Edwin J. Elton • Martin J. Gruber
Stephen J. Brown • William N. Goetzmann

MODERN PORTFOLIO THEORY AND INVESTMENT ANALYSIS

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NINTH EDITION

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To some of the future generation of our readers: Ned's grandchildren Erik Beitel, Sophia Beitel, Miranda Beitel, Chloe Elton, Jean Paul Elton, Petra Elton, Johanna Elton, and Klara Elton, and Marty's grandchildren Samuel Gruber, Jack Gruber, and Ava Gruber.

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New to the 9th Edition

There has been a renewed interest in the science of investment management in the years since the global financial crisis. The volatility of world markets and the shock to its financial institutions has caused a profound reexamination of risk, research into the methods of effective diversification, and exploration of the fundamental expected returns from financial assets. Rather than causing a rejection of modern portfolio theory, however, the financial crisis highlighted the validity of its fundamental tenants: higher expected returns require a willingness to accept higher risks; the methodology of diversification is extremely important; a longer-term perspective and an understanding of the broader scope of financial history is vital.

National and world events together with important new theoretical and empirical research have motivated a major revision of this book.

Almost all of the chapters have been revised, while more than half have been substantially rewritten. Modern developments in the theoretical and empirical literature have been incorporated into the text. All examples in the text have been brought up to date. A new chapter had been added to describe changing conditions in the mutual fund industry.

Some of the key changes in the text include the following:

- Recognizing the structural changes that have occurred in the markets in which securities are traded
- Recognizing the causes of the financial crisis of 2008 and the financial instruments that effected the crisis
- Recognizing new ways of estimating returns
- Incorporating recent developments in multiperiod consumption and investment models
- Recognizing the increased importance of international investing and diversification and the advances made in understanding emerging market investing
- Incorporating a new mode of investing: factor-based investing
- Incorporating the new theoretical and empirical literature, which helps us understand and diagnose mutual fund performance
- Incorporating new research on the efficient market theory and its origins
- Incorporating current research and applications of Bayesian methods in finance

The authors would like to thank our colleagues Joel Hasbrouck, Paul Zarowin, and Steve Figlewski for major contributions to the chapters on market structure, earnings estimation, and futures. We would also like to thank Nancy Mack and Jude Warne for assistance in preparing this manuscript.

Preface

This book, as the title suggests, is concerned with the characteristics and analysis of individual securities, as well as with the theory and practice of optimally combining securities into portfolios. Part 1 of the book provides a description of securities and markets. Two chapters provide the reader with the institutional background to place the analytics that follow in perspective.

The second, and longest, part of the book discusses modern portfolio theory. We begin Part 2 with a detailed presentation of the theory of modern portfolio analysis and show that the characteristics of portfolios are significantly different from those of the individual securities from which they are formed. In fact, portfolio analysis is the recipe for one of the few "free lunches" in economics. By the end of Chapter 6, the reader will have learned the basis of portfolio theory from the relationship of portfolio characteristics to security characteristics to the method of computing sets of portfolios that investors will find desirable.

The theory presented at the beginning of the book has been around long enough that major breakthroughs have occurred in its implementation. These breakthroughs involve simplification of the amount and type of inputs to the portfolio problem (Chapters 7 and 8), as well as simplification of the computational procedure to find sets of desirable portfolios (Chapter 9). The major advantage in the latter simplification is that the portfolio selection process and the final portfolios selected have a structure with a clear-cut economic rationale, one to which both the practicing security analyst and the economist can relate. Chapter 10 discusses the all-important input to portfolio management expected return.

The reader might note that up to now we have discussed sets of portfolios. These sets contain portfolios that would be desirable to any investor. In Chapter 11, we examine how an individual investor might choose the one optimal portfolio (for him or her) from among the sets of portfolios designed to appeal to any investor. We conclude Part 2 with a discussion of the potential benefits derived from diversifying portfolios internationally.

