

The Exchange Rate Forecasting Puzzle

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Abstract

We survey and update the empirical literature concerning the predictability of nominal exchange rates using structural macroeconomic models over the recent floating exchange rate period. In particular, we consider both flexible and sticky price versions of the monetary model of nominal exchange rate determination. In agreement with the existing empirical literature, we find that nominal exchange rate movements are difficult to forecast, with a random walk generally dominating the monetary model in terms of predictive accuracy conditional on observed monetary fundamentals at all horizons.

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1. Introduction

There exists a vast empirical literature concerning the predictability of nominal exchange rates using structural macroeconomic models over the recent floating exchange rate period. The general conclusion of this literature is that nominal exchange rate movements are difficult to forecast at short horizons, although there exists some evidence of long horizon predictability. The most influential negative empirical evidence was documented by Meese and Rogoff (1983a, 1983b), who evaluated the forecasting performance of a variety of structural macroeconomic models of nominal exchange rate determination. Their primary result was that no existing structural model could consistently outforecast the naïve alternative of a random walk at short horizons, even when forecasts were generated conditional on observed macroeconomic fundamentals. It follows that nominal exchange rate movements are difficult to rationalize on the basis of movements in macroeconomic fundamentals, even retrospectively. This exchange rate forecasting puzzle has never been decisively resolved despite numerous attempts to do so,

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and a random walk has since become the standard benchmark for evaluating the forecasting performance of structural models of nominal exchange rate determination.

At the time Meese and Rogoff (1983a, 1983b) conducted their forecast performance evaluation exercise, the principal structural model of nominal exchange rate determination was the monetary model, which remains influential in the analysis of target zones and balance of payments crises. The monetary model of nominal exchange rate determination consists of conditions characterizing equilibrium in the money, bond, and output markets. In the version of the monetary model developed by Frenkel (1976) and Mussa (1976), output market equilibrium is characterized under flexible prices, while the version of the monetary model developed by Dornbusch (1976) postulates output market equilibrium conditions under sticky prices.

We survey and update the empirical literature concerning the predictability of nominal exchange rates using structural macroeconomic models over the recent floating exchange rate period. In particular, we consider both flexible and sticky price versions of the monetary model of nominal exchange rate determination. In agreement with the existing empirical literature, we find that nominal exchange rate movements are difficult to forecast, with a random walk generally dominating the monetary model in terms of predictive accuracy conditional on observed monetary fundamentals at all horizons. This empirical disconnect between nominal exchange rate movements and movements in monetary fundamentals is consistent with the exchange rate forecasting puzzle. That the forecasting performance of the sticky price monetary model generally dominates that of its flexible price counterpart illustrates the empirical relevance of short run nominal price rigidities.

The organization of this paper is as follows. The next section develops flexible and sticky price versions of the monetary model. The empirical literature on the predictability of nominal exchange rates conditional on monetary fundamentals is surveyed and updated in section three. Finally, section four offers conclusions and recommendations for further research.

2. The Monetary Model

The monetary model of nominal exchange rate determination is based on the hypothesis that, since the nominal exchange rate is the relative price of two currencies, it should be determined by the relative supply of and demand for those currencies. Although the monetary model is ad hoc, many of its predictions are broadly consistent with those of open economy dynamic stochastic general equilibrium models based on rigorous microeconomic foundations under flexible or sticky prices.

The monetary model consists of three building blocks. The first is a transactions demand based characterization of money market equilibrium

$$m_t - p_t = \phi y_t - \eta i_t, \quad (1)$$

where m_t denotes the logarithmic money supply, p_t denotes the logarithmic price level, y_t denotes logarithmic real output, and i_t denotes the short term nominal interest rate. It is traditional to assume that a structurally symmetric relationship characterizes money market equilibrium in the foreign economy

$$m_t^* - p_t^* = \phi y_t^* - \eta i_t^*, \quad (2)$$

where variables with asterisks denote the foreign analogues of their domestic counterparts. The real output elasticity of real money demand $0 < \phi \leq 1$ and the nominal interest rate semi-elasticity of real money demand $\eta > 0$ are traditionally assumed to coincide across the domestic and foreign economies. Under these assumptions, combination of domestic and foreign money market equilibrium conditions (1) and (2) yields:

$$(m_t - p_t) - (m_t^* - p_t^*) = \phi(y_t - y_t^*) - \eta(i_t - i_t^*). \quad (3)$$

According to this result, relative demand for real money balances is increasing in the real output differential, and is decreasing in the nominal interest rate differential.

