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Three puzzles are closely related to the forward-bias puzzle and the failure of uncovered interest parity: (1) UIP failure is greater for short than long maturities, (2) forward bias is larger between developed than between developing countries and (3) there is no systematic forward bias in commodity markets. A convincing explanation for these puzzles should also explain two other 'facts': (a) the time dependency of the forward bias and failure of UIP and (b) that UIP holds better under a gold standard than under flexible rates. A combination of covered interest parity and monetary policy provides the best available explanation.

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1. Introduction.

Three puzzles are closely related to the forward-bias puzzle and the failure of uncovered interest parity (UIP): (1) the failure of UIP is greater for short than long maturities, (2) the forward bias is larger between developed countries than between developed and developing countries and (3) there is no systematic forward bias in commodity markets. A convincing explanation for these puzzles should also explain two other 'facts': (a) the time dependency of both the forward bias and the failure of UIP and (b) that UIP appears to hold better under a gold standard than under flexible exchange rates. A combination of covered interest parity (CIP) and monetary policy appears to provide the best available explanation.

2. The Puzzles.

2.1 Uncovered Interest Parity.

The theory of uncovered interest parity states that the expected change in the exchange rate, $E(\Delta s_{t+k})$, equals the current interest rate differential, $i_t - i_t^*$.

$$E(\Delta s_{t+k}) = (i_t - i_t^*) \qquad (1)$$

Where $E(s_{t+k})$ is the log of the expected domestic price of foreign exchange, i_t is a risk-free domestic interest rate with the same maturity as s_{t+k} and i_t^* is a risk-free foreign interest rate with the same maturity.

One approach to the theory behind UIP is to use CIP and to assume that $E(s_{t+1})$ equals the current forward rate, f_t.[1] That assumption presumes that speculation equates $E(s_{t+1})$ and f_t. Subtracting s_t from both variables implies that $E(\Delta s_{t+1})$ equals the forward premium, which CIP implies equals the interest rate differential. The result is eq. (1). When UIP fails, it is natural to question the presumption that speculation equates $E(s_{t+1})$ and f_t. That question appears to be the source of the idea that risk premia 'cause' UIP to fail.

Another approach is to use the expectations version of the Fisher equation, an expectations version of purchasing power parity (EPPP) and the assumption that real interest rates are equal. If the nominal

[1] This is the approach used in the New Palgrave Dictionary of Economics, Vol. 1 (2008, 451).

interest rate equals the real rate plus the expected rate of inflation, then $(i_t - i_t^*)$ approximately equals the difference in expected rates of inflation plus the difference in real interest rates. If the real differential is zero, then $(i_t - i_t^*)$ is just the difference in expected rates of inflation. Assuming that $E(\Delta s_{t+k})$ equals the difference in expected inflation, EPPP, produces eq. (1). When UIP fails, this approach suggests that it fails because either the Fisher equation fails, EPPP fails, or real rates are not equal.

While both risk premia and the inequality between real rates are used to explain why UIP fails, I am not aware of anyone claiming that UIP fails because either the Fisher equation or EPPP fails.

Whichever approach one prefers, eq. (2) is the standard test equation for uncovered interest parity.

$$\Delta s_{t+k} = a + b(i_t - i_t^*) + e_{t+k} \tag{2}$$

Where estimates of b denoted $\hat{b}$ should equal 1.0, but in fact are often negative. If expectations are rational, e_{t+k} has a zero mean, is uncorrelated and is orthogonal to $(i_t - i_t^*)$. Since the failure of rational expectations implies that e_{t+k} and $(i_t - i_t^*)$ can be correlated, the failure of rational expectations provides another explanation for why $\hat{b}$ might not equal 1.0. But that failure does not by itself explain why $\hat{b}$ are often negative and significant.

Chinn and Meredith (2004, 409-410) describe the status of UIP as follows. "Few propositions are more widely accepted in international economics than that uncovered interest parity (UIP) is at best useless – or at worse perverse – as a predictor of future exchange rate movements." As shown below, the perversity does not appear to hold for the gold standard.

2.2 Forward-Bias.

The modern forward-bias puzzle begins with Fama (1984) who splits the observed forward exchange rate f_t into the expected future spot rate $E(s_{t+1})$ and a "premium" denoted p_t.

$$f_t = E(s_{t+1}) + p_t \tag{3}$$

Although the subsequent literature almost universally interprets p_t as a risk premium, Fama (1984) is cautious about labeling it. He usually refers to p_t simply as a 'premium', not a 'risk premium'.

p_t should be interpreted as the expected return to speculation for several reasons. First p_t equals $f_t - E(s_{t+1})$, which *is* the expected return to speculation. If $E(s_{t+1})$ is greater than f_t, a speculator expects to earn $E(s_{t+1})$ minus f_t by buying the foreign currency forward and then selling it later for $E(s_{t+1})$. If $f_t - E(s_{t+1})$ is positive, speculators expect to make a return by selling the foreign currency forward and covering the sale by buying the currency at the lower $E(s_{t+1})$. I discuss speculation in terms of forward contracts only to simplify the exposition. A speculator who does not cover an equivalent CIP position expects to earn an additional $E(s_{t+1})$ minus f_t. So the expected speculative return is the same either way.

Second, it makes more sense to consider the expected speculative return as the 'cause' of the forward bias. Consider an initial equilibrium where both expected returns to speculation and risk premia are zero. There is no forward bias, UIP holds and speculators hold no forward contracts. An exogenous increase in the expected speculative return creates a forward bias, causes UIP to fail and induces speculators to buy the foreign currency forward. That forward position creates a risk premium for risk adverse speculators. But unless an exogenous increase in risk can somehow create an expected speculative return, it cannot create a forward bias or cause UIP to fail. Under these conditions, an exogenous increase in risk discourages speculators from taking any position. As a result, the expected return remains zero, there is no forward bias and UIP continues to hold.

The third reason for calling p_t an expected speculative return is that risk premia cannot explain the 'carry trade', but expected speculative returns can. For some recent articles on the carry trade see Burnside et al (2008), Hochradl and Wagner (2010) and Baillie and Chang (2011).

The fourth reason is that the literature often mistakenly assumes that risk neutrality implies that UIP holds. Risk neutrality guarantees that there is no risk premium. Risk neutrality does not guarantee that UIP holds because it does not guarantee that there is no expected speculative return.

Consider an equilibrium in which $f_t - E(s_{t+1})$ is zero and speculators hold no forward contracts. Whether or not potential speculators are risk neutral, there is no risk premium associated with foreign-exchange speculation because speculators hold no forward contracts. If an exogenous shock creates an expected speculative return, risk neutrality alone does not guarantee that UIP will hold. If portfolio adjustment is costly, in the short run there may not be enough speculative funds available to eliminate the expected return and maintain UIP. During the transition, adjustment costs can just offset the expected speculative return. As a result, UIP fails even though investors are risk neutral. When someone claims that risk neutrality implies that UIP holds, they implicitly assume either that adjustment costs are zero or that UIP describes a long run where adjustment costs are irrelevant.

The final reason for interpreting p_t as the expected speculative return rather than as a risk premium is that the explanation for the forward bias developed below is not directly associated with risk premia.