Part 3 provides a discussion of equilibrium in the capital markets. This material usually is included under the rubric of the capital asset pricing model or arbitrage pricing theory and shows how portfolio theory can be used to infer what equilibrium returns and prices will be for individual securities. This area is changing rapidly. But, as the reader will see, empirical tests suggest that the theory as it now stands provides great insight into the functioning of security markets and the pricing of individual issues. It also suggests ways that equilibrium theory can be used to manage portfolios more meaningfully.

Part 4 of this book deals with the characteristics and evaluation of individual securities. In this part we discuss whether security markets are efficient, the valuation of common stocks, the characteristics of earnings and their role in the valuation process, the valuation of bonds, the nature of and valuation of options, and finally the valuation and uses of futures. In addition, we explore the new field of behavioral finance and its implications for investor action and asset prices.

Part 5 is a discussion of the evaluation of the investment analysis and portfolio management process. In writing this part we have stressed techniques for evaluating every stage of the process, from the forecasting of earnings by security analysts to the performance of portfolios that are finally selected. It seems fitting that a book that deals primarily with investment analysis and portfolio management should end with a discussion of how to tell if these functions are performed well.

The book was designed to serve as a text for courses both in portfolio theory and in investment analysis that have an emphasis on portfolio theory. We have used it for these purposes at New York University for several years. For the course in portfolio analysis, we use Chapters 4–16 plus Chapters 25, 26, and 28. This thoroughly introduces the students to modern portfolio theory and general equilibrium models (capital asset pricing models and arbitrage pricing models).

The book can also be used in a course in investments where both portfolio analysis and security analysis are discussed. For these purposes, the institutional material in Chapters 1 and 2, the security analysis chapters of Part 4, as well as Chapter 26 on the evaluation of security analysis, are appropriate, and some of the advanced portfolio theory and general equilibrium chapters of Parts 2 and 3 can be deleted. Each professor's preference and the dictates of the course will ultimately determine the final choice. One possible choice that has been successfully used was the replacement of much of Chapter 6 and Chapters 8, 11, 14, 15, and 16 with the chapters on security analysis contained in Part 4. Courses covering portfolio theory and investments vary greatly in their content. We have included in this book those areas that we view as most relevant.

We believe that this book will be an aid to the practicing security analyst and portfolio manager. It is remarkable how quickly the ideas of modern portfolio theory have found their way into investment practice. The manager who wishes an overview of modern portfolio theory and investment analysis will find that Chapters 4, 5, 7, 9, 12, and 17–26 will provide a thorough and readable understanding of the issues. Specialists who are concerned with issues on implementation will find that the other chapters will equip them with the most modern tools available.

As the reader may know, New York University has not only the normal MBA and undergraduate student courses but also courses intended for full-time portfolio managers and securities analysts. The professional reader can be assured that the book has been used in these courses and that some of our most enthusiastic responses came from practicing managers who learned not only the ideas of modern portfolio theory and investment analysis but also its strengths and weaknesses.

In writing this book, our purpose has been to make all the material accessible to students of portfolio analysis and investment management, at both the undergraduate and the graduate levels. To the extent possible, the text stresses the economic intuition behind the subject matter. Mathematical proofs involving more than simple algebra are placed in footnotes, appendices, or specially noted sections of the text. They can be deleted without losing the general thrust of the subject matter. In addition, we have included problems both in the text and at the end of each chapter. We have tried to capture in this book the frontier of the state of the art of modern portfolio analysis, general equilibrium theory, and investment analysis, while presenting it in a form that is accessible and has intuitive appeal.

A book must, of necessity, present material in a certain order. We have tried to present the material so that much of it can be used in alternative sequences. For example, we tend to teach formal utility analysis after many of the concepts of portfolio analysis. However, we realize that many professors prefer to begin with a discussion of utility analysis. Thus this chapter in particular could be read immediately after the introductory chapter.

