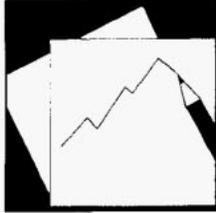


WP/06/96



IMF Working Paper

Uncovered Interest Parity

Peter Isard

IMF Working Paper

IMF Institute

Uncovered Interest Parity¹

Prepared by Peter Isard

April 2006

Abstract

This Working Paper should not be reported as representing the views of the IMF.

The views expressed in this Working Paper are those of the author(s) and do not necessarily represent those of the IMF or IMF policy. Working Papers describe research in progress by the author(s) and are published to elicit comments and to further debate.

This paper provides an overview of the uncovered interest parity assumption. It traces the history of the interest parity concept, summarizes evidence on the empirical validity of uncovered interest parity, and discusses different interpretations of the evidence and the implications for macroeconomic analysis. The uncovered interest parity assumption has been an important building block in multiperiod models of open economies, and although its validity is strongly challenged by the empirical evidence, at least at short time horizons, its retention in macroeconomic models is supported on pragmatic grounds by the lack of much empirical support for existing models of the exchange risk premium.

JEL Classification Numbers: F3, F41

Keywords: Interest parity, interest arbitrage, unbiasedness hypothesis, exchange risk premium

Author(s) E-Mail Address: pisard@imf.org

¹ This paper has been prepared for the next edition of the Palgrave Dictionary of Economics. It draws extensively on Isard (1991, 1995).

Contents	Page
I. Introduction	3
II. Basic concepts	3
III. Empirical Evidence	5
IV. Does Prediction Bias Refute the UIP Assumption?	7
V. Where Things Stand.....	8
References.....	10

I. INTRODUCTION

The assumption of uncovered interest parity (UIP) is an important building block for macroeconomic analysis of open economies. It provides a simple relationship between the interest rate on an asset denominated in any one country's currency unit, the interest rate on a similar asset denominated in another country's currency, and the expected rate of change in the spot exchange rate between the two currencies.

The theory of interest parity received prominence from expositions by Keynes (e.g., 1923: pp. 115-39), whose attention had been captured by the rapid expansion of organized trading in forward exchange following World War I (Einzig, 1962: pp. 239-41 and p. 275). Although an understanding of the forward exchange market must have developed within various banking circles during the second half of the nineteenth century, apart from an isolated exposition by a German economist, Walther Lotz (1889), the nineteenth-century literature on foreign exchange theory apparently dealt only with spot exchange rates (Einzig, 1962: pp. 214-15). Forward exchange trading gave rise to the notion of covered interest parity (CIP), which related the differential between domestic and foreign interest rates to the percentage difference between forward and spot exchange rates. Since it was clear that forward rates also reflected perceptions about future spot rates, it was a short step to the assumption of UIP, which builds on the theory of CIP by essentially postulating that market forces drive the forward exchange rate into equality with the expected future spot exchange rate.

II. BASIC CONCEPTS

The concept of interest parity recognizes that portfolio investors at any time t have the choice of holding assets denominated in domestic currency, offering the own rate of interest r_t between times t and $t+1$, or of holding assets denominated in foreign currency, offering the own rate of interest r^* . Thus, an investor starting with one unit of domestic currency should compare the option of accumulating $1+r_t$ units with the option of converting at the spot exchange rate into s_t units of foreign currency, investing in foreign assets to accumulate $s_t(1+r^*)$ units of foreign currency at time $t+1$, and then reconverting into domestic currency. If the domestic and foreign assets differ only in their currencies of denomination, and if investors have the opportunity to cover against exchange rate uncertainty by arranging at time t to reconvert from foreign to domestic currency one period later at the forward exchange rate f_t (in units of foreign currency per unit of domestic currency), then market equilibrium requires the condition of CIP:

$$(1) \quad 1+r_t = s_t(1+r^*)/f_t.$$

If condition (1) did not hold, profitable market arbitrage opportunities could be exploited without incurring any risks.