As Fama points out, eq. (3) implies eq. (4).

$$f_t - s_t = E(\Delta s_{t+1}) + p_t \tag{4}$$

Rearranging eq. (4) and assuming rational expectations produces eq. (5).

$$\Delta s_{t+1} = (f_t - s_t) - p_t + \varepsilon_{t+1} \tag{5}$$

Omitting p_t produces the 'Fama equation'.

$$\Delta s_{t+1} = \alpha + \beta(f_t - s_t) + \varepsilon_{t+1} \tag{6}$$

As Fama points out, eq. (7) describes $\hat{\beta}$.

$$\hat{\beta} = C(\Delta s_{t+1}, f_t - s_t)/V(f_t - s_t) \tag{7}$$

Where C(x,x*) is the covariance between x and x* and V(x*) is the variance of x*. If $\hat{\beta}$ is negative, $C(\Delta s_{t+1}, f_t - s_t)$ must be negative.

What I mean by the forward-bias puzzle is that, over a wide variety of time periods, when exchange rates are flexible, $\hat{\beta}$ for short maturities between developed countries are often negative and significant. For over 25 years no one has been able to explain *why* $C(\Delta s_{t+1}, f_t - s_t)$ is negative. Without some way of measuring p_t, all such attempts lack a solid empirical foundation. Covered interest parity provides a way of measuring p_t.

2.3 Developed versus Developing.

Frankel and Poonawala (2010) estimate eq. (6) between developed countries and the United States and between developing countries and the United States. The average $\hat{\beta}$ between developed countries and the U.S. is -4.3 while the average $\hat{\beta}$ between developing countries and the U.S. is 0.005.

I refer to the results in Frankel and Poonawala as the 'development puzzle'. For the failure of rational expectations to explain this puzzle expectations would have to be more rational in developing countries than in developed countries. That does not seem likely. For risk premia to explain this puzzle, developed countries would have to be more risky than developing countries. That does not seem likely.

2.4 Maturity.

Alexius (2001), Chinn and Meredith (2004) and Chinn (2006) use currencies from developed countries to show that uncovered interest parity works better for maturities longer than one year than for maturities of one year and less.[2] They presumably use eq. (2) rather than eq. (6) because forward exchange rates are hard to find beyond one year.[3]

Alexius (2001), Chinn and Meredith (2004) and Chinn (2006) all find that $\hat{b}$ are routinely negative for maturities of one year or less, but $\hat{b}$ are usually positive when maturities are greater than one year. I call that the 'maturity puzzle'.

Neither the failure of rational expectations nor risk premia explain this puzzle. To do so would require assuming that expectations are more rational at long maturities than at short maturities or assuming that there is less risk at long maturities than at short. Neither seems likely.

[2] Mehl and Cappiello (2009) find less support for UIP at long maturities for developing countries.

[3] As Steiner (2002,140) points out: "….the market in long dated forwards is not very liquid and spreads are very wide. The prices available in practice therefore depend partly on banks' individual positions and hence their interest in quoting a price."

Chinn (2006) reviews Alexius (2001), Chinn and Meredith (2004) and an early draft of Frankel and Poonawala (2010). He is unable to provide any explanations.

2.5 Commodity Puzzle.

Fama's decomposition of the forward exchange rate into an expected future spot rate and a premium is as valid for commodity markets as for foreign-exchange markets. $E(s_{t+1})$ can refer to the domestic price of wool just as well as the domestic price of foreign exchange. Eq. (6) is as relevant for the wool market, or any other commodity market with forward markets, as it is for foreign-exchange markets.

Given the importance of the bias in foreign-exchange markets, looking for the same puzzle in other markets would seem an obvious and important thing to do. To the best of my knowledge there have been only two attempts to do so: Fama and French (1987) and Kearns (2007). Using indexes, Kearns finds positive $\hat{\beta}$ for commodities. Using individual commodity prices, Fama and French find mostly positive $\hat{\beta}$. I call frequent negative $\hat{\beta}$ for flexible exchange rates and mostly positive $\hat{\beta}$ for commodities the 'commodity puzzle'.

3.0 CIP.

Akram et al (2008) provide the best available analysis of covered interest parity. They describe the relevant evidence as follows:

> Overall, the evidence is consistent with the Grossman-Stiglitz view of financial markets where efficiency is not interpreted as a statement about prices being correct at each point in time but the notion that in efficiently-functioning financial markets very short-term arbitrage opportunities can arise and invite traders to exploit them, which makes it worthwhile to watch the relevant markets. This is the arbitrage mechanism that restores the arbitrage-free prices we observe on average. Nevertheless, the lack of predictability of arbitrage and the fast speed at which arbitrage opportunities are exploited and eliminated imply that a typical researcher in international macro-finance using data at the daily or lower frequency can safely assume that CIP holds. Akram et al (2008, 238)

Their description of CIP should make it clear that CIP is not an identity or anything like an identity. Identities hold in every possible state of the world. Akram et al (2008) describe occasional failures. Indeed, as they point out, *the success of the theory depends on those occasional failures.*

Akram et al (2008) also say that one can assume that CIP holds for daily and lower frequency data. They do not distinguish between developed and developing countries nor between short and long maturities. Since they use maturities of one year or less from developed countries, strictly speaking their conclusions only hold under those conditions. Since all my data are for short maturities between developed countries and are daily or lower frequency, ignoring the effects of transaction costs and any flaws in the data, CIP should hold for my data.

The theory of covered interest parity says that forward premiums equal corresponding interest-rate differentials. Eq. (8) describes the *theory* of covered interest parity.

$$f_t - s_t - (i_t - i^*_t) = \mathbf{d}_t \tag{8}$$

Where the forward premium and interest rate differential have the same maturity and $\boldsymbol{d_t}$ is the deviation from CIP. For my data the $\boldsymbol{d_t}$ should be the result of transaction costs, particularly bid-ask spreads.

For now I ignore $\boldsymbol{d_t}$ and assume that covered interest parity holds exactly because that simplifies the discussion. I will return to $\boldsymbol{d_t}$ later.

With $\boldsymbol{d_t}$ zero, eq. (8) implies eq. (9).

$$\Delta s_{t+1} = \Delta f_{t+1} - \Delta(i_{t+1} - i^*_{t+1}) = (i_t - i^*_t) + [\Delta f_{t+1} - (i_{t+1} - i^*_{t+1})] \tag{9}$$

Using the equality between $(f_t - s_t)$ and $(i_t - i^*_t)$, covered interest parity also implies eq. (10).

$$\Delta s_{t+1} = \Delta f_{t+1} - \Delta(i_{t+1} - i^*_{t+1}) = (f_t - s_t) + [\Delta f_{t+1} - (i_{t+1} - i^*_{t+1})] \tag{10}$$

Until Pippenger (2011) there was no way to measure p_t directly. As he points out, and as is obvious from eq. (10), covered interest parity implies that p_t equals $[(i_{t+1} - i^*_{t+1}) - \Delta f_{t+1}]$. Using that equality and covered interest parity, eq. (5) can be written as eqs. (11) and (12).

$$\Delta s_{t+1} = (i_t - i^*_t) - p_t + \varepsilon_{t+1} = (i_t - i^*_t) + [\Delta f_{t+1} - (i_{t+1} - i^*_{t+1})] + \varepsilon_{t+1} \tag{11}$$

$$\Delta s_{t+1} = (f_t - s_t) - p_t + \varepsilon_{t+1} = (f_t - s_t) + [\Delta f_{t+1} - (i_{t+1} - i^*_{t+1})] + \varepsilon_{t+1} \tag{12}$$

The omission of $[(i_{t+1} - i^*_{t+1}) - \Delta f_{t+1}]$ is the econometric source of the forward bias and the perverse nature of UIP.

