater consumer price index weight at home than abroad.

The Dornbusch model predicts that the short-term exchange rate might overshoot its long-term level. To understand this, suppose that the domestic country cuts its nominal money supply. Sticky prices in the short term will determine a fall in the real money supply and an increase in the interest rates so that the money market reaches equilibrium. Higher interest rates will determine an inflow of foreign capital and consequently an appreciation of the nominal and real exchange rates. Short-term equilibrium is then achieved when the expected rate of depreciation is just equal to the interest rate differential. It follows that if the interest rate differential is different from zero the expected rate of depreciation also has to be different from zero. This implies that the short-term exchange must overshoot its long-term level. In the long-term, however, prices adjust by letting the exchange rate converge to its long-term level.

4. Empirical Studies

The early empirical studies were supportive of the monetary models of exchange rates, thus indicating that these were able to predict exchange rates. Frenkel's results, for

instance, were strongly supportive of the monetary model⁵ (see also Bilson). However, once the data was extended beyond 1978, the monetary model of exchange rate was again tested and the empirical results turned out to be negative. Frankel (1979), for instance, modified the simple exchange rate monetary model to account for real interest rate differentials and found that both original versions of the monetary models, i.e. Frenkel-Bilson with flexible prices and Dornbusch (1976) with sticky prices were rejected by the data.⁶ In a subsequent paper, Dornbusch (1980) tested the exchange rate monetary model for the German mark-US dollar and found that the model was not supported by the data.⁷

As already stated, beyond 1978 the exchange rate monetary model started to yield negative results. In particular, most of the empirical studies at the time suffered from:

- Endogeneity. The potential endogeneity between the money supply and the interest rate may represent a problem in the estimation of exchange rates monetary models (see for instance Frankel, 1979; Meese and Rogoff, 1983a).
- Misspecification and non-linearity. Econometricians generally believe that all econometric models are mis-specified. Exchange rate monetary models can be mis-specified in many respects, such as with regard to the functional form.

Other problems included poor fit, failure to pass diagnostic tests and breakdown of the estimated equations.

In summary, the early empirical studies on exchange rates attempted to assess whether fundamentals-based monetary models were able to explain exchange rate movements by looking at the in-sample fit of the monetary model. In other words, the full sample of data was used to fit the model of interest. However, as stressed by Ashley, Granger and Schmalense (1980), in-sample predictive accuracy is not a good test, for it simply tells us that the model fits the data reasonably well. Unfortunately, in-sample tests are well known to be biased in favor of detecting spurious predictability. They believed that a more rigorous evaluation criterion for assessing the forecasting ability of competing models should rely on out-of-sample testing. This methodology requires the replication of the data constraints faced by a real-time forecaster.

⁵ Frenkel (1976) tested the flexible price monetary model by regressing the monthly change on the German mark / US dollar exchange rate on the home-foreign differential of the logs of the stock of money, real output and expected inflation for the period 1920-1923. The key assumption of Frenkel's model is that the relative expected inflation differential is independent from the price level. This assumption is only valid because Frenkel's (1976) model was set up in the context of the German hyperinflation of the 1920s.

⁶ Frankel's (1979) model shares the characteristic of long-term equilibrium with the flexible price monetary model, while it shares the assumption of sticky prices in goods markets with the sticky price monetary model.

On the sticky price monetary model of exchange see also Driskill (1981) and Backus (1984).

⁷ In the 1990s the literature on sticky prices has focused on the relation between the real exchange rate and the interest rate differential. Enders and Lee (1997) use the Blanchard and Quah decomposition to investigate the effect of real and nominal shocks on real and nominal exchange rate movements. Nominal shocks have had a minor effect on the real and nominal bilateral exchange rates between the US and Canada, Japan and Germany. They found little evidence of exchange rate overshooting. Furthermore they report that real demand shocks, rather than supply shocks, have been responsible for volatile exchange rate movements.

The studies of Meese and Rogoff (1983a, b) shifted the focus of attention from in-sample estimation to out-of-sample forecasting^{8,9}. Meese and Rogoff (1983a) compared the out-of-sample forecasting performance of various structural and time series models using monthly data on the US dollar versus the British pound, German mark, Japanese yen and the trade weighted dollar exchange rates over the period March 1973 to June 1981.¹⁰ Their methodology was based on the following procedure: (1) the sample data is portioned into two sub-samples and each model is initially estimated for each exchange rate using the first sub-sample, which in Meese and Rogoff (1983a) corresponds to March 1973 to November 1976; (2) forecasts are generated at horizons of one, three, six and twelve months; (3) each data point from the second sub-sample is added (one by one) to the first, the parameters of each model are re-estimated using rolling regression and new forecasts are generated at one, three, six and twelve month horizons. The out-of-sample forecasting accuracy is measured by different statistics, the most important of which is the root-mean-squared error (RMSE). Table 1 sets out the RMSE statistics at one, three, six and twelve month horizons over the full sample as originally reported by Meese and Rogoff (1983a).

Meese and Rogoff (1983a) found that no model described in the international macroeconomics literature could beat the naïve random walk in out-of-sample forecasts (at least in the short-term, i.e. less than 12 months).¹¹ The studies of Meese and Rogoff (1983a, b) suffered from two main problems. The first is the one of endogeneity between variables while the second is that of spurious results.¹²

By using instrumental variables (IV) estimation and in sample grid search over possible combinations of parameter values, Meese and Rogoff (1983a) attempted to correct for the problem of endogeneity between variables. This implies that any failure to forecast cannot be attributed to endogeneity or small sample bias. The second problem remained unresolved because Meese and Rogoff (1983a) used as a dependent variable the log exchange rate which was almost surely non-stationary (integrated of order one $I(1)$), assuming however that it was, implying that the estimated regression coefficients were probably the result of a spurious regression. One of the main drawbacks of the rolling regression method adopted by Meese and Rogoff (1983a) to produce out-of-sample forecasts lies in the likely presence of parameter instability.

