CHAPTER 1

Introduction to Part I

The past fifty years or so have been a time of great bloom in the field of finance. This period has seen the birth of concepts such as variance as a quantitative definition of risk, portfolio diversification as a means of controlling risk, portfolio optimization in the mean/variance framework, expected utility maximization as an investment and consumption decision making criterion. These notions were applied in the development of Capital Asset Pricing Model to describe the market equilibrium, to the concepts of systematic and specific risks and the introduction of asset beta. We have witnessed the revolution brought by the theory of options pricing. We have seen the appearance of the general principle of asset pricing as the present value of the cash flows expected under the risk-neutral probability measure. We have seen the development of the theory of the term structure of interest rates and the pricing of interest rate derivatives.

These theoretical developments have been accompanied by equally exciting changes in investment practices and indeed in the nature of capital markets. Few of us can still envision investment decision making without quantitative risk measurement, without hedging techniques, without deep and efficient markets for futures and options, without swaps and interest rate derivatives, and without computer models to price such instruments. And yet, these are all very recent developments. It has not been much longer than some thirty years ago that the very notion of an index fund was greeted with disbelief, if not outright ridicule!

I had the great fortune to be cast right into the middle of such developments when I joined the Management Science Department of Wells Fargo Bank in 1969. The annual conferences organized by Wells Fargo in the early seventies brought together people such as Franco Modigliani, Merton Miller, Jack Treynor, William Sharpe, Fisher Black, Myron Scholes, Robert Merton, Richard Roll and many others. The second half of the twentieth century was

---

Risk, 72-73, December 2002

in my eyes as exciting in the field of finance as the first half must have been in physics.

I have worked on a variety of projects at Wells Fargo and later at the University of Rochester and the University of California at Berkeley, but one thing that bothered me for quite a while in the mid-seventies was the absence of solid results on the pricing of bonds. At that time, the CAPM was already in existence, and people had tried to apply it to bonds by measuring their betas to determine the yield, but that did not really lead anywhere. The options pricing theory had also been freshly developed by then, but it did not seem very feasible to apply a theory of pricing derivative assets to assets as primary as government bonds. What would be the underlying?

And yet, it was obvious that there must be some conditions that govern interest rate behavior in efficient markets. You cannot have, for instance, a fixed-income market in which the yield curves are always flat and move up and down in some random fashion through time, because then a barbell portfolio would always outperform a bullet portfolio of the same duration, and therefore it would be possible to set up a profitable riskless arbitrage. But what are these conditions?

The clue came from comparing the return to maturity on a term bond to that of a repeated investment in a shorter bond. The common denominator between bonds of any maturity would be a rollover of the very short bond, and thus it seemed natural to postulate that the pricing of a bond should be a function of the short rate over its term. And once the idea of describing the short rate by a Markov process came to me, it became obvious: the future behavior of the short rate is determined by its current value and therefore the price of the bond must be a function of the short rate! From then on, it's mathematics: in order to exclude riskless arbitrage, this function must be such that the expected excess return on each bond is proportional to its risk, which gives rise to a partial differential equation. The boundary condition of this equation is the maturity value, and the solution is the bond price. This was my 1977 paper. (Curiously, the thing that became known as the Vasicek model was just an example that I put in that paper to illustrate the general theory on a specific case. Well, you never know.)

Since then, it was like opening Pandora's box. Great many papers followed, extending the model in various ways—multiple factors, non-Markov risk sources, development of various specific models for practical use. One paper I have a great respect for is the Cox, Ingersoll and Ross article (for some reason, they did not publish the paper until 1985, although they did the work many years earlier), because it is about more than interest rates: it is about an equilibrium in the bond market.

A big shift came in 1986 with the publication of the Ho and Lee paper. This article presented a simple interest rate model, which was just a special case of my theory. The shift was in the interpretation: Ho and Lee assumed that the current bond prices were given (equal to the actual observed prices) and concerned themselves with pricing interest rate derivatives. This, of course, allows very useful applications for valuation of various instruments from simple callable bonds to the most complex swaptions.

The Ho and Lee paper engendered a great development effort in that direction, including the 1992 paper by Heath, Jarrow, and Morton, which formalized this approach. This direction was in fact taken further: There are models that assume as given not only the current bond prices, but also prices of caps and floors or even more. These models, used then to value other derivatives, have the great virtue of fitting the current market pricing of the more primary assets.

While I appreciate the usefulness of these models, I somewhat regret the direction away from the economics. To ask how derivatives are priced given the pricing of bonds seems to me assuming away the more interesting question: How are bonds priced? I personally hope to see a return to efforts to understand the economics, rather just to aid trading.

A similar situation has arisen in default risk measurement and pricing, another subject dear to my heart. The so-called reduced-form models, which have been advocated for the purpose of credit risk analysis, assume that corporate debt prices are given and use these prices to value debt derivatives. Again, to me it seems that the more interesting question is how to price corporate debt. Fortunately, this is possible given the legacy of Merton, Black, and Scholes, since corporate liabilities are derivatives of the firm's asset value, and a structural model of the firm can price its debt (and debt derivatives) from equity prices.

As appreciative as I am of the past in the field of finance, I am equally enthusiastic about its future. There will be no lack of problems to address, and there will be no lack of talent to solve them. Indeed, it is the professionals in this area of endeavor that are its greatest assets, and I am grateful to have worked with, and learned from, so many of them.