Macro Approaches to Foreign Exchange Determination

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Abstract

Macroeconomic approaches to exchange rate determination are reviewed, with an emphasis on empirical models. Monetary and portfolio balance models of nominal exchange rates are described and evaluated. The literature on real models of real exchange rates is reviewed. The chapter ends with a brief survey of recent developments in exchange rate modeling.

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1. Introduction

In this chapter I review a number of models of exchange rate developed during the post-Bretton Woods era. The approaches are broken down into categories of nominal and real exchange rate models, with particular reference to the empirical evidence. I then discuss recent approaches that do not neatly fall into either categorization.

The defining feature of the bulk of the models that have been empirically assessed is that they rely upon stock equilibrium conditions, and hence are often categorized as being within the "asset market" approach, to distinguish them from the earlier flow market approach. Although the underpinnings of these models are quite unsatisfying from the perspective of recent theoretical developments, they remain the workhorses of empirical exchange rate modeling. This is true largely because the empirical implications of, for instance, the New International Macroeconomics (Obstfeld and Rogoff, 1996) have not been proven easy to test in the econometric framework.

For this same reason, most of the empirical evidence discussed in the chapter comes from reduced form or quasi-reduced form specifications, rather from structural (i.e., calibrated) models of economies. While structural approaches, most prominently in the form of dynamic structural general equilibrium (DSGE) models, have become increasing important in the new research, evaluation of goodness-of-fit remains difficult, for a variety of reasons.[1]

[1] Most papers rely upon an informal assessment of how impulse response functions from a calibrated or estimated model conform to priors. In addition, the empirical results are often couched in terms of deviations from steady state, which in practice have to be estimated. See

2. Models of the Nominal Exchange Rate

The early empirical literature pertaining to monetary and portfolio balance models has been surveyed extensively (Taylor, 1995; Frankel and Rose, 1995; Sarno and Taylor, 2002).
In the wake of the collapse of the Bretton Woods system, two major strands of models dominated the literature: the monetary and portfolio balance approach. Both approaches focused on *stocks* of outside assets – money in the former and both money and bonds in the latter. While this perspective is completely natural from today's vantage point, it is easy to forget how much this approach differed from the older flow perspective of the Mundell-Fleming model. This approach stressed current account and capital account flows as the determinants of exchange rates, and was largely superseded in the 1970's. Consequently, I will not discuss this approach in detail.

Although the monetary and portfolio approaches share a focus upon stocks, they differ in their views of the substitutability of capital. In practice, the difference amounts to whether uncovered interest parity holds, or whether the forward rate differs from the expected future spot rate by an exchange risk premium. Of the two approaches, by far the most common approach in the nominal exchange rate literature has been the monetary model.

2.1 The Monetary Model

The monetary approach views the exchange rate as the relative price of currencies, when that relative price depends upon the relative demands and supplies of the stocks of money. Within that strand, two variants can be discerned: the flexible price (Frenkel, 1976; Bilson, 1981) and

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Morley (2010) for discussion.

sticky price versions (Dornbusch, 1976; Frankel, 1979); in the former, purchasing power parity (PPP) holds continuously, while in the latter, it only holds in the long run. To fix the notation and motivate the empirical modeling, these two models are derived. Assume purchasing power parity (PPP) in log-levels,

$$s_t = p_t - p_t^* \tag{1}$$

Where log *s* is the nominal exchange rate, expressed in units of home currency per foreign currency, and *p* is the log price level. Asterisks denote foreign variables. Money demand functions in the two countries are expressed as

$$m_t^d - p_t = \varphi y_t - \lambda i_t \tag{2}$$

where m is the log nominal money stock, *y* is log income, *i* is the short term interest rate, and the *d* superscripts indicate "demand". I assume for simplicity that the money demand parameters are the same across the two economies. Rearranging, assuming money supply equals money demand, and imposing PPP one obtains:

$$s_t = (m_t - m_t^*) - \varphi(y_t - y_t^*) + \lambda(i_t - i_t^*) \tag{3}$$

The monetary model yields two key implications. The first is the intuitive result that higher relative income induces a *stronger* currency. The second is that a higher relative interest rate induces a *weaker* currency. Both of these predictions are opposite of those obtained by the static version of the Mundell-Fleming model.

The reasons for these differences are obvious. In the Mundell-Fleming model, higher income induces higher imports, *ceteris paribus*, and hence a weaker currency. In the monetary model, a higher income induces a higher money demand relative to supply, and hence a stronger currency. Also, in the Mundell-Fleming model, a higher interest rate causes a capital inflow, by the *ad hoc* financial account function. In the monetary approach, a higher interest rate causes a lower money demand, relative to money supply, and hence a weaker currency.

In empirical work on the flexible price model, it will prove convenient to work with equation (3). However, additional insight into the intuition of the monetarist approach can be obtained by noting that uncovered interest rate parity (UIP) implies that a higher domestic interest rate implies a weaker currency in the future. To see this, note UIP is denoted by

$$E_t s_{t+1} - s_t \equiv \Delta s_{t+1}^e = i_t - i_t^* \tag{4}$$

The object in the middle of the equation is "expected depreciation" based on the time t information set. Substitution of this expression in to the equation (3), and re-arranging indicates that the current exchange rate is a function of the future expected exchange rate.

$$s_t = \left(\frac{1}{1+\lambda}\right) F_t + \left(\frac{\lambda}{1+\lambda}\right) s_{t+1}^e \tag{5}$$

Where

$$F_t \equiv (m_t - m_t^*) - \varphi(y_t - y_t^*)$$

Repeated substitution for the expected future spot rate will lead to an expression that relates the current spot rate to the current and future discounted expected fundamentals. Clearly, such expressions are not very tractable for empirical work; however, they do yield insights into how changes in expectations about future variables can affect the current exchange rate, even when the current values of macroeconomic variables remain unchanged.

The flexible price monetary approach (sometimes termed the “monetarist” model) yields some very strong predictions. One of the most implausible is that increasing interest differential will be associated with weakening currencies. In the context of a model with purchasing power parity holding in both the long run and short run, this result makes sense; positive interest differentials arise from positive inflation differentials (via the Fisher relation). The more rapid a currency loses value against a basket of real goods, the more rapid a currency loses value against another currency, given that PPP links prices of home and foreign real goods.

