James R. Lothian

Gabelli School of Business
Fordham University*

June 3, 2015
Draft 2

"Uncovered interest parity: The long and the short of it."

Abstract: Uncovered interest-rate parity (UIP) is a theoretical relation linking changes in exchange rates and corresponding interest-rate differentials. Despite its considerable intellectual appeal, uncovered interest-rate parity has very often been found wanting empirically. I reinvestigate this relation using an 17-country panel of historical time series data at its longest -- for the US-UK country pair -- spanning 217 years. I find results that are largely consistent with theory: over the long term, in most countries bond yields expressed in common currency bear a positive relationship to one another as UIP predicts. This is in contrast to the very nearly opposite findings reported in much of the literature and now taken as a stylized fact.

---

*113 West 60th Street, New York, NY 10023; lothian@fordham.edu, jrmlothian@aol.com.
I want to thank John Devereux, Norman Miller and participants in the Frank J. Petrilli Center Workshop in International Finance at Fordham University for their comments on an earlier version of this paper.

1. Introduction

According to the uncovered interest-rate parity (UIP) relation, countries with high interest rates should see their currencies depreciate relative to currencies of countries with low interest rates Most studies, however, have found the opposite. High interest rates countries over quite lengthy periods have very often experienced currency *appreciation* rather than depreciation. This in turn has come to be known in the literature as the “forward premium puzzle”. The proof of the pudding has also been found in the eating. Among practitioners, the phenomenon of “carry trades” – an implicit bet against UIP in which traders borrow low interest-rate currencies (the “funding currencies") and invest in high interest-rate currencies (the “target” or “investment currencies") – has become common.

In this study, I reexamine the performance of UIP using an even richer body of long-term historical data. These data span 16 foreign countries and the United States and periods ranging from 90 to 217 years. I find results that are largely consistent with theory: in most countries bond yields expressed in common currency bear a positive relationship to one another as UIP predicts. This is in contrast to the very nearly opposite findings reported in much of the literature and now taken as a stylized fact.

2. Data and theory

The data that I have constructed are for multi-country panel encompassing 18 countries and over two centuries. These data are for annual US dollar exchange rates and annual long-term bond yields for Australia, Belgium, Canada, Denmark, Finland, France, Germany, Italy, Japan, the Netherlands, New Zealand, Norway, Spain, Sweden, Switzerland, the United Kingdom and the United States. At their longest, for the UK-US country pair, the data span 217 years; at their shortest, for Finland-US, they span 98 years and on average, 159 years. Table 1 contains a list showing the length of the data series for the 17 various countries individually.

A major reason for focusing on yields on long-term bonds as opposed to yields on short-term money market instruments is data availability. For many countries, short-term money market interest rates simply are not available for very lengthy periods. A secondary, but not unimportant reason for doing so, is that over the longer horizons relevant to bonds, as Menzie Chinn and Guy Meredith (2004) have argued in their paper "Monetary Policy and Long-Horizon Uncovered Interest Rate Parity," economic “fundamentals,” become more important so for that reason too the UIP relation is less apt to be disturbed by idiosyncratic and accidental influences.

Using so long a sample period does, however, come with some potential costs. One is that the data are not all exact matches. The bond yields are long-term and not homogeneous across countries and in many instances not completely homogenous over time within the various countries. There are, moreover, war-time disruptions to markets in both bonds and currencies and in several cases missing observations for such periods and observations marred by the controls and the liquidity limitations that come with the thin markets characteristic of wartimes and their immediate aftermaths.

Uncovered interest parity posits a link between the exchange rate currencies two countries’ and their respective interest rates of the following form:

(1) $$E[\Delta s_{t+1}]_t = i_t - i_t\,*,$$

where $E[\Delta s_{t+1}]$ is the expected change from time t to t+1 in the log spot exchange rate, conditional on information at time t, and expressed as the foreign-currency price of a unit of the home currency, i_t is the one-period foreign interest rate and i_t* is the one-period home interest rate. If there is a forward market in currencies and covered interest parity is assumed to hold, this equation can be replaced by an equation linking the expected change in the exchange rate to the forward premium:

(2) $$E[\Delta s_{t+1}] = f_t - s_t,$$

where f_t is the log forward exchange rate.