An alternative approach is based on the time-varying parameters method to obtain out-of-sample forecasts of exchange rates. An important paper on this strand of literature

⁸ The advantage of the out-of-sample testing over the in-sample evaluation techniques is that the former test implicitly the stability of the estimated coefficients providing a rigorous evaluation criteria to assess the forecasting ability of competing models (see Gandolfo, 1998).

⁹ Inoue and Kilian (2002) investigate the trade-off between in-sample tests and out-of-sample tests of predictability in terms of their size and power. They point out that “there is not presumption that data mining renders in-sample tests of predictability less reliable than out-of-sample tests”.

¹⁰ Meese and Rogoff (1983a) tested the following versions of the monetary model: Frenkel-Bilson, Dornbusch-Frankel and Hooper-Morton.

¹¹ Woo (1985) estimated, using maximum likelihood, a monetary model with flexible prices for the dollar-deutschmark and found that the estimated coefficients were stable and correctly signed. Woo’s flexible price monetary model out-performed the simple random walk model up to a year ahead.

¹² See Neely and Sarno (2002).

is that of Schinasi and Swamy (1989). They estimated the interest differential model of Frankel with and without lagged exchange rate values on the right-hand side, to generate out-of-sample forecasts, by using monthly data on the British sterling, the German mark and ten exchange rates against the dollar for 15 periods after March 1980. The main result emerging from Schinasi and Swamy's (1989) empirical study is that the RMSE of the monetary model (obtained from out-of-sample forecasts by introducing a first order autoregressive structure on the parameters) was a better predictor than the random walk model. The main drawback of this estimation procedure, however, is that the researcher has to specify how the parameters are allowed to vary.

Despite the use of longer datasets or alternative and / or more sophisticated econometric techniques the negative results of Meese and Rogoff (1983a) have lead to at least three different reactions among researchers. First, some tried to improve either the short-term performance or the long-term performance of the structural models by using different datasets, more sophisticated techniques or new variables (see for instance the studies of Meese and Rogoff, 1983b; Mark, 1995; Chinn and Meese, 1995; MacDonald and Marsh, 1997; Blomberg and Hess, 1997; Groen, 2000; Mark and Sul, 2001). Second, others suggested that the researchers move away from the use of traditional single-equation structural exchange rate models toward the use of economy-wide macro-econometric models (see for instance the paper of Gandolfo, Padoan and Paladino, 1990). A third group introduced nonlinearity in the exchange rate models (see for instance Balke and Fomby, 1997; Taylor and Peel, 2000; Taylor, Peel and Sarno, 2001 and Kilian and Taylor 2003).

Table 1
Root mean square forecast errors^o

Model:		Random walk	Forward rate	Univariate autoregression	Vector autoregression	Frenkel-Bilson*	Dornbusch Frankel*	Hooper-Morton*
Exchange rate	Horizon							
	1 month	3.72	3.20	3.51	5.40	3.17	3.65	3.50
\$/mark	6 months	8.71	9.03	12.40	11.83	9.64	12.03	9.95
	12 months	12.98	12.60	22.53	15.06	16.12	18.87	15.69
\$/yen	1 month	3.68	3.72	4.46	7.76	4.11	4.40	4.20
	6 months	11.58	11.93	22.04	18.90	13.38	13.94	11.94
	12 months	18.31	18.95	52.18	22.98	18.55	20.41	19.20
\$/pound	1 month	2.56	2.67	2.79	5.56	2.82	2.90	3.03
	6 months	6.45	7.23	7.27	12.97	8.90	8.88	9.08
	12 months	9.96	11.62	13.35	21.28	14.62	13.66	14.57
Trade-weighted dollar	1 month	1.99	N.A.	2.72	4.10	2.40	2.50	2.74
	6 months	6.09	N.A.	6.82	8.91	7.07	6.49	7.11
	12 months	8.65	14.24	11.14	10.96	11.40	9.80	10.35

Source: Meese and Rogoff (1983a)

^o Approximately in percentage terms

* These are estimated using Fair's instrumental variable technique to correct for first order serial correlation.

4.1 *The short-run*¹³

Mark and Sul using quarterly data from 1973:Q1 to 1997:Q1 investigated the short-term predictability of 19 countries' exchange rates. The numeraire countries were in turn: the US, Japan and Switzerland. They examined the panel using a one-step-ahead forecasting regression. First, they tested whether exchange rates were co-integrated with long-term determinants predicted by economic theory and found that this was indeed the case. In particular, the null hypothesis of no co-integration between the exchange rate and the monetary fundamentals was rejected by the data (the evidence was based on bootstrap 5 results from the asymptotic *t*-test, parametric and non-parametric *P*-values).¹⁴ These results appeared to be robust to the three numeraire currencies considered (US dollar, Japanese yen and Swiss franc).

Second, they examined the ability of fundamentals to forecast future exchange rate returns and found that this forecasting power for panel-based estimates was significant. Mark and Sul's panel out-of-sample regression forecasts were generated at the 1($k = 1$) and 16($k = 16$)-step-ahead and are compared with those implied by the random walk. Theil's *U*-statistic was used to measure the relative forecasting accuracy.