The positive relationship between the interest differential and the exchange rate runs counter to casual empiricism, at least as far as the developed economies are concerned (economies experiencing high-inflation such as Argentina and Brazil during the 1980's are another matter). Hence consider a sticky price version of the monetary model that allows the PPP condition to hold only in the long run. Then the flexible price monetary model equation for the exchange rate pertains to the long run, (3) is re-written:

$$s_t = (\overline{m_t} - \overline{m_t^*}) - \varphi(\overline{y_t} - \overline{y_t^*}) + \lambda(\overline{\pi_t} - \overline{\pi_t^*}) \tag{6}$$

where the overbars denote long run values, and the secular inflation rates stand in for long run interest rates, given the Fisher relation holds in the long run.

Overshooting means that exchange rates tend to revert back towards the long run value at some rate θ. That is, if the exchange rate is too high (the domestic currency too weak), relative to some long run value, they will then tend to fall toward the long run value. Assuming rational expectations, this suggests the following mechanism:

$$s_{t+1}^e - s_t = -\theta(s_t - \overline{s_t}) + (\pi_t^e - \pi_t^{e*}) \tag{7}$$

The θ parameter is the rate of reversion to the long run nominal exchange rate, and is an inverse function of the degree of price stickiness. Since higher trend inflation implies a weaker expected future spot exchange rate, the secular inflation differential enters into this expression.

However, by uncovered interest parity, the left-hand side of equation (7) is also equal the interest differential.Solving for *s*, and substituting in the expression for the long run *s*, one obtains:

$$s_t = (m_t - m_t^*) - \varphi(y_t - y_t^*) - \left(\frac{1}{\theta}\right)(i_t - i_t^*) + \left(\lambda + \frac{1}{\theta}\right)(\pi_t^e - \pi_t^{e*}) \qquad (8)$$

This expression can be rewritten as:

$$s_t = (m_t - m_t^*) - \varphi(y_t - y_t^*) - \left(\frac{1}{\theta}\right)(r_t - r_t^*) + \lambda(\pi_t^e - \pi_t^{e*}) \qquad (9)$$

where $r_t \equiv i_t - \pi_t^e$

Since the real interest rate shows up in this expression, this model is sometimes called the "real interest differential" model.[2]

The current exchange rate depends positively on current money stocks, and inflation rates, and negatively on income levels and interest rates. This result regarding interest rates differs from the flex-price monetary model, because in the short run inflation rate differentials can differ from interest rate differentials.

The previous models have imposed PPP in the long run. However, there are persuasive reasons for allowing *long run* deviations from PPP (as discussed in Chapters 6 and 7 of this Handbook, on purchasing power parity), in which case some real factors enter into nominal exchange rate determination. One rationale ascribes such deviations to the presence of nontradable goods. Assuming that PPP holds only for tradable goods, one obtains the expression in (10),

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[2] Certain papers focus on the role of the real interest differential in determining the real exchange rate. See Edison and Pauls (1993), Meese and Rogoff (1998), Baxter (1994), and MacDonald and Nagayasu (2000).

$$s_t = (m_t - m_t^*) - \varphi(y_t - y_t^*) - (1/\theta)(i_t - i_t^*) + (\lambda + 1/\theta)(\pi_t^e - \pi_t^{e*}) - \alpha\omega_t \tag{10}$$

where $\omega_t \equiv [(p_t^N - p_t^T) - (p_t^{N*} - p_t^{T*})]$, and for simplicity, aggregate and tradable sector inflation rates are assumed to be approximately the same (otherwise, one has to include separate inflation terms).

Equation (10) indicates that in addition to the usual monetary factors, real factors can also affect the nominal exchange rate; in this case, anything that shifts the intercountry differential in the relative price of tradables to nontradables. This expression is a sticky price version of that used in Clements and Frenkel (1980) and is similar to that used by Wolff (1987).

What determines this relative price? In principle, this variable can be affected by supply factors (changes in endowments, productivity growth) or demand side factors (government spending, changing preferences). This seems to be an important factor for some currencies, but is not usually incorporated in the work on developed country currencies. Furthermore, the exact mechanisms underlying movements in ω are not usually outlined in such work. Since the determinants of these movements are usually thought of as real factors, we will reserve extensive discussion of this approach to Section 3.

2.2 Portfolio Balance Models

The portfolio balance model differs from the monetary model in that it assumes that assets denominated in different currencies are not perfectly substitutable; this means that returns on bonds, when expressed in a common currency, might differ due to a risk premium.[3] This is

[3] Risk premia can arise in models without this particular structure. In more microfounded approaches, the risk premia arises from the correlation of relative returns with consumption growth. The implications of this type of approach are discussed in Section 4.

shown in a model drawn from Frankel (1984). Assume perfect capital mobility (CIP) holds, while perfect capital substitutability does not. That is, investors view domestic and foreign bonds as imperfect substitutes. Then investor *j* will allocate her holdings in response to expected returns (expressed in a common currency). Aggregating over homogeneous investors yields:

$$B_t / S_t B_t^* = \gamma(i_t - i_t^* - E_t \Delta s_{t+1}) \tag{11}$$

where *B* and *B** are net supplies of domestic and foreign bonds, and it is assumed for simplicity that governments issue debt denominated only in their own currencies. The term in the parentheses on the right hand side of (11) is the deviation from uncovered interest parity, or equivalently, the exchange risk premium on domestic currency.

This expression indicates that holdings of domestic bonds, relative to foreign currency denominated bonds, are a positive function γ of the exchange risk premium. Assuming the functional form for relative bond demand is linear-exponential in γ, then after rearrangement, equation (11) becomes:

$$s_t = \gamma_0 + \gamma_1(i_t - i_t^* - E_t \Delta s_{t+1}) + b_t - b_t^* \tag{12}$$

The difficulty in implementing equation (12) is that the term in the parentheses is unobservable.[4] To obtain an empirically implementable specification, one could assume expected depreciation is zero -- an assumption that is consistent with the near random walk exchange rates. Then (12)

[4] As in the case of equation (5), one could recursively substitute out for the expected future exchange rate. This would lead to an expression stating that the current exchange rate is determined as a negative function of current and discounted future expected interest rates, and a positive function of current and discounted future expected stocks of domestic currency bonds, relative to foreign denominated bonds. This expression, likes its monetary counterpart, is not tractable from an empirical standpoint.

becomes:

$$s_t = \gamma_0 + \gamma_1(i_t - i_t^*) + b_t - b_t^* \tag{13}$$

Notice the equation indicates that as *b** increases, *s* falls (appreciates): As the stock of foreign assets held by home rises, the exchange rate appreciates.

