Lecture 1:
Risk and Return

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BUS 35000

Lecture Outline

- Introduction and Course Outline
- Overview of Finance
- Risk and Return
  - Expected returns, risk, and their relation
  - Historical returns
- Asset Pricing Formula
  - How prices are determined and why they vary
  - Need for asset pricing models

Introduction

About Me

- Joined Booth in 2014
  - Master in Business Economics from University of Mannheim
  - PhD from Haas School of Business, UC Berkeley
- Research interests:
  - Asset pricing, Macroeconomics, Household Finance, International Finance
  - Specific research topics:
    1. Downside Risk across Asset Classes
    2. Effects of firms' inability to adjust output prices to macroeconomic shocks (confidential BLS microdata)
    3. Microfoundations of price ridigities
    4. Distrust in finance and stock market participation
    5. Term structure of equity returns (anomalies)
    6. Production networks, real effects of monetary shocks

  → http://faculty.chicagobooth.edu/michael-weber
- Work experience
  - Investment banking
  - Consulting

Contact Information I

Professor **Michael Weber**

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Office hours

- Harper 314, by appointment
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Contact Information II

Teaching Assistant **Nishant Vats**

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Exercise Sessions

- 1/28, 2/4, 2/11, 2/25, 3/4, 3/11 6.00 pm – 7.00 pm (recorded)

Review Sessions

- Sun, 2/14, 10:30am–12:00pm (recorded)
- Sun, 3/14, 10:30am–12:00pm (recorded)

Virtual office hours

- Thursday 12:45 pm – 1:30pm
- Skype: by appointment

Resources and Responsibilities I

1. **Slides on Canvas**
   - May be revised after lectures to match (check revision date)
2. **Readings**
   - Bodie, Kane, and Marcus (BKM): Investments, 11th or 12th Edition
   - Malkiel: A Random Walk Down Wall Street, 10th Edition (optional)
   - Siegel: Stocks for the Long Run, 2008 (optional)
   - CoursePack
3. **Attendance**
4. **Problem Sets**
5. **Case**
6. **Midterm and Final Exam**
   - Closed-book exams
   - One/ two sheets of notes allowed (midterm/ final)

Resources and Responsibilities II

- I will always upload class notes on Canvas at the latest Wednesday 4pm. To avoid spamming you, I will **not** send an announcement every time!
- I will always upload problem sets precisely a week before they are due. To avoid spamming you, I will **not** send an announcement every time!
- Read the assigned readings **before** class to get most out of it!

Course Grading Guidelines

- The grade components are:
  1. Midterm exam (optional, required for provisional grade)
  2. Final exam
  3. Seven graded problem sets (optional, graded on 1–10 scale, weakest score automatically dropped)
  4. Case write-up
  5. Participation
- Note: Midterm and problem sets can only help you.

Alternative Grade Breakdowns

Class Participation	5%	5%	5%	5%
DFA Case Write-Up	10%	10%	10%	10%
Midterm	25%	25%	0%	0%
Problem Sets	20%	0%	20%	0%
Final Exam	40%	60%	65%	85%

- Your score is automatically the maximum over these four alternative scores

Should I Take the Midterm and Return the Problem Sets?

- Experience from last year:
- Regress their final score (0-170 scale) against:
  1. A constant
  2. Midterm dummy (0/1 variable)
  3. # of Problem Sets taken (0–7 variable)
- Regression estimates:
  - Those who took the midterm had 16.50 points higher final score; t-stat $= 2.9$
  - Each problem set increased the final score by 2.99 points; t-stat $= 2.3$
- Conclusion?

Regrading Guidelines

- A regrading request requires a written justification
- The whole exam will be regraded
- This might result in an increase of decrease of the overall score

Problem Sets

- Assignments are due at the beginning of the class
  - Submit all assignments via the electronic dropbox on Canvas
  - No late assignments!
- Answers will be posted on the web on Wednesday
- Computer use highly recommended
  - You may want to say something about how you solved the problem to qualify for partial credit
- Group work for homework assignments highly encouraged (four or fewer students)
  - The write-up groups turn in must be distinctly their own

Case Write-Up

Harvard Case on "Dimensional Fund Advisors"

- DFA started by two former Booth students—including David Booth—and currently advised by several Booth finance professors
- This case ties in with some of the key course material and will be discussed in class
- Form groups of four or fewer students from the same section
- The write-up should not exceed five typed pages (plus figures, tables, or an appendix)
- Further details provided with the case

Honor Code

- Each student shall sign the following pledge on each exam:

  “I pledge my honor that I have not violated the Honor Code during this examination”

- Students are required to adhere to the standards of conduct in the Honor Code and Standards of Scholarship

Teaching Philosophy

- Your success in class is important to us!
- Highly quantitative class (min 6–8 hours of work outside class)
- Emphasis on intuition for key concepts while maintaining rigor
- Questions and class discussions ensure understanding
- Many of you have professional experiences that can undoubtedly benefit our discussion
- **Aim**: provide toolkit to succeed beyond the classroom
- **Approach**: intuition and the big picture first, then rigorous derivation
- Will try to relate class material to (my own) current research

- **Gaining intuition is key as it helps you to apply learned material to new contexts**

What do we Learn?

