THE EMPIRICAL EVIDENCE ON THE EFFICIENCY OF FORWARD AND FUTURES FOREIGN EXCHANGE MARKETS

Robert J Hodrick
THE EMPIRICAL EVIDENCE ON THE EFFICIENCY OF FORWARD AND FUTURES FOREIGN EXCHANGE MARKETS
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ROBERT J HODRICK
The Empirical Evidence on the Efficiency of Forward and Futures Foreign Exchange Markets

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Contents

Introduction to the Series

1. Introduction 1
2. Asset Pricing Theory 7
3. Econometric Tests of the Efficiency Hypothesis: Autocorrelation and Unbiasedness 18
4. Alternative Interpretations of Rejections of the Unbiasedness Hypothesis 54
5. Econometric Models of Risk Premiums 84
6. Evaluation of Forecasts 132
7. Empirical Investigation of Foreign Currency Futures 138
8. Conclusions 153

References 158

Index 171
Introduction to the Series

Drawing on a personal network, an economist can still relatively easily stay well informed in the narrow field in which he works, but to keep up with the development of economics as a whole is a much more formidable challenge. Economists are confronted with difficulties associated with the rapid development of their discipline. There is a risk of “balkanisation” in economics, which may not be favorable to its development.

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The Empirical Evidence on the Efficiency of Forward and Futures Foreign Exchange Markets

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1. INTRODUCTION

This monograph is a critical review of the empirical literature that studies the efficiency of the forward and futures markets for foreign exchange. The importance of this topic to government policymakers, firms, investors, and economists and the ready availability of data have spawned a large volume of research in this area. Although much work has been done, there does not appear to be a strong consensus either in the opinions of those who have conducted the research or in those who have read it. That this difference of opinion can be readily traced to strong prior opinions and relatively uninformative data is not surprising. Yet, we have learned a lot, and my purpose here is to lay out, in a systematic way, what I think we have learned.

The importance of this topic for policymakers stems from their need to assess the performance of alternative international financial systems. The existence and efficiency of organized markets for future delivery of foreign currencies was a critical link in early arguments for flexible exchange rates. Friedman [78] argued that the existence of such markets provided international traders a convenient means of hedging risks of currency fluctuations. In contrast, Nurske [167] argued that flexible exchange rates would be inherently volatile and subject to the whims of speculators.

The volatility of exchange rates, since the abandonment of the Bretton Woods arrangement in the early 1970's, has proven surprising to many economists. Indeed, the results of Meese and
Rogoff [158, 159] indicate that current economic models of spot exchange rate determination are generally unable to explain the movement in major currency exchange rates. Yet, without economic models of the determination of exchange rates, how can we know whether we need fixed rates or flexible rates or more or less intervention in foreign exchange markets? How can we ascertain what is a fundamental disequilibrium that would trigger a change in a fixed-rate system? The studies described here offer a scientific foundation upon which we can hope to develop answers to these questions.

Corporations and investors obviously care about the efficiency of forward and futures markets for foreign exchange. Whenever uncovered foreign currency investments are made, one component of the domestic currency return is any change that occurs in the domestic value of the foreign currency. The expected rate of change of the exchange rate contributes to the expected return and an assessment of this must be made to determine expected returns on foreign investment. A substantial amount of resources flow each year into forecasting exchange rates, and the evidence presented here has a direct bearing on such activities. Furthermore, contentions of unexploited profit opportunities and insufficient or overabundant speculation are rampant in this literature, and the evidence on various trading strategies and filter rules is presented below.

Finally, this survey is of interest to financial economists because it collects together a number of recent approaches to testing asset pricing models that may be usefully employed in other contexts. In this regard, a major thrust of the analysis below is that asset pricing specification tests ought to allow for the presence of conditional heteroscedasticity. Estimation procedures that allow for conditional heteroscedasticity and ones that model it are discussed.

The monograph is divided into seven remaining sections. Section 2 draws on the Lucas [145] model and the arguments of Cox, Ingersoll and Ross [34] to examine a theoretical model of the determination of forward and futures prices for foreign exchange. Since the Lucas model is a complete dynamic two-country general equilibrium model, it provides a useful starting point for the discussion. Unfortunately, since the purpose of the monograph is to survey the empirical literature, alternative theoretical frameworks
cannot be addressed in the available space. Readers who desire more theoretical material ought to refer to the survey by Adler and Dumas [2] and the contribution of Branson and Henderson [24] in the excellent volume edited by Jones and Kenen [118]. Both of these articles do a good job of describing the state of the art in the theoretical modeling of international asset pricing.1

The empirical literature in this area has also been the subject of some recent surveys that ought to be read in conjunction with this monograph. Particular mention must be made of the contribution of Levich [133]. Levich surveys models of spot exchange rate determination as well as forward rates. The survey of Boothe and Longworth [21] also provides a different perspective and interpretation of the empirical literature on the efficiency of forward markets.