In the specification represented by equation (13), it is assumed that all investors have the same portfolio preferences, presumably because they consume the same basket of goods. If on the other hand the home country is a small country, such that only home residents wish to hold domestically denominated assets, then one can equate capital inflows with increases in the supply of foreign assets in the home market. If the home country is large relative to the foreign, then one might want to make the converse assumption. Clearly, neither of these versions fit the typical large country. Then what one needs to specify is a separate asset-demand function for each of the two countries. As long as the responsiveness of home residents to the expected return on domestic bonds exceeds the responsiveness of foreign residents, then the exchange rate will appreciate in response to cumulated trade balances that re-allocate world wealth.[5] In line with this approach, Hooper and Morton (1982) use a real exchange rate-target current account model to motivate inclusion of cumulated current account balances. [6]

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[5] So far, we have discussed matters as if the only way in which *B* and *B** can change is through current account imbalances. In fact, foreign exchange intervention can affect the stock of bonds, and hence the exchange rate. See Dooley and Isard (1982) for one study where the stocks of bonds take into account foreign exchange intervention.

[6] Frankel (1982) uses a portfolio demand for money so that wealth (measured as the sum of current account balances and domestic bonds and money) enters into the regression equation.

2.3 Empirical Evidence

The models described appear to constitute a quite disparate set of approaches; however, in terms of the empirics, the appearance is misleading. The above models can be subsumed into the following general expression:

$$s = f(\hat{m}, \hat{y}, \hat{i}, \hat{\pi}, \omega, b, b^{*}, ctb) \tag{14}$$

where the time subscripts have been suppressed, *ctb* denotes the cumulated trade balance, and the circumflexes denote intercountry differences. Different models imply the inclusion of different regressors within this set.

Most of the earlier studies cited include an empirical component. In most instances, some supportive evidence is found, particularly for the monetary model. Frankel (1979) provides evidence that the sticky price monetary model fit the dollar/deutschemark rate well, using a quasi-reduced form expression. Papell (1984, 1988) estimated the monetary model in a system, and find that the degree of overshooting and undershooting is dependent upon the monetary policy being conducted.

However, it is fair to say that the empirical results of the 1980's are not very robust to the addition of new data. The identified relationships often break down with the addition of new data, suggesting model overfitting. Frankel (1983) provides an early overview of the empirical inadequacies of the monetary (flexible and sticky price), portfolio-balance and hybrid models. Particularly in the latter two cases, the key portfolio-balance variables -- domestic and foreign bond stocks -- failed to show up with the correct coefficient signs.

Portfolio-balance models of exchange rates are merely transformations of portfolio-balance models of the exchange risk premium. The failure of these types of models reflects the failure of attempts to explain the exchange risk premium using measures of government bonds, in the context of an international capital asset pricing model.[7]

The fragile nature of these empirical results motivates a reliance on out-of sample simulations to guard against in-sample over-fitting. Among the first studies to adopt this approach was Meese and Rogoff (1983a,b). These authors tested the out of sample forecasting properties of these various exchange rate models, plus the forward rate, a univariate ARIMA, and a Vector AutoRegression (VAR). The procedure involves estimating the models over a certain period, forecast out k periods *using the actually realized values of the exogenous variables*, then "roll" the regression sample up a period, to account for parameter variation. This procedure is repeated until all of the remaining data points are exhausted. They then compare the forecasts statistics, Mean Error (ME), Mean Absolute Error (MAE) and Root Mean Absolute Error (RMSE).[8]

Meese and Rogoff (1983a) obtain the surprising result is that none of the structural models (nor time series models) consistently outperforms the random walk using any of the metrics, and over any of the forecast horizons. This finding was robust to relaxing coefficient restrictions (like the income elasticity being the same across countries), or replacing one proxy for inflationary expectations with another.

The analysis of exchange rate forecasts changes dramatically with the development of the

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7 See early studies by Frankel and Engel (1984), and more recent surveys by Hodrick (1987) and Engel (1996).

8 Notice that because in these exercises, actually realized values of the exogenous variables are used, the usual argument that asset prices should not be predictable ex ante becomes moot. In these forecast comparisons, knowledge about contemporaneous information is available. That is, by using the *ex post* values of the exogenous values in the forecasts, one "purges" the forecasts of uncertainty about the future paths of the exogenous variables. Hence, failure can be isolated to

literature relating to integrated variables. The study of variables that co-trend, namely the cointegration literature, suggests that one could respecify equations in terms of error correction models. A key issue here is what the nature of the cointegrating vector, *i.e.*, the error correction term, would be. In most cases, the cointegration results are based upon monetary fundamentals, either imposed or estimated.[9]

One of the implications of long run relationships holding, and possible short run nonlinearities, is that long horizon prediction might be more successful than short horizon. In the earliest implementation of this approach, Nelson Mark (1995) used a calibrated flexible price monetary model to perform out-of-sample predictions of the dollar-deutschemark rate, and finds substantial improvement for the monetary model's performance vis-a-vis the random walk. Chinn and Meese (1995) examine a broader number of models including the flexible price, the Hooper-Morton, and augmented monetary, and imposing the cointegrating vector in an error correction framework, find that a random walk can be outperformed, in a statistically significant sense, at longer horizons of two to three years.

This set of results is intuitive. The amount of "news" that moves exchange rates month to month that is not captured in typical macroeconomic variables such as money stocks, interest and inflation rates, is very large. Most likely, this type of news dominates at high frequencies, but is less likely to play a large role at longer horizons. Moreover, the random walk "model" is a very naive model as it yields a "no change" forecast, so as the horizon lengthens, the random

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the misspecification of the equations.

[9] ECTs may be empirically motivated, or based on theory. For the former, see for instance MacDonald and Taylor (1994). For the latter, see Edison (1991) replicates the Meese-Rogoff (1983a) study, but imposes a PPP error correction term. She finds some improvement, especially over longer horizons.

walk forecast is more and more likely to be proved wrong.

Nonetheless, these results did not prove to be conclusive. First, Faust et al. (2003) have shown that these long horizon results are specific to the particular time period examined, particularly in the case of Mark's study.[10] Second, examining a slightly different set of models, and taking into account the possibility of no-cointegration, Cheung, Chinn and Garcia Pascual (2005) find only very limited evidence of improved forecasting ability at long horizons, relative to shorter horizons. Specifically, they examine a more recent set of models developed over the last two decade -- interest rate parity,[11] productivity based models, and "behavioral equilibrium exchange rate" models.[12] The performance of these models is compared against a benchmark model -- the Dornbusch-Frankel sticky price monetary model in equation (8). The models are estimated in error correction and first-difference specifications.

