QUANTITATIVE FINANCIAL ECONOMICS

Stocks, Bonds and Foreign Exchange

Keith Cuthbertson

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Series Preface

This series aims to publish books which give authoritative accounts of major new topics in financial economics and general quantitative analysis. The coverage of the series includes both macro and micro economics and its aim is to be of interest to practitioners and policy-makers as well as the wider academic community.

The development of new techniques and ideas in econometrics has been rapid in recent years and these developments are now being applied to a wide range of areas and markets. Our hope is that this series will provide a rapid and effective means of communicating these ideas to a wide international audience and that in turn this will contribute to the growth of knowledge, the exchange of scientific information and techniques and the development of cooperation in the field of economics.

Stephen Hall
Imperial College, London, UK

Introduction

This book has its genesis in a final year undergraduate course in Financial Markets, although parts of it have also been used on postgraduate courses in quantitative aspects of the behaviour of financial markets. Participants in these courses usually have somewhat heterogeneous backgrounds: some have a strong basis in standard undergraduate economics, some in applied finance while some are professionals working in financial institutions. The mathematical and statistical knowledge of the participants in these courses is also very mixed. My aim in writing the book is to provide a self-contained, modern introduction to some of the theories and empirical methods used by financial economists in the analysis of speculative assets prices in the stock, bond and foreign exchange markets. It could be viewed as a selective introduction to some of the recent journal literature in this area, with the emphasis on applied work. The content should enable the student to grasp that although much of this literature is undoubtedly very innovative, it is often grounded in some fairly basic intuitive ideas. It is my hope that after reading the book, students and others will feel confident in tackling the original sources.

The book analyses a number of competing models of asset pricing and the methods used to test these. The baseline paradigm throughout the book is the efficient market hypothesis EMH. If stock prices always fully reflect the expected discounted present value of future dividends (i.e. fundamental value) then the market will allocate funds among competing firms, optimally. Of course, even in an efficient market, stock prices may be highly volatile but such volatility does not (generally) warrant government intervention since prices are the outcome of informed optimising traders. Volatility may increase risk (of bankruptcy) for some financial institutions who hold speculative assets, yet this can be mitigated via portfolio diversification and associated capital adequacy requirements.

Part 1 begins with some basic definitions and concepts used in the financial economics literature and demonstrates the 'separation principle' in the certainty case. The (one-period) Capital Asset Pricing Model (CAPM) and (to a much lesser extent) the Arbitrage Pricing Theory (APT) provide the baseline models of equilibrium asset returns. These two models, presented in Chapters 2 and 3, provide a rich enough menu to illustrate many of the empirical issues that arise in testing the EMH. It is of course repeatedly made clear that any test of the EMH is a joint test of an equilibrium returns model and rational expectations (RE). Also in Part 1, the theoretical basis of the CAPM (and its variants, including the consumption CAPM), the APT and some early empirical tests of these models are discussed, and it is concluded with an examination, in Chapter 4, of the relationship between returns and prices. It is demonstrated that any model of

expected returns, together with the assumption of rational expectations, implies the rational valuation formula (i.e. asset prices equal the expected discounted present value of future payments). This link between 'returns' and 'prices' and tests based on these two variables is a recurring theme throughout the book.

In Part 2, Chapter 5, the basic assumptions and mathematical formulation of the RE–EMH approach are outlined. One view of the EMH is that equilibrium excess returns are unpredictable, another slightly different interpretation is that one cannot make persistent abnormal profits after taking account of transactions costs and adjustment for risk. In Chapter 6, an examination is made of a variety of statistical tests which seek to establish whether stock returns (over different holding periods) are predictable and if so whether one can exploit this predictability to earn 'abnormal' profits. This is followed by a discussion of the behaviour of stock *prices* and whether these are determined solely by fundamentals or are excessively volatile. When discussing 'volatility tests' it is possible to highlight some issues associated with inference in small samples and problems encountered in the presence of non-stationary data. The usefulness of Monte Carlo methods in illuminating some of these problems is also examined. The empirical evidence in Part 2 provides the reader with an overview of the difficulties faced in establishing firm conclusions about competing hypotheses. However, at a minimum, a prima facie case is established that when using fairly simple models, the EMH may not adequately capture the behaviour of stock prices and returns.

