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I discovered the peso problem: Irving Fisher and the UIP puzzle

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A B S T R A C T

Irving Fisher was the first economist to posit what has come to be known as uncovered interest parity relation. He was also the first to offer a peso-problem type explanation for important episodes in which it was violated. After reviewing his theoretical and empirical work on this subject, we go on to reexamine both his data and several other bodies – two consisting of multi-country panel data and a third consisting of a two-century long time series for the United States and the United Kingdom. We find evidence in these data of the important role played by episodic phenomena in disturbing the UIP relation. Like Fisher, we find that the influence of such phenomena dissipates over time. Over the long term these errors prove to be less important and UIP receives empirical support.

1. Introduction

Irving Fisher is widely credited with being the first economist to posit a one-to-one relation between nominal interest rates and expected rates of inflation. As Fisher himself took great care pointing out, however, he was in fact not the first writer to come up with that idea (Fisher, 1896, 1907 pp. 4–5;

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pp. 356–358).[3] In that respect, though perhaps not in a broader context, the appellation "Fisher equation" is a misnomer.

Where it or something very like it does seem to apply is to a closely related subject – the concept of uncovered interest parity (UIP). Here Fisher appears to have had three firsts – first economist to provide a theoretical rationale for such a relationship, first to evaluate its empirical performance and first to apply an explanation of the peso-problem variety for several of the prominent departures from UIP observed in the data.[4]

These three firsts coupled with the fact that Fisher's contributions here have been largely ignored gave rise to the title of this paper. It is a conscious takeoff on the *Journal of. Political Economy's* (1973) reprint with the title "I Discovered the Phillips Curve: 'A Statistical Relation between Unemployment and Price Changes'" of a 1926 study by Fisher of the unemployment vs. inflation relation.

In Fisher's eyes UIP was simply the cross-country dual of the within-country relation between nominal interest rates and inflation. He viewed them as two sides of the same coin – two facets of a more general relation linking interest rates in different standards, the relation between "appreciation and interest" as the title of his first book on the subject has it. In the Fisher equation, the interest rates in question are, of course, the nominal and real rates of interest and the link between them, the expected rate of inflation – the rate at which money is expected to depreciate or appreciate in terms of goods. In the UIP relation, the interest rates are the nominal interest rates in the two currencies in question and the link between them the expected rate of change of the exchange rate – the rate at which one currency is expected to depreciate or appreciate in terms of the other. Fisher discussed these relations first in his 1896 monograph *Appreciation and Interest*, and later in two books on interest-rate determination, *The Rate of Interest* (1907) and his more often cited *The Theory of Interest* (1930).

Fisher saw both as very often subject to violation in the real world. Concerning the Fisher equation, he argued that people generally did not "adjust at all accurately and promptly" to changes in the behavior of prices but did so only with a long lag (Fisher, 1930, p. 415). For UIP he said somewhat the same thing, presenting evidence of incomplete and delayed adjustment of nominal interest rate differentials to exchange-rate movements, perhaps due to learning about the monetary regime, and also of two specific episodes in which agents anticipated changes that had not yet occurred and the peso-type problems alluded to above arose.

In this paper, we first briefly review Fisher's general discussion of the relationship between appreciation and interest. We then go on to consider his empirical work on UIP, which centered upon two extended episodes in the late nineteenth century in which bonds issued by the same country, but denominated in different monetary units, circulated simultaneously. The first of the two bodies of data that Fisher analyzed was for yields on long-term U.S. bonds over the period 1870 to 1896, one bond payable in gold and the other in paper, or "greenback," currency; the second was for yields on long-term Indian bonds traded in London between 1865 and 1894, one bond payable in sterling and the other in silver rupees.[5]

In his analysis of the data from these episodes Fisher reached several major conclusions. He found evidence in support of UIP in both, but that support was very far from perfect. Where UIP was violated, moreover, Fisher was able to provide coherent explanations for the failure. The major culprit, he argued, was agents' inability to accurately forecast the underlying monetary conditions. In some instances, agents appeared to have substantially underestimated the extent of the exchange-rate change; in others they overestimated the changes along the lines of what now are termed "peso problems." He

[3] Fisher (1896, p. 4–5) cites an anonymous author (later identified as William Douglass) who wrote in 1738, John Stuart Mill, Jacob de Haas, Alfred Marshall, and John B. Clark. He omits Henry Thornton, however. See in this regard, Dimand (1999) and Humphrey (1983).

[4] We should perhaps qualify these statements somewhat since Stigler's law of eponomy (Stigler, 1980) might indeed pertain here. Stated in its strongest form Stigler's law says that no scientific discovery is named after its original discoverer. In somewhat tongue and cheek fashion Stigler in turn names the sociologist Robert K. Merton as the discoverer of "Stigler's law." With this in mind and at John Devereux's suggestion, we examined Henry Thornton's work suspecting that he quite possibly could come up with UIP well before Fisher. As it turns out, Thornton came close in an 1811 speech on the Bullion Report (Thornton, 1811) but did not actually posit the full UIP relation.