Rather than estimating the cointegrating vector over the entire sample and treating it as part of the ex ante information set as is commonly done in the literature, they recursively update the cointegrating vector, thereby generating true ex ante forecasts. Model performance at various forecast horizons (1 quarter, 4 quarters, 20 quarters) is examined, using differing metrics (mean squared error, direction of change), as well as the "consistency" test of Cheung and Chinn

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[10] In addition, Kilian (1999) has argued that the apparent outperformance of the random walk at long horizons is largely spurious. He uses bootstrapping to demonstrate that the performance relative to a random walk is approximately the same at short and long horizons. Kilian argues that only if the underlying vector error correction model is nonlinear might a long horizon regression outperform a random walk. Kilian and Taylor (2003) argue that even if a specific form of nonlinearity is used, the outperformance may be difficult to detect.

[11] The use of interest rate parity is analogous with the forward rate examined by Meese and Rogoff (1983a,b). One should expect better performance at the long horizon because Chinn and Meredith (2004) and Alexius (2001) find that UIP holds better at long horizons than short.

[12] The productivity based model and BEER models can be considered variants of the productivity based model described in Section 3.2. See Section 3.4.

(1998).

They find that no model consistently outperforms a random walk, by a mean squared error measure; however, along a direction-of-change dimension, certain structural models do outperform a random walk with statistical significance. Moreover, they find that these forecasts are cointegrated with the actual values of exchange rates, although in a large number of cases, the elasticity of the forecasts with respect to the actual values is different from unity. Overall, model/specification/currency combinations that work well in one period will not necessarily work well in another period

A natural approach to improving the empirical performance of models is to use information across currencies.[13] One example of this approach includes Mark and Sul (2001). They use a panel of 17 exchange rates for industrialized countries to implement a panel version of Mark's (1995) paper. Specifically, they first test to see whether the exchange rate and the monetary fundamentals are cointegrated in the panel, using a panel version of dynamic OLS. After rejecting the null hypothesis of no cointegration, they use the estimated cointegrating vector to conduct long horizon regressions as in Mark (1995). Monetary fundamentals outpredict a random walk at short and long horizons, over the 1983q2-1997q1 period, when the US dollar is the numeraire currency. The results are slightly different if the numeraire currency is the yen; then the outperformance is not usually statistically significant, although the predictions from the monetary model typically have smaller root mean squared errors than those generated from a random walk forecast (and smaller, as well, than those from a PPP fundamentals model).

[13] Another approach is to extend the sample over time. Rapach and Wohar (2002) undertake an analysis of 14 industrialized country exchange rates over a period of 115 years. They assert that they find substantial evidence in favor of the monetary approach, despite the fact that the

Two other examples of using panel cointegration methods include Husted and MacDonald (1999) and Groen (2005). Husted and MacDonald (1997) use panel cointegration techniques derived from Pedroni (1997). They conclude that there is substantial evidence in favor of monetary models of the exchange rate, based on cointegration evidence. Groen (2005) uses a much smaller panel of three currencies, and finds both evidence of cointegration of the exchange rate with the monetary fundamentals, and model outperformance of a random walk at both short and long horizons. Most recently, Cerra and Saxonhouse (2010) have used a large panel of currencies to find that the monetary model works well at longer horizons.[14]

These results suggest that the empirical versions of the monetary model may enjoy renewed life, as researchers exploit cross-currency variation in order to pin down the coefficient estimates that have proven elusive in the pure time series context.[15]

3. Real Models of the Real Exchange Rate

Most real models of the exchange rate focus on real – as opposed to nominal – determinants of the price level adjusted exchange rate. Purchasing power parity is a particularly simple version, where the real exchange rate is assumed to be constant. The second portion of the section describes two other approaches to modeling the real exchange rate; the first of these two approaches is associated with the Balassa Samuelson framework, but more generally allows for the presence of nontradable goods. The second of these approaches encompasses the general

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samples span radically different exchange rate regimes.

[14] See Chapter 9 on panel methods.

[15] For the sake of brevity, I omit the discussion of functional nonlinearities (Diebold and Nason, 1990; Meese and Rose, 1991; Chinn, 1991), threshold autoregression (Taylor and Peel, 2000; Taylor, Peel and Sarno, 2001), regime switching (Engel and Hamilton, 1990; Engel, 1994).

equilibrium models of the exchange rate arose in response to the ad hoc nature of the extant models of the 1970's. In this sense, they represent the open economy analogue to the rejection of ad hoc macroeconomic models dominant in the domestic context.

3.1 Purchasing Power Parity

Purchasing power parity (PPP) is one of the most important concepts in international finance. Several excellent surveys exist on the subject, including Breuer (1994), Rogoff (1996), and Taylor and Taylor (2004). While a thoroughgoing discussion of purchasing power parity is beyond the scope of this chapter, some discussion of PPP is necessary to set the stage for a discussion of real exchange rate determination.[16] The simplest statement of PPP is that the common currency price of an identical bundle of goods is equalized:

$$s_t + p_t^* = p_t \tag{15}$$

Where p corresponds to the price of a bundle of goods.

Notice that there is, in this context, a direct relationship between the deviation from PPP, and the real exchange rate. Suppressing the constant and rearranging (15), one obtains:

$$q_t \equiv s_t - p_t + p_t^* \tag{16}$$

where q is measured in domestic units of the domestic basket of goods required to purchase a single basket of foreign goods. If absolute PPP holds, then the (log) real exchange rate should be a zero (and a constant if relative PPP holds). In practice, the distinction is of limited relevance,

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[16] As I alluded to earlier, there are a myriad of definitions for PPP. I define PPP as pertaining to relationships between relatively broad price indices such as the consumer price index (CPI), the producer price index (PPI), or GDP deflator, on the one hand, and the exchange rate on the other. In other words, I will not consider PPP to be a relationship between the exchange rate versus price levels ***and other variables***. Some authors have termed such relationships "generalized

since we typically have access to only price indexes, rather than prices of bundles of goods.

One can decompose the general price index along several dimensions. One is the tradable/nontradable distinction; furthermore, the tradable category can be further divided into importables and exportables. Consider the first dimension; then, writing the general price index as:

$$p_t = \alpha p_t^N + (1-\alpha) p_t^T \qquad (17)$$

where a N superscript denotes nontradables and T tradables, one obtains the resulting expression for the real exchange rate (assuming the weights are identical):

$$q_t = q_t^T + \alpha(\hat{p}_t^N - \hat{p}_t^T)$$
$$\text{where } q_t^T \equiv s_t - p_t^T + p_t^{T*} \qquad (18)$$

The real exchange rate thus deviates from zero if either tradables prices differ, or the relative price of nontradables versus tradables differs across countries. This decomposition underpins Engel's (1999) analysis of the sources of US real exchange rate movements.

