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Two Essays in International Finance: Interest Rate Parity and the Forward Premium Puzzle

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Interest Rate Parity and the Forward Premium Puzzle

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Interest Parity Conditions

Interest parity conditions are no-arbitrage profit conditions for financial capital. When such conditions hold, it is infeasible for investors to obtain higher returns by borrowing or lending. Hence, in principle, interest parity conditions define theoretical linkages between interest rates and exchange rates between countries.

The easiest way to understand parity conditions is to consider how a typical investor can save in different locations. Suppose the home currency is a dollar, and the foreign currency is a euro. Further assume a forward market exists. A forward contract allows an investor to enter into an agreement this period to exchange currencies k periods hence at a forward rate F known today. Then the investor can either save at home, receiving interest rate i, or save abroad, converting by the exchange rate S, receiving the foreign interest rate i^*, and then converting back to home currency by the forward rate F obtaining at time t for a trade at time $t+1$.

$$(1+i) \qquad \text{versus} \qquad (1+i_t^*) \times \frac{F_{t,t+1}}{S_t}$$

If the gross return on the left is greater than that on the right, then investors will place their capital in the home country; if it is less, then investors will place their capital abroad. With infinite amounts of capital moving in search of the highest return (and in this example, there is no risk in nominal terms), these returns will be equalized.

$$(1+i) = (1+i_t^*) \times \frac{F_{t,t+1}}{S_t} \qquad\qquad (1)$$

After manipulation,

$$\frac{(i-i^*)}{(1+i_t^*)} = \frac{F_{t,t+1} - S_t}{S_t} \qquad\qquad (2)$$

This condition is called "covered interest rate parity," reflecting the fact that investors are "covered" against nominal uncertainty by way of the forward market.

If the forward rate is equal to the future spot rate (see "Forward premium"), such that $F_{t,t+1} = S_{t,t+1}^e$ then (2) becomes:

$$\frac{(i-i^*)}{(1+i_t^*)} = \frac{S_{t,t+1}^e - S_t}{S_t} \tag{3}$$

where the e superscript denotes "expected". Equation (3) is termed "uncovered interest rate parity". This expression holds when investors do not require compensation for the uncertainty associated with trading currencies in the future. It states that *expected* nominal returns are equalized across borders in common currency terms.

When interest rates are low, the following log approximations are often used for equations (2) and (3).

$$(i_t - i_t^*) = f_{t,t+1} - s_t \tag{2'}$$

$$(i_t - i_t^*) = s_{t,t+1}^e - s_t \tag{3'}$$

Jeffrey Frankel (1991) has labeled condition (2) holding as characterizing perfect capital mobility, while condition (3) is associated with perfect capital substitutability. These terms arise from the view that if (2) does not hold, there must be some sort of impediment – capital controls or the threat thereof – to the free flow of financial capital. But even if capital is free to move, investors may still respond to risk; that response to risk might drive a wedge between the expected spot and forward rate. When investors are risk-neutral in nominal terms, then investors will treat capital (say debt instruments issued in different currencies) as perfectly substitutable.

The above conditions pertain to financial capital. In order to consider the mobility of physical capital, one has to bring into play the prices of commodities. Integration of goods

markets are often defined as relative purchasing power parity holding (see Purchasing power parity). Ex ante relative PPP can be written as:

$$s_{t,t+1}^e - s_t = (p_{t,t+1}^e - p_t) - (p_{t,t+1}^{*e} - p_t^*)$$ (4)

where p is the log price level. Equation 4 states that expected depreciation equals the expected inflation differential. Combining (4) with the uncovered interest rate parity condition (3') leads to real interest parity.

$$i_t - (p_{t,t+1}^e - p_t) = i_t^* - (p_{t,t+1}^{*e} - p_t^*)$$ (5)

This says the expected rate of return on capital, expressed in physical units, is equalized across borders. To the extent that in neoclassical models the marginal product of capital equals the real interest rate, this condition is equivalent to the equalization of marginal product of capital equalized across borders.

Covered Interest Parity Assessed

For developed economies since the dismantling of capital controls, covered interest parity holds fairly well. It should be noted that most tests are conducted using offshore rates, in which case (2) is sometimes termed "closed interest parity", although covered interest parity is often used as a term encompassing this concept.

Early tests were conducted by Jacob Frenkel and Richard Levich (1975). They found that, after accounting for transactions costs, covered interest parity held for 3 month horizons. Offshore rates sometimes diverge from onshore rates, so that the findings of covered interest parity are somewhat weaker.