The bulk of the literature features tests using a regression equation based on (2), like:

(3) $$s_{t+1} - s_t = \alpha + \beta(f_t - s_t*) + e_{t+1}.$$

where $s_{t+1} - s_t$ is the one-period change in the log spot exchange rate and where α captures risk premia and possibly other disturbing factors and *e* is a forecasting error assumed to be mean zero and serially uncorrelated. The assumption underlying (3) is that speculation by investors will eliminate differences between the expected future spot rate and the forward rate so that the latter becomes an unbiased predictor of future spot rates. A test of unbiasedness is a test of the hypothesis that $\beta = 1$ or, in the absence of risk premia, that $(\alpha, \beta) = (0, 1)$.

An alternative regression equation takes the form:

(4) $$s_{t+1} - s_t = \alpha + \beta(i_t - i_t*) + e_{t+1}.$$

The null hypothesis to be tested here is again $\beta = 1$ or $(\alpha, \beta) = (0, 1)$.

This equation focuses on UIP directly, which has several advantages. As McCallum (1994) has argued it is the UIP relation that is of primary economic interest. It is integral to many the theoretical models that are widely used in open-economy macroeconomics. It is also a feature of several large-scale models used in forecasting. It has the further advantage from a research standpoint of being observable in settings in which there are no forward markets in the currencies being studied.

Because of the long sub-periods in which exchange rates were fixed in the countries this paper examines and because of concerns about resultant errors-in-variables problems (see Lothian and Wu, 2011) the regressions that I run in this paper are based on the following variant of (4) relating returns in the two countries:

(5) $$i_{j,t} - (s_{t+1} - s_t) = \alpha + \beta i_t * + e_{t+1},$$

where $i_{,j,t}$ is the long-term government bond yield for the jth country, i_t* is the long-term home country (US) government bond yield and s_{t+1} - s_t, the one-period change in the log of the spot jth-country vs. USD exchange rate. The null hypothesis of uncovered interest-rate parity in this regression again is that $\beta = 1$ or $(\alpha, \beta) = (0, 1)$.

The rationale here is that investments in domestic and foreign bonds on average should generate the same return when denominated in the same currency. Investing in a US bond and holding it to maturity will result in a certain return of i_t*, while investing in a foreign bond, holding it to maturity and converting the proceeds back into the domestic currency, will generate a return of $i_{j,t}$ - $(s_{t+1} - s_t)$, the sum of the foreign yield, which also is certain at time *t,* plus the currency appreciation or depreciation return, which is uncertain at time *t* and only becomes known at time *t* +, the maturity date of the bond.

In the first two decades following the advent of floating rates, there was an outpouring of studies based on equations (3) and (4). The upshot of this research was that the forward rate was a biased predictor of the future spot rate and that UIP was violated. To make matters worse, estimates of the regression slopes, β, were generally found to be negative rather than positive. Hodrick (1987), Lewis (1995) and Engel (1996) summarize this early research. Froot and Thaler (1990) report results of a survey of empirical results obtained in 75 of these studies. In very few cases are the estimates of β positive; on average they are -.88. The phrases "forward premium puzzle" and "UIP failure" came into being to describe these findings. Replications of these studies and searches for explanations have continued. Miller (2014) contains a review of this literature as well as much of the earlier literature.

Potential explanations for these findings generally have fallen under two headings: time-varying risk premia and systematic expectations errors at least within the particular sample period, as Frankel and Poonawala (2010) put it. For the most part, these two sets of explanations have been treated as mutually exclusive, though logically there is no reason that they should be. My belief is that expectations errors are probably a good deal more prevalent than often thought to be the case and very likely the more important of the two, but that both factors may very well be operating in episodic fashion in different countries and in different time periods.