There are several issues to be considered when deciding to forecast using pooling data. First, one of the main disadvantages with pooling regression concerns the assumption of homogeneity between countries. In other words, pooling data across countries assumes that there is only one data-generating-process for all countries. If, however, the data-generating-process is different across countries, then pooling the data can result in an incorrect inference. Rapach and Wohar (2002), for example, tested whether the cross-country homogeneity assumptions made by Mark and Sul were justified and found that a Wald test rejected this one-data-generating process for most of the countries. Second, pooled parameter estimates are as good as the individual countries forecasts in the short term and better in the long term. Rapach and Wohar argued that it is plausible that the rejection of the homogeneity assumption might be due to omitted variables bias or measurement error.

4.2 *The long-run*

Meese and Rogoff (1983b), Mark and Chinn and Meese noticed that the performance of structural models appeared to improve over the random walk once one looks at forecast horizons greater than one year.

Meese and Rogoff (1983b) found that the RMSE for the random walk model were no longer consistently the lowest when one looked at two to three year forecast horizons.

¹³ Blomberg and Hess (1997) believed that the poor performance of the monetary model in predicting short-term movements in the exchange rate might be a result of the omission of political factors from the analysis. Blomberg and Hess derived results that showed that political economic models help to explain the short-term (1-12 months) movements of the exchange rate for three Western countries (Germany, US and UK).

¹⁴ See Mark and Sul, p 38, Table 1.

The most significant study in favor of long-term exchange rate predictability was by Mark who estimated the following monetary model:

$$s_{t+k} - s_t = \alpha_k + \beta_k [f_t - s_t] + u_t \quad (16)$$

where s_t is the log exchange rate, f_t is the fundamental monetary model equation $f_t = (m - m^*)_t - (y - y^*)_t$, α_k and β_k are parameters to be estimated and u_t is the error term. The monetary model proposed by Mark, equation (16), captured the long-term behavior of the exchange rate through an error correction mechanism (ECM). If the monetary model has some predictive power in explaining the exchange rate in the long term, β_k should be positive and different from zero. If on the other hand the model has no predictive power, then the coefficient is equal to zero and the exchange rate is unpredictable.

To bypass the coefficient bias problem that affected the majority of the empirical studies in the literature (including those of Meese and Rogoff, 1983a, b, and Mark) assessed the validity of both in-sample and out-of-sample results by using a bootstrap inference procedure.¹⁵ Twelve years after the surprising results of Meese and Rogoff (1983a), Mark's positive results in exchange rate long-term predictability led economists to refocus their attention from short-run towards long-run exchange rate predictability.¹⁶

This new wave of optimism, however, was tempered a few years later with the study of Berkowitz and Giorgianni (2001) and Faust, Rogers and Wright (2003) (see also Killian, 1999). They questioned Mark's results on the grounds that those obtained supporting long-run exchange rate predictability were driven by the particular assumptions he made on the nature of the null data generating process in the bootstrap procedure and on the sample period chosen.

Berkowitz and Giorgianni criticized Mark's implicit assumption of co-integration between the exchange rate and the macroeconomic fundamentals. This assumption implies that even though each series could be integrated of order one I(1) (stationary after differentiation) the linear combination of the series had to be stationary I(0) (the mean and the autocovariances are independent from the k horizon). In other words, even though the difference between fundamentals and exchange rate was non-stationary in the real data, the particular data generating process chosen by Mark did force this difference to be stationary. This implies that the critical values could be incorrect because they are almost certainly a product of a spurious regression.¹⁷

¹⁵ The estimated coefficients, α_k and β_k , would have been biased since the independent variable $[f-s]$, could be almost certainly highly autocorrelated.

¹⁶ Simone and Razzak (1999) examined the relationship between nominal exchange rate and interest rate differentials and provided a model of the behavior of exchange rate in the long run, where interest rates were determined in the bond market. Their model predicted that an increase in the interest rate differential appreciates the home currency. They used data on US dollar against German mark, British pound, Japanese yen and Canadian dollar and found that the first two pair of exchange rates display a strong relationship with interest rate differentials.

¹⁷ Granger and Newbold (1974).

Berkowitz and Giorgianni, exploring the possible alternative assumptions regarding the data generating process, found that Mark's results might be partially questioned. Furthermore they noted that long-horizon regressions offer no statistical power gains over short-horizons regressions thus contradicting Mark's long-run predictability results.

Following up on Mark's analysis, Faust, Rogers and Wright have extended the empirical evidence by using more than 30 periods of data spanning from 1980 to 2000 (only one period was used in Mark's study). Faust, Rogers and Wright's study reveals that Mark's results on long-run predictability were dependent on the particular data set he used in his study. Summing up, Faust, Rogers and Wright's findings suggest that most data periods give less evidence of exchange rate predictability than the one used by Mark especially for the mark and the yen.

4.3 The economy wide macro-econometric model

Isard (1987) believed that one way to counteract Meese and Rogoff's (1983a) negative results would have been to abandon the strategy of testing single equation monetary models in favor of a more complex system of equations. These were more suitable for capturing the complex nature of the economy. Gandolfo, Padoan and Paladino (1990) started by testing the forecasting performance of several structural models. They built an economy-wide macro-econometric model and tested this against several structural monetary models and the benchmark random walk. They used quarterly data on the Italian lira / US dollar exchange rate spanning from 1960:Q1 to 1987:QIV. Gandolfo, Padoan and Paladino portioned the full sample into two sub-samples: (1) 1961:Q1 to 1984:QIV and (2) 1985:Q1 to 1987:QIV. The first sub-sample was used for the in-sample estimation; the second for the out-of-sample forecasting.

