Investment Science

Introduction

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1 Course Information

2 Cash Flows

3 Investments and Markets

4 Typical Investment Problems
Outline

1. Course Information
2. Cash Flows
3. Investments and Markets
4. Typical Investment Problems
Overview:
1. Deterministic Cash Flow Streams
2. Single-period Random Cash Flow Streams
3. Numerical exercises including fixed income securities and their valuation, and portfolio selection in a single-period, mean-variance context (quadratic programming)

Textbook:
Name: Investment Science
Author: David G. Luenberger
Publisher: Oxford University Press

Programming Tools: Matlab

Preliminaries: Calculus, linear algebra, probability theory, statistics, operations research, C language
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Cash Flows

Definition

- When expenditures and receipts are denominated in cash, the net receipts at any time period are termed **cash flow**, and the series of flows over several periods is termed a **cash flow stream**. An investment over 4 years might be \((-1, 0.10, 0.10, 0.10, 1.10)\).

- An **investment** is defined in terms of its resulting cash flow sequence, namely, the amounts of money that will flow to and from an investor over time.

- The investment **objective** is that of tailoring this cash flow stream to be more desirable than it would be otherwise.

- **Investment science** is the application of scientific tools to investments.
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Example

Your uncle offers you a special investment. If you give him $100 now, he will repay you $110 in one year. His repayment is fully guaranteed by a trust fund of U.S. Treasury securities, and hence there is virtually no risk to the investment. Also, there is no moral or personal obligation to make this investment. You can either accept the offer or not. What should you do?

What if the prevailing interest rate is 7%, or 12%?

You evaluate the investment by comparing it with other investments available in the financial market that provides a basis for comparison.

Example

If your uncle offers you a family portrait whose value is hugely sentimental, you must decide whether, to you, the portrait is worth his asking price.
Arbitrage

Example

Consider (idealized) banks that offer to loan money or accept deposits at the same rate of interest. Suppose that the rate used at one bank for loans and deposits is 10% and at another bank the rate is 12%.

You could go to the first bank and borrow, say, $10,000 at 10% and then deposit that $10,000 in the second bank at 12%.

In one year, you would earn 2% at $10,000, which is $200, without investing any cash at your own.

This is a form of arbitrage: earning money without investing anything.

Often it is assumed, for purposes of analysis, that no arbitrage opportunity exists. This is the no arbitrage assumption.
The same or similar financial instruments are traded on a continuing basis. This means that the future price of an asset is not regarded as a single number, but rather as a process moving in time and subject to uncertainty.

There are a few standard frameworks that are used to represent price processes, including

- binomial lattice models,
- difference equation models,
- differential equation models.

Typically, a record of the past prices and other information are used to specify the parameters of such a model.
Example

Consider two investments.

- Investment 1 will pay a fixed 10% return with certainty as obtained perhaps from a government-guaranteed bank certificate of deposit.
- Investment 2, say the stock in a corporation, has an uncertain return.

Then, the expected rate of return on that stock must be greater than 10%; otherwise investors will not purchase the stock.

Individuals seeking investment rather than outright speculation will elect the certain alternative over the risky alternative.

The **mean-variance analysis** says that if several investment opportunities have the same mean but different variances, a risk-averse investor will select the one that has the smallest variance.
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Example

Imagine that there is an investment opportunity that will pay exactly $110 at the end of one year. How much is this investment worth today? In other words, what is the appropriate price of this investment, given the overall financial environment?

In general, if the interest rate is $r$, then the price, $P$, of an investment that pays $X$ after one year should be

$$P = \frac{X}{1 + r}.$$  

The general pricing problem: Given an investment with deterministic or random payoff characteristics, what is the reasonable price; or, equivalently, what price is consistent with the other securities that are available?
Hedging is the process of reducing the financial risks that either arise in the course of normal business operations or are associated with investments.

Example

A bakery will purchase flour (made from wheat) and other ingredients and transform these ingredients into baked goods, such as bread. Suppose the bakery wins a contract to supply a large quantity of bread to another company over the next year at a fixed price.

The bakery is happy to win the contract, but now faces risk with respect to flour prices. The bakery will not immediately purchase all the flour needed to satisfy the contract, but will instead purchase flour as needed during the year.

What if the price of flour increases, or decreases?
Example (contd.)

The bakery is in the baking rather the flour speculation. He wants to eliminate the risk associated with flour costs and concentrate on baking.

The bakery can do this by obtaining an appropriate number of wheat futures contracts in the futures market. Such a contract has small initial cash outlay and at a set future date gives a profit (or loss) equal to the amount that wheat prices have changed since entering the contract.

Now what if the price of flour increases, or decreases?

The net effect to the bakery—the profit from the wheat futures contracts together with the change in the cost of flour—is nearly zero.

There are many ways that hedging can be carried out: through futures contracts, options, and other special arrangements. Indeed, the use of such financial instruments is primarily for hedging, not for speculation.
Pure investment refers to the objective of obtaining increased future return for present allocation of capital. For example, the portfolio selection problem is to determine where to invest available capital.

**How to balance risk and expected reward?**

Investment problems do not always take the special shapes outlined in the preceding categories. For example, a hedging problem and a pure investment frequently coexist.

**Example (A combined consumption-investment problem)**

A married couple at retirement, living off the income from their investments, will most likely invest differently than a young couple investing for growth of capital.

**The requirement for income changes the nature of the investment!**