Investors also have the opportunity to leave their foreign currency positions uncovered at time t and to wait until time $t+1$ to make arrangements to reconvert into domestic currency at the spot exchange rate s_{t+1} . Unlike f_t , the value of s_{t+1} is unknown at time t , and so the attractiveness of holding an uncovered position must be assessed in terms of the probabilities of different outcomes for s_{t+1} . The assumption of UIP postulates that markets will equilibrate the return on the domestic currency asset with the expected value at time t (E_t) of the yield on an uncovered position in foreign currency:

$$(2) \quad 1+r_t = E_t [s_t (1+r_t^*)/s_{t+1}] = s_t (1+r_t^*) E_t (1/s_{t+1}).$$

This is essentially equivalent to combining the CIP condition with the assumption that exchange rates are driven, at the margin, by risk-neutral market participants who stand ready to take uncovered spot or forward positions whenever the forward rate deviates from the expected future spot rate.

By manipulating condition (1), it is easily seen that CIP implies

$$(3) \quad \frac{f_t - s_t}{s_t} = \frac{1+r_t^*}{1+r_t} - 1$$

Hence, as a first approximation (for values of $1+r_t$ in the vicinity of 1):

$$(4) \quad r_t^* - r_t \approx (f_t - s_t)/s_t$$

In addition, when Jensen's inequality—i.e., the difference between $E_t (1/s_{t+1})$ and $1/E_t (1/s_{t+1})$ —is ignored, the assumption of UIP can be approximated as

$$(5) \quad r_t^* - r_t \approx E_t [(s_{t+1} - s_t)/s_t] = (E_t s_{t+1} - s_t)/s_t.$$

The assumption of UIP adds an element of dynamics to the CIP condition by hypothesizing a relationship between the observed values of variables at time t and the value of the spot exchange rate that market participants expect at time t to prevail at time $t+1$. As such, UIP has been embedded in many multiperiod models of open economies. The CIP and UIP conditions can be written for any duration of the time period between t and $t+1$. Thus, if the UIP assumption was valid at all horizons, the observed values of the spot exchange rate and the term structures of domestic and foreign interest rates could be used to infer the expected future time path of the spot exchange rate (Porter, 1971).

In addition to playing an important role in the development of multiperiod models of open economies, the UIP condition has been a central focal point in the policy debate over the effectiveness of official intervention in exchange markets (Henderson and Sampson, 1983). To the extent that UIP was valid at short time horizons, official intervention could not succeed in

changing the spot exchange rate relative to the expected future spot rate unless the authorities chose to allow interest rates to change. In this sense, exchange market intervention could not be viewed as providing the authorities with an effective policy instrument in addition to interest rates. Thus, the case for intervention has been considered by some to depend on whether the empirical evidence rejects UIP.

III. EMPIRICAL EVIDENCE

The theory leading to the CIP condition—and hence also to the UIP assumption—abstracts entirely from any credit risks, capital controls, or explicit taxes on domestic and foreign currency investments. Keynes (1923: pp. 126-27) was well aware that investor choices between foreign and domestic assets do not depend on interest rates and exchange rates alone:

. . . the various uncertainties of financial and political risk . . . introduce a further element which sometimes quite transcends the factor of relative interest. The possibility of financial trouble or political disturbance, and the quite appreciable probability of a moratorium in the event of any difficulties arising, or of the sudden introduction of exchange regulations which would interfere with the movement of balances out of the country, and even sometimes the contingency of a drastic demonetization,—all these factors deter . . . [market participants], even when the exchange risk proper is eliminated, from maintaining large . . . balances at certain foreign centres.