There are three ways to deal with p_t. Pippenger (2011) treats p_t as an omitted variable. One could treat it as measurement error.[4] I follow Fama (1984) and use eqs.(11) and (12) to illustrate the effects of omitting $[(i_{t+1} - i^*_{t+1}) - \Delta f_{t+1}]$.

When CIP holds exactly, eq. (7) implies eq.(13).

$$\hat{\beta} = C(\Delta s_{t+1}, f_t - s_t)/V(f_t - s_t) = \hat{b} = C(\Delta s_{t+1}, i_t - i^*_t)/V(i_t - i^*_t) \quad (13)$$

Of course CIP does not hold exactly even for short maturities and developed countries. One important reason is the 'neutral range' created by bid-ask spreads. Recognizing that effect, I use eq. (6) to estimate $\hat{\beta}$ and eq. (2) to estimate $\hat{b}$. The better the data and the smaller the transaction costs, the closer should be $\hat{\beta}$ and $\hat{b}$.

As Chang (2011), King (2011) and Müller (2011) point out, CIP alone does not provide an economic explanation for why $\hat{\beta}$ and $\hat{b}$ are often negative. In Section 5 CIP plays an important role in the economic explanation

4.0 The Econometrics.

4.1 Data.

My data cover five intervals. Three are the same as in Pippenger (2011): (1) weekly data from the *Federal Reserve Bulletin* for the 1960s between the U.S. and Canada when rates were pegged, (2) weekly data from the *Federal Reserve Bulletin* for the early 1970s between the U.S. and Canada when rates were flexible and (3) daily data from Balke and Wohar (1998) for 1977 to 1993 between the U.S. and U.K. when rates were flexible. The two new data sets are: (a) weekly data from Einzig (1937) for the early 1920s between the U.S. and U.K. when rates were flexible and (b) weekly data between the U.K. and France from 1899 to 1908 under the gold standard.[5]

[4] The error would be $(i_t - i^*_t) - \{(i_t - i^*_t) + [\Delta f_{t+1} - (i_{t+1} - i^*_{t+1})]\} = -[\Delta f_{t+1} - (i_{t+1} - i^*_{t+1})]$, but it would be correlated with $(i_t - i^*_t)$ and $(f_t - s_t)$.

[5] The interest rates in Einzig (1937) and the *Bulletin* are three month. For more information on the Canadian data see the *Federal Reserve Bulletin* for October 1964. Interest rates in Balke and Wohar (1998) are one month. See Balke and Wohar (1998) for more information. The

Quality differs substantially. The best are from Balke and Wohar (1998). The Einzig data are not quite as good. On page 1253 the *Federal Reserve Bulletin* for October 1964 warns that "…the interest arbitrage incentives shown in these tables provide only an approximate indication of the covered differentials in treasury bill yields in the specified markets." The gold standard data has even more serious problems. The maturities of the interest rates probably do not match exactly. In addition, French interest rates are for Thursdays, U.K. interest rates are for Fridays and exchange rates are for Saturdays.

Table 1

Fama's p_t

$(f_t - s_{t+1}) = g_0 + g_1[(i_{t+1} - i^*_{t+1}) - \Delta f_{t+1}]$		
U.S.-U.K.: 1922-1925 (Flexible)		
$\hat{g}_0$	$\hat{g}_1$	$\bar{R}^2$/DW
0.03**	0.99**	0.998
(0.01)	(0.00)	0.232
U.S. - Canada: 1961- 1969 (Pegged)		
–0.02**	1.01**	0.984
(0.01)	(0.00)	0.153
U.S. - Canada: 1970- 1973 (Flexible)		
0.20**	0.86**	0.913
(0.02)	(0.03)	0.222
U.S. - U.K.: 1977-1993 (Flexible)		
–0.00**	1.00**	0.999
(0.00)	(0.00)	1.678

Standard errors in parentheses.* Significant at 5%.** Significant at 1%.

4.2 Premiums, Forward Bias and UIP.

Table 1 reports the results of regressing $f_t - s_{t+1}$ against the p_t implied by covered interest parity, $[(i_{t+1} - i^*_{t+1}) - \Delta f_{t+1}]$. The gold standard is excluded from Table 1 because I do not have forward exchange rates for the gold standard. Table 2 reports the results of estimating the standard Fama equation. Table 3 reports the results of estimating the standard UIP test equation. These and all later regressions use RATS with 'Robusterrors'. Durbin-Watson statistics are low due to multi-period overlapping horizons.

gold standard data are from the National Monetary Commission's *Statistics for Great Britain, Germany and France*. All data are available on request.

The smallest g_1 in Table 1 is 0.86 and the largest is 1.01. The average is 0.96 The smallest $\bar{R}^2$ is 0.913 and the largest 0.999. The average is 0.973. When CIP holds, Fama's premium equals $[(i_{t+1} - i^*_{t+1}) - \Delta f_{t+1}]$ and it explains the observed forward bias.

Table 2
Estimates of Equation 6

$\Delta s_{t+1} = \alpha + \beta(f_t - s_t) + \varepsilon_{t+1}$		
U.S.-U.K.: 1922-1925 (Flexible)		
$\hat{\alpha}$	$\hat{\beta}$	$\bar{R}^2$/DW
1.80**	–4.32**	0.148
(0.25)	(0.74)	0.119
U.S.-Canada: 1961- 1969 (Pegged)		
0.25**	–0.42*	0.003
(0.05)	(0.18)	0.100
U.S.-Canada: 1970- 1973 (Flexible)		
–0.24*	0.27	0.000
(0.09)	(0.37)	0.152
U.S.-U.K.: 1977-1993 (Flexible)		
0.59**	–2.40**	0.034
(0.06)	(0.21)	0.079

Standard errors in parentheses. * Significant at 5%. ** Significant at 1%.

Table 3
Estimates of Equation 2

$\Delta s_{t+1} = a + b(i_t - i^*_t) + e_{t+1}$		
U.S.-U.K.: 1922-1925 (Flexible)		
$\hat{a}$	$\hat{b}$	$\bar{R}^2$/DW
2.18**	-6.12**	0.274
(0.20)	(0.60)	0.136
U.S. - Canada: 1961- 1969 (Pegged)		
0.26**	-0.40	0.001
(0.04)	(0.27)	0.100
U.S.-Canada: 1970-1973 (Flexible)		
-0.43**	-0.91	0.013
(0.12)	(0.50)	0.157
U.S.-U.K.: 1977-1993 (Flexible)		
0.61**	-2.45**	0.032
(0.06)	(0.21)	0.078
U.K.-France: 1899-1908 (Gold Standard)		
0.01**	0.02**	0.038
(0.00)	(0.01)	1.957

Standard errors in parentheses.* Significant at 5%.** Significant at 1%.