It is well known that stock returns may contain a (rational) bubble which is unpredictable, yet this can lead to a discrepancy between the stock price and fundamental value. Such bubbles are a 'self-fulfilling prophecy' which may be generated exogenously or may depend on fundamentals such as dividends (i.e. intrinsic bubbles). The intrinsic bubble is 'anchored' to dividends and if dividends are fairly stable then the actual stock price might not differ too much from its fundamental value. However, the dividend process may be subject to 'regime changes' which can act as a catalyst in generating a change in an intrinsic bubble. Periodically collapsing bubbles are also possible: when the bubble is positive, stock prices and fundamentals diverge, but after the 'collapse' they are again brought into equality. These issues are addressed in Chapter 7 which also assesses whether the empirical evidence supports the presence of rational bubbles.

Stock market 'anomalies' and models of noise trader behaviour are discussed in Chapter 8, the final chapter in Part 2. The evidence on 'anomalies' in the stock market is voluminous and students love providing a 'list' of them in examination answers. While they are invaluable pieces of evidence, which may be viewed as being complementary to the statistical/regression-based approaches, I have chosen to 'list' only a few of the major ones, since the analytic content of these studies is usually not difficult for the student to follow, in the original sources. Such anomalies highlight the potential importance of noise traders, who follow 'fads and fashions' when investing in speculative assets. Here, asset prices are seen to be the outcome of the interaction between 'smart money' traders and 'noise traders'. The relative importance of these two groups in particular markets and at particular times may vary and hence prices may sometimes reflect fundamental value and at other times may predominantly reflect fads and fashions.

There are several approaches to modelling noise trader behaviour. For example, some are based on maximising an explicit objective function, while others involve non-linear responses to market signals. As soon as one enters the domain of non-linear models the possibility of chaotic behaviour arises. It is possible for a purely (non-linear) deterministic

process to produce an apparently random time series which may closely resemble the patterns found in actual speculative prices. The presence of noise traders may also give rise to 'short-termism'. The latter is a rather imprecise term but broadly speaking it implies that market participants place too much weight on expected events (e.g. higher dividends) in the near future, relative to those in the more distant future, when pricing stocks. Stocks are therefore mispriced and physical investment projects with returns over a short horizon are erroneously preferred to those with long horizon returns, even though the latter have a higher expected net present value. Illustrative models which embody the above ideas are presented in Chapter 8, along with some empirical tests.

Overall, the impression imparted by the theoretical models and empirical results presented in Part 2 is that for the stock market, the EMH under the assumption of a time invariant risk premium may not hold, particularly for the post-1950s period. However, the reader is made aware that such a conclusion is by no means clear cut and that more sophisticated tests are to be presented in Parts 5 and 6 of the book. Throughout Part 2, it is deliberately shown how an initial hypothesis and tests of the theory often lead to the unearthing of further puzzles, which in turn stimulates the search for either better theoretical models or improved data and test procedures. Hence, by the end of Part 2, the reader should be well versed in the basic theoretical constructs used in analysing asset prices and in testing hypotheses using a variety of statistical techniques.

Part 3 examines the EMH in the context of the bond market. Chapter 9 outlines the various hypotheses of the term structure of interest rates applied to spot yields, holding period yields and the yield to maturity and demonstrates how these are interrelated. The dominant paradigms here are the expectations hypothesis and the liquidity preference hypothesis, both of which assume a time invariant term premium. Chapter 10 examines empirical tests of the competing hypotheses, for the short and long ends of the maturity spectrum. In addition, cointegration techniques are used to examine the complete maturity spectrum. On balance, the results for the bond market (under a time invariant term premium) are found to be in greater conformity with the EMH than are the results for the stock market (as reported in Part 2). These differing results for these two speculative asset markets are re-examined later in the book.

Part 4 examines the FOREX market and in particular the behaviour of spot and forward exchange rates. Chapter 11 begins with a brief overview of the relationship between covered and uncovered interest parity, purchasing power parity and real interest rate parity. Chapter 12 is mainly devoted to testing covered and uncovered interest parity and forward rate unbiasedness. The degree to which the apparent failure of forward rate unbiasedness may be due to a failure either of rational expectations or of risk neutrality is examined. The difficulty in assessing 'efficiency' in the presence of the so-called Peso problem and the potential importance of noise traders (or chartists) are both discussed, in the light of the illustrative empirical results presented. In the final section of Part 4, in Chapter 13, various theories of the behaviour of the spot exchange rate based on 'fundamentals', including flex-price and sticky-price monetary models, are outlined. These monetary models are not pursued at great length since it soon becomes clear from empirical work that (other than for periods of hyperinflation) these models, based on economic fundamentals, are seriously deficient. The final chapter of Part 4 therefore also examines whether the 'stylised facts' of the behaviour of the spot rate may be explained by the interaction of noise traders and smart money and, in one such model, chaotic behaviour is possible. The overall conclusion is that the behaviour of spot and forward exchange rates is little understood.