[5] In the *Theory of Interest Fisher* extended these data another 12 years to 1906.

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went on to show, however, that in the long run the influence of appreciation on interest rates was, as he phrased it, "more certain," and departures from the theory much less prominent.

In line with Fisher's premise, substantial evidence abounds that UIP has not in fact rigidly held in recent decades, or at least not in the short term.[6] Engel (1996) and Chinn (2006) provide surveys of this literature. Indeed, one of the most puzzling features of exchange-rate behavior since the advent of floating exchange rates in the early 1970s is the tendency for countries with high interest rates to see their currencies appreciate rather than depreciate, as UIP would suggest. This UIP puzzle, also known as "the forward premium puzzle," is now so well documented that it has taken on the aura of a stylized fact. As a result, it has spawned an extensive second-generation body of literature that attempts to explain these departures from theory.

After we review Fisher's empirical work on UIP, we run regressions of the form used in many recent studies of the subject using Fisher's own data. As it turns out these produce results very similar to those reported in those later studies. We discuss the possible reasons for the similarities between the two.

Fisher's own explanation for failures of UIP and the appreciation–interest relation more generally to hold centered on small-sample problems and other stochastic factors affecting that relation. He argued that (1907, pp. 282–283) "When long periods of price movements are taken, the influence of appreciation on interest is more certain … because [i]n averages covering so many years we may be sure that accidental causes are almost wholly eliminated." To investigate the possible effects of such transitory influences, we run two sets of regressions. In the first we use long historical bond yield series for the U.S. and U.K. In the second we use multi-country data of two sorts. We first run five-year rolling regressions for the G7 countries. We then run regressions using pooled data for a larger sample of countries averaged over progressively longer time periods.

2. Fisher on appreciation and interest

Fisher's first discussion of the relationship between appreciation and interest is contained in his 1896 monograph of that name. The motivation for that work was the bimetallic controversy that had been raging for some time. One of the key questions of interest was whether, as some writers alleged, the appreciation of gold adversely affects debtors, whether, as Fisher put it, "contracting parties [were] powerless to forestall the gains or losses of an upward or downward moving currency." (Fisher, 1896, p. 1)

Fisher's response was in the negative. It was, Fisher said, "clear that if the unit of length were changed and its change were foreknown, contracts would be modified accordingly." He used a rather folksy example to illustrate his point (Fisher, 1896, p. 1):

> Suppose a yard were defined (as once it probably was) to be the length of the king's girdle and suppose the king to be a child. Everybody would then know that the "yard " would increase with age and a merchant who should agree to deliver 1000 "yards" ten years hence, would make his terms correspond to his expectations. To alter the mode of measurement does not alter the actual quantities involved but merely the numbers by which they are represented.

In both *The Rate of Interest* and *The Theory of Interest*, Fisher engaged in similar discussions, at many points using nearly identical phraseology to that in *Appreciation in Interest* (see Fisher, 1907 pp. 78–80 and Fisher, 1930 pp. 37–39). In both instances, however, he elaborated somewhat further on the question surrounding expectations formation and whether or not appreciation was fully anticipated.

In *The Rate of Interest*, Fisher stated (Fisher, 1907, p. 78):

> The influence of monetary appreciation or depreciation on the rate of interest will be different according to whether or not that appreciation or depreciation is foreseen. If it is not foreseen, the appreciation of money necessarily injures the debtor, because, the purchasing power of money being increased, the principal of his debt, when due, represents a larger quantum of goods than

[6] Lothian and Wu (2011) using long historical times series for the France, the United Kingdom and the United States report results largely in accord with UIP as do Lothian and Simaan (1998) using panel data.

> was anticipated when the debt was contracted. But if the appreciation is foreseen, any increased burden of "the principal" may be offset by a reduction in the rate of interest.

A bit further along, he went on to say (Fisher, 1907, p. 79):

> It would be strange, if, in some similar way, an escape could not be found from the effects of changes in the monetary yardstick, provided these changes were known in advance. To offset a foreseen appreciation, therefore, it would be necessary only that the rate of interest be correspondingly lower, and to offset a foreseen depreciation, that it be correspondingly higher.

To illustrate the effects of a foreseen appreciation on interest rates Fisher constructed a series of numerical examples of increasing complexity. Humphrey, in his review of the development of the relationship between real and nominal interest rates calls Fisher's expositions in *Appreciation and Interest* "the earliest complete account of his theory of inflation and interest … the high water mark in the pre-20th century development the subject." (Humphrey, 1983, p. 7).

