

The economics of exchange rates

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foreword by Jeffrey A. Frankel

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with a foreword by

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Foreword

Research is supposed to proceed according to what is called the scientific method. Hypotheses are proposed, tested, and enthroned if consistent with the evidence. The accretion of knowledge is supposed to be cumulative over time, discarding what is at odds with evidence and retaining what works. The ability to answer questions about the real world is supposed to be the ultimate motivation.

Unfortunately, economics does not always work that way. Intellectual fads and the effort to demonstrate mathematical prowess sometimes dominate the research agenda. Everyone becomes more specialised, and few seek to synthesise. Some even forget that the ultimate goal is to design models consistent with the real world and that, for example, the derivation of behaviour from principles of optimisation should be considered only a tool to that end.

After the rational expectations revolution of the 1970s, the study of exchange rates turned nihilistic in the 1980s. It was discovered that a decade or two of experience with floating currencies had not provided enough data to verify some of the systematic patterns of movement in real or nominal exchange rates that the theories of the time had predicted. Statistical tests failed to reject the hypothesis that the nominal exchange rate followed a random walk, or that the real exchange rate followed a random walk. This meant, embarrassingly, we had nothing to say that would help predict changes in such variables. But these demonstrations of the state of our ignorance were misleadingly labelled as evidence in favour of theories, versions of the random walk ‘theory’. More elaborate models were then designed, based on optimising behaviour, so as to have no testable implications, and thereby to correspond superficially to the empirical findings of no statistical significance. Never mind that the random walk proposition was in fact a proclamation of lack of knowledge rather than a proclamation of knowledge. Never mind that there was in any case excellent reason to believe that the failures to reject were due to low power – insufficient data – rather than the truth of the null hypothesis. (Never mind that the hypothesis of a random walk in the nominal exchange rate was inconsistent with the hypothesis of a random walk in the real exchange rate, given sustained inflation differentials. One can write about them in separate papers.)

The state of affairs improved a lot in the 1990s. Big data sets, based on long time series or panel studies, now allowed higher levels of statistical confidence, including rejections of

random walks at long horizons. Geography reappeared in international economics after a strangely long absence. The old question of exchange rate regimes was reinvigorated with theories of dynamically inconsistent monetary policy, credibility and target zone dynamics. New areas of research focused on specific real world questions, such as the study of pricing to market in exports, of monetary unions, of speculative attacks and of microstructure in the foreign exchange market. The ‘new open-economy macroeconomics’ managed to accomplish the craved derivations from micro-foundations of optimisation in dynamic general equilibrium *without* at the same time sacrificing the realism of imperfect integration, imperfect competition or imperfect adjustment, and without sacrificing the ability to address important questions regarding the effects of monetary policy.

What, then, is the current state of knowledge regarding exchange rate economics? Who can synthesise it all and present it clearly? For years, Mark Taylor has been pursuing the research of international money and finance in the way science is supposed to be done. The work is patient and careful. The accumulation of understanding is cumulative. Old theories are discarded when shown to be inconsistent with the evidence, and retained if supported by the evidence. New theories are incorporated when they too pass the hurdles. Occam’s razor is wielded. It all has to fit together. Above all, the enterprise is empirical, in the best sense of the word: the motivation is to explain the world. More recently, Lucio Sarno has been seen as a promising new researcher in the field.

Sarno and Taylor’s book is a *tour de force*. The exposition is comprehensive, covering contributions from all corners of the field, and covering the range from the seminal models of the 1970s to the latest discoveries on the theoretical and econometric frontiers of the 2000s. There is no excess verbiage or mathematics. Everything is there to serve a purpose. This is the current state of knowledge.

Jeffrey A. Frankel
Harvard University

Preface

The economics of exchange rates is an area within international finance which has generated and continues to generate strong excitement and interest among students, academics, policy-makers and practitioners. The last fifteen years or so in particular have seen a great flurry of activity in exchange rate economics, with important contributions to exchange rate theory, empirics and policy. Much of this activity has been so revolutionary as to induce a significant change in the profession's way of thinking about the area. In this book – part monograph, part advanced textbook – we seek to provide an overview of the exchange rate literature, focusing largely but not exclusively on work produced within the last fifteen years or so, expositing, criticising and interpreting those areas which, in our view, are representative of the most influential contributions made by the profession in this context. Our overall aim is to assess where we stand in the continuing learning and discovery process as exchange rate economists. In doing so, we hope to provide a framework which will be useful to the economics and financial community as a whole for thinking about exchange rate issues. The monograph is intended to be wide-ranging and we have attempted to make chapters easy to follow and largely self-contained.

