

DATASCI 385 Quantitative Finance

Lecture 0: Course Logistics and Overview

Instructor: Ruoxuan Xiong



Lecture plan

- Course structure
 - What is this class about?
 - Expectations
 - Course logistics
 - Evaluation
- Course outline

Making financial decisions

- You have saved 2000 dollars from your summer internship. Should you put it under your mattress, buy a Certificate of Deposit, Apple stock or an S&P 500 index fund?
- You are the manager of a mutual fund specializing in technology stocks. How should you allocate the funds' assets among the stocks recommended by your analysts?

Quantitative Finance

- In each situation, you need to
 - Commit resources (money, effort, time etc.)
 - In the face of uncertainty about the future
- *Quantitative finance* uses mathematical models and data to analyze financial markets and securities
- A fascinating interdisciplinary subject that uses methods from probability, statistics, finance, economics, machine learning, operations research , and computer science

What is this course about?

- Preliminary material on financial markets, financial institutions, and various types of securities
- *Modern portfolio theory*: Risk, return, portfolio optimization, and capital asset pricing model
- *Security valuation*: How bonds and derivatives are priced
- *Advanced topics*: How machine learning methods and new technologies are helpful for problems in finance

Why is quantitative finance relevant?

- In an *uncertain* world, we make decisions about alternatives whose outcomes cannot be predicted with certainty
- Suppose we can evaluate alternatives in terms of *money*
- Quantitative finance provides a quantitative framework to *analyze* these *decisions* and their *consequences*
- Quantitative finance has a *profound* impact how *securities* are *priced* and how *risk* is *measured* and *managed*

Expectations

- Require basic knowledge on
 - *Probability*: model uncertainty and characterize risk
 - *Optimization*: construct optimal strategies under constraints
 - *Statistics*: estimate the model parameters from observable data
- Do not require knowledge of advanced material from these areas
- Homework
 - Conceptual and computational questions
 - Computational questions can be finished in any programming language (e.g., R, Python, or excel)

Course logistics

- Instructor: Ruoxuan Xiong
- Time: Mondays and Wednesdays, 5:30-6:45 PM in White Hall 200
- Office hours: Tuesdays, 5:00-6:00 PM in my office, PAIS 581
- Details in the syllabus on Canvas
- Course website:
<http://www.ruoxuanxiong.com/DATASCI385/DATASCI385.html>

Evaluation

- Homework: 30%
- Take-home midterm: 30%
- Take-home final: 35%
- Participation: 5%



Homework

- 4 group homework assignments
 - Groups of 2-4 students. Target group size is 3. Students arrange their own group. Sign up via the [Google Sheet](#) by Wednesday 9/2
 - **Same group** for all homework assignments
- Late days (group policy)
 - Each group has **3 total late days** for the semester
 - You may use **at most 2 late days** on any single homework