3. Fisher's empirical evidence

A key feature of Fisher's investigation of UIP was his research design. The data Fisher used were for yields of bonds of similar maturities issued by the same government, but denominated in different currencies.[7] The result was something close to an ideal experiment, one in which differences in default risk and other influences on real interest rates were absent and in which errors in agents' forecasts of exchange-rates were left as the force behind departures from UIP.

The first of the two bodies of data that Fisher analyzed, yields on long-term U.S. bonds over the period 1870 to 1896, were for two types of bonds, one bond payable in gold and the other in paper, or "greenback," currency. The second body of data was for yields on long-term Indian bonds traded in London between 1865 and 1894, one bond payable in sterling and the other in silver rupees. Fisher discussed the results of this analysis first in his monograph *Appreciation and Interest* (1896), and then in his two later books on the subject (Fisher, 1907, 1930). In the last of these he extended the Indian data another 12 years to 1906.

In his analysis of the U.S. data, Fisher discussed two important episodes, the 1879 resumption of specie payments and the decades surrounding that episode, and the 1896 presidential election and three years preceding it. In both events, he presented evidence of rather mixed behavior, some consistent with theory and some not. Prior to resumption, yields on gold bonds exceeded yields on currency bonds, as they should have, given expectations of an appreciation in the value of the paper currency relative to gold. At its peak in 1870, the spread between the two stood at 100 basis points. As time passed and the U.S. price level expressed in terms of the paper currency converged to the price level expressed in terms of gold, the spread narrowed, and by mid-1878 had reversed sign. Over the next 15 years the spread between the yields on gold and currency bonds averaged only −37 basis points, and in the earlier part of that period generally stood at −20 basis points or less.

Fisher went on to compare the expected rates of appreciation of the greenback implicit in the yield differentials prior to resumption. In his comparisons he used realized rates over progressively shorter periods, beginning in January 1870 and ending in each instance in January 1879, the actual date of resumption. The expected rate at the start of this sample was 0.8 percent per annum compared to a realized rate of 2.1 percent per annum, a ratio of a bit less than two fifths. Such underestimation was not at all unusual during the course of that episode. Not until 1877 did the ratio of expected to actual appreciation finally break out of that general range. For a time in 1874 it actually went negative, implying expectations of depreciation rather than appreciation.

One way to view what went on prior to resumption is in terms of Bayesian learning. Only as time wore on and deflation continued, did agents become convinced that resumption would become a reality and anticipated rates of appreciation converge with actual rates.

[7] As Fisher (1907, p. 259) put it, "A definite test may be made where two standards are simultaneously used." As he pointed out a bit later (see the quote below), in such instances, factors other than agents' expectations of currency appreciation or depreciation could be ruled out as influences on yield differentials. It is for this reason, perhaps, that Fisher made no comparisons of yield behavior across countries even though he clearly had the necessary data.

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The near equality of the two bond yields for most of the two decades following resumption is fully in accord with UIP. It makes theoretical sense given the not unreasonable expectation that the greenback would remain at par with gold.

If the adjustment of expectations was incomplete for most of the period prior to resumption, that was certainly not the case in the years leading up to the 1896 presidential election. During that episode, the first of the two peso-problems uncovered by Fisher that we noted above developed. Yields on currency bonds and gold bonds both increased, and the spread between the two progressively widened from 30 basis points in 1893 to a peak of 110 basis points in 1896. Fisher's explanation, which subsequent research corroborates, attributed these developments to the free-silver agitation and the fears of impending inflation and dollar depreciation that it engendered.[8] In this connection, he wrote: "Both the increases and the wedging apart of the two rates are explainable as effects of the free-silver proposal and its incorporation (July 1896) in the platform of the Democratic party," (Fisher, 1896, p. 40).

The U.S. experience, therefore, was mixed. Prior to resumption, the yield differential was consistent with the direction of exchange-rate movement but not the magnitude. Following resumption, the yield differential shrunk appreciably. It was not literally zero but small enough that UIP could be viewed as approximately holding. In the years immediately prior to the Presidential election of 1896 it widened for the reasons discussed – fears that Bryan would be elected and inflation would follow. While those fears might have been reasonable ex ante they turned out to wrong ex post.

Fisher conducted a similar analysis using the yield data for India. In the period 1865–1874 when the exchange rate between sterling and the rupee was stable, the yields on gold and silver rupee bonds were almost identical, differing on average by roughly 20 basis points. Then, in 1875, as the rupee began to depreciate, the spreads gradually widened, from an average of close to 40 basis points in the period between 1875 and 1878, to 64 basis points during the period 1879–1887, to over 100 basis points from 1888 through the first half of 1890. After further depreciation in the half decade that followed, the exchange rate stabilized at the par value of 16 pence/rupee.

Fisher pointed out that market reactions, both to the initial decline and to the eventual stabilization of the rupee, although basically in line with theory, came with substantial lags. As in the case of resumption in the United States, agents apparently went through a type of learning process.