The primary target for the book is students taking advanced courses in international economics or international finance at about the level of a second-year US doctoral programme in economics or finance, although students at other levels, including master's degree students and advanced undergraduates, should also find the book accessible. The book should also prove useful to our professional colleagues, including researchers in international finance in universities and elsewhere, and specialists in other areas requiring an up-to-date overview of exchange rate economics. Last, but by no means least, we very much hope that the book will be of interest and use to financial market practitioners.

The intellectual history behind this monograph is long and tortuous. At one level it began while Mark Taylor, freshly graduated from Oxford in philosophy and economics, was working as a junior foreign exchange dealer in the City of London whilst simultaneously pursuing graduate studies part-time at London University in the early 1980s. At another level, it began while he was a senior economist at the International Monetary Fund (IMF) during the first half of the 1990s, in that his survey article on exchange rate economics, largely prepared at the IMF and published in the *Journal of Economic Literature* in 1995, initially

prompted Cambridge University Press to commission the book. Returning to academia, Taylor subsequently recruited one of his most promising graduate students at the time, Lucio Sarno, as a co-author, in order to ease the burden. Given, however, the large amount of material that we intended to cover, the high productivity of the area, and our other research commitments, it took us several further years to complete the book. One advantage of this long gestation period is that we have had the opportunity to test much of it in advanced graduate courses at Warwick, Oxford and Columbia, and to get valuable feedback from colleagues while we have held visiting positions at institutions such as the IMF, the World Bank and the Federal Reserve Bank of St Louis.

More generally, in preparing the book, we have become indebted to a large number of individuals. In particular, we are grateful for helpful conversations through the years of gestation, as well as for often very detailed comments on various draft chapters, to the following people: Michael Artis, Andrew Atkeson, Leonardo Bartolini, Tam Bayoumi, Giuseppe Bertola, Stanley Black, William Branson, Guillermo Calvo, Yin-Wong Cheung, Menzie Chinn, Richard Clarida, Giuseppe De Arcangelis, Michael Dooley, Rudiger Dornbusch, Hali Edison, Martin Evans, Robert Flood, Jeffrey Frankel, Kenneth Froot, Peter Garber, Charles Goodhart, Gene Grossman, Philipp Hartmann, Robert Hodrick, Peter Isard, Peter Kenen, Richard Lyons, Nelson Mark, Bennett McCallum, Paul Masson, Michael Melvin, Marcus Miller, Ashoka Mody, Maurice Obstfeld, Paul O'Connell, Lawrence Officer, David Papell, David Peel, William Poole, Kenneth Rogoff, Andrew Rose, Nouriel Roubini, Alan Stockman, Lars Svensson, Alan Taylor, Daniel Thornton, Sushil Wadhvani, Myles Wallace, Axel Weber and John Williamson.

Naturally, we are solely responsible for any errors that may still remain on these pages.

We must also offer our thanks, as well as our public apology, to Ashwin Rattan and Chris Harrison, our editors at Cambridge University Press. They patiently worked with us through the extensive preparation of the manuscript and quietly tolerated our failure to meet countless deadlines. The phrase 'the manuscript will be with you by the end of the month' will be as familiar to Ashwin and Chris as 'the cheque is in the mail'.

Finally, albeit most importantly, we owe our deepest thanks to our families and friends for providing essential moral support throughout this project.

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1 Introduction

In the last few decades or so exchange rate economics has seen a number of important developments, with substantial contributions to both the theory and the empirics of exchange rate determination. Important developments in econometrics and the increasing availability of high-quality data have also been responsible for stimulating the large amount of empirical work on exchange rates published over this period. Nevertheless, while our understanding of exchange rates has significantly improved, a number of challenges and open questions remain in the exchange rate debate, further enhanced by important events in this context such as the launch of the euro as the single European currency in January 1999 and the large number of currency crises which occurred during the 1990s.

In this book – part monograph, part advanced textbook – we provide a selective coverage of the literature on exchange rate economics, focusing particularly but not exclusively on contributions made during the last fifteen years or so. Throughout the book our aim is, in addition to giving a clear exposition, to provide constructive criticism of the literature and to suggest further avenues for research and analysis. The survey article by Taylor (1995) on ‘The Economics of Exchange Rates’, which provides a comprehensive review of the post-war literature on the subject until the early 1990s, may be seen as useful groundwork preliminary to the study of this book, although readers with a good general background in economics should be able to tackle the book head on. In this brief introduction, we provide a guide to the following chapters.