Important dates

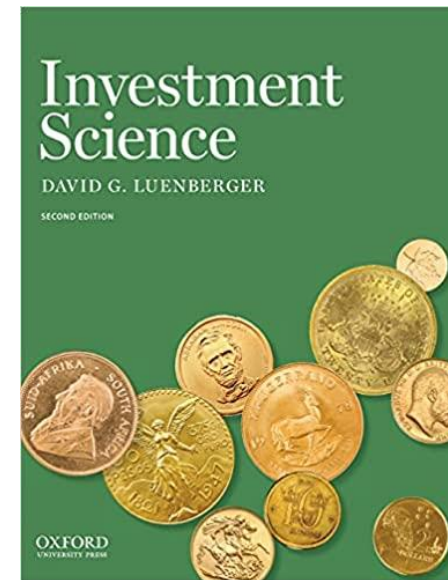
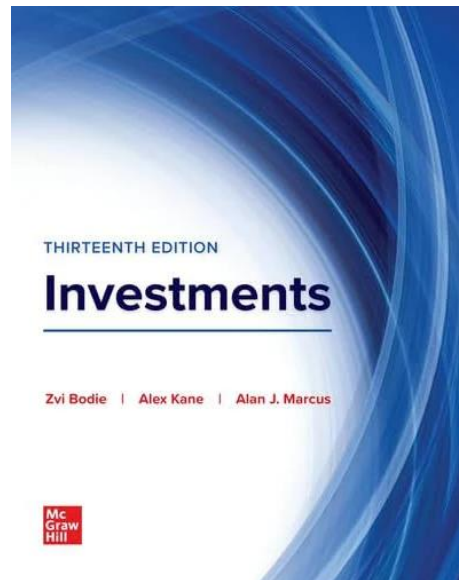
- Homework
 - Problem set 1: out 9/4, due 9/25
 - Problem set 2: out 9/25, due 10/16
 - Problem set 3: out 10/16, due 11/13
 - Problem set 4: out 11/13, due 12/4
- Take-home midterm
 - Out Friday 10/30 00:00 AM, due Monday 11/2 11:59 PM (no class on 11/2)
 - You can choose any 24 hours in between to complete
- Take-home final
 - Out Friday 12/11 00:00 AM, due Monday 12/14 11:59 PM
 - You can choose any 24 hours in between to complete

Participation

- You can fulfill your class participation through
 1. Attend the class, ask and answer questions
 2. Submit questions for lecture material or feedback for this course through the [Google Form](#)
 - Questions will be answered at the beginning of each lecture

Lecture notes and textbooks

- Lecture notes will be uploaded to Canvas before lecture
- Main reference
 - Bodie, Zvi, Kane, Alex, & Marcus, Alan. *Investments*. 2023 (13th edition)
- Supplementary reference
 - Luenberger, David G. *Investment science*. OUP Catalogue. 2013 (2nd edition)



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Securities

Fixed-income or debt securities

- Pay a stream of income over time
- For example, a corporate bond promises the bondholder a fixed amount of interest each year



Securities

Common stock or equity

- Equity holder are not promised any particular payments
- They may receive dividends from the firm
- Riskier than fixed-income securities



Securities

Derivatives

- Payoffs determined by the prices of other assets, such as bond or stock prices
- For example, call option (right to buy a share of stock at a given price on or before expiration date)



Calls In The Money

Options data delayed by 15 minutes.

Contract Name	Last Trade Date (EDT)	Strike	Last Price	Bid	Ask	Change	% Change	Volume	Open Interest	Implied Volatility
IBM260828C00115000	8/24/2026 2:36 PM	115	117.75	117.25	121.10	0.00	0.00%	22	4	504.98%
IBM260828C00120000	8/24/2026 2:36 PM	120	112.75	112.25	116.30	0.00	0.00%	32	4	293.75%
IBM260828C00125000	8/24/2026 11:29 AM	125	108.87	107.25	111.30	0.00	0.00%	14	3	276.56%
IBM260828C00130000	8/24/2026 11:12 AM	130	103.37	102.25	106.05	0.00	0.00%	4	2	426.86%
IBM260828C00135000	8/24/2026 2:10 PM	135	97.88	97.30	101.25	0.00	0.00%	4	1	245.31%
IBM260828C00140000	8/24/2026 2:10 PM	140	92.88	92.30	96.30	0.00	0.00%	4	0	237.50%
IBM260828C00145000	8/25/2026 11:48 AM	145	88.00	87.30	91.30	-2.00	-2.22%	1	1	223.06%
IBM260828C00150000	8/25/2026 3:09 PM	150	82.80	82.30	86.30	-4.86	-5.84%	2	1	208.59%
IBM260828C00155000	8/25/2026 10:37 AM	155	77.50	77.30	81.30	+10.80	+16.19%	4	0	194.53%
IBM260828C00160000	8/25/2026 10:37 AM	160	72.52	72.30	76.30	+0.88	+1.23%	4	2	181.25%
IBM260828C00165000	8/25/2026 9:52 AM	165	66.63	67.30	71.30	-0.03	-0.06%	2	1	167.97%
IBM260828C00170000	8/25/2026 9:55 AM	170	61.68	62.30	66.05	+3.18	+5.14%	2	2	259.38%
IBM260828C00175000	8/25/2026 9:59 AM	175	56.69	57.30	61.20	-6.06	-9.66%	2	0	132.03%
IBM260828C00180000	8/25/2026 10:03 AM	180	52.05	52.30	55.65	-2.79	-5.09%	2	17	209.08%
IBM260828C00185000	8/25/2026 10:05 AM	185	46.57	47.30	51.30	-8.63	-15.63%	2	1	118.36%
IBM260828C00190000	8/25/2026 2:34 PM	190	43.00	42.85	46.10	+1.55	+3.74%	122	122	123.63%
IBM260828C00195000	8/25/2026 10:06 AM	195	36.55	37.35	41.10	-6.10	-14.30%	2	0	82.03%