The question of whether covered interest parity holds for longer horizons is an open one. Helen Popper (1993) concludes that covered interest differentials at long maturities are not

appreciably greater than those for short (up to one year) maturities. This is a surprising result given that there are likely a number of regulatory impediments that would tend to introduce frictions into the arbitrage process.

Prior to the dismantling of capital controls, and in many emerging markets today, covered interest parity is unlikely to hold. In other words, covered interest differentials could be interpreted as political risk, associated with the possibility of governmental authorities placing restrictions on deposits located in different jurisdictions (clearly this is something that is not relevant when all the deposits are offshore). Robert Aliber (1973) is credited with this interpretation, while Michael Dooley and Peter Isard (1980) provided empirical estimates for the DM/dollar rate.

The Empirical Evidence for Uncovered Interest Parity

Uncovered interest parity is a more difficult condition to test, essentially because expected exchange rate changes are unobservable. In the literature, most tests of UIP are actually joint tests of UIP and the rational expectations hypothesis, i.e., that ex post realizations of the exchange rate are a unbiased measure of the ex ante exchange rate, viz., $s^e_{t,t+1} = E(s_{t+1} \mid I_t)$. This assumption combined with equation (2') yields this standard regression equation, sometimes called the "Fama equation" (Fama, 1984):

$$s_{t+1} - s = \beta_0 + \beta_1(f_{t,t+1} - s_t) + \upsilon_{t+1} \qquad (6)$$

Or by virtue of covered interest parity holding,

$$s_{t+1} - s = \beta_0 + \beta_1(i_t - i_t^*) + \upsilon_{t+1} \qquad (7)$$

where under the joint null hypothesis υ_{t+1} is a mean zero error unpredictable using past information, and $\beta_1 = 1$.

The evidence in favor of this joint hypothesis of UIP and rational expectations is quite weak. The regression of the ex post change of the spot exchange rate on either the forward discount (in equation 6), or the interest differential (in equation 7) typically yields a slope coefficient estimate that is not only different from unity, but in fact negative and different from zero at conventional levels of statistical significance. This is true for reserve currencies (the U.S. dollar, the yen, the Swiss franc, the deutschemark, the franc, or their successor currency, the euro) at horizons up to a year. It is also true for some emerging market currencies (see Frankel and Poonawala, 2006). One interesting characteristic of these regressions is that, although the coefficients are typically different from zero in a statistical sense, the proportion of total variation explained is typically very small.

At longer horizons, (3, 5, 10 years) the evidence is more supportive of the combined UIP-rational expectations hypothesis. Menzie Chinn and Guy Meredith (2004) document that estimates of the β_1 coefficient are usually not significantly different from the posited value of unity at 5 and 10 year horizons. The finding that the joint hypothesis of uncovered interest parity and rational expectations holds better at long horizons than at short appears to be robust. Nonetheless, some caution is necessary here. Consider regressions involving ten year interest differentials; by 2003, there would only be three non-overlapping observations available per currency. Interestingly, Chaboud et al. (2005) find that UIP also holds at extremely short horizons of a few minutes.

Other interesting results pertain to periods of extreme market turmoil. Robert Flood and Andrew Rose (2002), following their 1996 work, find that uncovered interest parity holds better in recent times when the sample encompasses successful attacks on currency pegs. Nonetheless, the still find lots of heterogeneity in experiences with UIP.

A different perspective on uncovered interest parity is provided by dropping the rational expectations hypothesis (see Forward premium puzzle).

A new area of research involves investigation of whether uncovered interest parity holds for emerging markets. Ravi Bansal and Magnus Dahlquist (2000) found that there was a basic asymmetry in whether UIP holds. In particular, they find that when the U.S. interest rate is lower than foreign country rates, UIP holds, while UIP fails to hold when the U.S. rate is higher. They also find that idiosyncratic factors, such as the GDP per capita of the foreign country, are important in determining the degree of failure of UIP to hold.

Using the forward discount in stead of interest differentials, Jeffrey Frankel and Jumana Poonawala (2006) find that there is substantial heterogeneity in the results. What matters importantly is the exchange rate regime; highly managed exchange rate regimes are associated with currencies that exhibit greater deviations from UIP.

Real Interest Parity Measured

If uncovered interest parity does not seem to hold at short horizons, it seems unlikely that real interest parity, described as exact equalization of real interest rates, would hold. However, one could still test the weaker condition that movements in real rates in one country would be met by one for one real movements in other countries.