Chapter 2 covers the literature on foreign exchange market efficiency. In an efficient speculative market prices should fully reflect information available to market participants and it should be impossible for a trader to earn excess returns to speculation. Academic interest in foreign exchange market efficiency can be traced to arguments concerning the information content of financial market prices and the implications for social efficiency. In its simplest form, the efficient markets hypothesis can be reduced to a joint hypothesis that foreign exchange market participants are, in an aggregate sense, endowed with rational expectations and are risk-neutral. The hypothesis can be modified to adjust for risk, so that it then becomes a joint hypothesis of a model of equilibrium returns (which may admit risk premia) and rational expectations. In particular, the chapter covers the literature relating to the covered and uncovered interest rate parity conditions which have direct implications for market efficiency, and provides an account of the recent econometric methods employed

in testing the foreign exchange market efficiency hypothesis. Regardless of – or indeed perhaps because of – the increasing sophistication of the econometric techniques employed and of the increasing quality of the data sets utilised, one conclusion emerges from this literature relatively uncontroversially: the foreign exchange market is not efficient in the sense that both risk neutrality and rational expectations appear to be rejected by the data.

Chapter 3 is devoted to recent studies on purchasing power parity (PPP) and the behaviour of the real exchange rate. Under PPP, price levels are the same across countries if expressed in a common currency. Academic opinion concerning the validity of PPP as a realistic description of exchange rate behaviour over both the short run and the long run has shifted quite significantly over time. A long list of studies suggests that deviations from PPP are characterised as conforming to martingale or random walk behaviour, indicating the violation of PPP in the long run. However, increasing support for PPP as a *long-run equilibrium* condition has emerged during the last decade or so. We survey much of the influential literature on testing the validity of the law of one price (the hypothesis that individual traded goods prices should be equal once expressed in a common currency at the going exchange rate) and of PPP, covering the tests of the random walk real exchange rate model, the cointegration literature on PPP and the most recent developments in econometric techniques applied to PPP testing, which include using long-span data, multivariate unit root tests and the recent state-of-the-art nonlinear econometric models of deviations from PPP. Overall, arguably the main conclusion emerging from the recent relevant literature appears to be that PPP might be viewed as a valid long-run international parity condition when applied to bilateral exchange rates obtaining among major industrialised countries and that, because of the effects of international transactions costs and other factors, real exchange rate adjustment displays significant nonlinearities.

Chapter 4 is devoted to an overview of the theory and evidence relating to standard macroeconomic models of exchange rate determination, namely the flexible price monetary model, the sticky price monetary model, equilibrium models and liquidity models, and the portfolio balance model. The exposition of the theoretical foundations of these theories is followed by an analysis of their empirical formulations and an account of the relevant empirical literature. We also assess the validity of asset-market-based exchange rate models on the basis of the evidence on their out-of-sample forecasting performance. In fact, we discuss selected articles on exchange rate predictability, recording the difficulties encountered in using standard empirical models of exchange rate determination to predict the nominal exchange rate. We conclude that, although there seems to be increasing evidence that empirical models of exchange rate determination may be helpful for forecasting exchange rates at long horizons, it is still difficult to beat a simple random walk forecasting model in the shorter run. This is an area of research where more work is very much warranted.¹

Chapter 5 offers an introduction to the recent literature on the ‘new open economy macroeconomics’. This literature reflects an attempt by researchers to formalise theories of exchange rate determination in the context of dynamic general equilibrium models with

¹ See Clarida, Sarno, Taylor and Valente (2001) and Kilian and Taylor (2001) for recent contributions on forecasting exchange rates and attempts to beat a random walk forecast.

explicitly defined microfoundations and allowing for both nominal rigidities and imperfect competition. This literature has been growing exponentially since the appearance of Obstfeld and Rogoff's (1995) seminal 'redux' paper. The increasing sophistication of stochastic open economy models allows rigorous welfare analysis and provides new explanations of several puzzles in international macroeconomics and finance. Whether, however, this approach will become the new workhorse model for open economy macroeconomics, whether a preferred specification within this class of models will be reached, and whether this approach will provide insights on developing better-fitting empirical exchange rate models remain, at present, open questions. Nevertheless, this is clearly an exciting area of research.