The second building block of the monetary model is an arbitrage based characterization of bond market equilibrium. Under the assumption that domestic and foreign bonds are perfect substitutes, equilibrium in the domestic and foreign bond markets is characterized by approximate uncovered interest parity condition

$$i_t - i_t^* = E_t(\Delta s_{t+1}), \quad (4)$$

where s_t denotes the logarithmic nominal exchange rate, expressed as the domestic currency price of foreign currency. Combination of this approximate uncovered interest parity condition with result (3) yields first order stochastic linear difference equation

$$s_t = \frac{1}{\eta} [(m_t - p_t) - (m_t^* - p_t^*) - \phi(y_t - y_t^*)] + E_t(s_{t+1}), \quad (5)$$

which implies that the expected future value of the nominal exchange rate is embodied in the current nominal exchange rate. According to this result, the domestic currency depreciates in response to an increase in the real money supply differential, and appreciates in response to an increase in the real output differential.

The third building block of the monetary model is a set of equilibrium conditions associated with the output market. The two versions of the monetary model differ according to whether these output market equilibrium conditions are postulated under flexible or sticky prices, and according to whether output is exogenously or endogenously determined.

2.1. The Monetary Model Under Flexible Prices

In the version of the monetary model developed by Frenkel (1976) and Mussa (1976), prices are flexible and output is exogenously determined. In the absence of transport costs, trade barriers and noncompetitive market structures, output market equilibrium is characterized by relative purchasing power parity condition

$$s_t + p_t^* - p_t = \bar{q}, \quad (6)$$

which implies a constant logarithmic real exchange rate $q_t \equiv s_t + p_t^* - p_t$. Combination of this relative purchasing power parity condition with result (3) yields:

$$s_t = \bar{q} + (m_t - m_t^*) - \phi(y_t - y_t^*) + \eta(i_t - i_t^*). \quad (7)$$

Empirical evaluation of the flexible price monetary model is generally based on a linear regression model which nests this predicted relationship.

The flexible price monetary model can account for the excess volatility of the nominal exchange rate relative to the volatility of monetary fundamentals. Combination of result (5) with relative purchasing power parity condition (6) yields first order stochastic linear difference equation:

$$s_t = \bar{q} + (m_t - m_t^*) - \phi(y_t - y_t^*) + \frac{\eta}{1+\eta} E_t(s_{t+1}). \quad (8)$$

Recursive forward substitution applying the law of iterated expectations reveals that the nominal exchange rate is increasing in current and expected future money supply differentials, and is decreasing in current and expected future real output differentials:

$$s_t = E_t \sum_{s=t}^{\infty} \left(\frac{\eta}{1+\eta} \right)^{s-t} [\bar{q} + (m_s - m_s^*) - \phi(y_s - y_s^*)]. \quad (9)$$

The derivation of this result, which emphasizes that the nominal exchange rate is an asset price, imposes a transversality condition ruling out speculative asset price bubbles.

Empirically, nominal and real exchange rates are both very volatile in the short run, while real exchange rates exhibit long run mean reversion. It follows that relative purchasing power parity is an empirically invalid characterization of output market equilibrium in the short run, and only characterizes long run output market equilibrium. This empirical evidence motivates the extension of the monetary model to allow for short run nominal price rigidities.

2.2. The Monetary Model Under Sticky Prices

The monetary model was extended to allow for short run nominal price rigidities and endogenous output determination by Dornbusch (1976), who rationalized the empirical tendency of the nominal exchange rate to overshoot adjustments in its long run equilibrium value. Further variations on the sticky price monetary model were provided by Frankel (1979), Mussa (1979), and Buitier and Miller (1982).

