The Feeble Link between Exchange Rates and Fundamentals: Can We Blame the Discount Factor?

Recent research demonstrates that the well-documented feeble link between exchange rates and economic fundamentals can be reconciled with conventional exchange rate theories under the assumption that the discount factor is near unity (Engel and West 2005). We provide empirical evidence that this assumption is valid, lending further support to the above explanation of the empirical disconnect between nominal exchange rates and fundamentals.

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The feeble link between nominal exchange rates and economic fundamentals, often termed the “exchange rate disconnect puzzle,” is a stylized fact documented with remarkable robustness in empirical research (Meese and Rogoff 1983, Mark 1995, Cheung, Chinn, and Pascual 2005, Sarno 2005). However, Engel and West (2005, hereafter EW) demonstrate that the puzzling disconnect between exchange rates and fundamentals can be reconciled with exchange rate theories using a stylized rational expectations model, where the exchange rate equals the discounted present value of expected economic fundamentals. Their result hinges upon two assumptions: (i) fundamentals are nonstationary (or near-random walk) processes, and (ii) the factor for discounting expected fundamentals in the exchange rate equation is relatively large, e.g., smaller than unity but greater than 0.9.

Under the above conditions, the EW model replicates the stylized facts on the relation between exchange rates and fundamentals, changing the interpretation of
the weak link between them, which has often been viewed as a rejection of conventional exchange rate determination theories. This framework shows that the empirical disconnect between exchange rates and fundamentals is exactly what these theories imply under assumptions (i) and (ii). Assumption (i) is uncontroversial in the literature in that fundamentals are generally found to be nonstationary processes (e.g., EW, Engel, Mark, and West 2007). However, assumption (ii) has not been tested, to the best of our knowledge. Therefore, a test of this assumption is important to shed light on whether the solution to the exchange rate disconnect puzzle offered by EW is likely to have empirical relevance.\(^1\) We test and find evidence supporting assumption (ii) by using expectations data on four major currency pairs.

1. EMPIRICAL IMPLEMENTATION

The exchange rate can be written as the discounted present value of expected fundamentals:

\[
 s_t = (1 - b) \sum_{j=0}^{\infty} b^j E_t f_{t+j},
\]

where \( s_t \) is the log nominal exchange rate (domestic price of the foreign currency) at time \( t \), \( f_{t+j} \) is the log fundamentals term at time \( t + j \), \( 0 < b < 1 \) is the discount factor, and \( E \) is the mathematical expectation operator. Equation (1) is the rational expectations solution to a variety of models that postulate that the spot exchange rate is related to economic fundamentals and to the expected exchange rate according to:

\[
 s_t = (1 - b) f_t + bE_t s_{t+1},
\]

upon imposing the no-bubbles condition that \( b/E_t s_{t+j} \) goes to zero as \( j \to \infty \) and assuming that current fundamentals are observable, i.e., \( f_t = E_t f_t \) (e.g., EW). In general, the precise menu of fundamentals, \( f \), and the specific form of \( b \) depend on the structural model in question. For example, in the monetary model of the exchange rate, \( b \), is a function of the interest rate semi-elasticity of the demand for money (e.g., Engel, Mark, and West 2007).

Testing the assumption that the discount factor \( b \) is near unity requires estimation of \( b \) in an equation of the form (2). Our empirical implementation is straightforward. We start from noting the stylized fact that the nominal exchange rate, \( s_t \), and economic fundamentals, \( f_t \), are nonstationary variables (EW), which suggests that the expectation of the future exchange rate, \( E_t s_{t+1} \) is also a nonstationary variable. Thus, exchange rate models of the form (2) imply the existence of a unique cointegrating relation linking \( s_t \), \( f_t \), and \( E_t s_{t+1} \), where the cointegrating parameter on \( E_t s_{t+1} \) is

\(^1\) EW provide evidence supporting some of the other empirical implications of the model without testing directly the assumption on the discount factor.
the discount factor. In turn, by the Granger Representation Theorem, the existence of cointegration implied by the theory requires the relation among \( s_t, f_t, \) and \( E_t S_{t+1} \) to possess a vector error correction model (VECM) representation, where the deviation from the cointegrating relation in equation (2) plays the part of the equilibrium error.