The $\hat{\beta}$ in Table 2 vary from a high of 0.27 to a low of -4.32 with all negative $\hat{\beta}$ significant. The $\hat{b}$ in Table 3 range from a high of 0.02 for the gold standard, which is significant, to a low of –6.12 for the 1920s. Both Canadian $\hat{b}$ are negative but not significant. The positive and significant $\hat{b}$ for the gold standard is consistent with Lothian and Wu (2011)

Note that, ignoring the gold standard, the average $\hat{\beta}$ in Table 2, –1.72, is closer to zero than the average $\hat{b}$ in Table 3, –2.47. The point becomes relevant in Section 5.

Tables 1 and 2 suggest that the econometric reason for why $\hat{\beta}$ are time dependent is that the effects of omitting $[(i_{t+1} - i^*_{t+1}) - \Delta f_{t+1}]$ are time dependent. Section 5 provides an economic explanation for that time dependency.

Table 4

Time Dependency of $\hat{\beta}_t$ and $\hat{b}_t$

Int.	$\hat{\beta}_t$	$\hat{b}_t$	Int.	$\hat{\beta}_t$	$\hat{b}_t$
1	0.64	0.65	18	-7.60	-8.13
2	-1.20	-1.25	19	-7.89	-8.48
3	-3.47	-3.62	20	-8.93	-9.75
4	-3.47	-3.62	21	-11.00	-12.40
5	-3.20	-3.33	22	-10.48	-12.35
6	-3.08	-3.20	23	-5.99	-10.36
7	-2.76	-2.85	24	-5.00	-7.60
8	-2.57	-2.65	25	-4.87	-6.47
9	-2.41	-2.50	26	-4.19	-4.71
10	-2.60	-2.67	27	-5.30	-5.87
11	-2.51	-2.57	28	-3.39	-3.25
12	-2.90	-3.02	29	-2.59	-2.42
13	-5.30	-5.32	30	-4.73	-4.73
14	-7.60	-8.02	31	-3.86	-3.55
15	-7.80	-8.19	32	-4.99	-4.83
16	-8.01	-8.49	33	-6.49	-4.71
17	-7.00	-7.49			

4.3 Time Dependency.

The time dependency of $\hat{\beta}$ is well known. See for example Han (2004) and Baillie (2011). I am not aware of similar documentation for the time dependency of $\hat{b}$. Table 4 uses my Balke-Wohar data to illustrate the time dependency of $\hat{\beta}$ and $\hat{b}$. The first interval uses the first 1,000 observations to obtain $\hat{\beta}_1$ and $\hat{b}_1$. The second interval uses observations 101 to 1,100 to obtain $\hat{\beta}_2$ and $\hat{b}_2$. The third interval uses observation 201 to 1,200 to obtain $\hat{\beta}_3$ and $\hat{b}_3$ and so on. As CIP implies, in Table 4 $\hat{\beta}_t$ and $\hat{b}_t$ are similar.

A time varying risk premium is a common explanation for the time dependency of $\hat{\beta}$. See for example Baillie (2011). Presumably the same explanation would hold for $\hat{b}$. Section 5 provides a different explanation.

4.4 $\mathbf{d}_t$.

So far I have ignored the deviations from CIP denoted $\boldsymbol{d}_t$. The $\boldsymbol{d}_t$ in Akram et al (2008) represent risk free returns because they are able to account for the effects of transaction costs, in particular, bid-ask spreads. I am not able to do that so my $\boldsymbol{d}_t$ represent primarily the effects of transaction costs.

Transaction costs such as bid-ask spreads introduce nonlinearity. Within the neutral range created by such costs CIP breaks down. $(i_t - i_t^*)$ can change without any corresponding change in $f_t - s_t$ and the reverse. That nonlinearity also biases $\hat{\beta}$ and $\hat{b}$ toward zero. Balke and Wohar (1998) show that there is nonlinearity in their data, but the effect is small. Since my other data are not as good as the data from Balke and Wohar, the effect is likely to be larger there. The effects of transaction costs play an important role in Section 5.

I assume that essentially all my $\boldsymbol{d}_t$ represent the effects of transaction costs because Akram et al (2008) say that there should be almost no risk-free profits in my data, which are for short maturities, between developed countries and are daily or lower frequency.

Paya et al (2010) show how $\boldsymbol{d}_t$ can affect $\hat{\beta}$ and $\hat{b}$. They use U.S.-U.K. data for the early 1920s from Einzig (1937) like mine to estimate a nonlinear equation like (14).

$$s_{t+1} - f_t = A + B(f_t - s_t)e^{K(\mathbf{d}_t)^2} + e_{t+1} \tag{14}$$

Their estimate of K is negative and significant. They conclude the following:

> We examined data for the interwar period for the dollar-sterling exchange rate and found that the degree of bias in the standard Fama regression varies significantly with the deviation from covered interest parity. When deviations are large, the degree of bias is much smaller than implied by the standard Fama regression. Paya et al (2010, 57)

Using a slightly different approach I replicate their results for the early 1920s.[6] I also apply the same approach to $\hat{\beta}$ and $\hat{b}$ using my other data sets. I omit the gold standard because I do not have forward rates.

To provide a more direct link between $\boldsymbol{d}_t$ and $\hat{\beta}$ and $\hat{b}$, I estimate eqs. (15) and (16)

$$\Delta s_{t+1} = \alpha_1 + \beta_1(f_t - s_t)e^{\chi_1(|\mathbf{d}_t|)} + \nu_{t+1} \tag{15}$$

$$\Delta s_{t+1} = a_1 + b_1(i_t - i_t^*)e^{\chi_2(|\mathbf{d}_t|)} + v_{t+1} \tag{16}$$

Where $|\boldsymbol{d}_t|$ is the absolute value of $\boldsymbol{d}_t$ rather than $\boldsymbol{d}_t$ squared as in Paya et al (2010).

Table 5 reports the results of estimating eq. (15). All $\hat{\chi}_1$ are negative and all but one significant. The $\hat{\beta}_1$ represent estimates of what $\hat{\beta}$ would be if there were no deviations from CIP. The average $\hat{\beta}$ in Table 2 is −1.72. The average $\hat{\beta}_1$ in Table 5 is -3.44. $\boldsymbol{d}_t$ appear to bias $\hat{\beta}$ toward zero.

Table 6 reports the results of estimating eq. (16). Although all the $\hat{\chi}_2$ are negative, only two are significant. The $\hat{b}_1$ in Table 6 represent estimates of what $\hat{b}$ would be if there were no deviations from

[6] The weekly data in Paya et al (2010) are from Einzig (1937). They use the forward premium from Einzig to calculate deviations from CIP. I use the same premia and Einzig's spot rates to retrieve forward rates.