We wish to thank Professor Chris Blake for his help in preparing the problem sets included in this book.

Finally, we wish to acknowledge Dr. Watson. We have noted her contribution to utility analysis and security valuation in previous books. Her contribution to earlier versions of this book were substantial. Her untimely death meant that we did not have the benefit of her excellent advice on this latest edition, though her help is still reflected in the book you have before you.

Final Thoughts

More than 35 years have passed since we began to write the first edition of this book. Progress has been made in several areas, and yet new changes have occurred that reopen old questions. The acceptance of quantitative techniques by the investment community both here and overseas has grown at a rate we would not have dreamed of then. The use of modern portfolio techniques for stocks and bonds, dividend discount models, concepts of passive portfolios, the incorporation of international assets in portfolios, and the use of futures and options as risk control techniques are very widespread. Yet the world of investments continues to change. No sooner do we begin to believe that the capital asset pricing model (CAPM) describes reality than the arbitrage pricing theory (APT) comes along. No sooner do we convince ourselves that markets are efficient than market anomalies become hot topics. No sooner do we say that security analysis does not pay than we justify the cost of analysis in a world of partially revealing prices. No sooner is market timing discredited than it arises again under the name of tactical asset allocation.

Will the field continue to evolve and will today's truths become less true tomorrow? Probably. We will continue to learn. We know more about the capital markets now than we did 20 years ago. There is still a lot more to learn. That is why there will no doubt be a tenth edition of this book and why there are securities and strategies that have expected returns above the riskless rate.

E. J. Elton
M. J. Gruber
S. J. Brown
W. N. Goetzmann

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Part 1

INTRODUCTION

1

Introduction

Almost everyone owns a portfolio (group) of assets. This portfolio is likely to contain real assets, such as a car, a house, or a refrigerator, as well as financial assets, such as stocks and bonds. The composition of the portfolio may be the result of a series of haphazard and unrelated decisions, or it may be the result of deliberate planning. In this book we discuss the basic principles underlying rational portfolio choice and what this means for prices determined in the marketplace. We confine our attention to financial assets, although much of the analysis we develop is equally applicable to real assets.

An investor is faced with a choice from among an enormous number of assets. When one considers the number of possible assets and the various possible proportions in which each can be held, the decision process seems overwhelming. In the first part of this book we analyze how decision makers can structure their problems so that they are left with a manageable number of alternatives. Later sections of the book deal with rational choice among these alternatives, methods for implementing and controlling the decision process, and equilibrium conditions in the capital markets to which the previous analysis leads.

Let us examine the composition of this book in more detail.

OUTLINE OF THE BOOK

This book is divided into five parts. The first part provides background material on securities and financial markets. The reader already familiar with these topics can go directly to Part 2.

The second and longest part deals with the subject of portfolio analysis. Portfolio analysis is concerned with finding the most desirable group of securities to hold, given the properties of each of the securities. This part of the book is itself divided into four sections. The first of these sections is titled "Mean Variance Portfolio Theory." This section deals with determining the properties of combinations (portfolios) of risky assets given the properties of the individual assets, delineating the characteristics of portfolios that make them preferable to others, and, finally, showing how the composition of the preferred portfolios can be determined.

At the end of this section readers will know almost all that they need to know about the theory of portfolio selection. This theory is more than 50 years old. In the ensuing years, a tremendous amount of work has been devoted to implementing this theory. The second

section of Part 2 is concerned with the implementation and simplification of portfolio theory. The topics covered include simplifying the quantity and type of input needed to do portfolio analysis and simplifying the computational procedure used to find the composition of the efficient portfolios.

The third section of Part 2 deals with the selection of that one portfolio that best meets the needs of an investor. We discuss not only techniques that rely on utility maximization but also other techniques suggested in the literature.

The final section of Part 2 deals with the impact of the opportunity to diversify a stock portfolio across international boundaries. As the reader might suspect, any increase in the set of possible investment opportunities should increase portfolio performance.