We test for cointegration and estimate the discount factor using the Johansen procedure, based on the trivariate VECM:

\[
\Delta z_t = \Pi z_{t-1} + \sum_{i=1}^{p} \Gamma_i \Delta z_{t-i} + \varepsilon_t,
\]

where \( z_t = [s_t, f_t, E_t S_{t+1}]' \); \( \Pi = \alpha \beta' \), where \( \alpha \) and \( \beta \) are \( 3 \times 1 \) vectors; and \( \Gamma_i \) is a \( 3 \times 3 \) matrix of parameters associated with \( \Delta z_{t-i} \). The existence of one cointegrating relation among \( s_t, f_t, \) and \( E_t S_{t+1} \) implies that the rank of the long-run matrix \( \Pi = 1 \) and the cointegrating vector \( \beta' = (-1 \ 1 - b \ b) \) under the EW framework.

We provide estimates of \( b \) as well as tests of the null hypothesis that \( b = 1 \) against the alternative hypothesis that \( b < 1 \), a condition required for rational-expectations exchange rate models to have well-behaved properties and satisfy the transversality condition.

2. DATA AND EMPIRICAL RESULTS

The data set used to estimate the VECM in equation (3) comprises monthly time series for \( s_t, f_t, \) and \( E_t S_{t+1} \). As a proxy for the expected future exchange rate, \( E_t S_{t+1} \), we use data from a survey carried out by \( FX \) Week across major banks and exchange rate analysts for their forecasts of four U.S. dollar exchange rates against the Swiss franc (CHF), euro (EUR), pound sterling (GBP), and Japanese yen (JPY). We use the mean of the 1-month-ahead forecasts of surveyed respondents. Data for the nominal exchange rate, \( s_t \), are also taken from \( FX \) Week for the same four currency pairs, recorded at the time of the survey to match exactly the expectations data.

With respect to the fundamentals, \( f_t \), we rely on the most common menu of fundamentals used in the literature, namely, the monetary fundamentals:

\[
f_t = (m - m^*)_t - \gamma (y - y^*)_t,
\]

where \( m_t \) and \( y_t \) denote money supply and an aggregate measure of output (real economic activity), respectively; both \( m_t \) and \( y_t \) are expressed in logs; and the asterisk denotes foreign country variables (we take the U.S. as the domestic country). For \( \gamma \) we experiment with two values: 1 and 0.5. The time series for money supply is M1, while output is proxied by industrial production. The data for money and industrial production, obtained from \( EcoWin \), are seasonally adjusted time series. The sample

2. Note that \( \alpha \) is unrestricted to allow for the possibility of feedback and endogeneity in the dynamic relation between the variables in the VECM.
Table 1
Johansen Cointegration Tests

<table>
<thead>
<tr>
<th></th>
<th>CHF</th>
<th>EUR</th>
<th>GBP</th>
<th>JPY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trace</td>
<td>Eig</td>
<td>Trace</td>
<td>Eig</td>
</tr>
<tr>
<td>$r = 0$</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>$r = 1$</td>
<td>0.50</td>
<td>0.55</td>
<td>0.93</td>
<td>0.90</td>
</tr>
<tr>
<td>$r = 2$</td>
<td>0.28</td>
<td>0.28</td>
<td>0.78</td>
<td>0.78</td>
</tr>
</tbody>
</table>

Notes: Figures reported are $p$-values for the Johansen Trace (Trace) and Eigenvalue (Eig) statistics for the null hypothesis that the number of cointegrating relations $r = k$, for $k = 0, 1, 2$. The VAR tested for cointegration is $z_t = [s_t, f_t, E_t s_t + 1]'$, where $f_t = (m - m^*) b_t - \gamma (y_t - y^*)$. The two panels refer to the cases where $\gamma$ is set equal to 1 and 0.5, respectively. Values reported as 0.00 are $p$-values that are equal to zero up to the third decimal point.

Table 2
Estimated Discount Factor and Test That $b = 1$

<table>
<thead>
<tr>
<th></th>
<th>b</th>
<th>$H_0^{asymp}$</th>
<th>$H_0^{boot}$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>$\gamma = 1$</td>
<td>$\gamma = 0.5$</td>
</tr>
<tr>
<td>CHF</td>
<td>0.991</td>
<td>0.19</td>
<td>0.00</td>
</tr>
<tr>
<td>EUR</td>
<td>0.985</td>
<td>0.11</td>
<td>0.00</td>
</tr>
<tr>
<td>GBP</td>
<td>0.988</td>
<td>0.21</td>
<td>0.00</td>
</tr>
<tr>
<td>JPY</td>
<td>0.993</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Notes: The table presents estimates of $b$ in the cointegrating vector $\beta' = (-1 - 1 - b)$; $H_0^{asymp}$ is the asymptotic $p$-value for the null hypothesis that $b = 1$ against the alternative that $b < 1$. $H_0^{boot}$ is the bootstrapped $p$-value for the same null hypothesis, calculated using the procedure described in the Appendix. The VECM estimated is given by equation (3) in the text, with $z_t = [s_t, f_t, E_t s_t + 1]'$ and $f_t = (m - m^*) b_t - \gamma (y_t - y^*)$. The two panels refer to the cases where $\gamma$ is set equal to 1 and 0.5, respectively. Values reported as 0.00 are $p$-values that are equal to zero up to the third decimal point.