CIP. The average $\hat{b}$ in Table 3 is −2.47. The average $\hat{b}_1$ in Table 6 is −3.58. Bid-ask spreads appear to bias $\hat{b}$ and $\hat{\beta}$ toward zero. This effect plays an important role in the next section.

Table 5

$\hat{\beta}$ and Deviations from CIP

$\Delta s_{t+1} = \alpha_1 + \beta_1(f_t - s_t)e^{\chi_1(\lvert d_t \rvert)} + \nu_{t+1}$			
U.S. - U.K.: 1922-1925			
$\hat{\alpha}_1$	$\hat{\beta}_1$	$\hat{\chi}_1$	$\bar{R}^2$/DW
1.928**	−9.60**	−6.68**	0.232
(0.236)	(1.65)	(2.04)	0.198
U.S. - Canada: 1961- 1969 (Fixed)			
0.28**	−1.77**	−10.70*	0.014
(0.05)	(0.47)	(5.30)	0.106
U.S. - Canada: 1970- 1973 (Flexible)			
−0.19	1.21	−7.69	0.001
(0.10)	(1.15)	(13.41)	0.155
U.S. - U.K.: 1977-1993			
0.68**	−3.62**	−15.83**	0.041
(0.06)	(0.35)	(4.56)	0.084

Standard errors in parentheses. * Significant at 5%. ** Significant at 1%.

Table 6

$\hat{b}$ and Deviations from CIP

$\Delta s_{t+1} = a_1 + b_1(i_t - i^*_t)e^{\chi_2(\lvert d_t \rvert)} + \nu_{t+1}$			
U.S. - U.K.: 1922-1925 (Flexible)			
$\hat{a}_1$	$\hat{b}_1$	$\hat{\chi}_2$	$\bar{R}^2$/DW
2.16**	-9.07**	-3.61*	0.307
(0.20)	(1.38)	(1.41)	0.174
U.S.-Canada: 1961-1969 (Fixed)			
0.26**	-2.24**	-27.15	0.008
(0.04)	(0.81)	(16.93)	0.109
U.S.-Canada: 1970-1973 (Flexible)			
-0.23	0.67	-12.46	0.000
(0.12)	(1.26)	(41.00)	0.155
U.S.-U.K.: 1977-1993 (Flexible)			
0.68**	-3.68**	-17.22**	0.040
(0.06)	(0.36)	(4.91)	0.085

Standard errors in parentheses. * Significant at 5%. ** Significant at 1%.

5. The Economics.

Covered interest parity provides an econometric explanation for the forward-bias puzzle and the perverse nature of uncovered interest parity. The purpose of this section is to provide an economic explanation. That explanation also explains the related puzzles and 'facts'.

Table 7
A Simple Model for Flexible Exchange Rates

$f_t - s_t = i_t - i^*_t = \bar{i}_t$	CIP	(I)
$s_t = (\lambda - 1)\bar{i}_t + \bar{p}_t + v_t$	CIP and PPP	(II)
$f_t = \lambda \bar{i}_t + \bar{p}_t + v_t$	Implied by eq. (II) and CIP	(III)
$\bar{i}_t = E\bar{\pi}_{t+1} + \bar{r}_t + e_t + \varepsilon_t$	Interest rate differential	(VI)
$e_t = -Du_t$	Monetary policy and its liquidity effect	(V)
$E\bar{\pi}_{t+1} = -Ce_t = CDu_t$	Monetary policy and expected inflation	(VI)
$\bar{i}_t = CDu_t - Du_t = (C-1)Du_t + \bar{r}_t + \varepsilon_t$	Interest rate differential	(VII)
$\Delta\bar{p}_{t+1} = \bar{\pi}_{t+1} = CDu_t + x_{t+1}$	Rational Expectations	(VIII)

$$\hat{b} = C(\Delta s_{t+1}, \bar{i}_t)/V(\bar{i}_t) = \{[(C-1)C+(\lambda-1)(U\text{-}1)(C-1)^2]D^2V(u_t)+(\lambda-1)(R-1)V(\bar{r}_t)+(\lambda-1)(A-1)V(\varepsilon_t)\} / \{(C-1)^2D^2V(u_t)+V(\bar{r}_t)+V(\varepsilon_t)\}$$

Definitions:

$E\bar{\pi}_{t+1}$	Expected inflation differential: $E\bar{p}_{t+1} - \bar{p}_t$
$\bar{r}_t$	Real interest rate differential
$\bar{i}_t$	Nominal interest rate differential
u_t	Actual rate of unemployment minus natural rate

Shocks:

$\varepsilon_t = A\varepsilon_{t-1} + z_t \quad 0 \le A < 1$

$v_t = Vv_{t-1} + \nu_t, \quad 0 \le V < 1$

$u_t = Uu_{t-1} + w_t \quad 0 \le U < 1$

$\bar{r}_t = R\bar{r}_{t-1} + y_t \quad 0 \le R < 1$

All shocks, w_t, x_t, y_t, ν_t and z_t have zero means, are uncorrelated and orthogonal.

The basic idea behind the economic explanation is simple. Under certain conditions, the liquidity effects of expansionary (contractionary) monetary policies can reduce (increase) short-term interest rates while creating expectations of depreciation (appreciation). A negative (positive) $i_t - i^*_t$ and positive (negative) $E(\Delta s_{t+1})$ can produce a negative $\hat{b}$. Covered interest parity transmits that negativity to $\hat{\beta}$.

A substantial literature uses impulse responses derived from vector auto-regression to analyze how shocks to monetary policy affect UIP. That literature includes Eichenbaum and Evans (1995), Grilli and Roubini (1996), Cushman and Zha (1997), Kim and Roubini (2000), Faust and Rogers (2003), Scholl and Uhlig (2008), Bjørnland (2009) and Bouakez and Normandin (2010). Most articles find that monetary shocks create short-run deviations from uncovered interest rate parity.

There are other suggestions in the literature that monetary policy plays a role in the forward-bias puzzle and/or failure of UIP. They include Chinn and Meredith (2004) and Lothian and Wu (2011).

Table 7 describes a simple model designed to highlight the role of monetary policy in the forward-bias puzzle and failure of UIP. It assumes that CIP holds and that, under certain conditions, UIP holds.[7] It ignores foreign central banks and assumes: (1) rational expectations, (2) that purchasing power parity holds in the long run, (3) that the expectations version of the Fisher equation holds in the long run, (4) that real interest rates are equal in the long run and (5) that there is a policy 'target'. I refer to that target u_t as deviations from the natural rate of unemployment only for exposition. I have no strong priors as to what u_t might represent. It is probably a mixture of targets that change over time.

5.1 $\hat{b}$.