Output market equilibrium in the sticky price monetary model is characterized by an aggregate demand relationship incorporating an expenditure switching mechanism, and an aggregate supply relationship capturing short run nominal price rigidities. The output gap is modeled as an increasing function of the real exchange rate gap according to aggregate demand relationship

$$y_t - \bar{y}_t = \delta(q_t - \bar{q}), \quad (10)$$

where \bar{y}_t denotes logarithmic real output under flexible price equilibrium, and \bar{q} denotes the constant logarithmic real exchange rate under flexible price equilibrium. Inflation is modeled as an increasing function of the output gap according to aggregate supply relationship

$$\Delta p_t - \Delta \tilde{p}_t = \psi(y_{t-1} - \bar{y}_{t-1}), \quad (11)$$

where $\tilde{p}_t \equiv s_t + p_t^* - \bar{q}$ denotes the logarithmic price level that would prevail if the output market cleared. Combination of aggregate demand relationship (10) with aggregate supply relationship (11) yields first order deterministic linear difference equation:

$$\Delta q_t = -\psi\delta(q_{t-1} - \bar{q}). \quad (12)$$

The sticky price monetary model nests the flexible price monetary model for $\delta = 0$ or $\psi = 0$, and allows for short run deviations from relative purchasing power parity for $\delta > 0$ and $\psi > 0$. Combination of result (3) with first order deterministic linear difference equation (12) yields:

$$\Delta s_t = (\Delta m_t - \Delta m_t^*) - \phi(\Delta y_t - \Delta y_t^*) + \eta(\Delta i_t - \Delta i_t^*) - \psi\delta(q_{t-1} - \bar{q}). \quad (13)$$

Empirical evaluation of the sticky price monetary model is generally based on a linear error correction model which nests this predicted relationship.

The sticky price monetary model offers an unambiguous prediction concerning the direction of the relationship between the real exchange rate and the real interest rate differential. Approximate uncovered interest parity condition (4) implies:

$$[i_t - E_t(\Delta p_{t+1})] - [i_t^* - E_t(\Delta p_{t+1}^*)] = E_t(\Delta q_{t+1}). \quad (14)$$

Combination of this result with first order deterministic linear difference equation (12) yields:

$$[i_t - E_t(\Delta p_{t+1})] - [i_t^* - E_t(\Delta p_{t+1}^*)] = -\psi\delta(q_t - \bar{q}). \quad (15)$$

According to this result, the degree of real depreciation of the domestic currency is inversely related to the real interest rate differential.

3. Empirical Evaluation of the Monetary Model

The recent floating exchange rate period is characterized by a number of empirical stylized facts first documented by Mussa (1979). The logarithmic nominal exchange rate approximately follows a random walk, with most nominal exchange rate movements being unanticipated. Furthermore, high rates of inflation are associated with currency depreciation, at a rate approximately equal to the inflation rate differential in the long run. Finally, nominal and real

exchange rates are both very volatile relative to macroeconomic fundamentals in the short run, with the nominal exchange rate tending to overshoot adjustments in its long run equilibrium value.

We survey and update the empirical literature concerning the predictability of nominal exchange rates using structural macroeconomic models over the recent floating exchange rate period. Given the empirical stylized facts associated with this period, it should come as no surprise that nominal exchange rate movements are difficult to forecast conditional on monetary fundamentals.

3.1. Literature Review

Following initial claims of success, serious empirical deficiencies of the monetary model of nominal exchange rate determination emerged, except perhaps under conditions of hyperinflation. Early empirical evaluations such as Frenkel (1976), Bilson (1978), and Hodrick (1978) documented poor within sample empirical performance of the flexible price monetary model, with parameter estimates frequently exhibiting statistically significant departures from theoretical restrictions, and with goodness of fit statistics indicating the existence of much unexplained variation in nominal exchange rates. Early empirical evaluations of the sticky price monetary model such as Backus (1984) also reported negative results within sample.