The major theoretical implications derived in Section 2 are that neither forward rates nor futures rates need be unbiased predictors of future spot rates in an efficient market. In each case the Lucas model allows a conditional covariance, which is related to the riskiness of an asset, to separate these prices from the expected value of the spot exchange rate. Since this conditional covariance can vary through time, the nature of the bias in forward rates and futures prices can be time varying.

Section 3 begins the discussion of the empirical analyses with an examination of the time-series properties of spot rates. Autocorrelations and empirical distributions of exchange rates are discussed. Then, tests of the unbiasedness of forward rates as predictors of future spot rates are examined. The relative merits of various strategies for testing the restrictions that such a hypothesis places on the data are discussed. This section incorporates a discussion of Hansen’s [96] Generalized Method of Moments which is often a computationally convenient way of testing restrictions that

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1 Adler and Dumas [2] survey the development of theories of international asset pricing from a finance viewpoint. Their modeling strategy follows Solnik [198], Kouri [123], Hodrick [105], and Stulz [202] in the use of stochastic calculus to address issues in international asset pricing. Stulz [203] provides an introduction to mean variance optimization models in international asset pricing, while Stulz [204] extends his earlier analysis to incorporate money explicitly. Branson and Henderson [24] present a complete derivation of macroeconomic portfolio balance models, derive many results from the literature as well as present complementary microeconomic foundations of these models from the stochastic calculus models of international finance.
arise in rational expectations models. The major conclusion of Section 3 is that very strong evidence exists against the hypothesis that forward exchange rates, of any maturity from one day, to one week, to one or three months, are unbiased predictors of future spot rates.

Section 4 explores several alternative interpretations of the rejection of the unbiasedness hypothesis. Since the statistical arguments that are used to reject unbiasedness are invariably based on asymptotic distribution theory, there is always the possibility that the sample moments of the data are poor reflections of their asymptotic counterparts. While this argument applies with equal force to virtually all modern time series analysis, it may be that the types of government policies and other exogenous processes that determine exchange rates make this problem particularly strikingly manifest in these studies. Such a possibility probably deserves more study than it has received.

A second interpretation of the rejection of the unbiasedness hypothesis relies on Fama's [59] ingenious decomposition argument. By viewing the forward premium as the sum of two unobservable components, the expected rate of depreciation plus a normalized risk premium, and by considering the algebra of least squares, Fama demonstrated that rejection of the unbiasedness hypothesis in most instances implies that risk premiums are more variable than expected rates of depreciation and that the two covary negatively. While Fama found the results troublesome and potentially at variance with theory, the results of Hodrick and Srivastava [108] indicate that negative covariation per se is not inconsistent with the Lucas model. The magnitude of variability in the risk premiums remains an open question.

Section 4 continues with a discussion of the profitability of various trading strategies and contentions that the forward exchange market is inefficient. The work of Hodrick and Srivastava [106] questions whether Bilson's [14] trading strategy produces expected profits that are too good to be consistent with risk aversion. Assessment of the profitability of trading rules is complicated by the necessity, documented in Section 3, of allowing the conditional variance of forward rate forecast errors to vary over time. This problem also plagues analysis of the profitability of the interesting filter rule
studies of Dooley and Shafer [44, 45] and Sweeney [207] that are addressed in this section.

A third alternative explanation of the rejection of the unbiasedness hypothesis involves the modeling of time varying risk premiums. Section 5 explores two complementary approaches to this subject. First, models that utilize only financial data are explored. This section includes a discussion of the latent variable model of Hansen and Hodrick [98] with its extensions by Hodrick and Srivastava [106], Campbell and Clarida [29], and Giovannini and Jorion [86].

The presence of conditional heteroscedasticity in forward rate forecast errors prompted Domowitz and Hakkio [42] to develop a model of the risk premium based on an autoregressive conditional heteroscedasticity framework. This is also discussed in Section 5.