All the elements of the model are relevant for determining $\hat{b}$, but C and D and the relative variances $V(\bar{r}_t)/V(u_t)$ and $V(\varepsilon_t)/V(u_t)$ are particularly important. Other things equal, the smaller $V(\bar{r}_t)/V(u_t)$ and $V(\varepsilon_t)/V(u_t)$, the more important is monetary policy. With no target D is zero and $\hat{b}$ is positive, but less than 1.0. With D positive and C zero, $\hat{b}$ remains positive and less than 1.0. If C exceeds 1.0, $\hat{b}$ remains

[7] The model implies that $E(\Delta s_{t+1}) = (\lambda - 1)E(\Delta \bar{i}_{t+1}) + E(\bar{\pi}_{t+1}) + E(\Delta v_t)$. When $E(\Delta v_t)$ and $E(\Delta \bar{i}_{t+1})$ are zero , $E(\Delta s_{t+1})$ equals $E(\bar{\pi}_{t+1})$. As long as real rates are equal and the expectations version of the Fisher equation holds, UIP holds because $E(\Delta s_{t+1})$ equals $i_t - i^*_t$.

positive. Other things equal, as *C* rises above zero, $\hat{b}$ declines and can become negative.[8] Monetary policy can produce negative $\hat{b}$.

The economic interpretation of the model is straightforward. *D* reflects how strongly the central bank responds to its target. *C* reflects how markets interpret that policy. When markets believe that price stability is the primary goal of the Bank, *C* is small and $\hat{b}$ is positive. Liquidity effects of an expansionary policy create negative $i_t - i_t^*$, but they do not create the positive $E(\Delta s_{t+1})$ necessary for negative $\hat{b}$.

As trust in the central bank deteriorates, *C* increases. Expansionary policies create larger positive $E(\Delta s_{t+1})$. As long as the liquidity effects outweigh the inflationary effects, an expansionary policy creates a negative differential and a positive $E(\Delta s_{t+1})$, which can create a negative $\hat{b}$. As the central bank becomes more and more inflation prone, *C* can exceed 1.0. Expectations of inflation overcome liquidity effects, which creates a positive differential, a positive $E(\Delta s_{t+1})$ and a positive $\hat{b}$.

Since the collapse of Bretton Woods, most central banks in developed countries have been somewhere between the two extremes of a *C* equal to zero and a *C* equal to 1.0 most of the time. As a result, monetary policies have often produced negative $\hat{b}$.

The Benanke Fed's response to the great recession is an example. It has been able to drive short-term interest rates to almost zero while so far creating only mild expectations of depreciation.

My interpretation of u_t as deviations from the natural rate of unemployment is only for exposition. I have no strong priors as to what kind of monetary policies have created negative $\hat{b}$. *If* u_t represented an unemployment target, one would expect negative $\hat{b}$ to be associated with the business cycle. If they were the result of attempts to stabilize short-term interest rates one would expect negative $\hat{b}$ to be seasonal.

[8] For example, if *C* equals 0.9 while *D, U, R, A* and λ all equal 0.5, then $\hat{b}=\{-0.021875V(u_t)+0.25[V(\bar{r}_t)+V(\varepsilon_t)\}/\{0.0025V(u_t)+V(\bar{r}_t)+V(\varepsilon_t)\}$. As $V(\bar{r}_t)/V(u_t)$ and $V(\varepsilon_t)/V(u_t)$ go to zero, $\hat{b}$ goes to –8.75.

Table 8
Cross Spectrum: Interest Rate Differential to Future Change in Spot Rate:
U.S.-U.K. 1977-1993

Frequency (Cycles/Month)	Coherency Squared	Gain	Phase
0.	0.10687	1.52828	0.55838
0.026	0.15864	2.07451	0.58060
0.053	0.26512*	3.19695*	0.54539†
0.079	0.26428*	4.39453*	0.47411†
0.105	0.13325	4.52223	0.46961
0.132	0.08539	3.99985	0.44427
0.158	0.14406	7.70533	0.39748
0.184	0.04831	5.51690	0.34840
0.211	0.03644	4.81444	0.26103
0.237	0.02772	5.74159	0.49688
0.263	0.12435	16.11395	0.58092
0.289	0.15790	19.37199	0.54135
0.316	0.02027	6.39092	0.39448
0.342	0.10784	11.34037	0.07819
0.368	0.12267	13.35366	0.11743
0.395	0.05398	7.55480	0.28529
0.421	0.11233	9.08803	0.36511
0.447	0.05574	7.92800	0.29856
0.474	0.00375	2.10390	0.45678
0.500	0.05719	7.62106	0.60293

* Significantly different from 0.0 at 5% level.
† Significantly different from zero but not significantly different from 0.5 at 5% level.

Using the Balke-Wohar data, Table 8 shows the cross spectrum from $i_t - i_t^*$ to Δs_{t+1}. A negative $\hat{b}$ would be associated with a phase angle of 0.5. There is no indication of negative $\hat{b}$ in either the very short run, over the business cycle or over the long run. For cycles less than one year, the phase angle is never significantly different from zero (1.0). For cycles longer than 19 months, the same is true. All of the significant inverse relation between Δs_{t+1} and $(i_t - i_t^*)$ comes from cycles between 12 and 19 months. The cross spectrum from $(f_t - s_t)$ to Δs_{t+1} is essential the same. The 'target' of monetary policy in this data appears to be largely seasonal.

The lack of significance for business or longer cycles could be due to the short time span of only 17 years of data where there are only three full five year cycles. Extending the data to 2013 would provide 37 years of data. Unfortunately I do not have access to such data.

5.2 $\hat{\beta}$.

The explanation for negative $\hat{\beta}$ follows directly from the explanation for negative $\hat{b}$. Monetary policies cause $\hat{b}$ to be negative. If CIP held exactly, $\hat{\beta}$ would equal $\hat{b}$. But, even when arbitrage is effective, transaction costs introduce errors into CIP. Whatever the sign of $\hat{b}$, those errors bias $\hat{\beta}$ toward zero. The greater the transaction costs, the greater the bias and the closer $\hat{\beta}$ are to zero relative to $\hat{b}$.

As pointed out earlier, Tables 2 and 3 illustrate this effect of transaction costs. The average $\hat{b}$ in Table 3 is –2.47. The average $\hat{\beta}$ in Table 2 is –1.72. [9]

5.3 The Carry Trade.

$E(s_{t+1})$ minus f_t is the return to speculation. My explanation for negative $\hat{\beta}$ implies positive $E(\Delta s_{t+1})$ with negative $f_t – s_t$ and $i_t – i^*_t$; a perfect combination for the carry trade. Once $E(s_{t+1})$ minus f_t exceeds the relevant transaction costs, any institution or individual that invests in a portfolio of carry trades can expect to make positive returns with little risk. See Burnside et al (2008) and Hochradl and Wagner(2010) for examples of such profits.

5.4. The Gold Standard.

The gold-standard $\hat{b}$ in Table 3 is positive and significant. The model in Table 7 provides a simple explanation. Let u_t represent a gold inflow. Other things equal, a positive D and a C close to zero produce a positive $\hat{b}$. Today inflation is the norm. A C equal to zero would seem irrational now. Under the gold standard that was not true. Then a C close to zero was rational.

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[9] Excluding the gold standard, using the absolute values of $\hat{b}$ and $\hat{\beta}$ the averages are 2.47 and 1.85 respectively.