Chapter 6 is devoted to the literature on monetary integration and target zones. The literature on monetary integration is largely dominated by the theory of optimum currency areas, developed in the 1960s and refined over the last few decades. The theory of optimum currency areas has increasingly attracted the interest of academics and policy-makers in the transition towards Economic and Monetary Union (EMU) and in the aftermath of the birth of the euro. A related literature, discussed in some detail in this chapter, is related to modelling exchange rate behaviour under target zone arrangements. Since the collapse of the Bretton Woods system, most of the major exchange rates have not in fact been officially pegged but have been allowed to float freely for the longest period of time in recent economic history. Many smaller central banks, however, have adopted policies of pegging their exchange rates to major currencies and the Exchange Rate Mechanism (ERM) of the European Monetary System (EMS) offers an important recent example of a pegged exchange rate system amongst major currencies.

Chapter 7 surveys and discusses the theoretical and empirical literature on foreign exchange market intervention. We start by examining the rationale for exchange rate management, and then discuss a number of relevant specific issues such as the secrecy of intervention, the role of international co-ordination, the profitability of intervention operations, and the availability and nature of data on official intervention. We describe the mechanics of official intervention through the portfolio balance channel and the signalling or expectations channel, and also provide a review of the empirical literature on the effectiveness of official intervention. We briefly present the simple positive theory of exchange rate intervention used by the literature to derive estimatable reaction functions and discuss the empirical evidence on central bank reaction functions.

Chapter 8 is devoted to an exposition and survey of the literature on speculative attacks and currency crises. In large part, this literature is a reaction to the relatively large number of currency crises which affected the international financial markets during the 1990s. The three strands of the literature we cover – so-called first-generation, second-generation and third-generation models of currency crisis – were largely developed, moreover, as a reaction to the apparently disparate nature of the various crises which have occurred. In particular, economies affected by speculative attacks and crises ranged from a number of Latin American economies, where economists were quick to point out apparent inconsistencies between the stance of domestic macroeconomic policy and a commitment to a fixed exchange rate; to advanced European economies where there appeared to be no inconsistency between the stance of macroeconomic policy but instead a perceived *temptation* of

the authorities to pursue a more expansionary domestic policy; to the 'tiger economies' of East Asia, where, prior to the crisis, the economic fundamentals appeared very strong and macroeconomic policy appeared entirely consistent with the fixed exchange rate rule.

In Chapter 9 we discuss the very recent literature on the microstructure of the foreign exchange market. As a reading of the first eight chapters of the book, and in particular of Chapter 4, will reveal only too clearly, an emerging stylised fact is that, while macroeconomic fundamentals appear to be an important determinant of exchange rate movements over relatively long horizons and in economies experiencing pathologically large movements in such fundamentals (such as during a hyperinflation), there seem to be substantial and often persistent movements in exchange rates which are largely unexplained by macroeconomic fundamentals. The recent and emerging literature on foreign exchange market microstructure in some measure reflects an attempt by researchers in international finance to understand these deviations from macroeconomic fundamentals. In addition, the microstructure literature is also concerned with other issues which are seen to be of interest in their own right by international financial economists, such as the transmission of information between market participants, the behaviour of market agents, the relationship between information flows, the importance of order flow, the heterogeneity of agents' expectations and the implications of such heterogeneity for trading volume and exchange rate volatility. We conclude that, to date, the foreign exchange market microstructure literature appears to shed light most strongly on issues such as the transmission of information between market participants, the heterogeneity of agents' expectations and the implications of such heterogeneity for trading volume and exchange rate volatility.

Although the sequence of presentation of the various chapters is, we hope, logical, it is not necessary to read the book in sequence from beginning to end, although this would be our preference. In particular we have attempted to make the chapters largely self-contained so that, if reference is made to results discussed in earlier chapters, it is brief enough to be easily remedied.

We very much hope that you enjoy using this book.

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2 Foreign exchange market efficiency

In an efficient speculative market prices should fully reflect information available to market participants and it should be impossible for a trader to earn excess returns to speculation. Academic interest in foreign exchange market efficiency can be traced to arguments concerning the information content of financial market prices and the implications for social efficiency. In its simplest form, the efficient markets hypothesis can be reduced to a joint hypothesis that foreign exchange market participants are, in an aggregate sense (a) endowed with rational expectations and (b) risk-neutral. The hypothesis can be modified to adjust for risk, so that it then becomes a joint hypothesis of a model of equilibrium returns (which may admit risk premia) and rational expectations.