The key difficulty with testing this condition, like that of uncovered interest parity, is that market expectations are not directly observable. Hence, one can conduct only joint tests for real interest parity. In Eiji Fujii and Menzie Chinn (2001), real interest rates are calculated using a variety of proxy measures of expected inflation: ex post inflation, and inflation predicted using lagged values of inflation models. Both approaches are consistent with rational expectations.

They find that there real interest parity holds with different strength at different horizons. As in numerous previous studies (Cumby and Obstfeld, 1984; Mark, 1985), the real interest parity (RIP) hypothesis is decisively rejected with short horizon data. At five to ten-year horizons, however, the empirical evidence becomes far more supportive and in some cases the RIP hypothesis is not rejected. In general, RIP, *up to a constant*, holds better at long horizons than at short horizons. These results are robust to alternative ways of modeling expected inflation rates.

In recent years, several countries, including the U.K., the U.S., France and Canada, have begun issuing inflation-indexed debt securities. These are marketable securities whose principal is adjusted by changes in the price level (usually the CPI). The principal increases with the inflation rate so that the real return can be directly observed. A cursory investigation reveals that there is no evidence of equalization. Moreover, while there is some covariation, it is not anywhere near one for one. However, the thinness of the markets and the differences in the maturities of the relevant debt instruments makes strong conclusions in either direction difficult.

Also see: Capital mobility, Forward premium, Peso problem, Purchasing power parity, Exchange rate regimes, Exchange rate volatility, Speculation, Sovereign risk.

Further Readings

Aliber, R.Z., 1973, "The Interest Parity Theorem: A Reinterpretation," *Journal of Political Economy* 81: 1451-1459.

Bansal, R. and M. Dahlquist, 2000, 'The forward premium puzzle: different tales from developed and emerging economies,' *Journal of International Economics, Volume 51*: 115-144.

Chaboud, A.P. and J. H. Wright, 2005, "Uncovered Interest Parity: It Works, But Not For Long," *Journal of International Economics* 66(2): Pages 349-362.

Chinn, Menzie D., 2006, "The (Partial) Rehabilitation of Interest Rate Parity: Longer Horizons, Alternative Expectations and Emerging Markets," *Journal of International Money and Finance* 25(1) (February): 7-21.

Chinn, Menzie D. and Guy Meredith, 2004, "Monetary Policy and Long Horizon Uncovered Interest Parity," *IMF Staff Papers 51*(3) (November): 409-430.

Cumby, Robert E. and M. Obstfeld (1984) "International Interest Rate and Price Level Linkages under Flexible Exchange Rates: A Review of Recent Evidence," in J. F. O. Bilson and R. C. Marston (editors) *Exchange rate Theory and Practice* (University of Chicago Press, Chicago, IL).

Dooley, M.P. and P. Isard, 1980, "Capital controls, political risk, and deviations from interest-rate parity," *Journal of Political Economy* 88(2): 370-84.

Fama, E.F., 1984, "Forward and Spot Exchange Rates", *Journal of Monetary Economics* 14: 319-338.

Flood, R.P. and A.K. Rose, 1996, "Fixes: Of the Forward Discount Puzzle," *Review of Economics and Statistics*: 748-752.

Flood, R.B. and A. K. Rose, 2002, "Uncovered Interest Parity in Crisis," *International Monetary Fund Staff Papers 49*: 252-66.

Frankel, Jeffrey and Jumana Poonawala, 2006, "The Forward Market in Emerging Currencies: Less Biased Than in Major Currencies," *NBER Working Paper* No. 12496 (August).

Frenkel, J.A., and R.M. Levich, 1975, "Covered Interest Parity: Unexploited Profits*?" Journal of Political Economy* 83(2): 325-338.

Froot, K.A. and J.A. Frankel, 1989,"Forward Discount Bias: Is It an Exchange Risk Premium?"
Quarterly Journal of Economics 104(1) (February): 139-161.

Fujii, Eiji and Menzie D. Chinn, 2001, "Fin de Siècle Real Interest Parity," *Journal of International Financial Markets, Institutions and Money* 11(3/4): 289-308.

Popper, H., 1993, "Long-Term Covered Interest Parity—Evidence From Currency Swaps,"
Journal of International Money and Finance, Vol. 12, No. 4, pp. 439-48.