His discussion of the first episode is revealing both with regard to his choice of research design and the role he ascribed to expectations. He wrote (1896 p. 48):

> Since the two bonds were issued by the same government, possess the same degree of security, are quoted side by side in the same market, and are in fact similar in all important respects except in the standard in which they are expressed, the results afford substantial poof that the fall of exchange (after it once began) was discounted in advance. Of course investors did not form perfectly definite estimates of the future fall, but the fear of a fall predominated in varying degrees over the hope of a rise.

During the course of this first episode, behavior appears very similar to behavior prior to resumption in the United States with agents learning about the new monetary regime gradually through time.

With regard to the latter episode, Fisher argued that market participants apparently anticipated a further depreciation in the exchange rate, but this depreciation never actually materialized. This incident is the second of the two peso problems highlighted by Fisher. In the *Theory of Interest* (1930, p. 407), Fisher wrote:

> "[T]he legal par was reached in 1898 and was maintained thereafter, subject only to the slight variations of exchange due to the cost of shipping specie. But until the par was proved actually stable by two or three years' experience, the public refused to have confidence that gold and the rupee were once more to run parallel. Their lack of confidence was shown in the difference in the rates of interest in gold and rupee securities during the transition period, 1893–1898, and the two or three succeeding years." (Emphasis is ours)

[8] Hallwood et al. (2000) provide econometric evidence supporting this interpretation. For discussions of this episode see Friedman and Schwartz (1963, Chapter 3) and Friedman and Schwartz, (1982, Chapter 7).

The remainder of Fisher's empirical investigation of the appreciation-versus-interest relation focused on the behavior of nominal interest rates and inflation rates within countries – seven countries in both *Appreciation and Interest* and *The Rate of Interest* and six in *The Theory of Interest*. While he found evidence of various sorts in support of theory, the relationship, as in the case of UIP, was very far from perfect. The standard deviations of ex post real interest rates in all instances were many multiples of the standard deviations of the nominal interest rates. Increases in inflation went hand in glove with decreases in ex post real rates.

Fisher's summation of this last bit of evidence is highly illuminating (1907, p. 278):

There are two possible explanations for [this inverse relation]. … One is that when prices are rising the cause may not be monetary but may lie in a progressive scarcity of commodities produced and exchanged ... The second reason is that these [price] movements are only imperfectly foreseen"

He opined further (1907, p. 279):

> Doubtless both of these causes play a part in the explanation in particular cases. Nevertheless there is internal evidence to show that in general the latter factor – unforeseen monetary changes – is the more important. This evidence consists in the fact that commodity interest fluctuates so widely in some instances becoming negative. (Emphasis is ours)

Using averages spanning a decade or more for Britain and the United States, he went on to present more positive results (1907, pp. 282–284). His argument here, to which we earlier alluded, was that "When long periods of price movements are taken, the influence of appreciation on interest is more certain … because [i]n averages covering so many years we may be sure that accidental causes are almost wholly eliminated."

Fisher's reasoning, though presented in a terse and somewhat offhand manner, is very much in line with the later emphasis of Friedman and Schwartz (1991) on the importance of accounting for errors in variables, defined as they put it, to include "all stochastic disturbances affecting the variables under study" and of filtering the data to capture fundamental long-run relations. (Friedman and Schwartz, 1991, p. 43). As in much else, Fisher again was ahead of his time.

4. UIP regressions with Fisher's data

Using Irving Fisher's original data for the United States and India, we ran standard UIP regressions of the following form to examine how well the relation held statistically in the two episodes that Fisher studied:

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

where $s_{t+1} - s_t$ is the one-period change in the log spot exchange rate and $i_t - i_t^*$ is the corresponding yield differential. In the case of U.S. bonds, the exchange rate is between gold and paper currency; in the case of the Indian bonds, the exchange rate is between the British pound sterling and the Indian rupee. The yield differential in the U.S. case is between bonds payable in gold and in paper currency and in the Indian case the yield differential is between bonds payable in sterling and silver rupees. We collected these data from Tables 11 and 12 in Chapter 19 of *The Theory of Interest* (1930). The regression results are reported in Table 1. In the U.S. case, the estimate of the slope coefficient β is positive, and in the Indian case, negative. In both cases, however, these estimates are both insignificantly different from zero and insignificantly different from unity. Furthermore, the regressions explain relatively little of the variation in exchange-rate changes. So, while Fisher – quite legitimately we believe – was able to point to subperiods in which UIP had some degree of validity, the relation does not pass econometric muster over his two full sample periods.