The relative price variable may be determined by any number of factors. In the Balassa (1964) and Samuelson (1964) model, relative prices are driven by relative differentials in productivity in the tradable and nontradable sectors.[17] With respect to the East Asian countries, there is a widespread belief that such factors are of central importance (Cheung and Lai, 1998; Chinn, 2000d).

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purchasing power parity".

[17] This view is adopted in DeGregorio and Wolf (1994), Canzoneri, Cumby and Diba (1996), Chinn (1997a,b) among others. The first two studies examine annual total factor productivity data for 14 OECD countries in a panel context, while Chinn (1997a) undertakes a higher frequency analysis. He uses quarterly time series regressions where labor productivity in manufacturing is used as a proxy for relative sectoral productivity, for the US, Canada, Germany, Japan and the UK.

Relative prices may also be affected by demand side factors. In the long run, the rising preference for services, which are largely nontradable, may induce a trend rise in the relative price of nontradables. Over shorter horizons, government spending on public services may also induce changes in relative prices (DeGregorio and Wolf (1994) and Chinn (1999)).[18]

Early work on PPP relied upon Classical regression techniques, and addressed the question of whether PPP held on a period by period basis. The early literature concluded that absolute PPP did not hold for broad price indices, on a period by period basis. One important exception was that identified by Frenkel (1976) who found that during the German hyperinflation of the 1920s, PPP did hold. Hence, the conclusion that PPP held only when nominal (monetary) shocks were large relative to real shocks.

The advent of the unit root and cointegration brought a resurgence in the PPP literature. At the same time, it produced a large amount of confusion between the economically interesting hypothesis of PPP in levels, and the statistical hypotheses. To see this, recall from equation (16) that PPP implies that the real exchange rate is equal to a constant. Findings of cointegration, but without unitary coefficients, was sometimes interpreted as "weak" PPP, when it was consistent with a trending real exchange rate. Even when cointegration with unitary coefficients was found, allowance for a deterministic trend meant that the real rate was not constant over time. The issue of purchasing power parity at the short and long horizon is examined at further length in Chapter 7 in this *Handbook*.

3.2 Balassa-Samuelson and Productivity Based Models

The basic motivation for most empirical exercises addressing the exchange rate productivity

[18] See also Chen and Rogoff (2003) for a commodities price channel.

nexus rely upon the tradable-nontradable distinction highlighted by Balassa (1964) and Samuelson (1964). Recall that in the presence of nontradables, one can write the real exchange rate as:

$$q_t = q_t^T - \alpha(\hat{p}_t^N - \hat{p}_t^T) \quad \text{where } q_t^T \equiv s_t - p_t^T + p_t^{T*} \qquad (18)$$

Assuming perfect capital mobility, free intersectoral factor mobility, the internal relative price of traded and nontraded goods is given by

$$p_t^N - p_t^T = a_t^T - a_t^N \qquad (19)$$

where for expository simplicity the production functions are assumed to be identical; a^T and a^N are the total factor productivity levels in the traded and nontraded sectors, respectively. In words, (19) implies that the relative price of traded goods moves one-for-one with the productivity differential. As tradable sector productivity rises relative to nontradable, the price of tradable goods relative to nontradable falls.

Combining (19) with (18) yields a standard expression for the real exchange rate:

$$q_t = q_t^T + \alpha(\hat{a}_t^N - \hat{a}_t^T) \quad \text{where } q_t^T \equiv s_t - p_t^T + p_t^{T*} \qquad (20)$$

In this framework, the real exchange rate is a function of the intercountry relative productivity differential. And if PPP holds for tradable goods, then q^T is 0, and the real exchange rate depends solely upon the productivity differential.

A number of papers have examined the relationship expressed in equation (20) for developed economies, including Hsieh (1982), Marston (1990), DeGregorio and Wolf (1994), Strauss (1996), Chinn (1997a,b), and Chinn (1999).

The first three papers, like many others, estimate the real exchange rate and productivity differential relationship in growth rates. Usually, a link is detected. However, the specification allows for permanent shocks to the relationship in levels, which might not be desirable.

The relationship in levels has been more elusive. While Chinn (1997a,b) finds evidence for individual currencies, and Strauss (1996) finds evidence of cointegration using the conventional asymptotic critical values in eight out of fourteen cases, he also finds the parameter restrictions implied by the model are generally rejected.

More evidence of a long run relationship between the level of the real exchange rate and the productivity differential is found in a panel context. Canzoneri, Cumby and Diba (1999, hereafter CCD) test the proposition in equation (20) using labor productivity differentials, and find that it holds fairly well in a panel cointegration context for the OECD countries. They also test the hypothesis that purchasing power parity holds for traded goods (i.e., that the second line of (20) equals zero), and while they do find evidence of cointegration, the estimated coefficients are not of the expected sign. Hence, CCD do not *directly* confirm the proposition embodied in the top line of equation (20).[19]

It is of interest to note that the expressions in equation (18) and the top line of (19) *with* $q^T=0$ require fairly strong assumptions. In particular, if the form of the production functions differs in the two sectors, then the coefficients on tradable and nontradable productivity need not be of equal and opposite sign. Moreover, in some dynamic models incorporating a fixed factor assumption (Rogoff, 1992), the coefficient on nontraded productivity differs from that of traded,

[19] Strauss (1999) found slightly more evidence in favor of a role for productivity and government

because consumption smoothing can only take place through traded goods production.

Finally, if exact PPP does not hold for traded goods, it may be the case that traded sector productivity affects the real exchange rate through the relative price of traded goods. Engel (1999) has argued that this is an important factor for developed country exchange rate behavior. If this turns out to be the case, then the symmetry restrictions on tradable and nontradable productivity in (20) may be invalidated.

Chinn and Johnston (1999) find some evidence that productivity does not enter in the expected manner, particularly when total factor productivity (which is implied by the theory), is substituted for labor productivity. The analysis is conducted on annual data over 1970-94 period, using panel dynamic OLS (DOLS).[20] They find that relative productivity does not have a significant impact on the real exchange rate, but tradable sector productivity does, with a coefficient of -0.420. If one believed that the coefficient relating relative prices to relative productivities should instead be one, then the implied value is -0.5; the actual point estimate is insignificantly different from this value.