The Forward Premium Puzzle

The forward premium puzzle is closely related to the failure of uncovered interest parity to hold (see Interest rate parity conditions), and the phenomenon of forward rate bias, the tendency for the forward exchange rate to systematically mispredict the future spot exchange rate. The puzzle is the finding that the forward premium usually points in the wrong direction for the subsequent actual movement in the spot exchange rate. Uncovered interest parity states that, if the covered interest parity holds for pair of currencies, then the forward discount and hence the interest differential between the two countries, should be an unbiased predictor of the subsequent change in the spot rate, assuming that actors make guesses about the future that are on average correct (what is sometimes termed "rational expectations").

The puzzle is of importance for what it suggests about the workings of international financial markets. To the extent that the puzzle reflects the failure of rational expectations to hold, then interest rate differentials will be poor guides to future exchange rate movements. In addition, the implied lack of market efficiency suggests a potential role for government intervention in markets.

On the other hand, if the puzzle reflects the presence of a premium to compensate for the riskiness of specific currencies, then capital may not be so ready to migrate from one currency to another.

Explaining the Forward Premium puzzle

To fix concepts and terms, define the forward rate at time t for a trade to occur at time k as F_t^k and the spot rate at time t as S_t. Further, let the subjective expectation of the spot rate at

time t+k, based upon time t information, be defined as $\varepsilon_t(S_{t+k})$. Assume for the moment rational expectations, viz., $E_t(S_{t+k})$. Then one should expect:

$$S_{t+k} = F_t^k + u_{t+k} \qquad (1)$$

where the error term is an expectational error.

In reality, regression estimates do not obtain a regression coefficient of unity, although the point estimate is often not statistically significantly far from the posited value..

The forward premium puzzle can be identified by assuming that the error term is log normally distributed, so that (1) can be rewritten as:

$$s_{t+k} = \beta_0 + \beta_1 f_t^k + \tilde{u}_{t+k} \qquad (2)$$

where under the null hypothesis, $\beta_1 = 1$, and β_0 is allowed to equal some constant impounding some Jensens Inequality terms (explain this).

Notice that one can subtract the current log spot rate s_t from both sides, since under the null $\beta_1 = 1$. This yields:

$$s_{t+k} - s_t = \beta_0 + \beta_1(f_t^k - s_t) + \tilde{u}_{t+k} \qquad (3)$$

The left hand side of equation (3) is ex post depreciation, while the term in the parentheses is the forward discount (or inverse of the forward premium).

The puzzle is that estimates of β_1 are not only different from the value of unity, and statistically significantly so, but also that the coefficient estimates are typically *negative*. This suggests that agents could make substantial profits by arbitraging. To be concrete, individuals could borrow in the low interest currency and lend in the high interest currency, in a process termed "the carry trade". This well known strategy can be highly profitable, although the profits are highly vulnerable to sharp movements in the exchange rate.

This issue is linked up to uncovered interest parity in the following sense. If covered interest parity holds, then:

$$(f_t^k - s_t) = (i_t^k - i_t^{k*})$$ (4)

Substituting this no arbitrage profits condition into (3), one finds that (3) can be re-written as:

$$s_{t+k} - s_t = \beta_0 + \beta_1(i_t^k - i_t^{k*}) + \tilde{u}_{t+k}$$ (5)

The above is the regression equation used to test the joint null hypothesis of uncovered interest parity and rational expectations. The finding of a negative slope coefficient in equation (5) is equivalent to the finding of a negative slope coefficient in (3), for instances where covered interest parity holds.

Reasons behind the Puzzle

A number of papers have investigated a wide variety of different econometric issues but overall it appears that the negative slope coefficient cannot be entirely explained by the time series characteristics of the variables. Leaving aside these econometric issues, the forward premium puzzle might exist even when capital is perfectly mobile according to the covered interest parity criterion either because of the invalidity of the rational expectations hypothesis or the existence of an exchange risk premium.

As discussed at greater length in the entry on Interest Rate Parity, estimates of equation (5) using values for k that range up to one year typically reject the unbiasedness restriction on the slope parameter. For instance, the survey by Kenneth Froot and Robert Thaler (1990), finds an average estimate for β of -0.88. Menzie Chinn and Guy Meredith (2004) document that this result holds for more recent periods extending up to 2000. They also show that the bias decreases at longer horizons.

It is important to recall that, in fact, uncovered interest parity properly defined as relating to expected depreciation, is untestable. Estimation of the standard UIP regression equation relies upon the rational expectations methodology embodied in equation (1). Of course, reliance upon the assumption of rational expectations is by no means uncontroversial. In a number of papers, Kenneth Froot and Jeffery Frankel (1989) demonstrate that the standard tests for UIP yield radically different results when one uses survey-based measures of exchange rate depreciation. They find that most of the variation of the forward discount appears to be related to expected depreciation, rather than a time varying risk premium, thereby lending credence to UIP.