Fisher's analysis and our reexamination of his data give rise to several broad conclusions. The first is that expectations clearly matter. In the case both of the United States and India, periods in which UPI is violated alternate with periods in which it holds to at least some degree. In the instances in which UIP is violated – the two peso-problem-type episodes that we identified above and the two episodes characterized by learning-type behavior – expectations provide the only possible explanation since Fisher's research design effectively rules out other potential causes. The second conclusion, which follows from the first, is that one does not, therefore, have to resort to risk-based explanations for such failures. Expectational errors are fully capable of explaining the UIP problem. The regressions that we ran with

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Table 1
Results of UIP regressions based on Irving Fisher's (1930) data for U.S. gold and greenback bonds and Indian sterling and rupee bonds. In the regressions summarized below we use the data reported in Tables 11 and 12 of Fisher's *The Theory of Interest* (1930). The U.S. data span the period 1870 to 1896. For the period 1870–1878, the data are bi-annual; afterward they are annual. The Indian data span the period 1865 to 1906. For the period from 1879 on these are continuous annual data. Prior to that there are annual observations for 1865 and 1868 alone. The regressions took the form $s_{t+1} - s_t = \alpha + \beta(i_t - i_t^*) + e_{t+1}$, where $s_{t+1} - s_t$ is the one-period change in the log of the spot exchange rate measured as the implicit exchange rate between gold and paper money, and the Indian rupee price of the U.K. pound sterling, respectively. The corresponding differential $i_t - i_t^*$ is measured as the difference in yields between bonds payable in gold and paper currency, and the difference in yields between sterling and rupee bonds, respectively.

	α	std. error	$t\ \alpha = 0$	β	Std. error	$T\beta = 1$	R^2
U.S. bonds	−1.037	0.724	−1.432	2.608	1.434	1.122	0.091
Indian bonds	−0.222	1.363	−0.163	−1.783	2.405	−1.157	0.016

Fisher's data make this apparent. These regressions produce the standard results – slope coefficients that are not significantly different from zero and in one instance is negative rather than positive. This, of course, does not mean that risk premia cannot and do not matter in other bodies of data.

One way to deal empirically with episodic phenomena of both sorts is to follow Fisher's suggestion and use averaged data. A second is to work with very long spans of data in which such episodic related problems cancel one another out. We do both below.

5. Evidence from U.K. and U.S. bond yields historically

It is impossible to extend Fisher's data over a longer time span. In their stead, we have collected annual time series of government bond yields for the United States and United Kingdom and for the dollar-sterling exchange rate for the period 1801 to 2011. We ran regressions using both the annual data themselves and ten-year averages of those data.

These regressions took the form:

$$i_{u,s,t} + dlnS = \alpha + \beta i_{\mathrm{uk},t} + e_{t+1}, \qquad (2)$$

where $i_{\mathrm{us},t}$ is the long-term U.S. government bond yield $i_{\mathrm{uk},t}$ is the long-term U.K. government bond yield and $dlnS = s_{t+1} - s_t$, the one-period change in the log of the spot dollar-sterling exchange rate. The null hypothesis of uncovered interest-rate parity implies $\alpha = 0$ and $\beta = 1$ in this regression.

Under UIP, investments in domestic and foreign bonds on average should generate the same return when denominated in the same currency. Investing in a U.K. bond and holding it to maturity generates a certain return of $i_{\mathrm{uk},t}$; investing in a U.S. bond, holding it to maturity, and converting it back to the domestic currency, generates a return of $i_{\mathrm{us},t} - (s_{t+1} - s_t)$, the sum of the U.S. yield, which is certain at time *t*. the time of investment, and the return due to currency appreciation or depreciation, which is uncertain at time *t* and becomes known at time $t + 1$, the maturity date of the bond.

We ran the regressions in this form rather than in the form of (1) because of the long periods of exchange-rate fixity during the 210 years encompassed by our data and because of concerns about errors in variables. We also ran the reverse regressions, with $i_{\mathrm{uk},t}$ as the dependent variable and $i_{\mathrm{us},t} - (s_{t+1} - s_t)$ as the independent variable. The motivation here again is potential problems of errors in variables.

Table 2 reports the results of these regressions. Consider the regressions with annual data in the top half of the table first. Most noticeable is that the slope coefficients in both instances are positive and statistically significant. In the first regressions, in which the exchange-rate adjusted U.S. rate is the dependent variable, we also cannot reject the theoretical restrictions of a zero intercept and a unit slope coefficient, tested either separately or jointly. This, however, is not the case in the reverse regressions in which the U.K. rate is the dependent variable. The regressions also only explain a small fraction of the variance of the dependent variable and in the second regression, the estimate of the slope coefficient is 0.12 versus 0.82 in the first regression. Nevertheless, the regressions over this long sample period do produce better results than those with Fisher's data that we have just reviewed or with those with *monthly* multi-country panel data described below.