Gandolfo et al. compared the out-of-sample forecasting performance of the following models with that of a benchmark random walk (RW): (1) Frenkel-Bilson (FB); Dornbusch-Frankel (DF); Hooper-Morton (HM); Hooper- Morton adjusted for risk (HM + risk); (2) The lagged version of FB; DF; HM; HM + risk; (3) The error correction forms of FB; DF; HM; HM + risk. They used the RMSE and the mean-absolute-error (MAE) evaluation criteria and both out-of-sample multi-step-ahead and rolling regression forecasting performances. Table 2 reproduces their out-of-sample multi-step-ahead forecasting results.¹⁸

The main characteristic of the multi-step-ahead technique is that the predicted value for any point of the forecasting period is always equal to the value observed in the last period of the estimation sample.¹⁹ The first column indicates the model, the second the RMSE in percentage points and the third the MAE in percentage terms.

¹⁸ See Gandolfo et al. (1990), p 104.

¹⁹ See Gandolfo et al. (1990), p 105.

Table 2
Out-of-Sample Multi-Step-Ahead Forecasting Performance (%)

Model	RMSE	MAE
FB	6.23	5.12
FB with lag	6.35	5.29
FB with lag and EC	8.61	7.41
DF	6.27	5.23
DF with lag	6.27	5.21
DF with lag and EC	8.71	7.48
HM	7.58	5.69
HM with lag	6.15	7.35
HM with lag and EC	8.82	7.37
HMR	8.29	6.73
HMR with lag	7.55	6.36
HMR with lag and EC	8.77	7.05
RW	4.76	4.00
RW multi-step-ahead	9.26	8.22

Notes: The numbers in bold denote that the structural model has a lower RMSE or MAE than the RW.

It should be stressed that Gandolfo et al. compared the multi-step-ahead out-of-sample forecasting performance of structural models both with the one-step-ahead RW and the multi-step-ahead RW. However, as pointed out by Schinasy and Swamy, the one-step-ahead RW is not the appropriate measure to use against multi-step-ahead structural models. Ignoring that measure, Table 2 reports that all structural models have a lower RMSE than the random walk. The numbers in bold denote the superiority of the structural models. Thus, structural models far outperform the multi-step-ahead random walk.

Table 3 contrasts the results of structural models with those of a benchmark RW using the out-of-sample rolling regression method.²⁰ The first column reports the model, the remaining columns the RMSE and the MAE at the three-, six- and twelve-month horizons.

²⁰ See Gandolfo et al. (1990), p 105.

Table 3
Out-of-Sample Rolling Regression Forecasting Performance (%)

Model	3 Months		Horizon 6 Months		12 Months	
	RMSE	MAE	RMSE	MAE	RMSE	MAE
FB	6.22	5.03	6.73	5.64	6.99	5.63
FB with lag	4.51	4.03	4.97	3.52	6.42	5.27
FB with lag and EC	7.11	5.74	7.16	6.32	8.23	6.86
DF	6.14	5.16	6.74	5.36	6.58	5.34
DF with lag	4.49	3.79	4.89	4.02	6.45	5.33
DF with lag and EC	7.13	5.78	7.6	6.16	9.13	7.52
HM	6.96	5.61	7.35	5.96	7.27	5.13
HM with lag	5.18	4.54	5.90	4.80	7.67	5.51
HM with lag and EC	7.36	5.81	7.75	6.19	8.75	6.95
HMR	7.46	5.98	7.84	6.34	7.59	5.46
HMR with lag	5.4	4.83	6.08	4.43	7.91	6.16
HMR with lag and EC	7.74	6.29	7.89	6.18	9.19	7.68
RW	4.48	4.18	5.29	4.07	7.65	6.05

Notes: The numbers in bold denote that the structural model has a lower RMSE or MAE than the RW.

Here the results show that the RW is generally superior to structural models at the three-month and six-month forecasting horizon, but generally inferior to them at the twelve-month forecasting horizon.

Gandolfo et al. stressed the fact that structural exchange rate models performed poorly out-of-sample, as measured by the RMSE and the MAE criteria, and that the failure of structural models to predict exchange rate movements depends on the presence of non-linearity in the data.²¹ Therefore, they estimated a wide macro-econometric model and compared the multi-step-ahead out-of-sample predictive performance of this macro-econometric model with that of the benchmark RW. They found that this systematically beats the RW and the fundamentals-based monetary models in out-of-sample-forecasts (see Table 4).²²

²¹ Meese and Rose (1990) used a variety of non-linear and non-parametric techniques in the context of structural models. Meese and Rose did not find strong evidence of non-linearity in the data. Chang and Osler (1999) reported that the common empirical departure from rationality in exchange rate forecasts can be considered as the product of non-linearity contained in the exchange rate data. They found that a non-linear pattern in recent exchange rate movements occurred when the second of three consecutive peaks is higher than the first and the third (head-and-shoulders).

²² The economy-wide macroeconometric model that Gandolfo et al. use is the MARK V version of the Gandolfo-Padoan Italian continuous time model, which consists of a simultaneous system of 24 stochastic differential equations (see Gandolfo and Padoan, 1990).