If the risk-neutral efficient markets hypothesis holds, then the expected foreign exchange gain from holding one currency rather than another – the expected exchange rate change – must be just offset by the opportunity cost of holding funds in this currency rather than the other – the interest rate differential. This condition, generally referred to as the uncovered interest rate parity (UIP) condition, represents the cornerstone parity condition for testing foreign exchange market efficiency:

$$\Delta_k s_{t+k}^e = i_t - i_t^*, \quad (2.1)$$

where s_t denotes the logarithm¹ of the spot exchange rate (domestic price of foreign currency) at time t , i_t and i_t^* are the nominal interest rates available on similar domestic and foreign securities respectively (with k periods to maturity), $\Delta_k s_{t+k} \equiv s_{t+k} - s_t$, and the superscript e denotes the market expectation based on information at time t . Most often, however, discussions of foreign exchange market efficiency have taken place in the context of the relationship between spot and forward exchange rates. Implicitly, researchers have used a link between spot and forward rates and interest rates, known as covered interest rate parity. Prior to discussing the uncovered interest rate parity condition in detail, therefore, we shall first examine covered interest rate parity.

¹ See Appendix B to this chapter for a discussion of the use of logarithmic transformations with exchange rates.

2.1 Covered interest rate parity

... forward quotations for the purchase of the currency of the dearer money market tend to be cheaper than spot quotations by a percentage per month equal to the excess of the interest which can be earned in a month in the dearer market over what can be earned in the cheaper (Keynes, 1923, ch. 3).

If there are no barriers to arbitrage across international financial markets, then arbitrage should ensure that the interest rate differential on two assets, identical in every relevant respect except currency of denomination, adjusted to cover the movement of currencies at the maturity of the underlying assets in the forward market, be continuously equal to zero, so that covered interest rate parity (CIP) should hold.

Algebraically, the CIP condition may be expressed (ignoring transactions costs) as:

$$\frac{F_t^{(k)}}{S_t} = \frac{1 + i_t}{1 + i_t^*} \quad (2.2)$$

where S_t is the spot exchange rate (domestic price of foreign currency) and $F_t^{(k)}$ is the k -period forward rate (i.e. the rate agreed now for an exchange of currencies k periods ahead).

A standard story as to why CIP should hold is that market deviations from (2.2) will result in arbitrage activity which will force the equality to hold. Suppose, for example, (2.2) did not hold at time t because of a relatively low domestic interest rate:

$$i_t < \frac{F_t^{(k)}}{S_t}(1 + i_t^*) - 1. \quad (2.3)$$

If (2.3) held, arbitrageurs could make a riskless profit by borrowing the domestic currency for k periods at the interest rate i , selling it spot for the foreign currency (yielding $1/S$ units of foreign currency for every unit of domestic currency), lending the foreign currency for k periods at the interest rate i^* , and selling the foreign currency proceeds (principal plus interest) in the k -period forward market against the domestic currency. At the end of k periods, the arbitrageur will have to repay $(1 + i_t)$ for every unit of domestic currency borrowed, but will receive $(F_t^{(k)}/S_t)(1 + i_t^*)$ units of domestic currency for every unit of domestic currency borrowed and used in the arbitrage. Hence, the arbitrageur will make a net profit of $[(F_t^{(k)}/S_t)(1 + i_t^*) - (1 + i_t)]$ which, from (2.3), is positive. The simple laws of supply and demand imply that such arbitrage will induce movements in i , i^* , S and F until (2.2) holds.

On reflection, however, it should be clear that no such arbitrage need logically occur for (2.2) to hold, since any lender of domestic funds at an interest rate which satisfies (2.3) must be either irrational or ill-informed, or both. This follows because either a higher rate could have been extracted (demand for domestic funds should be perfectly elastic so long as (2.3) holds), or else a return equivalent to:

$$(F_t^{(k)}/S_t)(1 + i_t^*) - 1 \quad (2.4)$$

could have been risklessly earned by selling the domestic funds against foreign currency spot, lending the foreign currency and selling the proceeds against domestic currency

forward. Clearly, similar reasoning could be applied to any of the four arguments of (2.2) – i.e. $F_t^{(k)}$, S_t , i_t^* and i_t .