Table 2
Regressions for U.K and exchange-rate adjusted U.S. bond yields over the period 1801-2011. The regressions summarized below took the form $i_{us} + dlnS = \alpha + \beta\, i_{uk} + e_{t+1}$ and its reverse, where $dlnS = S_{t+1} - S_t$, is the one-period change in the log of the spot dollar-sterling exchange rate.

	Constant	i_{uk}	i_{us} + dlnS	R^2/SEE
Yearly data				
Dep. variable $i_{us} + dlnS$	1.422	0.821		0.098
Std. error	0.952	0.172		6.679
$t\ \alpha = 0$ or $\beta = 0$	1.494	4.774		
$t\ \beta = 1$		−1.041		
F $\alpha = 0$ and $\beta = 1$				1.270
Dep. variable i_{uk}	4.199		0.120	0.098
Std. error	0.222		0.025	2.551
$t\ \alpha = 0$ or $\beta = 0$	18.933		4.774	
$t\ \beta = 1$			−35.090	
F $\alpha = 0$ and $\beta = 1$				2698.7
10-year averaged data				
Dep. variable $i_{us} + dlnS$	2.088	0.688		0.536
Std. error	0.807	0.147		1.724
$t\ \alpha = 0$ or $\beta = 0$	2.588	4.681		
$t\ \beta = 1$		−2.121		
F $\alpha = 0$ and $\beta = 1$				3.414
Dep. variable i_{uk}	0.629		0.778	0.536
Std. error	0.987		0.166	1.834
$t\ \alpha = 0$ or $\beta = 0$	0.638		4.681	
$t\ \beta = 1$			−1.334	
F $\alpha = 0$ and $\beta = 1$				1.919

If the statistical issues related to UIP are episodic phenomena due, as Fisher put it (1907, p. 282), to "accidental causes," then his solution of averaging is a way to filter the data and thus mitigate the effects of temporary disturbances.[9] This is the motivation for the regressions using 10-year averages. We report the results of these regressions in the bottom half of Table 2. Both estimated slope coefficients are substantially positive and not that far from unity. The regressions, moreover, explain close to 60 percent of the variance of the dependent variable. We cannot reject the theoretical restrictions of a zero intercept and a unit slope coefficient in the regression with the U.K. rate as the dependent variable. In the other regression, the test results are on the borderline of the five percent level of significance.

In both cases, the results are, therefore, quite different from those reported in most of the literature. The longer sample period used here appears to be one reason for the difference. In principle, it allows small-sample departures to cancel on another out. The use of ten-year averaged data makes even more difference. It apparently dampens the effects of other stochastic disturbances to UIP that operate over shorter horizons.

6. Evidence from the recent era of floating exchange rates

We began by running UIP regressions in the form of Equation (1) using monthly data[10]. We report the regression results in Appendix A. These results were very much in line with results reported in other studies. In all but one of the 23 countries – Israel – was the estimates of β significantly different

[9] In this connection, see Lucas (1980) and Lothian (1985) for discussions of data filtering to isolate long-term relationships.
[10] We collected monthly data for the period January 1976 to December 2011 for 23 countries relative to the United States: Australia, Austria, Belgium, Canada, China, Denmark, Finland, France, Germany, Greece, Ireland, Israel, Italy, Japan, Netherlands, New Zealand, Norway, Portugal, Singapore Spain, Sweden, Switzerland, and the United Kingdom. The data were mostly obtained from the CD version of the International Monetary Fund's *International Financial Statistics*. Exchange rates are denominated in units of foreign currency per U.S. dollar; interest rates are short-term domestic Treasury bill or money market rates. Note that post 1998, 11 of the 23 were part of the euro bloc as were 3 of the countries in the G7 sample used in the rolling regressions reported below.

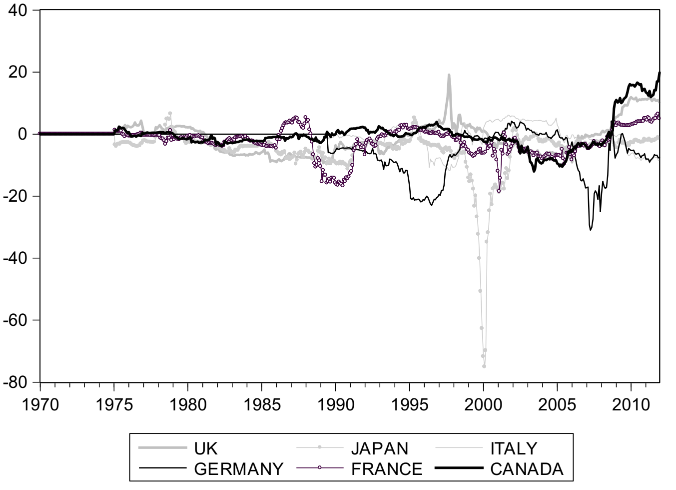

Fig. 1. Averages of coefficients from five-year rolling regressions for the G7 countries.