Numerous empirical studies have attempted to detect the relationship between the real exchange rate and the real interest rate differential predicted by the sticky price monetary model, generally with limited success. The null hypothesis of no cointegration between the real exchange rate and the real interest rate differential could not be rejected by Meese and Rogoff (1988). Evidence that movements in real interest rate differentials have been neither sufficiently large nor sufficiently persistent to explain movements in real exchange rates was documented by Cambell and Clarida (1987). Cointegration tests and error correction mechanisms that controlled for additional explanatory variables were applied by Edison and Pauls (1993), again with generally negative results. However poorly the sticky price monetary model performs in predicting the relationship between the real exchange rate and the real interest rate differential, its performance in forecasting the nominal exchange rate can only be described as worse, although it is not clear that a superior structural forecasting model exists.

In a very influential empirical study, Meese and Rogoff (1983a) evaluated the out of sample forecasting performance of a variety of structural macroeconomic models of nominal exchange rate determination, including variants of the flexible and sticky price monetary model. They found that no structural model could consistently outforecast the naïve alternative of a random

walk at short horizons, even when forecasts were generated conditional on observed macroeconomic fundamentals. It follows that nominal exchange rate movements are difficult to rationalize on the basis of movements in monetary fundamentals, even retrospectively. This seminal contribution permanently shifted the focus of empirical studies of nominal exchange rate determination from within sample goodness of fit to out of sample forecast performance evaluation.

As noted by Neely and Sarno (2002), this exchange rate forecasting puzzle has withstood numerous attempts to resolve it. The reasons underlying such poor empirical performance of the monetary model are not yet fully understood. A variety of explanations were proposed by Meese and Rogoff (1983b), including instability of money demand functions and prolonged deviations from relative purchasing power parity. Other researchers such as Frankel (1996) have argued that nominal exchange rate movements are detached from monetary fundamentals by volatile expectations and departures from rationality. Nevertheless, Meese and Rogoff (1983b) did find some evidence of long horizon nominal exchange rate predictability conditional on observed monetary fundamentals. This evidence was corroborated by Chinn and Meese (1995) and Mark (1995), who documented statistically significant forecasting power of monetary models over a random walk at long horizons.

In attempts to uncover evidence of nominal exchange rate predictability conditional on monetary fundamentals at short horizons, relatively sophisticated econometric models have been employed. Monetary fundamentals were incorporated into nonlinear and nonparametric models of nominal exchange rate determination by Meese and Rose (1990), who found little or no evidence of nonlinearity. Time varying parameter models were employed by Wolff (1987, 1988), Schinasi and Swamy (1989), and Canova (1993) in order to accommodate parameter instability in monetary models, with generally negative results. More recently, monetary fundamentals were incorporated into panel regression models by Groen (2000) and Mark and Sul (2001), with mixed results.

3.2. Literature Update

In an extension of the forecast performance evaluation exercises of Groen (2000) and Mark and Sul (2001), we evaluate both flexible and sticky price versions of the monetary model within a panel regression framework. In the absence of model misspecification, pooling information across numerous countries within a panel regression framework generates efficiency gains in estimation, increasing forecasting power.

3.2.1. The Flexible Price Monetary Model

Our empirical evaluation of the flexible price monetary model is based on panel regression model

$$s_{i,t} = \bar{q}_i + (m_{i,t} - m_t^*) - (y_{i,t} - y_t^*) + \eta(i_{i,t} - i_t^*) + \varepsilon_{i,t}, \quad (16)$$

where $E(\varepsilon_{i,t}) = 0$ and $E(\varepsilon_{i,t}^2) = \sigma_i^2$. Comparison with result (7) reveals that the real output elasticity of real money demand ϕ has been restricted to equal one.

We estimate panel regression model (16) by the generalized method of moments for nineteen industrialized countries over the period 1973Q1 through 1997Q4. Details concerning the countries considered and the time series employed are contained in the appendix. The estimated nominal interest rate semi-elasticity of real money demand is 1.772, with a heteroskedasticity and autocorrelation consistent standard error of 0.502. This estimated elasticity is economically plausible and statistically significant at conventional levels, while the model passes a test of its overidentifying restrictions.