Part 3 deals with models of equilibrium prices and returns in the capital markets. If investors behave as portfolio theory suggests they should, then their actions can be aggregated to determine prices at which securities will sell.

The first two chapters of Part 3 deal with some alternative forms of equilibrium relationships. Different assumptions about the characteristics of capital markets and the way investors behave lead to different models of equilibrium. The third chapter in this part of the book deals with empirical tests of how well these theoretical models describe reality. The final chapter in Part 3 presents both the theoretical basis of and empirical evidence on the newest theory of relative prices: the Arbitrage Pricing Theory.

The fourth part of the book deals with some issues in investment analysis. The first question examined is the speed with which new information is incorporated into the share price. If new information is immediately and accurately incorporated into the share price, then there can be no payoff from security analysis, whereas if information is more slowly incorporated into the share price, it may pay to engage in certain types of analysis. The key to security analysis is the method used to turn forecasts of fundamental firm characteristics into forecasts of price performance. This is the subject of the second chapter in Part 4, titled "The Valuation Process." Virtually every valuation process employs forecasts of earnings as one important input. A detailed analysis of earnings is presented as an example of methods of forecasting inputs to valuation models. This is followed by a chapter that discusses noneconomic behavior and the impact of this behavior on security prices. The next two chapters in Part 4 deal with the theory of interest rates, the pricing of bonds, and the management of bond portfolios. The final two chapters in Part 4 deal with the valuation of options and financial futures. The markets for security options and for futures are among the fastest-growing markets in the country. In addition, the theory of option pricing has important implications for generating the inputs to portfolio analysis. Futures, because of their low transaction costs, are an important tool for modifying portfolio composition.

The fifth part of the book is concerned with evaluating the investment process. The first chapter in this section contains a description of the principal types of mutual funds and reviews two specific types, closed-end funds and exchange-traded funds, in some detail. The second chapter deals with the evaluation of portfolio performance with an emphasis on open-end mutual funds. In this chapter we discuss the best methods of evaluating portfolio performance and how well-managed portfolios have performed. In contrast to the voluminous literature on portfolio performance, almost nothing has been written about how to evaluate the other steps in the investment process. For example, very little has been written about how to evaluate forecasts of security analysts or how to evaluate the valuation process. The third chapter in this part of the book deals with these problems. The final chapter of the book integrates the material contained in the earlier parts.

THE ECONOMIC THEORY OF CHOICE: AN ILLUSTRATION UNDER CERTAINTY

All decision problems have certain elements in common. Any problem involves the delineation of alternatives, the selection of criteria for choosing among those alternatives, and, finally, the solution of the problem. Furthermore, individual solutions can often be aggregated to describe equilibrium conditions that prevail in the marketplace. A large part of this book will be concerned with following these steps for the selection of risky assets. But before we start this problem, let us examine a simpler one, under certainty, to illustrate the elements of the solution to any economic problem.

Consider an investor who will receive with certainty an income of $10,000 in each of two years. Assume that the only investment available is a savings account yielding 5% per year. In addition, the investor can borrow money at a 5% rate.

How much should the investor save and how much should he or she consume each year? The economic theory of choice proposes to solve this problem by splitting the analysis into two parts: first, specify those options that are available to the investor; second, specify how to choose among these options. This framework for analysis carries over to more complex problems.

The Opportunity Set

The first part of the analysis is to determine the options open to the investor. One option available is to save nothing and consume $10,000 in each period. This option is indicated by the point *B* in Figure 1.1.

Scrooge would choose another option. He would save all income in the first period and consume everything in the second. In the second period his savings account would be worth the $10,000 he saves in period 1 plus interest of 5% on the $10,000, or $10,500.