Table 3
Results of UIP regressions for non-overlapping averages of the data. These regressions, like those for the monthly data for the same sample of 23 countries reported in the appendix, took the form $s_{t+1} - s_t = \alpha + \beta(i_t - i_t^*) + e_{t+1}$.

	α	std. error	$t\ \alpha = 0$	β	std. error	$t\ \beta = 1$	R^2	N
5-year avg.	0.000	0.447	0.001	0.262	0.016	−61.950	0.621	184
15-year avg.	−0.496	0.154	−3.228	0.688	0.020	−48.518	0.947	69
Full-sample avg.	−1.177	0.189	−6.242	0.798	0.031	−31.388	0.969	23

from zero at the five percent level or below. In more than half the estimates were negative. In most instances, however, the estimates were also not significantly different from unity.

Fisher's explanation for the failures of UIP and the appreciation–interest relation more generally, as we have already discussed, centered on small-sample problems and Fisher's other "accidental" factors affecting that relation. In order to investigate the possible effects of such transitory influences, we ran five-year rolling regressions for the G7 countries and regressions using pooled data for the full sample of countries averaged over progressively longer time periods.[11] In both instances these regressions took the form of equation (1).

We plot the coefficients for the rolling regressions in Fig. 1. What stand out in the chart are the often sizable variations in the slope coefficients over time. We see periods in which the estimated coefficients are positive and UIP appears approximately to have held, but these are relatively brief and not always the same across countries. We see such behavior in the mid-1970s and then later in the late 1980s and early 1990s. In the late 1970s and early 1980s and then again from the mid 1990s on, however, we see the reverse – substantially negative coefficients typical of the UIP puzzle. Interestingly these latter two episodes are associated with regime changes – the Reagan-Volcker move to disinflationary monetary policy in the United States and the adoption of the Euro.

Following Fisher, we again turn to averages of the data, this time the data for countries listed in the Appendix Table. We plot data for averages of returns taken over five-year and fifteen-year subperiods and over the full sample period. We report the corresponding regressions results in Table 3. To provide a theoretical frame of reference in the plots, we drawn a 45 degree line through the origin in each.

[11] We use data for the G7 alone for ease of presentation.

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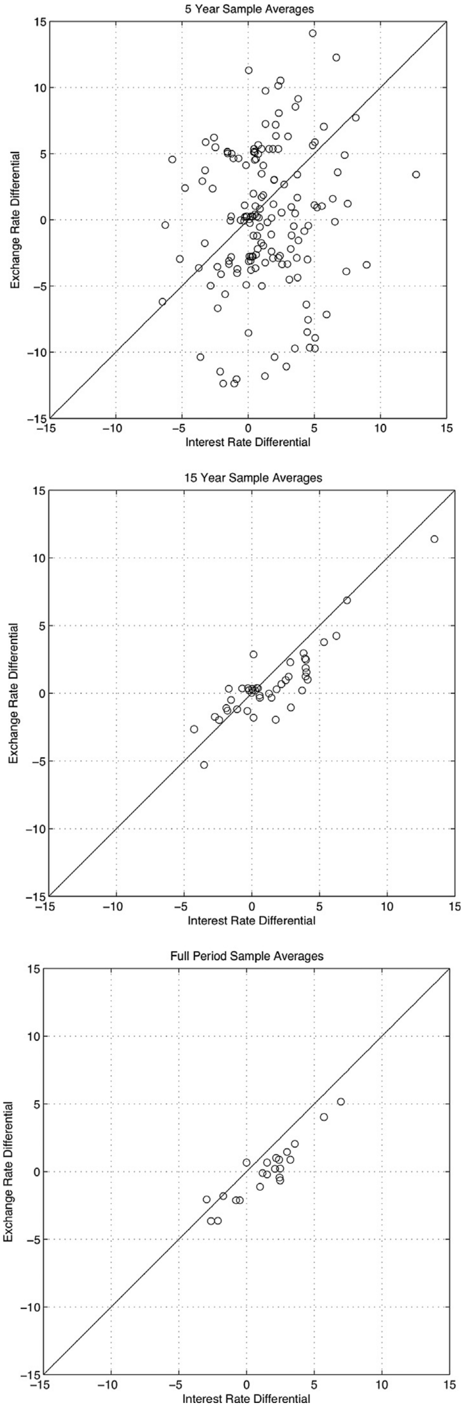

Fig. 2. UIP relations based on five-year, 15-year and full-period averages.

In the five-year averaged data, there is a positive, but nevertheless weak, relation between the two returns. However, the picture changes markedly as the period over which we average the data lengthens. We see this relation clearly improving in the bottom two panels of Fig. 2. When we look at the fifteen-year and full-period averages we find a strong positive relation between the two series.