Table 4
The Out-of-Sample Predictive Performance of MARK V (%)

Model	Horizon							
	1 Month		3 Months		6 Months		12 Months	
	RMSE	MAE	RMSE	MAE	RMSE	MAE	RMSE	MAE
MARK V	2.63	1.94	2.62	2.04	2.47	2.06	2.24	2.14
RW	3.37	2.76	5.39	4.66	10.8	10.57	19.76	19.05

Notes: The numbers in bold denote that the structural model has a lower RMSE or MAE than the RW.

These results, for the Italian lira–US dollar nominal exchange rate, are quite encouraging because they weaken the Meese and Rogoff (1983a) argument that structural models cannot forecast the exchange rate movements better than a naïve RW model.

4.4 Nonlinear models

A significant number of economists believed that introducing non-linearity into exchange rate models could improve their predictions, overcoming the problem of the weak short-term relationship between exchange rates and macroeconomic fundamentals (Frankel and Froot, 1987; Taylor and Peel).²³ In particular, Taylor and Peel, using a smooth transition autoregressive model (STAR)²⁴ which implies nonlinear error correction towards long-run monetary equilibrium, investigate the ability of nonlinear exchange rate models to account for the empirical observation that exchange rates are relatively insensitive to macroeconomic fundamentals when close to their equilibrium values.²⁵ They used as their starting point the following STAR formulation.

$$z_t = \mu + \sum_{j=1}^p \pi_j [z_{t-j} - \mu] + \sum_{j=1}^p \pi_j^* [z_{t-j} - \mu] \Phi[\theta(z_{t-d} - \mu)] + u_t \quad (17)$$

where, z_t , a measure of the deviation from fundamental monetary equilibrium (e.g. $z_t \equiv s_t + [m - y]_t - [m^* - y^*]_t$), is assumed to be stationary and ergodic with $u_t \sim \text{iid } N(0, \sigma^2)$. As before, s , m and y represent the nominal exchange rate, money supply and real output. $\Phi[\theta(z_{t-d} - \mu)]$ is the transition function, assumed by Taylor and Peel (2000) to be exponential (bounded between zero and unity), which determines the degree of mean reversion and is itself governed by the parameters q and m .

Taylor and Peel, using quarterly data for the US dollar versus the UK sterling and the German mark spanning from 1973:Q1 to 1996:QIV, first tested for the presence of

²³ Baxter and Stockman showed that the transition from fixed to floating exchange rates leads to a strong increase in nominal and real exchange rate variability not followed by a similar increase in the variability of macroeconomic fundamentals. This implies that monetary models alone cannot explain the high variability of the exchange rates during the recent float. See also Flood and Rose.

²⁴ See Granger and Terasvirta (1993).

²⁵ See also Taylor, Peel and Sarno, and Kilian and Taylor.

nonlinearity in the data and selected the appropriate variables that determine the regimes. They then estimated, by nonlinear least squares, an exponential-smooth-transition-autoregressive model (ESTAR).²⁶ Taylor and Peel found statistically significant evidence of nonlinearity in the series, indicating deviations of the nominal exchange rate from the monetary fundamental equilibrium level. Results confirmed their intuition that the nonlinearity found in the data could be well approximated by an ESTAR. The parameters of this model implied near unit-root behavior for small deviations but fast adjustment for large deviations from equilibrium.

One of the main drawbacks of their paper, however, is that they did not assess the forecasting ability of their proposed ESTAR model against the benchmark random walk. In other words, the credibility of nominal exchange rate models, since the seminal work of Meese and Rogoff (1983a) is normally assessed in an out-of-sample test based on its forecasting accuracy with respect to competing models.

Kilian and Taylor, to overcome this problem, specified an ESTAR model to analyze the nonlinear dynamics of a number of real exchange rates to find out whether smooth transition dynamics provide a plausible source of increased long-horizon nominal exchange rate predictability. In other words, they tried to understand whether the documented nonlinear relationship between the nominal exchange rate and the underlying macroeconomic fundamentals may help to understand the well known difficulties in forecasting the nominal exchange rates. Kilian and Taylor's main results can be summarized as follows.

Close to the equilibrium the real exchange rate can be approximated by a random walk. This fact helps to explain the apparent success of the random walk forecasts for nominal exchange rates and it also suggests that formal statistical tests of the RW hypothesis against fundamentals based macroeconomic models may have low power in small sample sizes. The presence of ESTAR dynamics in the real exchange rate suggests that the power of the tests of the RW hypothesis against fundamentals based models should increase with a longer forecast horizon. Kilian and Taylor found strong evidence of predictability at horizons of two to three years, but not at shorter horizons. This short-horizon negative result can be explained by the small exchange rate sample size available.

Clarida, Sarno, Taylor and Valente (2003) use a non-linear model of exchange rates and utilizing a multivariate Markov-switching framework. They use weekly data on spot and forward dollar exchange rates for the G5 countries over the period January 1979 to December 1995. They then use this model to forecast dynamically out-of-sample over the period January 1996 to December 1998 and they found that their forecasts were strongly superior to the RW forecasts especially up to 52 weeks ahead.

²⁶ Taylor and Peel, to assess the validity of their results, tested that the transition function, $\Phi[\theta[Z_{t-d} - \mu]]$, can be well approximated by an exponential function rather than a logistic one (see Granger and Terasvirta).