The period includes 41 monthly observations from January 2, 2004 to June 1, 2007; the start date is dictated by data availability for the exchange rate expectations time series. We treat the fundamentals term $f_t$ as a nonstationary process.

Table 1 presents the $p$-values from the Johansen cointegration test applied to the vector $z_t = [s_t, f_t, E_t s_t + 1]'$. These results indicate that there exists one cointegrating relation among the variables in the vector $z_t$, consistent with the theory. Table 2 gives the estimates of $b$ in the cointegrating vector $\beta' = (-1 - 1 - b)$. The discount factor, $b$, is estimated to be very similar across the exchange rates examined and close

3. In fact, preliminary unit root tests (not reported) suggest that all the time series of interest for the empirical analysis—namely, $s_t$, $f_t$, and $E_t s_{t+1}$—are realizations from unit root stochastic processes.
to unity, consistent with the assumption in the EW framework. The average estimate of $b$ in Table 2 is approximately 0.989.\footnote{Recall that in the monetary model $b = a/(1 + a)$, where $a$ is the interest rate semi-elasticity of the demand for money. Our average estimate of the monthly discount rate $b \approx 0.989$ implies that $a \approx 90$ for monthly interest rates, $a \approx 30$ for quarterly interest rates, and $a \approx 7$ for annual interest rates. This is in the range of estimates provided by the literature; for example, EW (p. 497) list a range for plausible quarterly estimates of $a$ between 29 and 60.} However, given that the condition $0 < b < 1$ is required for the model to imply convergence of the nominal exchange rate to an economically meaningful long-run equilibrium, it is also instructive to test the null hypothesis that $b = 1$. Using the asymptotic standard errors provided by the maximum likelihood estimation of the VECM to construct a test statistic of this null hypothesis ($H_{0}^{\text{asym}}$), we find that the hypothesis of $b = 1$ is not rejected at conventional significance levels for CHF, EUR, and GBP, while it is rejected for JPY. Nevertheless, since our number of observations is too small to rely on asymptotic results, we carry out a bootstrap test of this hypothesis ($H_{0}^{\text{boot}}$), described in the Appendix and reported in the last column of Table 2. The results indicate that the null hypothesis that $b = 1$ is strongly rejected against the alternative that $b < 1$ for all exchange rates examined.

3. CONCLUSIONS

Using survey data on exchange rate expectations, we provide estimates of the factor for discounting expected fundamentals in exchange rate equations. This exercise is relevant because the well-documented feeble link between exchange rates and fundamentals can be reconciled with conventional theories of exchange rate determination under the assumption that the discount factor is smaller than but close to unity. We present empirical evidence that supports this assumption and, in turn, the resolution to the exchange rate disconnect puzzle proposed by EW.

APPENDIX: BOOTSTRAP PROCEDURE

The bootstrap algorithm used to determine the $p$-value of the test statistic for the null hypothesis that $b = 1$ consists of the following steps:

(i) Given the sequence of observations $\{z\}$ where $z_t = [s_t, f_t, E_t s_{t+1}]'$, estimate the trivariate VECM in equation (3) to obtain a maximum likelihood estimate of $b$ and the residuals.

(ii) Postulate a data-generating process (DGP) for the trivariate VECM in equation (3), where $b$ is assumed to be equal to 1 under the null hypothesis.

(iii) Based on the DGP specified in the previous Step (ii), generate a sequence of pseudo observations $\{z^*\}$ of the same length as the original data series $\{z\}$. The pseudo innovation terms are random and drawn with replacement from the set of observed residuals estimated in Step (i). Repeat this step 100,000 times.
(iv) For each of the 100,000 bootstrap replications \( \{ z^* \} \), estimate the trivariate VECM in equation (3) and the bootstrapped estimate of \( b, b^* \).

(v) Use the empirical distribution of the 100,000 replications of \( b^* \) to determine the \( p \)-value for the null hypothesis that \( b = 1 \) against the alternative that \( b < 1 \).

LITERATURE CITED