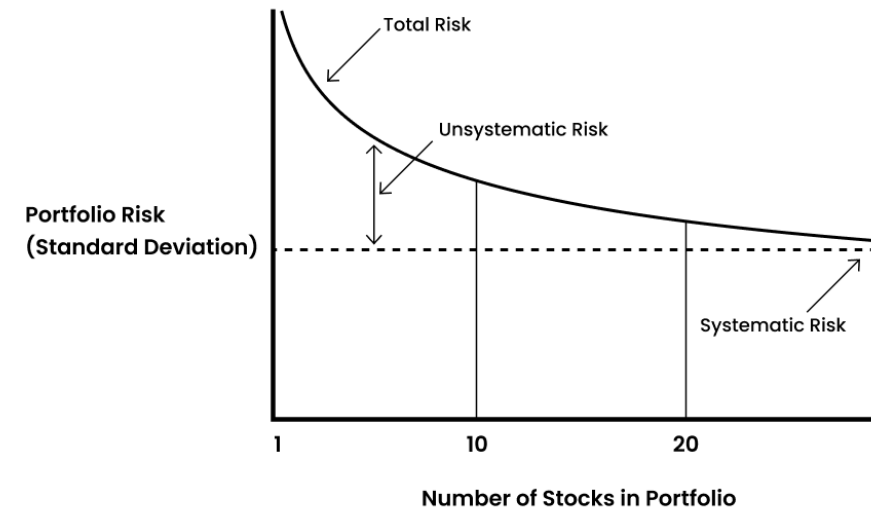
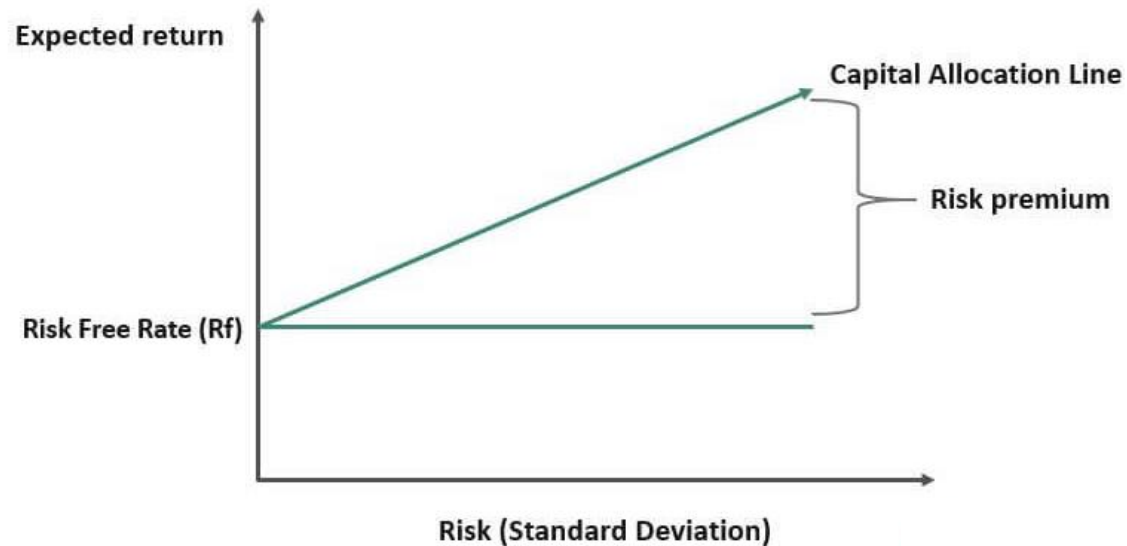
Risk and return