5. Recent Studies

5.1 Microeconomic and macroeconomic explanations

There have been a number of recent theoretical attempts at trying to resolve the disconnect puzzle. These recent attempts have tried using different microeconomic and macroeconomic approaches. The work by Evans and Lyons (2005a) tackles this issue by addressing the microeconomic mechanism by which information concerning macro variances is incorporated in the exchange rate by the market. They use an asset pricing model and “order flow.”²⁷ They attempt this by expressing the log spot exchange rate, S_t , as the sum of the two terms: the present value on measured fundamentals, f_t^M , and the present value of the unmeasured fundamentals f_t^U :

$$s_t = (1-b) \sum_{i=0}^{\infty} b^i E_t f_{t+i}^M + (1-b) \sum_{i=0}^{\infty} b^i E_t f_{t+i}^U \quad (18)$$

where $0 < b < 1$ is a discount factor, E_t is the conditional expectations operator using market information in period t .

Given the lack of data to estimate (18), empirical analysis of the link between spot rates and macro variables must be based on

$$s_t = (1-b) \sum_{i=0}^{\infty} b^i \hat{E}_t f_{t+i}^M + \xi_t \quad (19)$$

where $\hat{E}_t f_{t+i}^M$ denotes the econometric estimates of market forecasts, and ξ_t represents the “unexplained” portion of the spot rate:

$$\xi_t = (1-b) \sum_{i=0}^{\infty} b^i E_t f_{t+i}^U + (1-b) \sum_{i=0}^{\infty} b^i (E_t - \hat{E}_t) f_{t+i}^M \quad (20)$$

Equation (20) shows that the movements in ξ_t could originate from variations in the present value of unobserved fundamentals. An alternative approach is suggested by the second term in (20). Differences between the market’s forecasts of measured fundamentals and econometric estimates of these forecasts could also account for the large movements in ξ_t . The approach thus focuses on the gap between the information sets of the econometrician and the market. They conclude that “(1) transaction flows forecast future exchange rates changes and do so more effectively than forward discounts; (2) transaction flows forecast subsequent macroeconomic variables such as money growth, output growth, and inflation, and (3) in cases where transaction flows convey significant new information about future fundamentals, much of this information is still not impounded in the exchange rate itself three months later.”²⁸

²⁷ Killeen, Lyons and Moore (2006) also use order flow. This is, spot returns are determined by foreign exchange order flows and they examine exchange rate volatility. “Order flow is signed volume; seller-initiated trades are negative order flow and buyer-initiated trades are positive order flow” (p 1).

²⁸ Evans and Lyons (2005a), p 3. Sarno (2005) also discusses inter alia the exchange rate disconnect puzzle and is optimistic about a solution.

The gap between the information sets of the econometrician and the market is similar to the approach by Engel and West (2005). Whereas Engel and West argue that the spot rate has forecasting power for future measures of fundamentals, Evans and Lyons argue that it is transaction flows which carry information useful in forecasting future fundamentals and this information is incremental to the information contained in observed macro variables used in econometric estimates.

The model used by Engel and West also use an asset-pricing model in which the exchange rate is the expected present discounted value of a linear combination of observable and unobservable shocks. They demonstrates that in this type of model, as asset price manifests random walk behavior if fundamentals are integrated of order I (1) and the discount factor for future fundamentals in one. This assumption implies that as the discount factor approaches one, more weight is placed on future fundamentals in explaining the asset price. They first set up the following asset price equation where s_t is the asset price:

$$s_t = (1-b) \sum_{j=0}^{\infty} b^j E_t(a'_1 x_{t+j}) + b \sum_{j=0}^{\infty} b^j E_t(a'_2 x_{t+j}), \quad 0 < b < 1, \quad (21)$$

where x_t is the $n \times 1$ vector of fundamentals, b is a discount factor, and a_1 and a_2 are $n \times 1$ vectors.

They then relate the exchange rate to economic fundamentals and to the expected future exchange rate as:

$$s_t = (1-b)(f_{1t} + z_{1t}) + b(f_{2t} + z_{2t}) + bE_t s_{t+1} \quad (22)$$

where here the exchange rate s_t is defined as the log of the home currency price of foreign currency. The terms f_{it} and z_{it} ($i = 1, 2$) are economic fundamentals that ultimately drive the exchange rate, such as money supplies, money demand shocks, productivity shocks, and so forth, where f_{it} are fundamentals that are observable to the econometrician and z_{it} those that are not observable. Note the similarity to equations (18) and (19) of Evans and Lyons above.

They then consider a series of monetary models to test their model and conclude (1) that exchanges rates may incorporate information about future fundamentals, (2) under some empirically plausible assumptions, the inability to forecast exchange rates is a natural implication of the model, (3) that innovation in exchange rates are highly correlated with news about future fundamentals, (4) exchange rates can help forecast future fundamentals and finally that exchange rate fundamentals are linked in a way that is broadly consistent with asset-pricing models of the exchange rate.²⁹ Their conclusions, therefore, provide a counterbalance to the results initiated by Meese and Rogoff (1983a, 1983b) and confirmed later by others.

²⁹ Evans and Lyons (2005c) extend the Engel and West analysis by focusing on exchange rate dynamics that come from expectational surprise. They argue that types of non-public information may exist that should be useful for forecasting exchange rate surprises. By exchange rate surprises they mean changes that cannot be explained based on measures of public information.