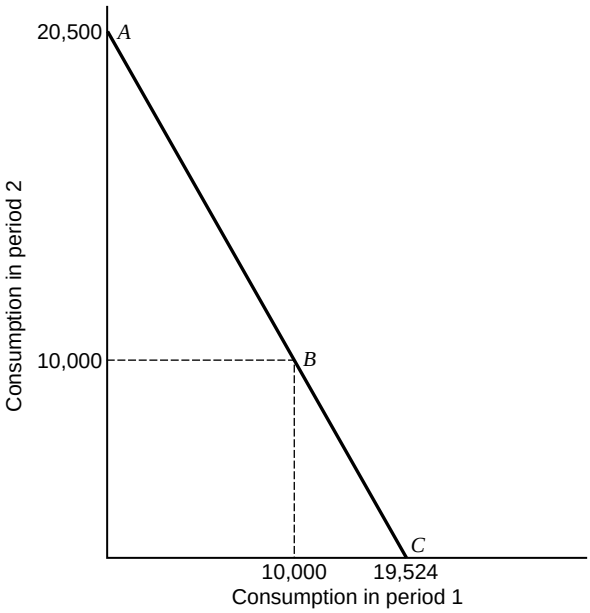

Figure 1.1 The investor's opportunity set.

Adding this to his second-period income of $10,000 gives him a consumption in period 2 of $10,500 + $10,000 = $20,500. This is indicated by point *A* in Figure 1.1.

Another possibility is to consume everything now and not worry about tomorrow. This would result in consumption of $10,000 from this period's income plus the maximum the investor could borrow against next period's income. If *X* is the amount borrowed, then *X* plus the interest paid for borrowing *X* equals the amount paid back. Because the investor's income in the second period is $10,000, the maximum amount is borrowed if *X* plus the interest on *X* at 5% equals $10,000:

$$X + 0.05X = 10{,}000$$

or

$$X = \frac{10{,}000}{1.05} = \$9{,}524$$

Thus the maximum the investor can consume in the first period is $19,524. This is indicated by point *C* in Figure 1.1. Note that points *A*, *B*, and *C* lie along a straight line. This did not happen by accident. In fact, all of the enormous possible patterns of consumption in periods 1 and 2 will lie along this straight line. Let us see why.

The amount the investor consumes in the two periods is constrained by the amount of income the investor has available in the two periods. Let C_1 be the consumption in period 1 and C_2 be the consumption in period 2. The amount consumed in period 2 is the income in period 2 of $10,000 plus the period 2 value of the savings in period 1. Remember that the value of period 1 savings can be negative, for the investor could have dissaved. That is, he could have borrowed in period 1 and consumed more than his period 1 income. As of period 2, the value of the savings in period 1 is the amount saved in period 1 ($10,000 minus what is consumed) plus accumulated interest. Putting this in equation form, we have

$$\begin{bmatrix}\text{Period 2}\\ \text{consumption}\end{bmatrix} = \begin{bmatrix}\text{Period 2}\\ \text{income}\end{bmatrix} + \begin{bmatrix}\text{Amount}\\ \text{saved in 1}\end{bmatrix}[1+0.05]$$

$$C_2 = \$10{,}000 + (10{,}000 - C_1)(1.05)$$

$$C_2 = \$20{,}500 - (1.05)C_1$$

This is, of course, the equation for a straight line and is the line shown in Figure 1.1. It has an intercept of $20,500, which results from zero consumption in period 1 ($C_1 = 0$) and is the point *A* we determined earlier. It has a slope equal to -1.05 or minus the quantity 1 plus the interest rate. The value of the slope reflects the fact that each dollar the investor consumes in period 1 is a dollar he cannot invest and, hence, reduces period 2 consumption by one dollar plus the interest he could earn on the dollar, or a total of $1.05. Thus an increase in period 1's consumption of a dollar reduces period 2's consumption by $1.05.

The investor is left with a large number of choices. We usually refer to the set of choices facing the investor as the opportunity set. Let us now examine how an investor selects the optimum consumption pattern from the opportunity set.

