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Comment

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Engel, Mark, and West (EMW) have produced an extremely clear exposition of the recent literature on empirical exchange rate modeling, which has been enjoying a minor renaissance, not least due to the contributions of these three authors. EMW argue that monetary models of exchange rates are finally gaining empirical traction, and that the dismal results found in the literature during the first three decades of the modern (post-1973) float are gradually giving way to more positive ones. Whereas EMW clearly intend to persuade the reader that empirical exchange rate models are back, they deserve credit, too, for emphasizing the still very tentative nature of the new results. These include, not least, the potential sensitivity to sample period that has so plagued earlier attempts to provide robust evidence in favor of structural exchange rate models. There are some important ideas and impressive advances here, but evaluating success is a matter of perspective. Is the glass 10 percent full or 90 percent empty?[1]

1 Noncontroversial Successes of Empirical Exchange Rate Models at Very Long and Very Short Forecast Horizons

Standard textbook empirical exchange rate models have two longstanding areas of success to their credit, about which (for the moment) there is relatively little controversy. EMW present new results to emphasize and strengthen these points. A small number of studies have found that canonical monetary models appear to be able to robustly explain some fraction of long-run movements in the nominal exchange rate. Mark (1995) was the first to formally demonstrate this traction, although Meese and Rogoff (1983b) also found that, at forecasting horizons over two years, the models appeared to outperform the random walk model over a wide range of parameter grids. Especially in the case of monetary models, it seems plausible to suppose that there must be a link between their ability to forecast long-term nominal exchange rates and the PPP literature, which finds that shocks to the *real* exchange rate tend to damp out only very slowly, with a half-life of two to four years (e.g., Rogoff 1996).[2]

Perhaps the most concrete success for the models comes at very high frequencies. There is now substantial evidence that monetary models, possibly incorporating Taylor rule reaction functions, capture the *qualitative* reaction of exchange rates to central bank interest rate announcements. Thus, for example, when news arrives that raises market expectations about the future path of short-term interest rates (such as a central bank interest rate announcement), a country's currency tends to appreciate. However, both theoretically (e.g., according to plausible parametrizations of either the Dornbusch [1976] model or a modern new open-economy macroeconomics model) or empirically (e.g., Reifschneider, Tetlow, and Williams 1999), interest rate shocks seem to be drowned out by other factors at intermediate time intervals, say from one month to one year.

2 The Big Challenge: One Month to One Year Horizons

The real debate now is over how well structural models can perform at intermediate forecast horizons of one month to one year, arguably the most relevant for policy purposes. Up until now, the main finding in the literature is that it is very difficult to find empirical models that work on a *consistent and robust* basis, even against the apparently weak benchmark of the random model, as Meese and Rogoff (1983a, b) first demonstrated. EMW do not claim to decisively overturn this result, but they do give a wide variety of evidence aimed at raising one's confidence in the relevance of monetary models. It should be noted that the Meese-Rogoff result applies to major floating currencies (e.g., the yen, pound and euro against the dollar) and not necessarily to emerging-market currencies where interest and inflation differentials are often much larger. Also, even among developed economies, Chen and Rogoff (2003) show that there is an important exception for what they term "commodity currencies," such as the Australian, New Zealand, and Canadian dollars. These are countries where commodities form a significant component of the country's overall export basket, and where the world price of the country's major commodity exports appears to be highly correlated with exchange rate changes, even in out-of-sample fit exercises.

3 A Brief Review of the Meese-Rogoff Result

Given that a core focus of EMW's paper is to show that exchange rate models outperform the naïve random walk model, it is perhaps useful to review Meese and Rogoff (1983a, b) where this benchmark was first established. Meese and Rogoff's paper was published only a decade after the start of the modern floating exchange period, in 1973. (We need not concern ourselves here with how the earlier Bretton Woods system evolved, as post-World War II capital controls were gradually ended across Europe and Japan.) Early research by Dornbusch, Hooper, Morton, Frenkel, Bilson, Frankel and others suggested that simple structural monetary models could do a pretty good job explaining exchange rate movement under floating, at least on an in-sample basis. The typical model included variables such as long- and short-term interest rates, outputs, money supplies, inflation rates, and trade balances (and perhaps other real shocks). For simplicity, the models were typically specified as the difference between home and foreign variables, although most research, including Meese and Rogoff's, did not find this constraint to be a major issue. The canonical empirical equation in the literature could typically be written in semi-reduced form as:

$$s = a_0 + a_1(m - m^*) - a_2(y - y^*) + a_3(i - i^*)$$
$$+ a_4(\pi^e - \pi^{e*}) + a_5 \sum (TB - TB^*) + u$$

where "*" denotes the foreign country, s, m, and y are the (log) exchange rate, money supply, and output, i is the short-term nominal interest rate, π is the expected inflation rate, TB is the trade balance (or sometimes cumulated trade balance), and u is a (possibly serially correlated) error term. The main point of departure in Meese and Rogoff was an effort to test the models out of sample, on the grounds that in-sample tests may obscure problems such as parameter instability and model misspecification.