Most of the recent empirical studies use developed country data for various parts of the period from the breakdown of Bretton Woods and advent of floating exchange rates in the early 1970s until recently. Much of this period, however, was dominated by sizable and persistent fluctuations in the US dollar and somewhat later by similar fluctuations in the Euro, suggesting in turn that the negative results may be driven in part by the unique features of this period. If small sample problems of this sort have in fact distorted the results, then an obvious solution is to turn to longer bodies of data in which even fairly long-lived events are not nearly so dominant. Thinking of this sort was the principal motivation behind the study that Liuren Wu and I conducted using two-century long time series data on UIP for France-UK and US-UK Lothian and Wu (2011). The results of that study were much more in accord with UIP than those typically reported in the literature. Flood and Taylor (1996) and Lothian and Simaan (1998) provide similar evidence using cross-country averaged data. Lothian, Pownall and Koedijk (2013) report additional evidence supporting UIP using both long-term UK vs. US time series data and a recent sample of multi-country cross-section data. See Moosa and Bhatti (1997) and Lambelet and Mihailov (2007) for supportive evidence on UIP in the context of the three international parity conditions, real interest equality and purchasing power parity, as well as UIP. Baillie and Cho (2014) provide somewhat more mixed evidence in their study of time variation in forward-premium regressions.

The potential importance of various idiosyncratic factors in disturbing the UIP relation goes back to Irving Fisher's early work on this subject, beginning with his *Appreciation and Interest* published in 1896.[1]

Friedman and Schwartz (1983, pp. 556-557), in the course of their analysis of interest-rate behavior, provide an illuminating more recent discussion of this phenomenon in the context of US historical experience. They write:

> One way that [the rational expectations hypothesis] has been made operational is by regarding rationality of expectations as requiring that on average the expectations are correct and hence by testing rationality of expectations by the direct or indirect comparisons of expectations with the actual subsequent values of variables about which expectations were formed.

But doing so, they argue, can be quite problematic. As a case in point, they cite the period from 1880 to 1896 in the United States:

> It was surely not irrational by a commonsense interpretation of [the] term [rational expectations] for participants in the financial markets to fear that a growing political support for free silver would lead the United States to depart from the gold standard and to experience subsequent inflation -- and this despite actual deflation during the period.
> …
> As it happened, the departure from gold was avoided. That does not prove that the persons who bet the other way were wrong -- any more than losing a two-to-one wager that a fair coin will turn up heads proves that it was wrong to take the short side of that wager. Given a sufficiently long sequence of events, of course, it could be maintained that all such events will average out, that in the century our data cover, for example, there are enough independent episodes so that it is appropriate to test rationality of expectations by their average accuracy. But that is cold comfort, since few studies cover so long a period, and our aim is surely to derive propositions that can be applied to shorter periods. Moreover, one hundred years only contain six periods as long as that from 1880 to 1896, hardly a sufficiently large sample to assure "averaging out."

---

[1] See Lothian, Pownall and Koedijk (2013) for discussion of Fisher's theoretical and empirical work on UIP including his peso-problem type explanation for empirical violations of the relationship between interest rates and exchange rates.

Indeed that is the major reason for my choice of data for this study, to see whether when all is said and done the tendency for UIP to assert itself over the long term would in fact emerge in the broader body of data used here. Strengthening my belief that this might be the case were the studies of purchasing power parity (PPP) that I and others have conducted. See, for example, See, e.g. Lothian and Taylor (1996) and Lothian (1998). The results of those studies were similar to those obtained in the studies of long-term UIP I have cited. In the shorter spans of post-Bretton Woods data used to investigate purchasing power parity in the 1970s and 1980s purchasing power parity seemed not to hold at all. Tests were generally unable to reject the hypothesis of non-mean-reversion of real exchange rates and hence of non-reversion to PPP. That, however, was not the case once the data series were lengthened. New tests using those longer data series did point to mean reversion of real exchange-rates. Further work on the subject, moreover, confirmed what some researchers had otherwise intuited, that in the presence of long-lived disturbances long-spans of data were necessary for sufficient test power to distinguish between mean-reverting and unit-root behavior (Lothian and Taylor, 1997).

3. Empirical results

Table 2 reports the results of the regressions of adjusted foreign returns on US returns for the 16 foreign countries in the sample. These regressions all took the form of equation (5). Shown in the table are the coefficient estimates and their standard errors directly beneath them, conventional t statistics for tests of the hypothesis that the coefficient are zero are in parentheses below the standard errors, additional t statistics for tests of the hypothesis that β=1 are in brackets. Also shown are the R^2s and standard errors of the regressions.