A logarithmic approximation to (2.2) is often used:

$$f_t^{(k)} - s_t = i_t - i_t^* \quad (2.5)$$

where $f_t^{(k)} \equiv \log_e F_t^{(k)}$, $s_t \equiv \log_e S_t$ and use has been made of the conventional approximation $\log_e(1+x) \approx x$ for small x – in our case $x = i_t, i_t^*$.

In any computation of CIP, it is clearly important to consider home and foreign assets which are comparable in terms of maturity and in terms of other characteristics such as default and political risk (Aliber, 1973; Dooley and Isard, 1980; Frankel and MacArthur, 1988). For this reason, empirical analyses of CIP have most often employed interest rate data on Euro-deposits: ‘Since Euro-currency deposits are comparable in terms of issuer, credit risk, maturity and all other respects *except* currency of denomination, they offer a proper test of [CIP]’ (Levich, 1985, p. 1027). A typical barrier to arbitrage would be capital controls, and deviations from CIP using domestic security interest rates (or the spread between offshore and onshore rates) have often been used as an indirect indicator of the presence and effectiveness of capital controls (Dooley and Isard, 1980).

In practice, two approaches have been taken by researchers in testing CIP empirically. The first approach relies on computing the actual deviations from interest parity to see if they differ ‘significantly’ from zero. The significance of departures from CIP is often defined with respect to a neutral band, which is determined by transactions costs. For example, Frenkel and Levich (1975, 1977), for a selection of currencies, demonstrate that around 80 per cent of apparent profit opportunities lie within the neutral band when Treasury bills are used and almost 100 per cent when Euro-rates are considered. Furthermore, in Frenkel and Levich (1977) it is demonstrated that in periods of turbulence a much smaller percentage of deviations from CIP may be explained by transactions costs; this is interpreted as reflecting higher financial uncertainty in such periods. Clinton (1988) also demonstrates that deviations from CIP should be no greater than the minimum transactions costs in one of three markets: the two underlying deposit markets (e.g. Euro-marks and Euro-dollars) and the foreign exchange swap market (i.e. the market in which a currency can be simultaneously bought and sold forward against another currency). On the basis of analysis of data for five major currencies against the US dollar ‘taken from mid morning quotes on the Reuter Money Rates Service from November 1985 to May 1986’, Clinton finds that the neutral band should be within + 0.06 per cent per annum from parity and that, although the hypothesis of zero profitable deviations from parity can be rejected, ‘empirically, profitable trading opportunities are neither large enough nor long-lived enough to yield a flow of excess returns over time to any factor’.

By questioning the quality of the data used by Frenkel and Levich, various researchers have often arrived at different conclusions. For example, McCormick (1979) finds, using higher-quality data, that most of the deviations from CIP (70–80 per cent) lie *outside* the neutral band for UK–US Treasury bills. Taylor (1987, 1989), however, goes further than McCormick and argues that in order to provide a proper test of CIP it is important to have data on the appropriate exchange rates and interest rates recorded at the same

instant in time at which a dealer could have dealt. Taylor uses high-quality, high-frequency, contemporaneously sampled data for spot and forward dollar–sterling and dollar–mark exchange rates and corresponding Euro-deposit interest rates for a number of maturities and makes allowance for bid–ask spreads and brokerage costs in his calculations. He finds, *inter alia*, that there are few profitable violations of CIP, even during periods of market uncertainty and turbulence. One interesting feature of Taylor’s work is the finding of a *maturity effect* – the frequency, size and persistence of profitable arbitrage opportunities appear to be an increasing function of the length of the period to maturity of the underlying financial instruments. A rationale is offered for this in terms of banks’ prudential credit limits. Since banks impose prudential limits on the amount of outstanding liabilities they have with other parties, arbitraging at the shorter maturities will result in limits being filled for shorter periods, leaving dealers on average freer to take advantage of other profitable opportunities as they arise.