The regression results in Table 3 confirm these observations. As the period over which we compute the averages lengthens, the slope coefficients in the regressions increase from less than 0.262 to 0.798, and the coefficients of determination increase from 0.65 to 0.97. Although we can always reject the hypothesis of a unit slope, it is clear from these results that as a long-run first approximation, UIP still contains a substantial kernel of truth.[12]

7. Conclusions

Irving Fisher was the first economist to posit what has come to be known as the uncovered interest parity relation. He also was the first to investigate it empirically and the first to offer a peso-problem type explanation for several important episodes in which it was violated, one in the United States during the free silver agitation of the late 19th century and the other in India in the period 1893–1900.

After reviewing Fisher's theoretical and empirical work on this subject, we reexamined his data using modern econometric techniques. Running standard UIP regressions, we got what are now regarded as standard results – estimated slope coefficients insignificantly different from zero, and in one instance of the wrong sign, and R^2s close to zero.

Fisher (1907, p. 287) concluded that his empirical investigations of UIP and the interest rate versus inflation relation had proved "first, that men do actually, even if unaware of so doing, contrive to offset the effects of changes in the monetary standard by adjusting the rate of interest; and, secondly, that this adjustment is far from adequate." The cause of this inadequate adjustment, he claimed, was "unforeseen monetary changes" (Fisher, 1907, p. 279) and the problems related to expectations formation to which they gave rise.

If the episodes surrounding such changes are lengthy, as they seem to have been in Fisher's data samples, then long spans may be necessary to provide sufficient degrees of freedom to uncover the true relationships. Over such long periods expectational errors, will have a greater chance of averaging out. The same will be true for time-varying risk premia. An alternative solution to such problems is to focus on low-frequency movements in the data, which is what Fisher did in his empirical work on interest rates and inflation in which he examined long-period averages of the data.

In this paper, we have done both. We turned first to a very long historical time series for the United States and the United Kingdom, using both the annual data themselves and ten-year averages of the annual data as our units of observation. We then turned to multi-country panel data, first using the monthly data and then progressively longer averages of those data as our units of observation. The results, in general, were much more in accord with theory than those that we obtained with Fisher's data and those reported in the literature. This is particularly so in the two sets of regressions with the averaged data – slope coefficients not very far removed from unity and regressions that explain substantial portions of the variance of the independent variables.

Our results on the empirical performance of uncovered interest parity are consistent with those reported more than a century ago by Fisher. Consistent with Fisher's view, we find evidence of the important role played by episodic phenomena in disturbing that relation. Like Fisher, we find too that the influence of such phenomena dissipates over time.

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[12] Flood and Taylor (1997) and Lothian and Simaan (1998) provide similar evidence for samples including many of these countries over time periods ending the mid-1990s.

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Appendix A. Summary of results of individual-country UIP regressions

We ran the regressions summarized below by using monthly data from 1976:1-2011:12 obtained from *International Financial Statistics*. These regressions took the form

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

where $s_{t+1} - s_t$ is the one-period change in the log of the spot foreign exchange rate measured as the foreign currency price of the U.S. dollar. The corresponding interest rate differential $i_t - i_t^*$ is measured as the foreign minus the U.S. interest rate.

Appendix A. Summary of results of individual-country UIP regressions

	α	$t\ \alpha = 0$	β	$t\ \beta = 0$	$t\ \beta = 1$
Australia	0.637	0.276	0.013	0.022	−1.696
Austria	−3.527	−1.680	−1.577	−1.905	−2.785
Belgium	0.585	0.305	−1.711	−2.039	−2.903
Canada	−0.432	−0.355	0.268	0.455	−1.429
China	−0.014	−0.051	−0.008	−0.033	−4.105
Denmark	1.438	0.656	−0.882	−1.709	−2.818
Finland	0.180	0.081	0.038	0.070	−1.806
France	1.185	0.580	−0.930	−1.243	−2.268
Germany	−3.237	−1.505	−1.561	−1.843	−2.741
Greece	−0.323	−0.098	0.551	1.583	−2.324
Ireland	0.720	0.238	0.273	0.434	−1.318
Israel	2.078	1.241	0.333	20.813	−62.399
Italy	−1.078	−0.407	0.727	1.367	−1.151
Japan	−9.501	−3.831	−2.268	−3.259	−3.705
Netherlands	−18.469	−4.232	−9.316	−5.251	−9.880
Norway	−0.638	−0.305	0.116	0.227	−1.839
New Zealand	6.141	2.172	−1.483	−2.476	−3.153
Portugal	6.223	1.064	−0.445	−0.519	−1.610
Singapore	−3.647	−2.296	−0.691	−1.589	−2.990
Spain	0.492	0.258	0.118	0.214	−1.697
Sweden	0.000	0.000	0.000	0	0.000
Switzerland	−6.818	−2.468	−2.370	−2.930	−3.606
UK	4.034	1.780	−1.381	−1.856	−2.724

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