Two features of these regressions in particular stand out. The first is the sign and magnitude of the slope coefficients in the regressions. All of these estimates are positive. Two-thirds of them, moreover, are in the .75 to 1.25 range. Their average is 1.005. In all instances, we can reject the hypothesis that β=0 and cannot reject the hypothesis that β=1 at levels of significance of .05 or better. In no instance, can we reject the related hypothesis that the regression intercept term is zero at the .05 level of significance.

Returns expressed in the same currency are related positively and in most instances close to one-to-one. The UIP relation, therefore, does in fact appear to hold over the long run.

The second notable feature of these results, however, is the very low R^2 obtained in virtually every one of the regressions. The average is only .054 and in only in the case of Canada and New Zealand is the R^2 greater than .10. So while UIP cannot be rejected in these regressions it nevertheless explains very little. That as, Liuren Wu and I earlier argued, may be the real puzzle requiring explanation.

3. Conclusions

Replication of experiments is part of any science. In this paper, I replicate the earlier work by Lothian and Wu (2011) that used ultra-long time series for UK-France and UK- and the extension of that work for UK-US by Lothian, Pownall and Koedijk (2011). To do so I constructed a multi-country panel of similarly long historical series that includes an additional 14 countries. The results that I get are in line with those reported in those two earlier studies and quite different from those reported in most of the literature. Here the UIP puzzle as conventionally defined disappears. The longer sample period used in this study and in the two earlier studies appears to be the reason. In principle, it allows small-sample departures to cancel one another out and they apparently do so.

The issue now becomes one of short- vs. long-run validity of the theory rather than validity per se. This, in turn, can inform future research and help redirect thinking with regard to the reasons for the poor performance of UIP over shorter periods.

Table 1 Number of observations by country

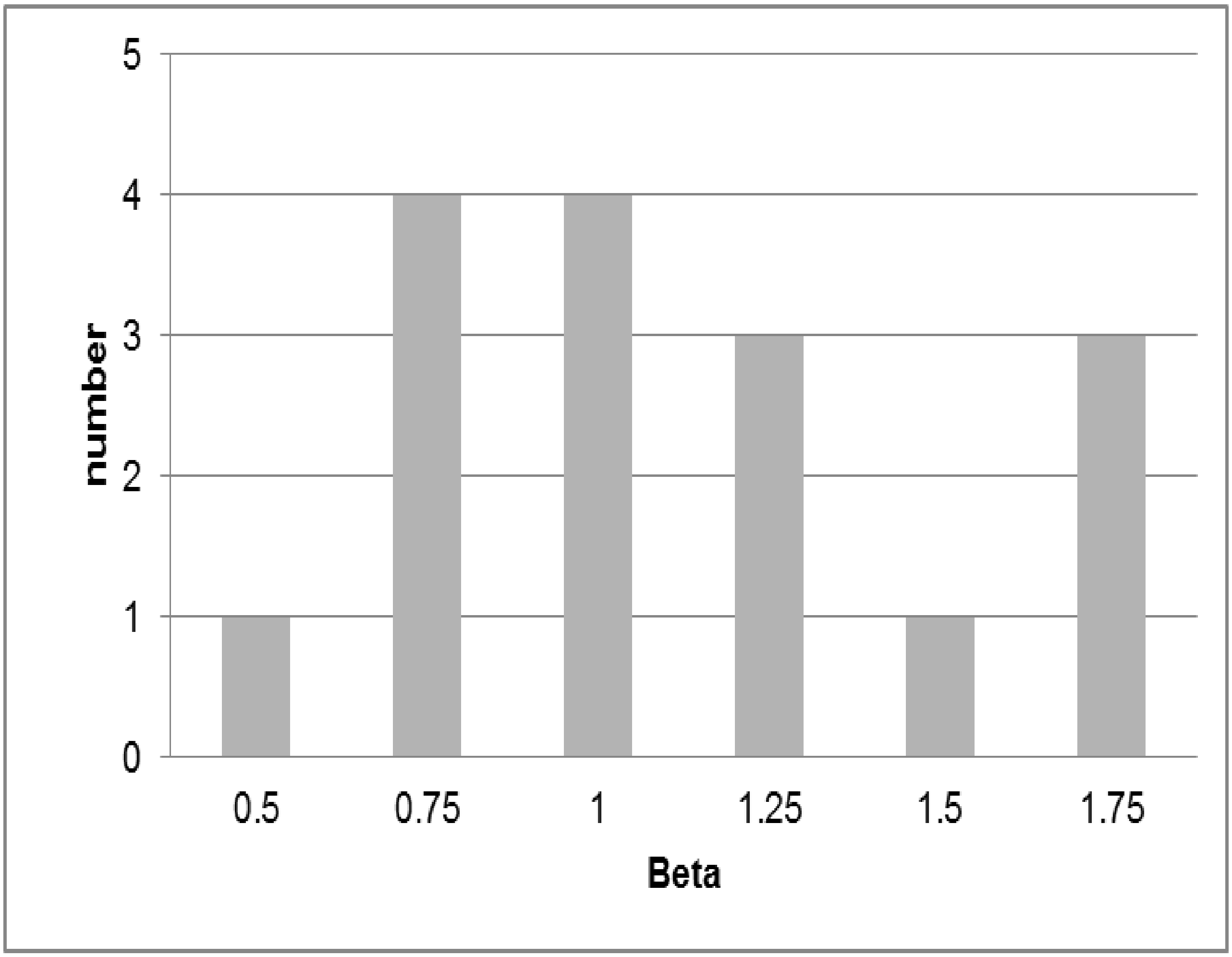
Country	Years
Australia	156
Belgium	182
Canada	156
Denmark	150
Finland	92
France	214
Germany	176
Italy	152
Japan	133
Netherlands	199
New Zealand	109
Norway	135
Spain	183
Sweden	145
Switzerland	100
UK	217
US	217
Mean	159.8