The Indifference Curves

The economic theory of choice states that an investor chooses among the opportunities shown in Figure 1.1 by specifying a series of curves called *utility functions* or *indifference curves*. A representative set is shown in Figure 1.2. These curves represent the investor's preference for income in the two periods. The name "indifference curves" is used because

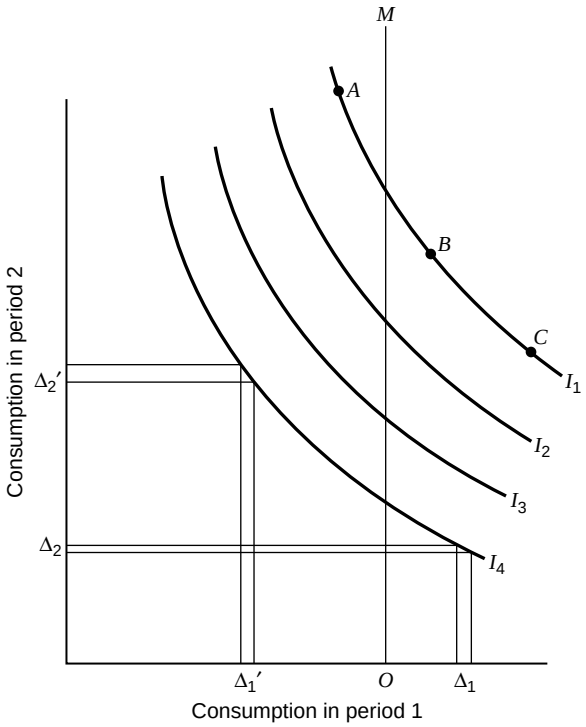

Figure 1.2 Indifference curves.

the curves are constructed so that everywhere along the same curve the investor is assumed to be equally happy. In other words, the investor does not care whether he obtains point *A*, *B*, or *C* along curve I_1.

Choices along I_1 will be preferred to choices along I_2, and choices along I_2 will be preferred to choices along I_3, and so on. This ordering results from an assumption that the investor prefers more to less. Consider the line *OM*. Along this line the amount of consumption in period 1 is held constant. As can be seen from Figure 1.2, along the line representing equal consumption in period 1, I_1 represents the most consumption in period 2, I_2 the next most, and so on. Thus, if investors prefer more to less, I_1 dominates I_2, which dominates I_3.

The curved shape results from an assumption that each additional dollar of consumption forgone in period 1 requires greater consumption in period 2. For example, if consumption in period 1 is large relative to consumption in period 2, the investor should be willing to give up a dollar of consumption in period 1 in return for a small increase in consumption in period 2. In Figure 1.2 this is illustrated by Δ_1 for the amount the investor gives up in period 1 and Δ_2 for the amount the investor gains in period 2. However, if the investor has very few dollars of consumption in period 1, then a large increase in period 2 is required to be indifferent about giving up the extra consumption in period 1. This is represented by the Δ_1' in period 1 (which is the same size as Δ_1) and the Δ_2' in period 2 (which is much larger than Δ_2).

The Solution

The indifference curves and the opportunity set represent the tools necessary for the investor to reach a solution. The optimum consumption pattern for the investor is determined by the

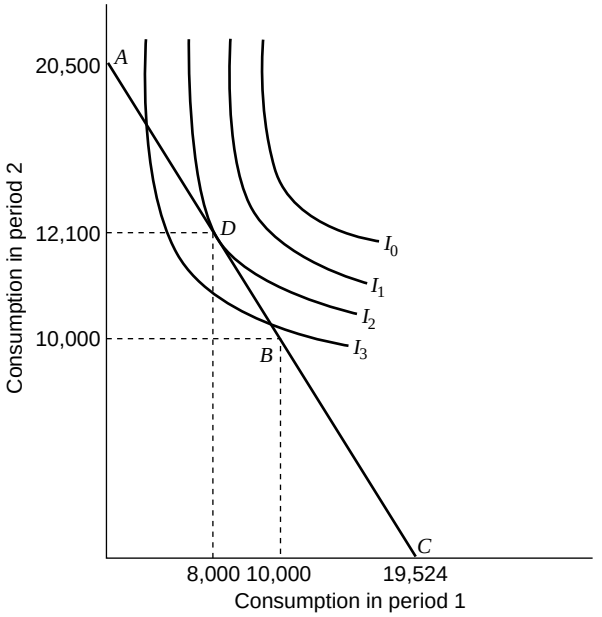

Figure 1.3 Investor equilibrium.