Table 9
Cross Spectrum: Interest Rate Differential to Future Change in Spot Rate: U.K.-France 1899-1908

Frequency (Cycles/Week)	Coherence Squared	Gain	Phase	Frequency (Cycles/Week)	Coherence Squared	Gain	Phase
0.	0.11144	0.00359	0.80550	0.260	0.19410	0.09755	0.91729
0.010	0.27405*	0.00802*	0.82702	0.269	0.24025*	0.12069*	0.92457
0.019	0.44568*	0.01443*	0.83369*	0.279	0.22714	0.17119	0.93941
0.029	0.43765*	0.02407*	0.81220*	0.288	0.21773	0.14753	0.02915
0.038	0.46842*	0.05094*	0.77445*	0.298	0.32772*	0.12061*	0.06589
0.048	0.65693*	0.06429*	0.83512*	0.308	0.15964	0.09497	0.03127
0.058	0.74318*	0.06652*	0.85133*	0.317	0.18765	0.15429	0.75306
0.067	0.74646*	0.08787*	0.85294*	0.327	0.05411	0.08313	0.75593
0.077	0.81783*	0.10435*	0.84635*	0.337	0.06287	0.10197	0.87169
0.087	0.73327*	0.10051*	0.85355*	0.346	0.18913	0.18849	0.90268
0.096	0.66130*	0.08759*	0.84996*	0.356	0.40170*	0.26342	0.88486
0.106	0.47486*	0.08336*	0.82846*	0.365	0.14563	0.15323	0.84644
0.115	0.26057*	0.08445*	0.84752*	0.375	0.04133	0.09428	0.96983
0.125	0.33403*	0.12481*	0.85865*	0.385	0.12221	0.16475	0.13304
0.135	0.28566*	0.14265*	0.83544*	0.394	0.17691	0.19947	0.21877
0.144	0.15220	0.06687*	0.92139	0.404	0.13006	0.16402	0.18381
0.154	0.26395*	0.07014*	0.90382	0.413	0.04906	0.09487	0.28848
0.163	0.24715*	0.07799*	0.81583	0.423	0.17000	0.11817	0.49022
0.173	0.45276*	0.12134*	0.80350*	0.433	0.06805	0.12702	0.62155
0.183	0.33993*	0.13199*	0.83173*	0.442	0.00429	0.03700	0.16541
0.192	0.45863*	0.16599*	0.80468*	0.452	0.02535	0.06903	0.97670
0.202	0.40396*	0.15367*	0.80403*	0.462	0.14045	0.13495	0.92101
0.212	0.20287	0.10961	0.80515	0.471	0.10996	0.12092	0.95376
0.221	0.47477*	0.18955*	0.78034*	0.481	0.01102	0.03564	0.01728
0.231	0.64154*	0.21342*	0.79436*	0.490	0.07480	0.09867	0.53701
0.240	0.31638*	0.16324*	0.82374*	0.500	0.04928	0.09911	0.54948
0.250	0.11685	0.09354	0.83032				

* Significantly different from 0.0 at 5% level. † Significantly different from zero but not significantly different from 0.5 at 5% level.

Table 9 shows the cross spectrum from $i_t - i_t^*$ to Δs_{t+1} using the weekly data for the gold standard. I make no attempt to eliminate the overlap for this data because I am not sure about the maturity of the interest rates.

In Table 8 only cycles between about 12 and 19 months produce significant phase angles that are consistent with a negative $\hat{b}$. In Table 9 there is no evidence of a negative $\hat{b}$ while coherence squared and gain are significant over a wide range of frequencies. UIP appears to work much better under a gold standard than under flexible exchange rates, which is consistent with monetary policy being the source of the perverse nature of UIP under flexible rates.

Of course one could claim that UIP works better under a gold standard because there is less risk under a gold standard. But risk premia cannot explain the related puzzles.

5.4 Time Dependency.

The $\hat{b}_t$ and $\hat{\beta}_t$ in Table 4 are time dependent for the same reason they tend to be negative; they omit Fama's p_t, which covered interest parity implies equals $[(i_{t+1}-i^*_{t+1})-\Delta f_{t+1}]$. Let $\hat{b}^p_t$ and $\hat{\beta}^p_t$ denote the estimates of $\hat{b}_t$ and $\hat{\beta}_t$ that include $[(i_{t+1}-i^*_{t+1})-\Delta f_{t+1}]$.

$$\hat{b}^p_t = C(\Delta s_{t+1}, (i_t-i^*_t)-p_t)_t/V[(i_t-i^*_t)-p_t]_t \tag{17}$$

$$\hat{\beta}^p_t = C(\Delta s_{t+1}, (f_t-s_t)-p_t)/V[(f_t-s_t)-p_t] \tag{18}$$

Table 10

Time Dependency of $\hat{\beta}^p_t$ and $\hat{b}^p_t$

Int.	$\hat{\beta}^p_t$	$\hat{b}^p_t$	Int.	$\hat{\beta}^p_t$	$\hat{b}^p_t$
1	1.000	1.000	18	1.000	0.999
2	1.000	1.000	19	1.000	0.999
3	1.000	1.001	20	1.000	0.999
4	1.000	1.001	21	1.000	0.999
5	1.000	1.002	22	0.999	0.999
6	1.001	1.002	23	1.000	0.999
7	1.000	1.002	24	0.999	0.999
8	1.000	1.002	25	0.998	0.999
9	1.000	1.002	26	0.997	0.998
10	0.999	1.001	27	0.998	0.999
11	0.999	1.000	28	0.996	0.998
12	0.999	1.000	29	0.997	0.998
13	0.998	0.999	30	0.996	0.998
14	0.999	0.999	31	0.996	0.998
15	0.999	0.999	32	0.996	0.998
16	1.000	1.000	33	0.997	0.998
17	1.000	0.999			

Table 10 shows the $\hat{b}^p_t$ and $\hat{\beta}^p_t$ corresponding to Table 4. As implied by effective arbitrage and covered interest parity, $\hat{b}^p_t$ and $\hat{\beta}^p_t$ are not time dependent. They vary within a narrow range around 1.0.

For simplicity, the model in Table 7 treats all the parameters and $V(\bar{r}_t)/V(u_t)$ and $V(\varepsilon_t)/V(u_t)$ as though they were constant over time. $\hat{b}$ and $\hat{\beta}$ are highly time dependent because they are not constant. C, D, $V(\bar{r}_t)/V(u_t)$ and $V(\varepsilon_t)/V(u_t)$ in particular are likely to vary over time. For example, monetary policy is likely to be asymmetric. A central bank is likely to respond to a high level of unemployment more strongly that a low level. In addition, targets change over time as economic conditions change; reducing unemployment replaces supporting financial stability.

5.5 The Maturity Puzzle.

The economic explanation for the maturity puzzle is fairly simple. The liquidity effects of expansionary policies weaken as maturity increases. Consider a D and C in Table 7 that would produce negative $\hat{b}$ at very short maturities. As maturity increases and D goes to zero, the effects of monetary policy disappear and $\hat{b}$ increases. For long maturities $\hat{b}$ turns positive.

This explanation for the maturity puzzle has an interesting implication. $\hat{b}$ should increase as maturity increases from short to long. That is the pattern in Chinn and Meredith (2004).