It appears that a freely floating spot rate is not firmly 'anchored' by fundamentals such as the money supply. Also, changes in the spot rate in the presence of sticky goods prices can have a major impact on the real economy. This has led some governments in Western industrialised nations to adopt currency bands to 'guide' the exchange rate expectations of market participants (although space constraints prevent a discussion of target zone models).

In Part 5 the EMH using the VAR methodology is tested. Chapter 14 begins with the term structure of interest rates and demonstrates how the VAR equations can be used to provide a time series for the forecast of (a weighted average of) future changes in short-term rates of interest, which can then be compared with movements in the long–short spread, using a variety of metrics. Under the null of the expectations hypothesis the VAR yields a set of cross-equation parameter restrictions. These restrictions are shown to have an intuitive interpretation, namely, that forecast errors are independent of information used in generating the forecast and that no abnormal profits can be made. Having established the basic principles behind the VAR methodology it is then possible succinctly to deal with its application to the FOREX (Chapter 15) and stock market (Chapter 16). There are two further interesting aspects to the VAR methodology applied to the stock market. First, the VAR methodology is useful in establishing links between early empirical work that looked at the predictably of *one-period* returns and *multi-period returns* and those that examined volatility tests on stock *prices*. Second, the link between the *persistence* of one-period returns and the volatility of stock prices is easily examined within the VAR framework. Broadly speaking the empirical results based on the VAR approach suggest that the stock and FOREX markets (under a time invariant risk premium) do not conform to the EMH, while for the bond market the results are more in conformity — although some puzzles still remain.

Part 6 examines the potential impact of time varying risk premia in the stock and bond markets. If returns depend on a time varying risk premium which is persistent, then sharp movements in stock prices may ensue as a result of shocks to such premia: hence, observed price movements may not be 'excessively' volatile. An analysis is made of the usefulness of the CAPM with time varying variances and covariances which are modelled by ARCH and GARCH processes. This framework is applied to both the (international) stock and bond markets. There appears to be more support for a time varying (GARCH type) risk premium influencing expected returns in the stock market than in the bond market. Some unresolved issues are whether such effects are stable over time and are robust to the inclusion of other variables that represent trading conditions (e.g. turnover in the market).

As the book progresses, the reader should become aware that to establish whether a particular speculative market is efficient, in the sense that either no excess (abnormal) profits can be earned or that market price reflects economic fundamentals, is far from straightforward. It often requires the use of sophisticated statistical tests many of which have only recently appeared in the literature. Data on asset prices often exhibit 'trends' and such 'non-stationary' data require analysis using concepts from the literature on unit roots and cointegration — otherwise grossly misleading inferences may ensue. Some readers will also be aware that, although the existence of time varying risk premia has always been acknowledged in the theoretical finance literature, it is only recently that empirical work has been able to make advances in this area using ARCH and GARCH

models. The assumption of rational expectations has also played a major role in the analysis of asset prices and this too involves special econometric procedures.

I believe that the above statistical techniques, which are extensively used in the analysis of speculative asset prices, are complex enough to warrant specific treatment in the book. However, I did not want these issues to dominate the book and 'crowd-out' the economic and behavioural insights. I therefore decided that the best way forward, given the heterogeneous background of the potential readership of the book, was to provide an overview of the purely statistical aspects in a self-contained section (Part 7) at the end of the book. This has allowed me to limit my comments on the statistical nuances to a minimum, in the main body of the text. A pre-requisite for understanding Part 7 would be a final year undergraduate course or a specialist option on an MBA in applied time series econometrics.

Naturally, space constraints imply that there are some interesting areas that had to be omitted. To have included general equilibrium and other 'factor models' of equilibrium returns based on continuous time mathematics (and associated econometric procedures) would have added considerably to the mathematical complexity and length of the book. While continuous time equilibrium models of the term structure would have provided a useful comparison to the discrete time approach adopted, I nevertheless felt it necessary to exclude this material. This also applies to some material I initially wrote on options and futures — I could not do justice to these topics without making the book inordinately long and there are already some very good specialist, academically oriented texts in this area. I also do not cover the recent burgeoning theoretical and applied literature on 'market micro-structure' and applications of neural networks to financial markets.