Lee and Tang (2007) provide one of the most recent test of the Balassa-Samuelson hypothesis. Using data for ten OECD countries over the 1970-1995 period, they show (using panel regression techniques) that the findings regarding the link between productivity and the real exchange rate -- or the relative price of tradables (bottom line of equation 19) – is highly sensitive to the productivity measure that is used. Increases in total factor productivity, which is

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spending for exchange rates.

[20] Bilateral exchange rates are are deflated by general price while the tradable and nontradable sector total factor productivity (TFP) data were constructed from the ISDB database which contains TFP disaggregated by sector. The tradable and nontradable categorization is the same as that used by DeGregorio and Wolf (1994). Tradable sectors include agriculture, mining,

suggested by theory, tends to *depreciate* the q_T, so that the net effect on the real exchange rate is muted.

Ricci, Milessi-Ferretti and Lee (forthcoming) extends this analysis to a sample encompassing 48 industrial and emerging market economies. They find that while productivity measures have a statistically significant impact on real exchange rates, in the posited direction, the size of the effect is fairly small. Other effects, including those associated with government consumption and net foreign asset accumulation, are also statistically significant.

To sum up, the evidence in favor of the standard Balassa-Samuelson hypothesis is weak, when focusing on the developed economies, and using total factor, rather than labor, productivity. The most recent research suggests that this is the case because PPP rarely holds for traded goods, perhaps because these goods are highly differentiated (see Cheung, Chinn and Fujii, 2001). In fact, productivity growth in the tradable sector might have a bigger impact on the intercountry price of traded goods than on the relative price of traded to nontraded goods. If this is the case – at least for developed economies – then the difficulty in identifying the productivity/real exchange rate link might be more explicable.

3.3 Two-Good Models

Now depart from the case where there are nontradable goods, and suppose all goods are tradable, but these traded goods are not perfect substitutes. One can then define the real exchange rate as the ratio of the two traded goods prices. The nominal exchange rate is then the real exchange rate, adjusted for the stocks of monies. This can be seen most clearly in the Lucas (1982) model.

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manufacturing, and transportation, while the nontradable sectors include all other services.

Assume there are infinitely lived agents in two countries are subject to a stochastic endowment and monetary shocks. The model uses a Clower, or cash-in-advance, constraint to motivate the holding of money. Each agent maximizes discounted utility. In a complete markets framework, with perfect pooling of risk, each trader consumes his/her share of both endowments. Hence the equilibrium spot price of Y^* in terms of Y (call this P_{Y^*}, the "real exchange rate") is given by the ratio of the marginal utilities of consumption of the two goods.

The nominal exchange rate is given by the ratio of nominal monies, the amounts of endowments of each good, and the relative price of Y^*. This result is interesting, since this implies that as endowments change and the ratio of marginal utilities change, then the real and hence nominal exchange rates also change. Under the typical convention that an increase in endowment of the home good only decreases the relative price slightly, then the exchange rate appreciates.[21] Otherwise, the currency will depreciate.

In terms of observables, the Lucas model is observationally equivalent to the flexible price monetary model. Consider the specification that allows for endowments to be proxied by output. Then the resulting estimating equation is:

$$s_t = (m_t - m_t^*) - (y_t - y_t^*) + p_{y^*} \tag{21}$$

where a complicating factor is that p_{y^*} depends upon the endowments Y and Y^*. This equation is therefore functionally similar to the flexible price monetary model, with the exception of the absence of interest rate terms arises from the binding cash-in-advance constraint. One difference

[21] Lucas (1982) notes the conditions under which the home currency appreciates. Suppose U is homothetic, such that the marginal rate of substitution is a positive, negatively sloped function of the endowment ratio, $r = \eta/\xi$, call it $g(r)$. Then if the derivative of $rg(r)$ with respect to r is greater than zero, then the currency will appreciate. Else, it will depreciate as the terms of trade turn against the home country's goods.

is that in the monetary approach, the response of the exchange rate to a rise in income is unambiguously negative – that is an increase in home income raises money demand and hence the value of the home currency. Here, notice that as y rises, p_{y^*} also rises as before, since more of the home good, holding constant foreign, should induce a price change. The more inelastic demand for the home good (the poorer a substitute the home good is for the foreign) the bigger the price drop. Stockman terms this the "relative price effect". On the other hand, as y in equation (25) rises the "money demand effect" on the exchange rate is negative. Hence there are two countervailing effects.

What is the net effect? Given the binding Clower constraint, one knows that the income elasticity of money demand is unity; however, $\partial \ln(p_{y^*})/\partial \ln(y)$ is unknown. If this object is greater than unity because of low substitutability between y and y^*, then the overall effect of higher GDP is a *weaker* currency. When $\partial \ln(p_{y^*})/\partial \ln(y) < 1$ (y and y^* are good substitutes) the standard effect of higher income leading to a stronger currency, familiar from the flex-price monetary model, holds. However, only when $\partial \ln(p_y^*)/\partial \ln(y) = 0$ (perfect substitutability) will the exact *quantitative* result from the flex-price monetary model hold.[22]

Apte, Sercu and Uppal (2004) have provided a recent general equilibrium endowment model of the exchange rate that nests the Lucas model, PPP and the Balassa-Samuelson formulation. Using the no-arbitrage condition, homothetic utility functions characterized by

[22] The key distinction in this model vis a vis a sticky-price monetary model is that the key driving variable in determining real exchange rates is the py variable. To see this, consider the Dornbusch model. In that framework, a nominal exchange rate movement gets translated into a deviation from PPP because prices are sticky. In the Stockman model, prices are perfectly flexible, so that movements in real exchange rates get translated into movements into the nominal exchange rate. Movements in the nominal magnitudes (such as M) have an impact on the nominal exchange rate, but not the real. Hence, this model possesses the Classical dichotomy

constant relative risk aversion, they find that the nominal exchange rate can be expressed as a function of price levels and nominal consumption (really expenditure), where the elasticities of nominal consumption and the price level sum to unity.

$$s_t = p_t - p_t^* - \kappa y_t + \kappa^* y_t^* \qquad (22)$$

Instead of estimating this equation, they rearrange (26) to yield the real exchange rate on the right side. They proxy y using real consumption data, and find that there is a long run cointegrating relationship between the real exchange rate and consumption levels. The authors take this as evidence in favor of the standard power utility model.