Their average $\hat{b}$ for 3, 6 and 12 months are respectively −1.006, −0.992 and −0.368. Their average $\hat{b}$ for 5 and 10 year bond yields are respectively 0.566 and 0.667. The pattern in Chinn and Meredith (2004) is not just that $\hat{b}$ is negative for maturities of one year and less and positive for maturities over one year. As suggested by the model in Table 7, their $\hat{b}$ rise systematically as maturity increases.

5.6 The Development Puzzle.

Before proposing an explanation for the development puzzle, I need to describe the puzzle in more detail. The puzzle is not that $\hat{\beta}$ are routinely negative and significant for developed countries but positive and significant for developing countries. The first proposition holds, but not the second. For the developing countries in Frankel and Poonawala (2010) only one is significant at 5 percent, South Africa, and it is negative. Of the other 13 $\hat{\beta}$ only seven are positive.

Earlier I provided an explanation for why $\hat{\beta}$ are negative and significant between developed countries. That explanation would also apply to South Africa. So what I need to explain is why the $\hat{\beta}$ for the other 13 developing countries have mixed signs that are not significant.

I start with the choice of developing countries and the possibility of bias due to sample selection. Frankel and Poonawala (2010) do not discuss their sample selection in any detail.[10] One obvious problem is the omission of all the BRICS except South Africa. Why include one of the BRICS but not the others? They also choose, without any explanation, to include three newly industrialized countries: Hong Kong, Singapore and Taiwan. Why were other newly industrialized countries excluded? Finally countries like Argentina where the central bank is often forced to finance government debt seem to have been excluded. Having said that, their results for developing countries are about what my explanation for negative $\hat{\beta}$ suggests: mixed signs and relatively low significance.

First my explanation for mixed signs: Almost all central banks for developed countries have similar mandates: low inflation, financial stability and low unemployment. That is not true for central banks in their developing countries. For some like Hong Kong the mandate is a stable exchange rate. Over the sample period in Frankel and Poonawala (2010) the Honk Kong dollar fluctuates between a low of 7.7 and a high of 7.8. The Kuwaiti dinar fluctuates between 0.294 and 0.308. The Hong Kong dollar and Kuwaiti dinar were effectively on a dollar standard. The earlier discussion of the gold standard explains why the $\hat{\beta}$ for such countries would be positive.[11] The differing targets of central banks in developing countries explain the mixed signs.

Now for the low significance: Between developed countries $\hat{b}$ are often highly significant and the link between $\hat{\beta}$ and $\hat{b}$ is relatively tight because the data are good and transaction costs are relatively small. But even under those conditions the link is not perfect because CIP does not hold exactly. As pointed out earlier, ignoring the gold standard, $\hat{\beta}$ in Table 2 are closer to zero than the $\hat{b}$ in Table 3.

[10] The article refers the reader to Appendix I in Working Paper RWP09-023, Harvard Kennedy School. But I did not find any relevant Appendix.

[11] The relatively large $\hat{\beta}$ and $\hat{b}$ for Canada in Tables 2 and 3 is probably due, at least partly, to the Bank of Canada have parity with the U.S. dollar as one of its targets.

Markets within developing countries and between those countries and the United States are often not well developed. Even when all the relevant markets exist, they are much thinner. As a result, transaction costs including bid-ask spreads are much larger. Large transaction costs bias $\hat{b}$ toward zero and reduce their significance. Large transaction costs also weaken CIP. As a result, whatever the sign of $\hat{b}$ for a developing country, it will tend to be relatively close to zero and have relatively low significance. Large transaction costs also weaken CIP. As a result, the corresponding $\hat{\beta}$ will tend to be even closer to zero and to be even less significant. The downward bias and low significance for $\hat{b}$ due to high transaction costs, and the additional downward bias and reduction in significance for $\hat{\beta}$ due to high transaction costs*,* explains why the $\hat{\beta}$ for developing countries in Frankel and Poonawala (2010) tend to be close to zero and insignificant.

5.7 The Commodity Puzzle.

Under flexible exchange rates $\hat{\beta}$ are often negative. $\hat{\beta}$ in commodity markets are usually positive. My explanation for this puzzle is straightforward. As just pointed out, foreign-exchange $\hat{\beta}s$ between developed countries are negative and significant because corresponding $\hat{b}s$ are even more negative and significant. The link between the two being covered interest parity. $\hat{\beta}$ for commodity markets are not systematically negative because, for commodities, nothing like CIP creates a direct link from the $\hat{b}$ in foreign exchange markets to the $\hat{\beta}$ in commodity markets.[12]

6. Summary and Conclusions.

The failure of uncovered interest parity and the forward-bias puzzle do not exist in isolation. There are three related puzzles: (1) UIP works better at long than short maturities, (2) the forward bias is smaller between the U.S. and developing countries than between the U.S. and other developed countries and (3) there is no systematic forward-bias in commodity markets. There also are two related 'facts' that an

[12] The law of one price could provide an indirect link.

explanation of these puzzles should explain: (a) the coefficients associated with the forward-bias puzzle and the failure of UIP are highly time dependent and (b) UIP appears to hold better under a gold standard than under flexible exchange rates. Finally there is the carry trade. A convincing explanation for the failure of UIP and the forward-bias should also explain (1), (2), (3), (a), (b) and the carry trade. The explanation proposed here does so.

The failure of rational expectations and risk premia are conventional explanations for the failure of UIP and the forward-bias puzzle. Not only have these explanations not been widely accepted, they do not explain the other three puzzles.

For the failure of rational expectations or risk premia to explain (1), expectations would have to be more rational at long than at short maturities or long maturities would have to be less risky than short. Neither option seems likely.

For the failure of rational expectations or risk premia to explain (2), expectations would have to be more rational in developing countries than in developed countries or developing countries would have to be less risky than developed countries. Again neither option seems likely.

For the failure of rational expectations or risk premia to explain (3), expectations would have to be more rational in commodity markets than in foreign exchange markets or commodity markets would have to be less risky than foreign exchange markets. Once again neither option seems likely.

As Sherlock Holmes says, "… when you have eliminated the impossible, whatever remains, *however improbable*, must be the truth.." Following Holmes, after rejecting the failure of rational expectations and risk premia, I propose an improbable explanation: monetary policy. A combination of monetary policy and covered interest parity can explain the failure of uncovered interest parity and the forward bias.

When the liquidity effects of an expansionary monetary policy produce a negative interest rate differential and the inflationary effects of that policy create expected depreciation, the policy causes uncovered interest parity to fail. Covered interest parity transforms that failure into a forward bias. As shown in Section 5, this explanation for the failure of uncovered interest parity and the forward-bias puzzle also explains (1), (2), (3), (a), (b) and the carry trade.

Unlike most economists, I am a logical positivist. As such I view all theories as false. But some theories are more false than others. What I look for are theories that are less false than those that are generally accepted. That is I look for theories that are more consistent with the relevant evidence. I believe that my explanation for the facts and puzzles described earlier is more consistent with all the relevant evidence than any proposed alternative including risk premia and the failure of rational expectations.

That does not mean that I believe that my explanation is 'True'. Quite the opposite! I am sure that it is false. But I hope that it will serve as the foundation for an even better explanation.

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