A second approach for testing the validity of CIP is based on regression analysis, generally inspired by equation (2.5). In fact, if CIP holds, in the absence of transactions costs, estimation of the following equation:

$$f_t^{(k)} - s_t = \alpha + \beta(i_t - i_t^*) + u_t \quad (2.6)$$

(where u_t is the regression error) should result in estimates of α and β differing insignificantly from zero and unity respectively and a non-autocorrelated error. Equation (2.6) has been tested by a number of researchers for a variety of currencies and time periods (see, for example, the early study by Branson, 1969). The main conclusion to be drawn from this line of research is that, broadly speaking, CIP is supported in that although there are significant deviations of α from zero (reflecting perhaps non-zero transactions costs) the estimates of β differ insignificantly from unity in the majority of cases. As noted by Taylor (1989), however, it is not clear what regression-based analyses of CIP are actually testing. For example, it may be that a researcher cannot reject the hypothesis that $\alpha = 0$ and $\beta = 1$ in equation (2.6) but that the fitted residuals themselves represent substantial arbitrage opportunities. Put another way, such a test may suggest strongly that CIP held *on average* over a period when in fact it did not hold *continuously* during the period. Thus, although regression-based tests may be useful for testing the broad stylised fact of CIP (which may be of interest, for example, for exchange rate modelling), they can say virtually nothing about market efficiency.

Some recent empirical work on testing CIP and modelling the spot–forward relationship has also taken into account the importance of transactions costs. Balke and Wohar (1998) examine the dynamics of deviations from CIP using daily data on the UK–US spot and forward exchange rates and interest rates over the period January 1974 to September 1993. Balke and Wohar find a substantial number of instances in the sample in which the CIP condition exceeds the transactions costs band, implying arbitrage profit opportunities. While most of these implied profit opportunities are relatively small, Balke and Wohar also provide evidence of some very large deviations from CIP in their sample. In order to examine the persistence of these deviations, they estimate a threshold autoregression in which the dynamic behaviour of deviations from CIP is different outside the transactions costs band than

it is inside the band. They also find that while the impulse response functions when inside the transactions costs band are nearly symmetric, those for the outside the bands are asymmetric and suggest less persistence outside of the transactions costs band than inside the band.

More recently, Peel and Taylor (2002) have applied a threshold model to test CIP on weekly data for US–UK rates during the 1920s exchange rate float. Peel and Taylor provide support for the conjecture advanced by Keynes (1923) and Einzig (1937) that, during the 1920s, deviations from CIP were not be arbitrated unless the arbitrage opportunity yielded a substantial profit of a half of one percentage point on an annualised basis. Their results suggest that the no-arbitrage bandwidth is indeed insignificantly different from plus or minus fifty basis points and that deviations from CIP are moderately persistent even outside of the band. A neutral bandwidth of plus or minus fifty basis points on an annualised basis is very large by modern standards, so that these results raise further issues, in particular the issue of why the minimum covered interest rate differential needed for international arbitrage activity should have been so high in the inter-war period. One obvious possibility is simply that markets were to this extent inefficient, which indeed seems to be a modern interpretation of the explanation given by Keynes (1923) and Einzig (1937). An alternative but related view, also developed by Einzig (1937) as well as Hawtrey (1932), would be that banks were unwilling to place large deposits in pursuance of covered interest arbitrage unless the resulting profit were large enough in percentage terms, because of the effect this would have had on their overall liquidity.

This, however, only raises a further question, namely why should banks care about liquidity in this fashion, over and above any issues of political risk? As noted above, Taylor (1987, 1989) suggests that banks may wish to retain liquidity in order to be ready to exploit other arbitrage opportunities which may arise (although a fifty basis points deviation would still seem large). It is also possible that banks may have wished to retain liquidity because of the fear of a run on the bank, and that this effect may have declined in the post-war period because of the growth in the asset base of large investment banks and the general deepening of the forward exchange markets (Einzig, 1962). Yet another possibility may be related to the assumed risklessness of covered interest arbitrage. Covered arbitrage is only riskless if all of the transactions – the taking of a deposit, the placing of a deposit, a spot foreign exchange transaction and a forward foreign exchange transaction – are effected simultaneously. In a modern foreign exchange dealing room, equipped with highly sophisticated communication equipment and served by a sophisticated system of foreign exchange and money market brokers, prices can be obtained and orders carried out literally within seconds (and may even be automated and synchronised), so that covered arbitrage will indeed be virtually riskless. Although poorly documented, the dealing room environment of the 1920s must have been quite different, with communication between London and New York banks taking place by cable and ‘long-distance trunk calls’ (Einzig, 1937, p. 57) and therefore being much slower. In this environment, it may have been prudent to wait for a sizeable deviation from CIP to arise before arbitraging in order to be sure of effecting the necessary transactions before prices moved against the arbitrageur.

The 1920s experience apart, however, an overall reading of the literature on CIP provides strong empirical support in favour of CIP, especially as applied to Euro-deposit interest rates.