- Risk-return tradeoff: High risk high return, low risk low return
- Estimate expected returns and risk from historical data



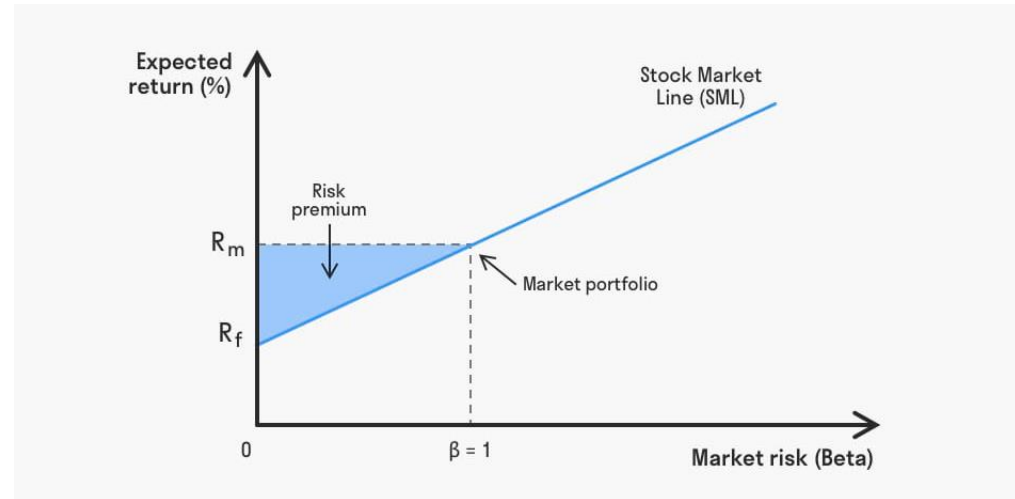
Capital allocation

- Capital allocation between risk-free (e.g., Treasury bills) and risky assets (e.g., stocks)
- Efficient risk diversification



Asset pricing models

- A prediction of the relationship between risk and return
- Capital asset pricing model
- Arbitrage pricing theory and multifactor models of risk and return