Equation (22) highlights the fact that micro-founded models often yields specifications that are difficult to differentiate empirically from ad hoc models.23

4. New Directions in Exchange Rate Modeling

4.1 Taking Reaction Functions Seriously

One strand of development in macroeconomic based models has involved the incorporation of central bank reaction functions into exchange rates models. Recent research reports that out-of-sample exchange rate forecasting can be improved by incorporating monetary policy reaction functions (Taylor rules) into standard models. Essentially, output gaps and inflation gaps are then brought into the determination of exchange rates.

Engel and West (2005) were the first to incorporate Taylor rule fundamentals in a formal derivation of a model of exchange rates. In analyzing the dollar exchange rate, they posited a

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between nominal and real variables.

[23] Discussion of "generalized PPP" models and behavioral equilibrium exchange rate (BEER) models are discussed in Chapter 11 on "fair value models".

standard Taylor rule for the US, and an interest rate targeting rule for the foreign country that incorporated an exchange rate gap, where the foreign country targets a PPP value of the nominal exchange rate. Combined with interest rate parity (allowing for an exchange risk premium), they solve out for the present value expression for the exchange rate. One of the implications of this present value relationship is, with a discount factor close to unity, the exchange rate *should* be essentially unpredictable. In this context, there is no "exchange rate disconnect", i.e., there is no puzzle why the exchange rate does not seem to be predictable on the basis of currently observed fundamentals.

Another implication of the model with highly persistent fundamentals is that the exchange rate should Granger cause the fundamentals. Of course, in their approach, only interest rates and price levels are observable (since target output and inflation are not). For the G-7 bilateral exchange rates, the null hypothesis of no Granger causality is rejected in most cases. By contrast, the null hypothesis that the fundamentals do not cause Granger cause the exchange rate is almost never rejected.

Engel and West also evaluate the model by assessing the correlation between the change in the exchange rates and the change in constructed fundamentals. They construct the fundamentals using either univariate regressions or bivariate VARs (with imposed discount factors), and find that the correlations are positive, thereby supportive of the model.

Engel and West (2006) examine the dollar-deutschemark rate more closely, and bring into the analysis estimates of the output and inflation gaps. Depending on the imposed parameters and detrending technique, the correlation between the actual and fitted real exchange rate changes is as high as 0.49.

Following the insights of Engel and West (2005, 2006), Chinn (2008) takes a more direct route, regressing exchange rate changes on output and inflation gaps. He finds substantial in-sample predictive power for Taylor rule fundamentals. The analysis proceeds in the following manner. assume that policymakers follow Taylor rules, allowing for smoothing of interest rates:

$$\begin{aligned} & i_t = \pi_t + \beta_y \tilde{y}_t + \beta_\pi \tilde{\pi}_t + \beta_q \tilde{q}_t + \bar{r}_t + \rho i_{t-1} \\ & \beta_y > 0, \beta_\pi > 0, \beta_q > 0, \rho > 0 \end{aligned} \tag{23}$$

Where $\tilde{q}$ is the deviation of the real exchange rate from a target exchange rate, and the tilde's denote "gaps". The monetary authorities move the policy rate in response to the deviations of output from potential GDP, deviations of inflation from target inflation, after accounting for a natural level of interest rates (i.e., the sum of the natural real interest rate and the inflation rate), as well as a deviation of the real exchange rate from the target rate.

A lagged interest rate is included in order to account for the tendency of central banks to smooth interest rates. The inclusion of the real exchange rate is not uncontroversial; it presupposes that the monetary authority attempts to stabilize the exchange rate. However, it is not an uncommon approach, and has been employed by Clarida, Gali and Gertler (1998), as well as Chinn and Dooley (1998).

In order to introduce the exchange rate, I drop the uncovered interest parity assumption, and rely upon an ad hoc characterization of the exchange rate/interest differential relationship.

$$\begin{aligned} & s_{t+k} - s_t = \kappa(i_t - i_t^*) \\ & \kappa < 0 \end{aligned} \tag{24}$$

In words, a larger interest differential is associated with an appreciation of the currency over a four quarter horizon.

Combining (23) and (24), and assuming the foreign country is characterized by a similar Taylor rule, one obtains the following expression:

$$s_{t+k} - s_t = \kappa\beta_y \hat{\tilde{y}}_t + \kappa(\beta_y + 1)\hat{\pi}_t + \kappa\beta_q \hat{\tilde{q}}_t + \kappa\rho\hat{i}_{t-1} + c \tag{25}$$

Where the circumflexes indicate intercountry differentials.[24]

This specification accords well with practitioner intuition for how interest rates (and hence exchange rates) move in response to inflation and output gaps. Consider what happens if the inflation gap rises in the US relative to the foreign economy. Then the Fed will raise the policy rate, thereby appreciating the currency.

What about inflation? This framework implies that when inflation rises above the target level, then the currency will appreciate. Hence, the answer to Clarida and Waldmann's (2007) question "Is bad news about inflation good news for the dollar?" is yes.

Finally, if the real exchange rate rises (currency depreciates), then the central bank will "lean against the wind" and raise interest rates, thereby inducing a strengthening of the currency over the next four quarters.

Chinn (2008) finds that the resulting specification fits well, in sample. In particular, the output and inflation gaps enter in with expected sign, and typically with statistical significance, for the dollar/euro (1999-2007). For a longer period using synthetic dollar/euro exchange rates and variables, the evidence is a little less supportive, particularly with respect to the output gap.[25]

The coefficient on the exchange rate gap is not often statistically significant. This might

[24] Note that I am imposing the same coefficients for inflation and output gaps for both economies. Hence, this specification is a homogenous, asymmetric specification with smoothing, in Molodtsova and Papell's (2008) lexicon.

[25] There is a substantial complication in terms of implementation, since the output gap is directly observable. It can be measured by either use of detrending methods (HP or band-pass filters) or

be because the importance of this variable depends upon the two respective central bank reaction functions ascribing different weights on the exchange rate. If they ascribe the same weight, then the exchange rate gap term drops out.