In those circumstances where it is valid to abstract from the types of considerations cited by Keynes, the CIP condition has been generally confirmed. As one source of evidence, interviews at large banks have established that the CIP condition is used as a formula for determining the exchange rates and interest rates at which trading is actually conducted. Foreign exchange traders use Eurocurrency interest rate differentials to determine the forward exchange rates (in relation to spot rates) that they quote to customers, while traders in Eurocurrency deposits use the spreads between forward and spot exchange rates to set the spreads between the interest rates that their banks offer on domestic and foreign currency deposits (Herring and Marston, 1976; Levich, 1985). As additional evidence, Taylor (1989) has constructed a database of the bid and offer rates quoted contemporaneously for exchange rates and interest rates by foreign exchange and money market brokers, as recorded on the “pad” of the chief dealer at the Bank of England. The data include observations on one-, two-, three-, six-, and twelve-month maturities during selected intervals between 1967 and 1987. Taylor’s study found no evidence of unexploited profit opportunities during relatively calm periods in foreign exchange and money markets, although potentially exploitable profitable arbitrage opportunities did “occasionally occur” during periods of market turbulence, where the frequency, size, and persistence of such opportunities were positively related to length of maturity.²

² Consistently, in circumstances when it is not valid to abstract from capital controls and risks, empirical research has confirmed that deviations from CIP can be related systematically to the

(continued...)

The UIP assumption is more difficult to test than the CIP condition, since market expectations of future exchange rates are not directly observable.³ Accordingly, UIP has generally been tested jointly with the assumption that exchange market participants form rational expectations, such that future realizations of the exchange rate will equal the value expected at time t plus an error term that is uncorrelated with all information known at time t . Together the two assumptions imply that

$$(6) \quad s_{t+1} = f_t + u_{t+1}$$

and hence

$$(7) \quad s_{t+1} - s_t = r_t - r_t^* + u_{t+1}$$

where u represents a prediction error. This has led economists to assess the UIP assumption empirically by estimating the values of the a and b coefficients in the specification forms

$$(8) \quad s_{t+1} = a_0 + a_1 f_t + u_{t+1}$$

and

$$(9) \quad s_{t+1} - s_t = b_0 + b_1 (r_t - r_t^*) + u_{t+1}$$

where it is assumed that the error terms have zero means and are serially uncorrelated.

Empirical assessments of UIP as a framework for predicting the future spot exchange rate have distinguished two issues: the size of the prediction errors, and the question of whether the predictions are systematically biased. On the first issue, it has become widely acknowledged that interest differentials explain only a small proportion of subsequent changes in exchange rates.⁴ This finding has been generally interpreted as implying that observed changes in exchange rates are predominantly the result of unexpected information or “news” about economic developments, policies, or other relevant factors.

effective taxes imposed by capital controls and to non-currency-specific risk premiums associated with prospective controls (Dooley and Isard, 1980).

³ As discussed in Section V below, indirect tests of UIP have been conducted using survey data on exchange rate expectations.

⁴ Isard (1978), Mussa (1979), Frenkel (1981).

On the second issue, the hypothesis of unbiasedness can be assessed by testing whether $(a_0, a_1) = (0, 1)$ in equation (8) or $(b_0, b_1) = (0, 1)$ in equation (9). Notably, the test that the slope coefficient is unity receives strong support from studies based on (8) but is soundly rejected by studies based on (9)—at least for prediction horizons of a year or less. However, the apparent conflict between the two sets of regression evidence has been resolved in favor of the latter finding, as it is now accepted that (8) is not a legitimate regression equation.⁵

Although the empirical evidence strongly rejects the unbiasedness hypothesis at prediction horizons of up to one year, the evidence is much more favorable to unbiasedness at horizons of five to twenty years. In particular, when data for industrial countries are pooled, and when annual exchange rate changes and interest differentials (for each country relative to a numeraire country) are averaged over non-overlapping five- to twenty-year periods, the slope coefficients in equation (9) become insignificantly different from unity.⁶

IV. DOES PREDICTION BIAS REFUTE THE UIP ASSUMPTION?

Economists have not resolved how to interpret the strong rejection of the unbiasedness hypothesis at short prediction horizons. Several possible explanations have been suggested, with different implications for UIP.

One interpretation rejects the UIP hypothesis but not the rational expectations assumption. According to this view, the finding of systematic prediction bias suggests that market participants are risk averse and require risk premiums to hold uncovered foreign currency positions. The prediction bias is thus perceived as an omitted variable problem that can be addressed, in concept, by extending the right-hand side of equation (9) to include an expression for the risk premium. A second interpretation of prediction bias abandons the assumption that market participants are fully rational.