Readership

In order to make the book as self-contained as possible and noting the often short half-life of even some central concepts in the minds of some students, I have included some key basic theoretical material at the beginning of the book (e.g. the CAPM and its variants, the APT and valuation models). As noted above, I have also relegated detailed statistical issues to a separate chapter. Throughout, I have kept the algebra as simple as possible and usually I provide a simple exposition and then build up to the more general case. This I hope will allow the reader to interpret the algebra in terms of the economic intuition which lies behind it. Any technically difficult issues or tedious (yet important) derivations I relegate to footnotes and appendices. The empirical results presented in the book are merely illustrative of particular techniques and are not therefore meant to be exhaustive. In some cases they may not even be representative of 'seminal contributions', if the latter are thought to be too technically advanced for the intended readership. As the reader will already have gathered, the empirics is almost exclusively biased towards time series analysis using discrete time data.

This book has been organised so that the 'average student' can move from simple to more complex topics as he/she progresses through the book. Theoretical ideas and constructs are developed to a particular level and then tests of these ideas are presented. By switching between theory and evidence using progressively more difficult material, the reader becomes aware of the limitations of particular approaches and can see how this leads to the further development of the theories and test procedures. Hence, for the less adventuresome student one could end the course after Part 4. On the other hand, the advanced student would probably omit the more basic material in Part 1 but would

cover the rest of the book including the somewhat more challenging issues of the VAR methodology (Part 5), modelling time varying risk premia (Part 6) and the details of the econometric methodology (Part 7).

Had I been writing a survey article, I would not of course have adopted the above approach. In a survey article, one often presents a general framework from which most other models may be viewed as special cases. This has the merit of great elegance but it can often be difficult for the average student to follow, since it requires an immediate understanding of the general model. My alternative approach, I believe, is to be preferred on pedagogic grounds but it does have some drawbacks. Most notably, not all of the possible theoretical approaches and empirical evidence for a particular market, be it for stocks, bonds or foreign exchange, appear in one single chapter. However, this is deliberate and I can only hope my ordering of the material does not obscure the underlying common approaches that may be applied to all speculative markets.

The book should appeal to the rising undergraduate final year, core financial markets area and to postgraduate courses in financial economics, including electives on specialist MBA finance courses. It should also provide useful material for those working in the research departments of large financial institutions (e.g. investment banks, pension funds and central and commercial banks). The book covers a number of important recent advances in the financial markets area, both theoretical and econometric/empirical. Recent innovative areas that are covered include chaos, rational and intrinsic bubbles, the interaction of noise traders and smart money, short-termism, anomalies, predictability, the VAR methodology and time varying risk premia. On the econometrics side problems of non-stationarity, cointegration, rational expectations, ARCH and GARCH models are examined. These issues are discussed with empirical examples taken from the stock, bond and FOREX markets.

Professional traders, portfolio managers and policy-makers will, I hope, find the book of interest because it provides an overview of some of the theoretical models used in explaining the determination of asset prices and returns, together with the techniques used to assess their empirical validity. The performance of such models provides the basic input to key policy issues such as capital adequacy proposals (e.g. for securities dealers), the analysis of mergers and takeovers and other aspects of trading arrangements such as margin requirements and the use of trading halts in stock markets. Also, to the extent that monetary policy works via changes in interest rates across the maturity spectrum and changes in the exchange rate, the analysis of the bond and FOREX markets is of direct relevance. At a minimum the book highlights some alternative ways of examining the behaviour of asset prices and demonstrates possible pitfalls in the empirical analysis of these markets.

I remember, from reading books dealing with the development of quantum mechanics, that for several years, even decades, there would coexist a number of competing theories of the behaviour of elementary particles. Great debates would ensue, where often more 'heat than light' would be generated — although both could be construed as manifestations of (intellectual) energy. What becomes clear, to the layman at least, is that as one tries to get closer to the 'micro-behaviour' of the atom, the more difficult it becomes to understand the underlying physical processes at work. These controversies in natural science made me a little more sanguine about disputes that persist in economics. We know (or at least I think we know) that in a risky and uncertain world our 'simple' economic models often do not work terribly well. Even more problematic is our lack of data and inability to replicate

results via controlled experiments. Also, we have the additional problem that individuals learn and adapt and that 'group behaviour' may be different from the aggregate of each individual's behaviour. However, given the resources devoted to economics as compared to natural science, I hold the view that substantial progress has and is being made in the analysis of speculative asset prices and I hope this is reflected in the material in the book.

It has been said that some write so that other colleagues can better understand, while others write so that colleagues know that only they understand. I hope this book will achieve the former aim and will convey some of the recent advances in the analysis of speculative asset prices. In short, I hope it ameliorates the learning process of some, stimulates others to go further and earns me a modicum of 'holiday money'. Of course, if the textbook market were (instantaneously) efficient, there would be no need for this book — it would already be available from a variety of publishers. My expectations of success are therefore based on a view that the market for this type of book is not 'efficient' and is currently subject to favourable fads.

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