A necessary condition for the generalized method of moments to consistently estimate panel regression model (16) is the existence of cointegration between the logarithmic nominal exchange rate and its monetary fundamental. While there are prolonged periods during which the logarithmic nominal exchange rate deviates from its estimated monetary fundamental, Figure 1 suggests that these variables exhibit common stochastic trends.

Our evaluation of the flexible price monetary model is based on a recursive forecast performance evaluation exercise employing an expanding estimation sample, conditional on observed monetary fundamentals. The forecasting performance of the monetary model is measured relative to that of a random walk over a holdout sample of size M at various horizons $h \leq H$ on the basis of the U statistic due to Theil (1966), which equals the ratio of root mean square prediction errors:

$$U_{i,h} = \frac{\sqrt{\frac{1}{M-H+1} \sum_{j=0}^{M-H} (\hat{s}_{i,T-M+h+j|T-M+j} - s_{i,T-M+h+j})^2}}{\sqrt{\frac{1}{M-H+1} \sum_{j=0}^{M-H} (s_{i,T-M+j} - s_{i,T-M+h+j})^2}}. \quad (17)$$

If $U_{i,h} < 1$ then the forecasting performance of the monetary model dominates that of a random walk for country i at horizon h , while if $U_{i,h} > 1$ then the monetary model is dominated by a random walk for country i at horizon h in terms of predictive accuracy.

Figure 1. Logarithmic nominal exchange rates versus estimated monetary fundamentals



Note: Logarithmic nominal exchange rates are represented by solid lines while dashed lines depict estimated fundamentals.

The results of this forecast performance evaluation exercise over the period 1988Q1 through 1997Q4 are reported in Table 1. Consistent with the exchange rate forecasting puzzle, we find

overwhelming evidence that the forecasting performance of the flexible price monetary model is dominated by that of a random walk conditional on observed monetary fundamentals at all horizons.

Table 1. Forecast performance evaluation of flexible price monetary model versus random walk

Country	Forecast Horizon									
	2	4	6	8	10	12	14	16	18	20
Australia	3.001	3.099	3.759	4.007	4.371	5.302	5.565	5.929	6.368	6.344
Austria	3.137	3.822	4.823	7.515	6.766	6.570	6.891	7.659	7.503	7.207
Belgium	1.529	2.016	2.906	4.917	4.797	4.838	5.337	5.950	6.079	6.160
Canada	1.902	2.127	2.316	2.548	2.793	3.160	3.573	4.361	4.902	4.778
Denmark	2.463	2.905	3.568	5.377	5.269	5.092	5.272	5.968	5.724	5.272
Finland	2.792	2.257	2.002	1.940	1.902	1.817	1.656	1.479	1.220	0.959
France	0.856	0.971	1.171	1.786	2.359	2.782	3.147	3.836	3.679	3.491
Germany	2.886	3.705	4.816	7.546	7.383	7.435	8.081	9.378	9.179	8.688
Greece	0.664	0.617	0.594	0.636	0.679	0.691	0.711	0.758	0.754	0.736
Italy	1.584	1.424	1.323	1.283	1.148	1.046	0.973	0.954	0.823	0.597
Japan	3.976	4.227	4.183	4.321	4.088	4.263	4.408	4.549	4.611	4.622
Korea	0.901	1.097	1.524	2.456	3.742	5.321	7.834	10.614	6.574	1.707
Netherlands	2.455	3.001	3.734	5.751	5.514	5.422	5.733	6.546	6.267	5.727
Norway	1.023	1.012	0.977	0.915	0.984	1.002	0.982	0.923	0.855	0.713
Spain	4.343	3.901	3.601	3.641	3.668	3.759	3.726	3.577	3.050	2.533
Sweden	1.148	0.913	0.800	0.720	0.714	0.693	0.644	0.617	0.566	0.532
Switzerland	1.737	1.923	2.339	3.135	3.792	4.047	4.452	5.317	5.426	5.175
United Kingdom	1.469	1.301	1.246	1.164	1.131	1.084	1.037	0.995	0.979	0.981
Mean	2.104	2.240	2.538	3.314	3.394	3.574	3.890	4.412	4.142	3.679
Median	1.820	2.072	2.327	2.841	3.705	3.903	4.067	4.455	4.756	4.056

Note: Table entries are U statistics.