Meese and Rogoff proceeded by using several alternative estimation methodologies, including OLS rolling regressions, independent variable (IV) rolling regressions, and imposing a grid of parameter restrictions (the latter approach is developed comprehensively in Meese and Rogoff [1983b]). In each case, the model parameters were estimated using data available up to the initial forecast period. The forecasts themselves, however, were generated using actual realized values of the explanatory variable. Remarkably, the models failed to outperform the random walk model, despite the advantage of being supplied with ex post information. Meese and Rogoff (1983b) found this result to be true across a wide grid of imposed parameters as long as the model predictions were constrained to conform with theoretically imposed signs. Meese and Rogoff considered both mean square forecast error as well as mean absolute forecast error (a nuance forgotten in much of the subsequent literature, but an important one, given evidence the distribution of exchange rate changes typically appears to have fat tails). They also considered a number of variations of the models, including, for example, using price levels to substitute out for money supplies in the core specification to immunize the models from instability in money-demand equations.

Importantly, Meese and Rogoff also experimented with allowing for lagged adjustment and, notably, serial correlation in the error terms. That is, they allowed (say) the one-year-ahead exchange rate forecast to reflect not only actual realized ex post values of the explanatory variables (the "fundamentals" in EMW's terminology), but also projected changes in u, the serially correlated error. In addition to structural models, Meese and Rogoff also looked at a wide variety of time series models, ranging from vector autoregressions to a random walk model with drift. Incredibly, no model seemed to outperform the random walk model across a wide variety of robustness checks. Meese and Rogoff did not actually prove that the random walk model was a *better* forecaster of exchange rates, only that it was not worse; the root mean square errors (RMSEs) for the random walk model were almost never larger across the many experiments. Meese and Rogoff also found that the random walk model outperformed the forward rate (a version of what later became known as "the forward premium" puzzle), but this result is not central to the main point, which is the poor performance of structural models out of sample. Meese and Rogoff's main positive result, as already noted, is that the models appeared to perform better than the random walk at very long time horizons (over two years).

Although these extremely negative results had the salient effect of bringing discipline to the exchange rate literature, it has certainly come as a surprise that they remain so robust some 25 years later. For one thing, Meese and Rogoff had less than ten years of data to work with.

Also, during the time period they examined, financial markets were still evolving. Japan's money markets, for example, were still highly regulated. Even the United States still had interest rate restrictions on consumer checking and savings accounts during most of the time period. At the same time, monetary policy was extremely volatile, making it difficult for markets to anchor expectations in the transition to floating exchange rates. Given these limitations, the presumption was that the models would begin to do better as financial markets developed and as more data accumulated.

Yet, even as more data have become available, the basic empirical result has continued to hold, and is noted in many studies, including those cited by EMW and Rossi—for example, the Frankel and Rose (1995) chapter for the *Handbook of International Economics.* Even the post-1984 "Great Moderation," which has also led to slightly less volatile exchange rates, does not appear to have made them all that much easier to explain.

4 Are Out-of-Sample Tests Too Harsh?

In EMW's argument, out-of-sample fit (where models continue to perform poorly) is at best too harsh a criterion, and possibly inappropriate. They give two arguments, one of which seems easily finessed. The other has been dealt with in the literature but is nevertheless potentially significant. The weaker of EMW's arguments is their claim that there is a certain arbitrariness to out-of-sample fit because root mean forecast error can be reduced by (what they claim) is an innocent transformation of the model. In particular, suppose the exchange rate s is governed by

$$s = x + u$$

where x is the fundamental variable and u is the error term. EMW point out that this simple model can just as well be written as, say,

$$s = \frac{2}{3}s + \frac{1}{3}(x + u).$$

Then if one substitutes in realized values for the explanatory variables (now s and x, instead of just x) the standard error of the resulting equation is only one third as large as in the original equation (since two-thirds of the exchange rate is simply being explained by itself). If I am interpreting this correctly, it would strike me that this "flaw" in using out-of-sample fit as a criterion for exchange rate models would be better described as a "potential pitfall," which the vast majority of studies manage to avoid.

To be fair, EMW give a more subtle version of the same problem in which, after substituting out for the short-term interest rate differential, the forward exchange rate appears on the right-hand side of the estimating equation, instead of the spot exchange rate. Since, empirically, forward and spot rates move almost one for one in the data (as interest rate differentials are small compared to exchange rate volatility), this amounts to virtually the same sleight of hand. Again, it would seem that this problem would be easily avoided, although perhaps some future application will appear where the pitfall is less obvious.