Korajczyk [122] noted that the variability of risk premiums in theory can be related to variations in expected real interest rates. He developed and tested this approach which is discussed in Section 5. His empirical work also utilized bootstrap and Monte Carlo simulations in addition to the asymptotic distribution theory, and potential problems with this approach are reviewed.

Most of the econometric models of risk premiums that have involved market fundamentals, such as asset stocks, and not just financial data, have been of the two-period mean-variance type. Section 5 considers the papers of Frankel [67] and Frankel and Engel [69] in detail. The inability of this model to explain the data suggests that sterilized intervention in foreign exchange markets is unlikely to be successful, and Section 5 also surveys the literature relating to intervention and risk premiums.

The most direct test to date of the Lucas model was conducted by Mark [148]. He follows Hansen and Singleton [100, 101, 102] in adopting expenditures on nondurables and nondurables plus services as his measures of consumption. His estimation results and some potential problems with the approach are discussed in Section 5.

Section 6 explores the relation between forecasts of exchange rates and risk premiums. Frankel and Froot [70] and Froot and Frankel [79] have used available survey data of experts to attempt to quantify expected rates of depreciation and risk premiums. Unfortunately, their data series are relatively short, but the results
are quite provocative and may be indicative of substantial nonstationarities in the data. Wolff [217] adopts a Kalman filtering approach to measuring risk premiums. He finds that the best forecasting models have highly autocorrelated risk premiums and large innovation variances of exchange rates relative to innovations in risk premiums. In no case does one of his models have a smaller mean-square error of its forecasts than the assumption that the exchange rate follows a random walk.

Section 7 examines the limited empirical work on futures prices of foreign exchange. The first issue addressed is whether there is any meaningful economic difference between futures prices and forward prices for the same terminal date in the future. Cornell and Reinganum [33] examined this issue and concluded that the potential difference that was derived by Cox, Ingersoll and Ross [34] does not manifest itself in the data. Consequently, if forward prices are biased predictors of future spot prices, futures prices must be biased predictors, as well, and by application of the law of iterated expectations, futures prices must be biased predictors of the next day’s futures price. Hodrick and Srivastava [107] explored this hypothesis and their analysis is discussed. They are able to reject the hypothesis but find evidence of low variability of daily risk premiums. Consistency of daily and monthly evidence consequently requires highly serially correlated risk premiums. Some conflicting evidence on these issues is provided by McCurdy and Morgan [154]. They are unable to reject the unbiasedness hypothesis with weekly data.

Feinstein [62] also argues that such serial correlation is absent from the data. Her study involves the analysis of intradaily price changes in the foreign currency futures market. While nonnormality of price changes and nonstationarity of distribution across different days complicates the analysis of serial correlation, Feinstein argues that the movement of future prices is best modeled with a serially uncorrelated compound Poisson-normal process. With such a process prices jump only at the arrival of new information. If a jump occurs, its size is drawn from a normal distribution while the number of jumps in a given interval of time is assumed to be drawn from an independent Poisson distribution.

Conclusions and a short discussion of outstanding issues are presented in Section 8.
than a decade. One issue that needs to be addressed more formally is the role of learning in determining interest rates, exchange rates and stock prices. Another difficult area of research is quantifying the influence of government policies on asset prices. The rational expectations revolution in macroeconomics alerted us to the role of the influence of expected future policies on current variables. Is history useful in determining the expected future path of government policies or must we bring more theory to bear on the problem? My intuition here is that simple extrapolations of the past (or autoregressive time series models) are not very useful in determining expectations of future government policies.

The world is rapidly changing and becoming more integrated. A global marketplace in assets and commodities is emerging as technological change has decreased the cost of communication around the world. Will governments embrace this opportunity for increased intersectoral and intertemporal trade or will they shy away and attempt to erect protectionist barriers that prohibit the flows of goods and the flows of wealth? What causes exchange rate volatility and is it harmful to trade and welfare? Studies that seek answers to these and other issues in international finance and macroeconomics must base their models on the intertemporal paradigm. The work presented here suggests that simple models may not work well, but we have only begun to develop the first models based on rational maximizing agents.

As economists, we would like to be able to advise policy makers on the conduct of policy. We would like to be able to advise firms on the nature of exchange risk. We need to know how well international financial markets are functioning in the allocation of savings and investment throughout the world. We need to know how monetary and fiscal policies and trade policies ought to be conducted. Answers to these questions are important, and I hope that the readers of this monograph will be able to use the research presented here in their quest for the truth.

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FORWARD AND FUTURES FOREIGN EXCHANGE MARKETS 169


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