Table 2. Results of returns regressions

country/nobs	α	β	R^2/s.e.	country/nobs	α	β	R^2/s.e.
Australia	0.144	0.875	0.041	Japan	1.183	0.750	0.038
156	2.031	0.342	9.525	133	2.006	0.330	8.547
	(0.316)	(2.557)			(0.590)	(2.274)	
		[0.366]				[0.760]	
Belgium	-0.529	0.825	0.023	Netherlands	-1.019	1.037	0.074
182	2.37	0.401	11.24	199	1.559	0.261	7.469
	(-0.223)	(2.059)			(-0.653)	(3.975)	
		[0.437]				[-0.140]	
Canada	0.37	0.851	0.187	New Zealand	-2.181	1.593	0.160
156	0.849	0.143	3.98	109	2.164	0.353	9.543
	(0.436)	(5.954}			(-1.008)	(4.518)	
		[1.040]				[-1.681]	
Denmark	-0.141	1.058	0.052	Norway	-0.373	0.871	0.041
150	2.2	0.371	10.291	135	2.207	0.367	10.136
	(-0.064)	(2.849)			(-0.169)	(2.3700	
		[-0.157]				[0.352	
Finland	-3.062	1.284	0.032	Spain	-1.512	1.141	0.027
92	4.869	0.750	19.328	183	3.020	0.506	13.884
	(-0.629)	(1.712)			(-0.501)	(2.254)	
		[-0.378]				[-0.279]	
France	-6.441	1.684	0.029	Sweden	0.858	0.711	0.034
214	4.012	0.662	19.523	145	1.881	0.318	8.797
	(-1.605)	(2.543)			(0.456)	(2.234)	
		[-1.033]				[0.907]	
Germany	1.872	0.686	0.028	Switzerland	3.545	0.367	0.009
176	1.900	0.307	7.978	100	2.500	0.393	10.332
	(0.986)	(2.230)			(1.418)	(0.934)	
		[1.022]				[1.612]	
Italy	-6.428	1.674	0.041	UK	0.054	0.676	0.041
152	3.908	0.660	18.299	217	1.360	0.223	6.673
	(-1.645)	(2.535)			(0.039)	(3.034)	
		[-1.020]				[1.455]	

Notes to table 2: Regressions took the form $i_{j,t} - (s_{t+1} - s_t) = \alpha + \beta i_t * + e_{t+1}$, where $i_{j,t}$ is the long-term government bond yield for the jth country, i_t* is the long-term home country (US) government bond yield and s_{t+1} - s_t is the one-period change in the log of the spot jth-country vs. USD exchange rate. The figures in the first and second lines below the coefficient estimates are standard errors of the coefficients and in parentheses conventional t values, respectively. The figures in the bottom lines in brackets are t values for tests of the hypothesis β=1.