Although they give it less emphasis, EMW's second critique of out-of-sample fit, originally due to Rossi (2005), is more substantive, although it certainly does not really imply dismissing out-of-sample tests. Rossi notes that if the error term u in the exchange rate forecasting equation is serially correlated, then the models may perform poorly when their forecasts fail to take this into account, even when ex post realized values of the explanatory variables are used to construct forecasts. As EMW note, Meese and Rogoff (1983a, b) do in fact report experimenting extensively with incorporating serial correlation into their forecasts. Although they report that these experiments did not overturn their results, one must bear in mind that Meese and Rogoff had only ten years worth of data. Presumably, with a long enough data set, allowing for serial correlation would make a bigger, and potentially decisive, difference.

Ultimately, there is no question that the aim is to have models that can forecast out of sample (as opposed to simply fit out of sample), as well as models that are useful for policy analysis. As Rossi notes in her comments here, out-of-sample tests (of fit and forecasting) will likely remain a fundamental reality check on the success of empirical exchange rate models for long into the future.

5 Do Rationales for the Near-Random Walk Behavior of Exchange Rates also Explain Why a Model May Fit Poorly Out of Sample?

The distinction between out-of-sample fit and out-of-sample forecasting is also relevant in interpreting EMW's very clever observation, based on Engel and West (2005), which is that the exchange rates may exhibit near-random walk behavior even if the underlying fundamentals exhibit substantial serial correlation. The key relationship is their equation (8), where the exchange rate depends on present and future expected values of the fundamentals. Engel and West show the discounting relationship between the exchange rate and the future fundamentals, implying that the exchange rate may exhibit surprisingly-near random walk behavior, even when the fundamentals damp out at a moderate rate over time. Thus, they argue, one should not be surprised that the exchange rate approximates a random walk, and this should not be interpreted as any kind of evidence against the monetary models. As EMW generously note, their equation (8) is very closely related to an isomorphic equation in Obstfeld and Rogoff (2003), reproduced below:

$$s_t = \frac{\bar{i}\varepsilon}{1+\bar{i}\varepsilon}\sum_{j=t}^{\infty}\left(\frac{1}{1+\bar{i}\varepsilon}\right)^{j-t} E_t\left(m_j - m_j^* + \frac{\rho_j - \rho_j^*}{\bar{i}\varepsilon}\right).$$

Obstfeld and Rogoff (whose derivation is based on a micro-based New Open Economy Macroeconomics Model) argue that for plausible values of the steady-state interest rate i and the interest semielasticity of money demand ε, the discount factor is near 1, and thus relatively small shocks to the risk premium ρ can potentially have very large and long-lasting effects on the exchange rate. (In their model, the risk premium is derived endogenously.) Since risk premia shocks are likely a major source of exchange rate fluctuations, this is potentially an important explanation of exchange rate volatility. Engel and West's explicit calibrations take this point much further and make it more convincing.

The fact that the exchange rate can follow near random walk behavior when governed by mean-reverting monetary fundamentals just might explain why the latter seem of so little use in predicting exchange rates, at least over the relatively short samples international economists typically have to work with. It does not, however, explain why the models fit so badly out of sample using actual realized values of the explanatory variables. Take equation (9) from EMW,

$$(1 - b)(s_t - \mathbf{a}'\mathbf{x}_t) = b\rho_t + b(i_t - i_t^*),$$

where (again) ρ is the unobserved risk premium and $\mathbf{a}'\mathbf{x}_t$ are the observed monetary fundamentals. This equation is an example of the type simulated by Meese and Rogoff, discussed above. In this formulation, which is standard in the out-of-sample testing literature, there is no forward-looking sum because expectations are already embodied in the interest differential $i - i^*$. If the model fits poorly out of sample, it must be attributable to parameter instability, misspecification, or some other problem, not to discounting.

Rossi discusses another very intriguing and clever result from Engel and West (2005) that is also applied here. The authors show that even if fundamentals are of only marginal use in predicting the exchange rate (because of near random walk behavior), it is possible that the exchange rate might be useful in predicting the fundamentals, since the exchange rate embodies expectations about their future evolution. This is a tremendously constructive result that promises to open up a range of new applications. If the relationship is strong, however, it is not clear why it does not show up more strongly in tests of out-of-sample fit. Certainly, if one looks at the one known major exception to the Meese-Rogoff result (the commodity currencies), there is a strong link between commodity currency exchange rates and world commodity prices.