In a related study Evans and Lyons (2005b) propose combining the micro and macro approaches by embedding a micro process of information aggregation into a macro dynamic general equilibrium setting. They use a micro level model and forecast over horizons from one day to one month concluding that their findings are consistent with the exchange rate being driven by standard fundamentals. Bacchetta and van Wincoop (2005) introduce a similar idea to that of Evans and Lyons by making the assumption of heterogeneous information. That is, they introduce “symmetric information dispersion about future fundamentals in a dynamic expectations model”. They conclude, *inter alia*, that over long horizons, the exchange rate is closely related to observed fundamentals.³⁰

Another aspect of the disconnect puzzle that has attracted recent attention is the approach by Dekle, Jeong and Ryoo (2005), Dekle and Ryoo (2004) and Fitzgerald (2004). This approach by Dekle et al. (2005) uses firm level data to try and explain the relationship between export volumes and exchange rates. They set out a simple macroeconomic model and show that an appreciation of the exchange rate reduces export volumes at the firm level. They then show that by aggregating in a consistent manner, the relationship remains significant at the aggregate level. In order to aggregate consistently they argue that it is important to include variables representing firm level heterogeneity such as firm-specific import shares and productivity. The inclusion of these variables results in the correct sign for the relationship between exchange rates and exports. Although their model is partial in nature, it does suggest that in a general equilibrium model, the inclusion of firm level heterogeneities in productivity and its relationship to a firms export shares if included may provide a solution to the disconnect puzzle. In an earlier study, Dekle and Ryoo (2004) estimate a structural model of the exporting firm using Japanese firm level data from 1982 to 1997 and find a large elasticity of export volumes to the exchange rate in many industries.

The approach by Fitzgerald (2004) is to analyze the effect of trade costs on the feedback from exchange rates to inflation and concludes that trade costs can explain why exchange rate volatility does not feed back to inflation. Other explanations for this lack of feedback include sticky prices, pricing to market and distribution costs but Fitzgerald argues that the trade costs hypothesis has many advantages over these other explanations. Trade costs exist and are economically important, they are as valid for large changes as for small changes and are relatively easy to calibrate using a gravity model.³¹

5.2 Parameter instability

Rossi (2006) address the problem of model selection between economic models of exchange rate determination and the random walk using optimal tests for nested models in the presence of parameter instability. The advantage of these tests, over those commonly

³⁰ In an earlier paper, Devereux and Engel argue that exchange rate volatility is due to (a) incomplete international financial markets, (b) international pricing structure and product distribution such that the wealth effects of exchange rate changes are minimized, and (c) stochastic deviations from uncovered interest rate parity.

³¹ The paper by Moore and Roche (2006) and the earlier Moore and Roche (2002) introduces a consumption externality with habit persistence to resolve the exchange rate disconnect puzzle.

used in the literature, is that these can be used to jointly tests for both a “null hypothesis on the parameters” and “parameter instability”, and thus can be applied to investigate whether given model is a good description of the data and whether this relationship is stable over time.³²

Rossi (2006) motivates the use of the optimal tests as follows. Testing in-sample whether the exchange rate in levels is a random walk (and thus its rate of growth, defined as x_{1t} , is unpredictable) against the possibility that x_{1t} can be explained by the lagged values of the rates of growth of some fundamentals x_{2t-1} requires to compare the following two models and test the null of $\beta = 0$ versus the alternative that the parameters are different from zero ($\beta \neq 0$):

$$\text{Model 1: } x_{1t} = \varepsilon_t$$

$$\text{Model 2: } x_{1t} = x_{2t-1}\beta + \varepsilon_t$$

where ε_t is unforecastable, model 1 is the random walk and model 2 is the economic model.

The null hypothesis could be tested using an in-sample likelihood ratio test. But if the test does not reject the null hypothesis, so that b is not significantly different from zero, does this imply that the random walk is the best description of the data? Meese and Rogoff (1983b) suggested that when in-sample tests are not reliable because of parameter instability, out-of-sample tests should be used instead, however, the out-of-sample tests still favor the random walk. Rossi (2006) suggests that if the relationship between the exchange rate and the fundamentals is very unstable over time, the true comparison should be done on the following two models:

$$\text{Model 1: } x_{1t} = \varepsilon_t$$

$$\text{Model 2': } x_{1t} = x_{2t-1}\beta_t + \varepsilon_t$$

where the parameter β is now indexed by t to imply that can be time-varying. Thus, the random walk model is imposing two restrictions: first, parameters are constant over time, i.e. $\beta_t = \beta$; second, parameters are equal to zero, i.e. $\beta = 0$. Rossi (2006) proposes an in-sample test for this joint hypothesis employing four model of exchange rates using monthly data from 1973:3 to 1998:12 for Canada, France, Germany, Italy and Japan versus the US:³³

³² The commonly used tests for model selection such us the Likelihood Ratio Tests fail to detect parameter instability, while tests for parameter instability are not designed to choose between nested models. Out-of-sample tests are, however, a robust way of choosing between two models in the presence of parameter instability, but these do not have the highest asymptotic local power for the joint null hypothesis of interest. Optimal tests, on the other hand, have the highest asymptotic local power (see Rossi, 2005).

³³ Rossi considers the following four tests: (i) Likelihood Ratio Test; (ii) Tests for time-varying parameters; (iii) Optimal tests for model specification and time-varying parameters, and (iv) Out-of- sample tests.