Figure 1. Frequency distribution of slope coefficient estimates in Table 2



References

Baillie, R.T; Cho, D. 2014. Time variation in the standard forward premium regression: Some new models and tests. *Journal of Empirical Finance* 29:52-63.

Chinn, M.D., 2006. The (partial) rehabilitation of interest rate parity in the floating rate era: Longer horizons, alternative expectations, and emerging markets. *Journal of International Money and Finance* 25, 7-21.

Chinn, M.D., Meredith, G., 2004. Monetary policy and long horizon uncovered interest parity. *IMF Staff Papers* 51, 409-430.

Chinn, M.D.; Quayyum, S. 2012. Long Horizon Uncovered Interest Parity Re-Assessed NBER Working Paper No. 18482.

Doskov, N.; Swinkels, L. Empirical Evidence on the Currency Carry Trade, 1900-2012. *Journal of International Money and Finance* 51, 370-389

Engel, C., 1996. The forward discount anomaly and the risk premium, a survey of recent evidence. *Journal of Empirical Finance* 3, 123-192.

Flood R.P. and Taylor M.P. 1996. "Exchange rate economics: what's wrong with the conventional macro approach," *The microstructure of foreign exchange markets,* National Bureau of Economic Research, 261-294.

Frankel, J.A. Poonawala, J., 2010. The forward market in emerging currencies: Less biased than in major currencies *Journal of International Money and Finance* 585–598.

Friedman, Milton and Anna J. Schwartz. 1983. *Monetary Trends in the United States and the United Kingdom: Their Relation to Income, Prices, and Interest Rates, 1867-1975*. Chicago: University of Chicago Press for the NBER.

Froot, K.; Thaler, R. 1990. Foreign Exchange. *Journal of Economic Perspectives* 4, 179-92.

Hodrick, R.J. 1987. *The empirical evidence on the efficiency of forward and futures foreign exchange markets* Harwood Academic Publishers, Chur, Switzerland.

Lambelet, J.-C., Mihailov, A. 2007. The triple-parity law, Unpublished working paper, University of Reading.

Lewis, K.K., 1995. Puzzles in International Financial Markets, *The Handbook of International Economics*, vol. III., Amsterdam: North Holland: 1913-1971.

Lothian, J.R. 1998. Some New Stylized Facts of Exchange Rate Behavior, *Journal of International Money and Finance*, 17, 29-39.

Lothian, J.R., Pownall, R.A.J., Koedijk, K.G. 2013, I discovered the peso problem: Irving Fisher and the UIP puzzle. *Journal of International Money and Finance* 38, 5-17.

Lothian, J.R., Simaan, Y., 1998. International financial relations under the current float, evidence from panel data. *Open Economies Review* 9, 293-313.

Lothian, J.R : Taylor, M.P. 1996. Real Exchange Rate Behavior: The Recent Float from the Perspective of the Past Two Centuries. *Journal of Political Economy*, 104, 488-509.

Lothian, J.R : Taylor, M.P. 1997. Real Exchange Rate Behavior, *Journal of International Money and Finance*, 16, 945-954.

Lothian, J.R., Wu L., 2011, Uncovered interest rate parity over the past two centuries. *Journal of International Money and Finance* 30, 448-473.

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

Miller, N.C. 2014. *Exchange Rate Economics: The Uncovered Interest Parity Puzzle and Other Anomalies* , Cheltenham UK and Northampton, MA.

Moosa, I.A. and Bhatti, R.H., 1997. *International Parity Conditions: Theory, Econometric Testing and Empirical Evidence* , London: Macmillan.