3.2.2. The Sticky Price Monetary Model

Our empirical evaluation of the sticky price monetary model is based on panel error correction model

$$\Delta s_{i,t} = (\Delta m_{i,t} - \Delta m_t^*) - (\Delta y_{i,t} - \Delta y_t^*) + \eta(\Delta i_{i,t} - \Delta i_t^*) - \alpha(q_{i,t-1} - \bar{q}_i) + \varepsilon_{i,t}, \quad (18)$$

where $E(\varepsilon_{i,t}) = 0$ and $E(\varepsilon_{i,t}^2) = \sigma_i^2$. Comparison with result (13) reveals that the real output elasticity of real money demand ϕ has been restricted to equal one. The speed of adjustment towards long run equilibrium is determined by $\alpha = \psi\delta$.

We estimate panel error correction model (18) by the generalized method of moments for nineteen industrialized countries over the period 1973Q2 through 1997Q4. The estimated nominal interest rate semi-elasticity of real money demand is 0.999, with a heteroskedasticity and autocorrelation consistent standard error of 0.326. Our estimate of the speed of adjustment parameter is 0.027, with a heteroskedasticity and autocorrelation consistent standard error of 0.011. Both of these parameter estimates are economically plausible and statistically significant at conventional levels, while the model passes a test of its overidentifying restrictions.

While there are prolonged periods during which the logarithmic nominal exchange rate deviates from its estimated purchasing power parity fundamental, Figure 2 suggests that these variables are cointegrated. That departures from relative purchasing power parity appear to be stationary is encouraging, as satisfaction of relative purchasing power parity is a necessary condition for the generalized method of moments to consistently estimate panel error correction model (18).

The results of a forecast performance evaluation exercise over the period 1988Q1 through 1997Q4 are reported in Table 2. In agreement with the exchange rate forecasting puzzle, we find abundant evidence that the forecasting performance of the sticky price monetary model is dominated by that of a random walk conditional on observed monetary fundamentals at all horizons. A comparison between the results reported in Table 1 and Table 2 reveals that the sticky price monetary model generally dominates its flexible price counterpart in terms of predictive accuracy, illustrating the empirical relevance of short run nominal price rigidities.

Figure 2. Logarithmic nominal exchange rates versus estimated purchasing power parity fundamentals



Note: Logarithmic nominal exchange rates are represented by solid lines while dashed lines depict estimated fundamentals.

Table 2. Forecast performance evaluation of sticky price monetary model versus random walk

Country	Forecast Horizon									
	2	4	6	8	10	12	14	16	18	20
Australia	1.148	1.655	2.053	2.447	2.776	3.226	3.136	3.075	3.107	2.779
Austria	1.098	1.221	1.724	2.040	2.138	2.287	2.567	2.649	2.509	2.558
Belgium	0.913	1.191	1.785	2.869	2.984	3.243	3.729	4.244	4.398	4.587
Canada	0.438	0.742	1.005	1.245	1.449	1.650	1.842	2.128	2.388	2.333
Denmark	1.038	1.081	1.435	1.543	1.677	1.536	1.818	1.975	1.920	1.834
Finland	0.701	0.838	0.987	1.103	1.181	1.186	1.156	1.156	1.173	1.255
France	1.067	1.176	1.536	1.673	2.201	2.705	3.336	4.053	3.921	3.814
Germany	1.255	1.494	2.039	2.741	2.926	3.170	3.685	4.262	4.222	4.042
Greece	0.378	0.331	0.311	0.235	0.300	0.309	0.347	0.340	0.324	0.332
Italy	1.437	0.752	1.145	0.734	1.061	0.715	0.910	0.587	0.743	0.498
Japan	0.841	1.015	1.379	1.591	1.661	1.803	1.891	1.950	1.933	1.916
Korea	0.790	1.333	1.934	2.865	4.190	5.932	8.929	12.336	7.937	2.204
Netherlands	0.963	1.177	1.393	1.325	1.242	1.588	1.849	1.980	1.707	1.635
Norway	1.408	1.381	1.341	1.089	1.181	1.346	1.368	1.254	0.952	1.124
Spain	1.269	1.339	1.493	1.559	1.698	1.772	1.815	1.749	1.537	1.321
Sweden	0.930	0.942	1.020	1.007	1.060	1.050	0.960	0.826	0.701	0.634
Switzerland	0.721	0.785	0.995	1.036	1.415	1.773	2.051	2.333	2.236	2.166
United Kingdom	1.049	0.778	0.834	0.759	0.962	0.794	0.839	0.874	0.936	1.044
Mean	0.969	1.068	1.356	1.548	1.783	2.005	2.346	2.654	2.369	2.004
Median	1.001	1.128	1.386	1.434	1.555	1.711	1.846	1.978	1.927	1.875