Other possible explanations do not require rejection of either UIP or the rational expectations hypothesis. These include explanations based on the “peso problem,” simultaneity bias, incomplete information with rational learning, and self-fulfilling prophecies or rational “bubbles.”

The suggestion that prediction bias reflects a “peso problem” is generally attributed to Rogoff (1980) and Krasker (1980), who drew attention to an episode in which the Mexican peso sold at a forward discount for a prolonged period prior to its widely anticipated devaluation in

⁵ Meese (1989). The explanation is based on the fact that the sample variances of the spot rate and forward rate are essentially equal.

⁶ Flood and Taylor (1997), who note that the average one-year change over n years is equivalent to the change over n years multiplied by a scale factor. See also Chinn and Meredith (2004).

1976. Although market expectations eventually proved correct and may well have been rational *ex ante*, the fact that the devaluation did not occur immediately after it became anticipated made the forward rate a biased predictor over finite data samples that included the pre-devaluation period. The general point is that even if market participants are risk neutral and form rational expectations, the forward rate can be biased as a predictor of the future spot rate—and the interest rate differential biased as a predictor of the change in the spot rate—whenever market participants repeatedly expect the spot rate to change in response to a policy action or some other event that fails to materialize over a relatively long series of observations.

The suggestion that rejection of the unbiasedness hypothesis reflects simultaneity bias was alluded to by Isard (1988) and later emphasized by McCallum (1994). In particular, given that the monetary authorities in most countries rely on a short-term interest rate as a policy instrument that they are prepared to adjust, *inter alia*, in response to undesired exchange rate movements, the estimates of b_1 may be biased by the failure to estimate (9) simultaneously with a second relationship between the interest rate differential and the change in the exchange rate.

As suggested by Lewis (1988, 1989), prediction bias can also emerge under UIP and rational expectations if market participants lack complete information but engage in a process of rational learning. This explanation is analogous to the peso problem insofar as it provides an interpretation in which market participants are risk neutral and fully rational but prone to making repeated mistakes.

Yet another possibility consistent with UIP is the conjecture that prediction bias arises from the self-fulfilling prophecies of rational, risk-neutral market participants. Such prophecies, which are often referred to as “rational bubbles,” have received attention as logical possibilities, but few economists, if any, consider them to have much plausibility as empirical phenomena (Mussa, 1990).

V. WHERE THINGS STAND

Because the validity of the UIP hypothesis cannot be tested directly and is not resolved by the rejection of the unbiasedness hypothesis, economists have resorted to indirect tests as a means of obtaining suggestive evidence. In particular, survey data on exchange rate expectations have been collected by several different sources since the early 1980s, and a number of studies have shown that exchange rate expectations, as measured by the average forecasts of sample respondents, deviate considerably from prevailing forward exchange rates (Frankel and Froot, 1987; Takagi, 1991; Chinn and Frankel, 2002). To the extent that survey measures of average expectations are meaningful, this would appear to be strong evidence against UIP.

That said, it also needs to be recognized that intertemporal models of open-economy macroeconomics require equations that link current spot exchange rates to expected future exchange rates. Thus, on pragmatic grounds, the case for abandoning the UIP hypothesis depends on how well economists can model the deviation from UIP—namely, the difference

between the forward exchange rate and the expected future spot rate, which is generally referred to as the exchange risk premium.