point at which a number of the set of indifference curves is tangent to the opportunity set (point *D* in Figure 1.3). Let us see why. The investor can select either of the two consumption patterns indicated by the points where I_3 intersects the line *ABC* in Figure 1.3. But we have argued that the investor is better off selecting a consumption pattern lying on an indifference curve located above and to the right of I_3, if possible. The investor will move to higher indifference curves until the highest one that contains a feasible consumption pattern is reached. That is the one just tangent to the opportunity set. This is I_2 in Figure 1.3, and the consumption pattern the investor will choose is given by the point of tangency, point *D*. The question might be asked, why doesn't the investor move up to a point along I_0 because this would be preferable to a point along I_2? The answer is that there is no investment opportunity available on line I_0.

An Example: Determining Equilibrium Interest Rates

We take another look at the investor's possible decision to see how it can help in determining equilibrium conditions in the market. The optimum decision could occur in three sections of Figure 1.3: *A* to *B*, point *B*, or *B* to *C*. If the optimum occurs in the segment *AB*, then the investor lends money at the 5% rate. If the optimum occurs at point *B*, then the investor is neither a borrower nor a lender. Finally, if the optimum occurs in segment *BC*, then the investor borrows against future income at the 5% rate.

In this simple framework, equilibrium in the marketplace is easy to determine. At a 5% interest rate this investor wishes to lend $2,000, the difference between $10,000 in income and $8,000 in consumption. Summing across all investors who wish to lend when the interest rate is 5% gives one point on the supply curve. Similarly, summing across investors who wish to borrow at a 5% interest rate gives one point on the demand curve. As the interest rate changes, the amount our hypothetical investor wishes to lend also changes. In fact, if the interest rate is low enough, the investor may change from a lender to a borrower. By

varying the interest rate, the supply and demand curve can be traced out, and the equilibrium interest rate can be determined. The equilibrium interest rate is that rate at which the amount investors wish to borrow is equal to the amount investors wish to lend. This is often called a *market clearing condition*. The equilibrium interest rate depends on what each investor's decision problem looks like, or the characteristics of a figure like Figure 1.3 for each investor. Figure 1.3 depends on the investor's income in the two periods and the investor's tastes or preferences. Thus, in this simple world, equilibrium interest rates are also determined by the same influences: investors' tastes and investors' income.

CONCLUSION

This simple example has revealed the elements that are necessary to analyze a portfolio problem. We need two components to reach a solution: a representation of the choices available to the investor, called the opportunity set, and a representation of the investor's tastes or preferences, called indifference or utility curves. With these two components we solved this simple problem and can solve the more realistic problems that follow. In addition, this simple example taught us that by aggregating across investors, we can construct models of equilibrium conditions in the capital markets. Now we turn to an examination of why and how this framework must be modified to deal realistically with multiple investment alternatives.