6 Panel Tests and Advances in Out-of-Sample Forecasting Tests

Last but not least, EMW use panel estimation techniques to test the model's out-of-sample forecasting ability. As I have already stated, the authors' results are broadly consistent with the previous literature; there appears to be forecasting power at very long horizons but not at short horizons. It is worth noting that the Meese-Rogoff literature suggests that *in practice* the simple random walk model is a much tougher alternative to beat than the random walk with drift. Most likely the same parameter instability that plagues the structural models also plagues the random walk with drift model. The final tables of the present paper confirm this well-known empirical result; the models perform much less impressively when compared against the simple random walk model than when compared against the random walk with drift.[3] It is also worth noting that the table reveals some differences across tests for whether the monetary models improve on the random walk model; in some cases, Theil's *U*-statistic is greater than 1 and yet the Clark-West test is significant. The latter, of course, is a state-of-the-art test based on the premise standard comparisons are biased in favor of the random walk model (since there are no parameters to be estimated) and contains an adjustment for that bias that favors the models with fundamentals. One wonders whether there may be cases where the adjustment (which is asymptotically correct) may prove to be too large, although further applications and study should resolve this lingering doubt over time.

7 Concluding Remarks

This is a very nice paper that synthesizes the successes of a valuable research program. But despite important methodological improvements, and a number of clever new ideas, exchange rates remain a very tough nut to crack, even after the Great Moderation in macroeconomic variables. Right now, things still look pretty good if we can call the glass 10 percent full.

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Endnotes

1. The continuing difficulties in understanding exchange rates have important implications not only for policymakers but also for economic theorists. For example, there has been a large recent literature on explaining speculative attacks in fixed exchange rates. Although there are a couple notable exceptions, most of this literature assumes a clear and stable connection between fundamentals in the post-attack floating exchange rate. But a great body of evidence weighs against this assumption. As Flood and Garber (1984) first illustrated (see also Obstfeld and Rogoff 1996), if one cannot tie down the post-attack floating rate, one cannot tie down the timing of the attack either. Difficulties in explaining floating rates may indeed be the root of instability, even under fixed rates.

2. EMW endorse the Benigno (2004) explanation of the purchasing power parity puzzle, where very high correlation in the error term on the Taylor rule, interacting with fixed Calvo contracts, can lead to very long half-lives for deviations from PPP. This explanation, too, is very clever, although one wonders whether the Calvo price-setting parameters should be thought of as fixed regardless of the Taylor rule, especially when serial correlation in the error term is producing such long-lived real exchange rate effects.

3. The first paper to implement the panel approach, Mark and Sul (2001), used the random walk with drift model on logical a priori grounds; the newer results here suggest that this approach may overstate the performance of the structural models.

References

Benigno, Gianluca. 2004. Real exchange rate persistence and monetary policy rules. *Journal of Monetary Economics* 51:473–502.

Chen, Yu-chin, and Kenneth Rogoff. 2003. Commodity currences. *Journal of International Economics* 60:133–60.

Dornbusch, Rudiger. 1976. Expectations and exchange rate dynamics. *Journal of Political Economy* 84:1161–76.

Engel, Charles, and Kenneth D. West. 2005. Exchange rates and fundamentals. *Journal of Political Economy* 113:485–517.

Flood, Robert P., and Peter M. Garber. 1984. Collapsing exchange rate regimes: Some linear examples. *Journal of International Economics* 17:1–13.

Frankel, Jeffrey A., and Andrew K. Rose. 1995. Empirical research on nominal exchange rates. In *Handbook of international economics,* vol. 3, ed. G. M. Grossman and K. Rogoff, 1243–77. Amsterdam: Elsevier.

Mark, Nelson. 1995. Exchange rates and fundamentals: Evidence on long-horizon predictability. *American Economic Review* 85 (1): 201–18.

Mark, Nelson, and Donggyu Sul. 2001. Nominal exchange rates and monetary fundamentals: Evidence from a small post-Bretton Woods sample. *Journal of International Economics* 53:29–52.

Meese, Richard A., and Kenneth Rogoff. 1983a. Empirical exchange rate models of the seventies: Do they fit out of sample? *Journal of International Economics* 14:3–24.

———. 1983b. The out-of-sample failure of empirical exchange rate models: Sampling error or misspecification. In *Exchange rates and international macroeconomics,* ed. Jacob A. Frenkel, 67–105. Chicago: University of Chicago Press.

Obstfeld, Maurice, and Kenneth Rogoff. 1996. *Foundations of international macroeconomics.* Cambridge, MA: MIT Press.

———. 2003. Risk and exchange rates. *Economic policy in the international economy: Essays in honor of Assaf Razin,* ed. E. Helpman and E. Sadka, 74–120. Cambridge: Cambridge University Press.

Reifschneider, David, Robert Tetlow, and John Williams. 1999. Aggregate disturbances, monetary policy, and the macroeconomy: The FRB/US Perspective. *Federal Reserve Bulletin* January: 1–19.

Rogoff, Kenneth. 1996. The purchasing power parity puzzle. *Journal of Economic Literature* 34:647–68.

Rossi, Barbara. 2005. Testing long-horizon predictive ability with high persistence, and the Meese-Rogoff puzzle. *International Economic Review* 46:61–92.