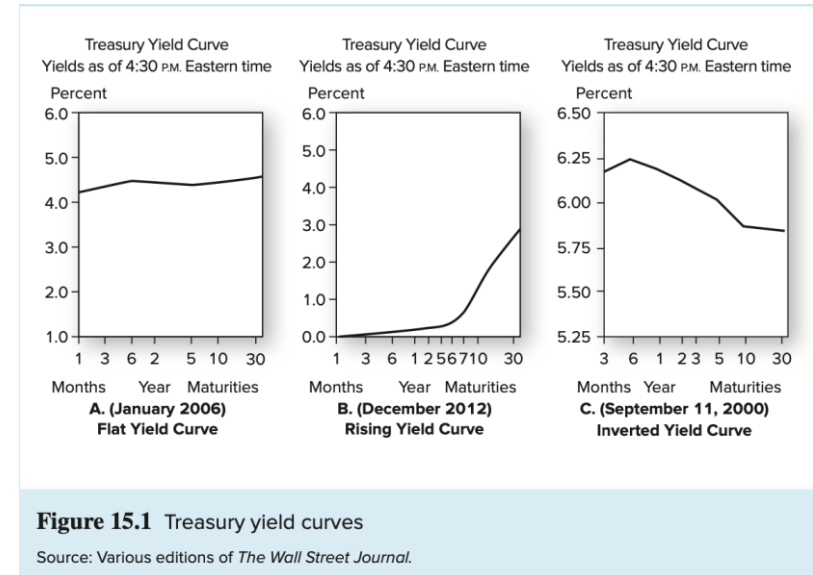
Fixed-income security valuation

- Bond characteristics: time to maturity, coupon payments and par value
- How to calculate **bond price**?
- How to calculate **bond yield** (rate of return)?
- How does **yield curve** (yield vs time to maturity) inform expectation on future interest rates?

Table 14.2

Bond prices at different interest rates (8% coupon bond, coupons paid semiannually)

Time to Maturity	Bond Price at Given Market Interest Rate				
	2%	4%	6%	8%	10%
1 year	1,059.11	1,038.83	1,019.13	1,000.00	981.41
10 years	1,541.37	1,327.03	1,148.77	1,000.00	875.35
20 years	1,985.04	1,547.11	1,231.15	1,000.00	828.41
30 years	2,348.65	1,695.22	1,276.76	1,000.00	810.71



Derivative pricing

Option pricing

- Binomial option pricing
- Black-Scholes option valuation

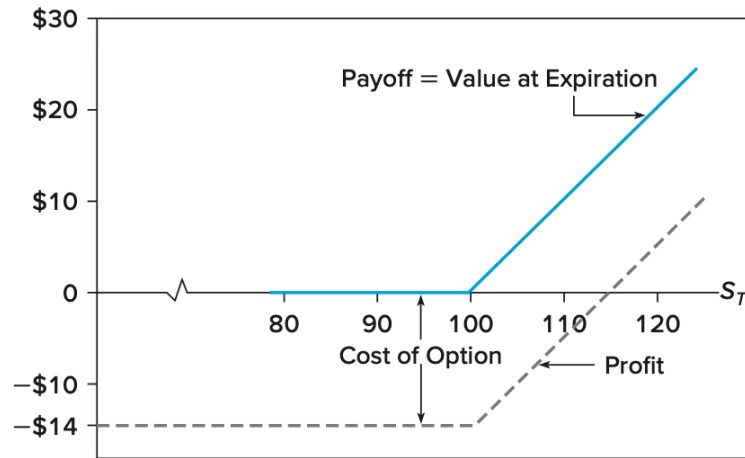


Figure 20.2 Payoff and profit to call option at expiration

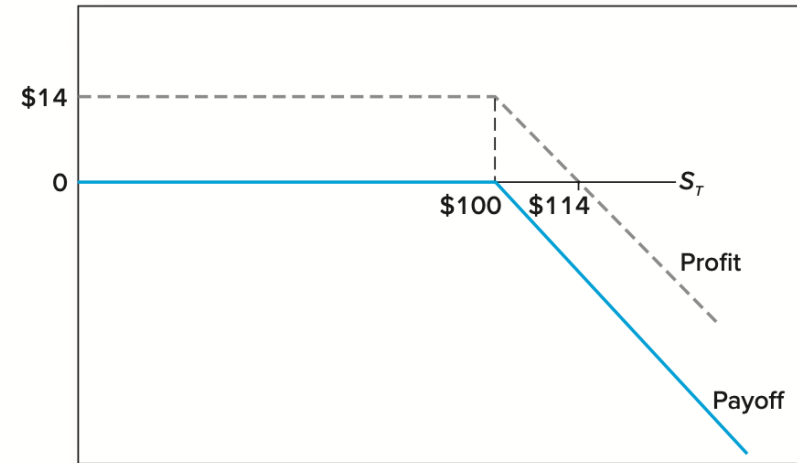


Figure 20.3 Payoff and profit to call writer at expiration