Behavioral hypotheses about the exchange risk premium can be tested by embedding them in models of observable exchange rates. The first conceptual models of the exchange risk premium were based on a portfolio balance framework in which financial claims were distinguished by currencies of denomination but not by the countries obligated to meet the claims (see, for example, Dooley and Isard, 1983). Empirical tests of this class of portfolio balance model have explained at most a small portion of the variation over time in the exchange risk premium (Tryon, 1983; Boughton, 1987). More sophisticated behavioral hypotheses have recognized—in the spirit of the above quotation from Keynes—that exchange risks and credit risks are interrelated, and that the magnitudes of these risks reflect the relative macroeconomic and political conditions, prospects, and uncertainties of the countries that have issued the portfolio claims (Dooley and Isard, 1983; Isard, 1988). While casual evidence suggests that this type of hypothesis is broadly capable of explaining the empirical behavior of exchange rates (Dooley and Isard, 1991), formal empirical tests that capture the many factors contributing to exchange rate risk are difficult to design, and economists have not yet provided a well-specified replacement for the UIP assumption.

Accordingly, many intertemporal open-economy macroeconomic models continue to impose the UIP assumption—or the assumption of UIP adjusted by an exogenous exchange risk premium. However, consistent with the evidence that rejects the unbiasedness hypothesis, it has proven difficult to mimic the observed behavior of key macroeconomic variables with models that impose the UIP assumption and also treat exchange rate expectations as fully model-consistent. Thus, models that impose the UIP assumption tend to treat exchange rate expectations as not completely rational. One fairly common practice, for example, is to treat exchange rate expectations (and inflation expectations) as having both forward-looking (model-consistent) and backward-looking components.

Quite apart from ongoing debates over the validity of the UIP assumption as an *ex ante* hypothesis and the usefulness of incorporating the UIP assumption into macroeconomic models, there is abundant evidence, as noted above, that the changes in spot exchange rates that are expected *ex ante* are generally dominated by unexpected changes. Thus, regardless of the usefulness of UIP as an *ex ante* hypothesis for macroeconomic modeling, it is quite clear that UIP by itself provides a very inaccurate framework for predicting the changes in exchange rates that are observed *ex post*.

REFERENCES

- Boughton, J.M., 1987, "Tests of the Performance of Reduced-Form Exchange Rate Models," *Journal of International Economics*, Vol. 23, pp. 41-56.
- Chinn, M.D., and Frenkel, J.A., 2002, "Survey Data on Exchange Rate Expectations: More Currencies, More Horizons, More Tests," in W. Allen and D. Dickinson (eds.), *Monetary Policy, Capital Flows, and Financial Market Developments in an Era of Financial Globalization: Essays in Honour of Max Fry* (London: Routledge), pp. 145-67.
- Chinn, M.D., and Meredith, G., 2004, "Monetary Policy and Long Horizon Uncovered Interest Parity," *IMF Staff Papers*, Vol. 51, pp. 409-30.
- Dooley, M.P., and Isard, P., 1980, "Capital Controls, Political Risk and Deviations from Interest-Rate Parity," *Journal of Political Economy*, Vol. 88, pp. 370-84.
- _____. 1983, "The Portfolio-Balance Model of Exchange Rates and Some Structural Estimates of the Risk Premium," *IMF Staff Papers*, Vol. 30, pp. 683-702.
- _____. 1991, "A Note on Fiscal Policy, Investment Location Decisions, and Exchange Rates," *Journal of International Money and Finance*, Vol. 10, pp. 161-68.
- Einzig, P., 1962, *The History of Foreign Exchange* (London: Macmillan).
- Flood, R.P., and Taylor, M.P., 1997, "Exchange Rate Economics: What's Wrong with the Conventional Macro Approach?" in J.A. Frankel, G. Galli, and A. Giovannini (eds.), *The Microstructure of Foreign Exchange Markets* (Chicago: University of Chicago Press), pp. 261-94.
- Frankel, J.A., and Froot, K.A., 1987, "Using Survey Data to Test Standard Propositions Regarding Exchange Rate Expectations," *American Economic Review*, Vol. 77, pp. 133-53.
- Frenkel, J.A., 1981, "Flexible Exchange Rates, Prices and the Role of 'News': Lessons from the 1970s," *Journal of Political Economy*, Vol. 89, pp. 665-705.
- Henderson, D.W., and Sampson S., 1983, "Intervention in Foreign Exchange Markets: A Summary of Ten Staff Studies," *Federal Reserve Bulletin* (November), pp. 830-36.
- Herring, R.J., and Marston, R.C., 1976, "The Forward Market and Interest Rates in the Eurocurrency and National Money Markets," in C.H. Stern, J.H. Makin, and D.E. Logue (eds.), *Eurocurrencies and the International Monetary System* (Washington: American Enterprise Institute), pp. 139-63.