Note: Table entries are U statistics.

4. Conclusion

Studies such as Backus (1984), Meese and Rogoff (1983a, 1983b, 1988), and Campbell and Clarida (1987) are typical of the empirical literature that seeks to explain or forecast nominal exchange rates using structural macroeconomic models. The general conclusion of this literature is that monetary models of nominal exchange rate determination have limited explanatory power, with forecasts conditional on observed monetary fundamentals being dominated by no change forecasts at short horizons. This exchange rate forecasting puzzle has withstood numerous attempts to resolve it. In an empirical evaluation of the monetary model within a panel regression framework, we confirm that nominal exchange rate movements are difficult to forecast, with a random walk dominating both flexible and sticky price versions of the monetary model in terms of predictive accuracy conditional on observed monetary fundamentals at all horizons.

The exchange rate forecasting puzzle is an empirical property of an obsolete class of models, and further attempts to resolve it should evaluate the forecasting performance of alternative models. The new open economy model introduced by Obstfeld and Rogoff (1995, 1996) has recently emerged as the principal model of open economy macroeconomic analysis. This dynamic stochastic general equilibrium model is based on rigorous microeconomic foundations, with households and firms interacting in an uncertain environment to determine equilibrium prices and quantities. The new open economy model features both short run nominal price and wage rigidities generated by monopolistic competition and staggered reoptimization in output and labour markets. The current account balance is determined by both intertemporal and intratemporal optimization, while the nominal exchange rate is determined by an uncovered interest parity condition. Versions of the new open economy model differ primarily according to the degree of exchange rate pass through. Models featuring complete exchange rate pass through include those of McCallum and Nelson (2000), Clarida, Galí and Gertler (2001, 2002), and Gertler, Gilchrist and Natalucci (2001), while models in which exchange rate pass through is incomplete include those of Adolfson (2001), Corsetti and Pesenti (2002), and Monacelli (2002). Thus far, empirical evaluations of the new open economy model have primarily focused on impulse response dynamics, and we regard the implementation of forecast performance evaluation exercises as an important direction for future research.

Appendix

The data set consists of quarterly observations on several macroeconomic variables for nineteen industrialized countries over the period 1973Q1 through 1997Q4. The countries under consideration are Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Italy, Japan, Korea, the Netherlands, Norway, Spain, Sweden, Switzerland, the United Kingdom, and the United States.

The variables under consideration are the nominal exchange rate, the money supply, the price level, real output, and the short term nominal interest rate. The nominal exchange rate is quoted in European terms and corresponds to an end of period value. The money supply is measured by an internationally consistent definition of money plus quasi money. The price level is proxied by the consumer price index, while real output is proxied by industrial production. The short term nominal interest rate is measured by the three month Treasury bill rate where available, and the bank rate where necessary. All time series are seasonally unadjusted, and were retrieved from the International Financial Statistics database maintained by the International Monetary Fund.

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