MULTIPLE ASSETS AND RISK

If everyone knew with certainty the returns on all assets, then the framework just presented could easily be extended to multiple assets. If a second asset existed that yielded 10%, then the opportunity set involving investment in this asset would be the line $A'BC'$ shown in Figure 1.4. Its intercept on the vertical axis would be $10{,}000 + (1.10)(10{,}000) = \$21{,}000$, and the slope would be $-(1.10)$. If such an asset existed, the investor would surely prefer

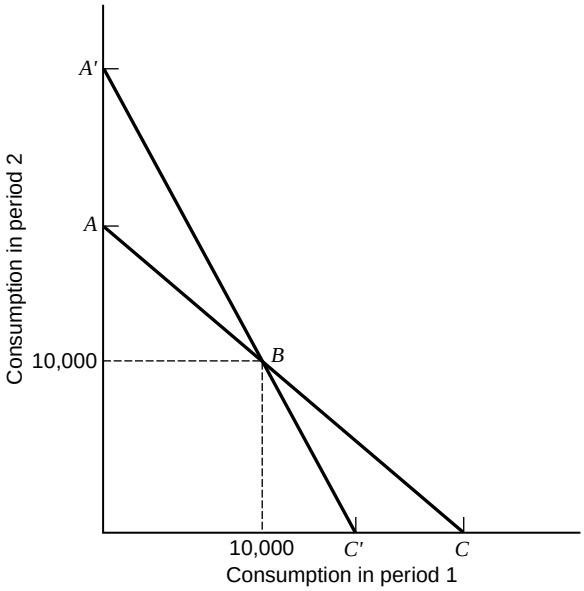

Figure 1.4 Investor's opportunity set with several alternatives.

it if lending and prefer the 5% asset if borrowing. The preferred opportunity set would be A', B, C. Additional assets could be added in a straightforward manner. But this situation is inherently unstable. Two assets yielding different certain returns cannot both be available because everyone will want to invest in the higher-yielding one and no one will purchase the lower-yielding one. We are left with two possibilities: either there is only one interest rate available in the marketplace or returns are not certain.[1] Because we observe many different interest rates, uncertainty must play an important role in the determination of market rates of return. To deal with uncertainty, we need to develop a more complex opportunity set.

The remainder of this book is concerned with the development of the framework necessary to solve the more complex asset choice problems in the presence of risk. In the next two chapters we deal with the basic notions of the investor's opportunity set under risk.

QUESTIONS AND PROBLEMS

1. Walking down an unfamiliar street one day, you come across an old-fashioned candy store. They have red hots five for one penny, and rock candy—one small piece for one penny. You decide to purchase some for yourself and your friends, but you find that you have only $1.00 in your pocket. Construct your opportunity set both geometrically and algebraically. Draw in your indifference map (set of indifference curves). Explain why you have drawn your indifference curves as you have drawn them.

2. Let us solve a two-period consumption investment decision similar to the one presented in the text. Assume that you have income equal to $20 in each of two periods. Furthermore, you have the ability to both lend and borrow money at a 10% rate. Draw the opportunity set and your indifference map. Show the optimum amount of consumption in each period.

3. Assume you can lend and borrow at 10% and have $5,000 in income in each of two periods. What is your opportunity set?

4. Assume you can lend and borrow at 5% and have $20,000 in income in each of two periods. Further assume you have current wealth of $50,000. What is your opportunity set?

5. An individual has two employment opportunities involving the same work conditions but different incomes. Job 1 yields $Y_1 = 50$, $Y_2 = 30$. Job 2 yields $Y_1 = 40$, $Y_2 = 40$. Given that markets are perfect and bonds yield 5%, which should be selected?

6. Assume you have income of $5,000 in each of two periods and can lend at 10% but pay 20% on borrowing. What is your opportunity set?

7. Assume your preference function P is $P = C_1 + C_2 + C_1C_2$. Plot the location of all points with $P = 50$, $P = 100$.

8. In Problem 3, what is the preferred choice if the preference function discussed in Problem 7 holds?

9. Suppose you have $10.00 to spend on dinner. There are two possibilities: pizza at $2.00 a slice or hamburgers at $2.50 a piece. Construct an opportunity set algebraically and graphically. Add indifference curves according to your own individual taste.

[1]Transaction costs, or alternative tax treatment of income from different securities, can explain the existence of some differential rates but nothing like the variety and magnitude of differentials found in the marketplace.