- Isard, P., 1978, "Exchange-Rate Determination: A Survey of Popular Views and Recent Models," Princeton Studies in International Finance, No. 42 (Princeton: International Finance Section, Department of Economics, Princeton University).
- _____, 1988, "Exchange Rate Modeling: An Assessment of Alternative Approaches," in R.C. Bryant, D.W. Henderson, G. Holtham, P. Hooper, and S.A. Symansky (eds.), *Empirical Macroeconomics for Interdependent Economies* (Washington: Brookings Institution), pp. 183-201.
- _____, 1991, "Uncovered Interest Parity," *The New Palgrave Dictionary of Money and Finance*, first edition (also issued as Working Paper WP/91/51, Washington: International Monetary Fund).
- _____, 1995, *Exchange Rate Economics* (Cambridge: Cambridge University Press).
- Keynes, J.M., 1923, *A Tract on Monetary Reform* (London: Macmillan).
- Krasker, W.S., 1980, "The Peso Problem in Testing the Efficiency of Forward Exchange Markets," *Journal of Monetary Economics*, Vol. 6, pp. 269-76.
- Levich, R.M., 1985, "Empirical Studies of Exchange Rates: Price Behavior, Rate Determination and Market Efficiency," in R.W. Jones and P.B. Kenen (eds.), *Handbook of International Economics*, Vol. 2 (Amsterdam: North Holland), pp. 979-1040.
- Lewis, K.K., 1988, "The Persistence of the 'Peso Problem' when Policy is Noisy," *Journal of International Money and Finance*, Vol. 7, pp. 5-21.
- _____, 1989, "Changing Beliefs and Systematic Rational Forecast Errors with Evidence from Foreign Exchange," *American Economic Review*, Vol. 79, pp. 621-36.
- Lotz, W., 1889, "Die Währungsfrage in Österreich-Ungarn," *Schmollers Jahrbuch*, Vol. 13, pp. 34-35.
- McCallum, B.T., 1994, "A Reconsideration of the Uncovered Interest Parity Relationship," *Journal of Monetary Economics*, Vol. 33, pp. 105-32.
- Meese, R.A., 1989, "Empirical Assessment of Foreign Currency Risk Premiums," in C.C. Stone (ed.), *Financial Risk: Theory, Evidence and Implications* (Boston: Kluwer), pp. 157-80.
- Mussa, M., 1979, "Empirical Regularities in the Behavior of Exchange Rates and Theories of the Foreign Exchange Market," *Carnegie-Rochester Conference Series on Public Policy*, Vol. 11, pp. 9-57.

- _____, 1990, "Exchange Rates in Theory and Reality," *Essays in International Finance* No. 179 (Princeton: International Finance Section, Department of Economics, Princeton University).
- Porter, M.G., 1971, "A Theoretical and Empirical Framework for Analyzing the Term Structure of Exchange Rate Expectations," *IMF Staff Papers*, Vol. 18, pp. 613-42.
- Rogoff, K., 1980, "Tests of the Martingale Model for Foreign Exchange Futures Markets," in *Essays on Expectations and Exchange Rate Volatility* (doctoral dissertation; Cambridge, Massachusetts: Massachusetts Institute of Technology).
- Takagi, S., 1991, "Exchange Rate Expectations: A Survey of Survey Studies," *IMF Staff Papers*, Vol. 38, pp. 156-83.
- Taylor, M.P., 1989, "Covered Interest Arbitrage and Market Turbulence," *Economic Journal*, Vol. 99, pp. 376-91.
- Tryon, R.W., 1983, "Small Empirical Models of Exchange Market Intervention: A Review of the Literature," Staff Studies 134 (Washington: Board of Governors of the Federal Reserve System).