Molodtsova, Nikolsko-Rzhevskyy and Papell (2008, 2011) and Molodtsova and Papell (2009) investigate the out of sample forecasting properties of Taylor-rule based fundamentals. They find that incorporating Taylor rule variables helps with out-of-sample forecasting at short horizons, improving upon conventional interest rate, purchasing power parity, or monetary models. For the exchange rates for the legacy currencies of the euro, as well as other key bilateral rates (pound, yen, Swiss franc, Australian and New Zealand dollars), Molodtsova and Papell (2009) find that a specification that allows the coefficients on the gap terms to vary across countries, and the exchange rate gap to enter, typically does well in out of sample forecasting exercises, at the one quarter horizon. This outperformance is statistically significant, using tests

Molodtsova, et al. (2011) examines the dollar/euro exchange rate. In this case, they find that the specification imposing common coefficients, and omitting the exchange rate, and omitting interest rate smoothing does best in out of sample forecasting. This is true at the one-month horizon, as well as longer horizons up to one year.[26] Molodtsova and Papell (2010) show that these results largely survive the arrival of zero interest rate policy to the US and the euro area.[27]

Benigno (2004), Corsetti, Dedola, Leduc (2010) and Engel, West and Zhu (2010) show that monetary policy rules that can, among other things, generate some of the observed

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production function based approaches. See Chinn (2008) for discussion.

[26] Less promising results are obtained by Binici and Cheung (2011).

[27] One concern is that equation (24) is ad hoc in nature, and represents an empirical relationship.

persistence in real exchange rates.

Combining monetary fundamentals and policy, with yield curve factors – which reflect expectations and risk premiums – further helps to explain exchange rate movements and excess currency returns one month to two years ahead, outperforming the random walk (Chen and Tsang, 2011). Conversely, as Engel and West (2005) show, exchange rates are useful in forecasting future monetary policy, consistent with the idea that the exchange rate reflects the market's expectations of monetary policy. These findings suggest that excess currency returns reflect both real (business cycle) as well as financial factors.

4.2 The Impact of Financial Globalization

Another strand of research focuses on the implications of financial globalization, particularly on valuation effects and the impact on exchange rates. With the substantial increase in gross cross-border holdings and assets and liabilities, the debate has shifted from the traditional role of current account imbalances on re-allocating net assets, to the roles played by financial variables in explaining exchange rates. Balance sheet and valuation effects, for example, appear to be important in driving exchange rates and in turn real variables.

Confirmation of the quantitative importance of this channel for the U.S. has been provided by Gourinchas and Rey (2007). They use a log-linearized budget constraint to show how adjustment can be accomplished by a traditional trade channel (changes in net exports) and a financial channel involving asset and liability returns. One important component of these returns is the exchange rate change.

Gourinchas and Rey find that exchange rate effects have contributed to about 30 percent of

U.S. external adjustment since the 1950s. This is not to deny that exchange rates affect net exports, thereby aiding adjustment; rather, this financial adjustment channel results in a high degree of predictability at the two to four year horizon. Other recent tests also find evidence for the importance of balance sheets variables. Alquist and Chinn (2008), for example, compare the relative predictive power of the sticky price monetary model, uncovered interest rate parity and the Gourinchas-Rey (2007) models, even when assessing bilateral exchange rates. They find some support for the Gourinchas-Rey model at short-horizons, even though the G-R model does not make specific predictions about *bilateral* exchange rates. Note that they find no model outperforms the random walk model.

Despite the empirical importance of this financial adjustment channel, it is unclear where this effect is coming from. Gourinchas and Rey argue the effect is consistent with home bias in asset holdings in the context of a portfolio balance model, but do not provide a formal model.

Evans and Fuertes (2011) also examine the predictive power of the US external position for the US dollar. The innovation they incorporate is to use a VAR to model the trend and cyclical components, and not just the cyclical components as in Gourinchas and Rey.[28]

Finally, some research has sought to more seriously deal with the financial sector, and in particular address the issue of segmented markets. Alvarez, Atkeson and Kehoe (2009) build a two-country model in which the fraction of agents in each country that participate in financial markets varies over time, due to costs in transacting across assets. The exchange rate is much more volatile than consumption – something difficult to achieve in models with complete markets, but is consistent with real world observations.

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[28] The authors log-linearize around zero net exports and net foreign assets, rather than around the

4.3 The Risk Premium and Order Flow

One of the enduring puzzles in international finance is the presence of deviations from uncovered interest parity, when rational expectations is assumed. Alternatively, interest differentials do not predict either well, or the direction, of subsequent exchange rate changes implied by interest rate parity. Chinn (2006) highlight these well known facts. One way to explain the failure of uncovered interest parity combined with rational expectations (sometimes called the unbiasedness hypothesis) is by positing an exchange risk premium. The portfolio balance models discussed in Section 2.2 provide one (but not the only) rationale for the existence of an exchange risk premium. The lack of success in relating ex post risk premia to government bond stocks (Frankel and Engel, 1984; Engel and Rodriguez, 1989; Engel, 1996), has suggested alternative routes to modeling the exchange risk premia.

Engel (2010) has pointed out that any successful model of the exchange rate must explain why, simultaneously, high interest rate currencies tend to earn excess returns (the forward premium puzzle) and at the same time high real interest rate currencies tend to be stronger than the discounted rationally expected future real interest differentials. This in turn means that if there is an exchange risk premium, it is one that tends to shrink as real interest rates rise.

Deviations from ex post uncovered interest parity might arise from other sources. In the very short-run, order-flow affects exchange rate behavior over periods varying from minutes to a couple of months (see Chapter 3 on market microstructure effects). It also seems related to the information in order flow about underlying macroeconomic factors. Evans (2010), for example, provides evidence that order flow information reaching dealers provides information concerning the slowly

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balanced growth path as in Gourinchas and Rey.

evolving state of the macroeconomy, information which then in turn affects exchange rate behavior. Chinn and Moore (forthcoming) also show that combining a monetary fundamental model with order flow information can improve on out-of-sample exchange rate forecasting.

4.4 Concluding Thoughts

The literature on macroeconomic determinants has split into several directions over the past few decades, with greater reliance on certain types of models in certain areas. In the theoretical aspects, greater and greater emphasis has been placed on modeling exchange rates in the context of general equilibrium models, using either calibration methods, or estimated dynamic stochastic general equilibrium models. In academic empirical work, most of the recent advances have been derived from either the application of new panel econometric methods to existing asset based approaches (such as the monetary approach), or time series modeling as applied to newer models incorporating either reaction functions like the Taylor rule, or balance sheet variables. Among the theoretical innovations, the Taylor fundamentals approach has had a greater impact. This is probably because the data are easier to obtain, and the familiarity and intuitive appeal of the Taylor rules.

Finally, in the practitioner and policy areas, pragmatism rules. Differing models gain greater adherence mostly on the basis of goodness of fit; the prevalence of behavioral equilibrium exchange rate models in assessing currency fair values is one manifestation of that phenomenon.

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