$$e_t = \beta_{1,t-1} + \beta_{2,t}e_{t-1} + \beta_{3,t}m_{t-1} + \beta_{4,t}y_{t-1} + \beta_{5,t}i_{t-1} + \varepsilon_t \quad (\text{ARX}(1))$$

$$e_t = \beta_{1,t-1} + \beta_{2,t}e_{t-1} + \beta_{3,t}e_{t-2} + \beta_{4,t}m_{t-1} + \beta_{5,t}y_{t-1} + \beta_{6,t}i_{t-1} + \beta_{7,t}m_{t-2} + \beta_{8,t}y_{t-2} + \beta_{9,t}i_{t-2} + \varepsilon_t \quad (\text{ARX}(2))$$

$$e_t = \beta_{1,t-1} + \beta_{2,t}e_{t-1} + \varepsilon_t \quad (\text{AR}(1))$$

$$e_t = \beta_{1,t-1} + \beta_{2,t}e_{t-1} + \beta_{3,t}e_{t-2} + \varepsilon_t \quad (\text{AR}(2))$$

where e_t is the rate of growth of the bilateral nominal exchange rate, m_t is the rate of growth of the money ratio (with the US variable is in the denominator), y_t is the rate of growth of the real output ratio (with the US variable is in the denominator), i_t is the first difference of the difference between each country nominal short-term interest rate relative to the US. Fundamentals are lagged, parameters are indexed by t to imply that can be time-varying. The models ARX(1) and ARX(2) are used to assess the relationship of the rate of growth of the exchange rate with the rate of growth of its lags (1 or 2) and the rate of growth of its lagged fundamentals (1 or 2). The models AR(1) and AR(2) differ from those above because the fundamentals are dropped.³⁴

Rossi (2006) finds that, for some currencies, optimal tests that are robust to parameter instability do reject the hypothesis that a random walk is the best description of the data.³⁵ This may imply that economic models were previously rejected not because the fundamentals are completely unrelated to exchange rate fluctuations, but because the relationship is unstable over time and, thus difficult to capture by Granger Causality tests or by forecast comparisons. This would explain why, although economic models exploit the information contained in other economic series, they nevertheless do not forecast better than a random walk. Rossi also finds that “by estimating both the random walk time-varying parameter model and a forecast combination model designed to improve forecasts in the presence of structural breaks” the latter methods are capable of improving forecasts relative to the random walk”.³⁶

Abhyankar, Sarno and Valente adopt a new approach to the debate on monetary models versus random walk.³⁷ They argue that what is important is the predictive power of monetary fundamentals for the exchange rate and use the concept of economic value or utility-based value to an investor relying on the model to allocate her wealth between two identical assets except for the currency of denomination. This criterion is just as important as the statistical measure of forecast accuracy such as root mean squared

³⁴ See Rossi (2006), p 10.

³⁵ See Rossi (2006), Tables (1)–(3). Even though out-of-sample tests do not reject that the random walk forecasts are better.

³⁶ While Guo and Savickas (2005) in their study found strong evidence against the random walk hypothesis of exchange rate, they concluded that the US idiosyncratic stock market volatility was a powerful prediction of the US\$ exchange rate against most currencies.

³⁷ West et al. (1993) also focused on a utility-based metric of forecast evaluation rather than the conventional statistical criteria.

error. They quantify this economic value and then compare it to that of an investor using a naïve RW model. They conclude that the gain from using a fundamentals model is positively related to the investment horizon and inversely related to the level of risk aversion.

In summary, a series of alternative theoretical and empirical explanations have been offered in the recent literature and provide an alternative resolution to the disconnect puzzle.

6. Conclusions

This review, although selective, provides the reader with a sense of the richness of the literature and the considerable advances in our understanding of exchange rate determinants that has emerged. The early empirical studies were largely of the monetary models. Examples include those of Frenkel; Bilson, and Hodrick. Later, the paper of Meese and Rogoff (1983a) shook the academic community. They showed that fundamentals based monetary models were unable to out-perform the benchmark random walk model in out-of-sample forecasts.

It was over 10 years before the Meese and Rogoff (1983a) results were convincingly overturned. One of the most important studies was that of Mark (1995) who found evidence in favor of long-run exchange rate predictability. The Mark's study shifted the attention of the researchers towards long-term predictability. However, this new wave of optimism was tempered by the work of Kilian (1999), Berkowitz and Giorgianni, and Faust, Roger and Wright who questioned the underlying assumptions of the analysis, namely, a) the stationarity of the data, and b) the robustness of the sample period. These misgivings about the long-term predictability of exchange rates had led some economists to refocus their attention with some success on short-term predictability. Mark and Sul (2001), for example, using one-step-ahead panel data for 19 countries, obtained encouraging results.

Another promising area of research was the investigation of non-linear exchange rate models. Taylor and Peel, and Kilian and Taylor, for example, using exponential smooth transition autoregressive models, shed some light on the exchange rates fundamentals disconnection puzzle while Clarida, Sarno, Taylor and Valente use a non-linear model with a multivariate Markov-switching framework. More recent theoretical work on exchange rate determination include those adopting a microeconomic structure such as Evans and Lyons (2005a, 2005b), Bacchetta and van Wincoop (2005), Dekle, Jeong and Ryoo, and Fitzgerald (2004), a utility-based new open economy macroeconomic framework like Devereux and Engel, a rational expectations present value model such as Engel and West. The use of asset pricing models and microeconomic explanations such as heterogeneous information, consumption externality and habit persistence, have been used to resolve the disconnect puzzle.

Other empirical attempts at supporting the use of macro models to predict nominal exchange rates include Rossi (2005, 2006) who argues that if you adjust the models for parameter instability, it is a good predictor and Guo and Savickas who use aggregate idiosyncratic volatility to generate good predictions. This latest theoretical and empirical research supports the idea that fundamental economic variables are likely to influence

exchange rates especially in the long run and further that the emphasis should change to the economic-value or utility-based value to assess these macroeconomic models.³⁸

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³⁸ Laganà and Sgro (2006) show in their paper that some simple monetary models, with imperfect capital markets, can out-perform the random walk model.

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