Menzie Chinn and Jeffery Frankel (1994) document the fact that it is difficult to reject UIP for a broader set of currencies, although there is some evidence of a risk premium at the 12 month horizon. The authors interpret the differing results as arising from a wider set of currencies – they examine 17 currencies as opposed to the 5 or so examined by Frankel and Froot (1987) – where the assumption of perfect substitutability of debt instruments is less likely to hold. As these authors have stressed, rejection of the rational expectations hypothesis does not necessarily mean one accepts the proposition that agents are irrational. It may be that agents are constantly learning about the economic environment such that their forecasts are biased for long stretches of time.

Perhaps the most natural explanation for why the forward premium predicts the wrong direction of exchange rate movements is that a risk premium drives a wedge between expected changes and actual changes. However, the modeling of the risk premium has proven quite challenging. A standard model motivates the risk premium as a function of the correlation between relative returns on assets denominated in the two currencies, and the ratio of marginal utilities of consumption in the two respective countries. While the theory is quite

straightforward, an implausibly high degree of risk aversion is necessary to rationalize the observed volatility of the risk premium.

Also see: Capital mobility, Interest parity conditions, Monetary policy rules, Peso problem, risk premium, Sovereign risk,

References

Chinn, M.D. and J.A. Frankel, 1994, "Patterns in Exchange Rate Forecasts for 25 Currencies," *Journal of Money, Credit and Banking 26* (4) (November): 759-770.

Frankel, J.A. and C.M. Engel, 1984, "Do Asset Demands Optimize over the Mean and Variance of Returns? A Six Currency Test," Journal of International Economics. 17: 309-323.

Frankel, J.A. and K.A. Froot, 1987,"Using Survey Data to Test Standard Propositions Regarding Exchange Rate Expectations," *American Economic Review. 77*(1) (March): 133-153.

Froot, K.A. and J.A. Frankel, 1989,"Forward Discount Bias: Is It an Exchange Risk Premium?" *Quarterly Journal of Economics 104*(1) (February): 139-161.

Froot, K.A. and R.H. Thaler, 1990, "Foreign Exchange," *Journal of Economic Perspectives 4*(3) (Summer): 179-192.

Further Readings

Alvarez, F., Atkeson, A. and Kehoe, P.J., 2002, "Money, interest rates, and exchange rates in endogenously segmented markets," *Journal of Political Economy* 110 (1): 73-112.

Baillie, R. T. and T. Bollerslev, 2000, "The Forward Premium Anomaly Is Not As Bad As You Think," *Journal of International Money and Finance 19*: 471-488.

This paper argues that there is a nonlinearity in the relationship between the spot rate and the forward discount. When the forward discount is large in absolute value, then the forward discount is likely to point in the right direction. When the forward discount is small, it is likely to point in the wrong direction, perhaps because transactions costs are large relative to potential gains.

Engel, C., 1999, "On the Foreign Exchange Risk Premium in Sticky-Price General Equilibrium Models," *International Finance and Financial Crises: Essays in Honor of Robert P. Flood*, Peter Isard, Assaf Razin and Andrew Rose, eds., (IMF and Kluwer), pp. 71-85.

Engel, C., 1996, "The Forward Discount Anomaly and the Risk Premium: A Survey of Recent Evidence," *Journal of Empirical Finance* 3 (June): 123-92.

Lewis, K.K., 1989, "Changing Beliefs and Systematic Rational Forecast Errors with Evidence from Foreign Exchange," *American Economic Review 79*(4): 621-636.

Lyons, Richard, 2001, *The Microstructure Approach to Exchange Rates* (Cambridge and London: MIT Press).

Maynard, A. and P.C.B. Phillips, 2001, "Rethinking an Old Empirical Puzzle: Econometric Evidence on the Forward Discount Anomaly", *Journal of Applied Econometrics, 16*(6): 671-708.

Maynard, A., 2003, "Testing for Forward-rate Unbiasedness on Regression in Levels and in Returns," *Review of Economics and Statistics 85*(2): 313–327.

McCallum, B.T., 1994, "A Reconsideration of the Uncovered Interest Parity Relationship," *Journal of Monetary Economics* 33: 105-132.

Moore, M.J., 1994, "Testing for Unbiasedness in Forward Markets," *The Manchester School 62* (Supplement): 67-78.

Villanueva, O. Miguel, 2005, "FX Dynamics, Limited Participation, and the Forward Bias Anomaly," *The Financial Review* 40: 67-93.