The course is designed to:

- teach you how to make good **investment decisions**
- give you the **tools** to value investment opportunities
- show how to **combine** different investments optimally
- make sure you **understand** the way the other market participants operate and how market **prices** are determined
- **think systematically about investment problems**

Why is this Class Useful for me?

- Individual investors
  - Should I invest in stocks, bonds, commodities, ...?
  - Should I try to time the market?
  - How do I tell whether the active fund manager is worth the fees?
  - etc..
- Asset managers, CFOs, investment banker, securities traders
  - How should I manage a fund portfolio to reach the stated aims of the fund?
  - How can I create value for my clients?
  - Do certain securities offer better return for risk, over the long run?
- Everyone in daily life
  - Should I defer consumption and save and invest
  - Getting a MBA is an investment!
  - Should I study a bit more or enjoy a beer in the pub next door?

Course Outline

(or: "*What could I learn in this course?*")

Course Outline I

Week 1: Risk and Return

- Overview of Finance
- Risk and return: what do we need asset pricing models for?
- Time value of money

Week 2: Fixed Income (Bonds)

- Different fixed income instruments: treasuries, corporate bonds, mortgage-backed securities
- Valuation of known ("fixed") income streams
- Important concepts: yield-to-maturity, yield curve, duration, etc.
- Hedging: reducing or eliminating risk

Course Outline II

Week 3: Introduction to Asset Allocation

- What do we need to take into account when building a portfolio?
- Portfolio mathematics: expected return and variance

Week 4: Mean-Variance Analysis and the CAPM

- Mean-variance analysis
- What is the "best" portfolio for us and how do we compute it?
- The Capital Asset Pricing Model: linking expected returns and risk
- "How much should you expect to get by investing in Dell?"

Course Outline III

Week 5: Practical Asset Allocation and APT

- Can we make use of portfolio theory in practice?
- Arbitrage Pricing Theory: a CAPM-like model that connects expected returns to *multiple* sources of risk

Week 6: Market Efficiency and Anomalies

- Are markets efficient or inefficient, or, to *what degree* are markets efficient? How should we think about efficiency?
- How *could* markets be efficient when people exhibit so many behavioral biases?
- Anomalies: Seeming violations of market efficiency

Course Outline IV

Week 7: Forwards and Futures

- Forwards and Futures: Instead of buying or selling something today, enter a binding contract to buy or sell in the future
- How do we value these contracts?
- Introduction to arbitrage-free pricing

Course Outline V

Week 8: Options I

- Call and put options: a right, *not an obligation*, to buy or sell something in the future at a predetermined price
- Basic concepts
- Binomial option pricing: What is the fair value of an option?

Week 9: Options II

- The Black-Scholes option pricing formula
- Even if we do not believe the model assumptions, do we learn something from it?
- Derivatives in practice: Who uses them and for what?

Learning Objectives

- Overview of finance
  - Understanding difference real vs financial assets and different types and market participants
- Risk and return
  - What is a holding period return, expected vs realized, multiperiod return, compounding?
  - Arithmetic vs geometric mean?
  - History of risk and return
- Asset Pricing and the present value formula
  - Price today is sum present discounted value of future dividends
  - What does this mean?
- Compounding frequency and annuity

Overview of Finance

Overview of Finance

- Brief overview of finance
  - Types of assets
  - Relating finance to accounting
  - What finance studies
  - Financial market participants
  - Financial asset types
- Finance is all about assets
  - We buy assets to defer consumption
  - If you do not want to spend all your money today, what is the best way to transfer this money into the future?

Types of Assets

Real assets

- Assets used to produce goods and services
- Factories and machines
- Illiquid, specific purpose, not traded frequently
- Left-hand side of firms' balance sheet

Financial assets = claims on real assets

- Liquid, traded frequently
- Right-hand side of firms' balance sheet
- Real asset cash flows passed to financial claimants

Relating Finance to Accounting

- The corporate balance sheet

Assets	**Liabilities and Equity**
Real assets	Financial assets to investors:
Plant and equipment	Debt
Financial assets	Equity
Cash	
Marketable securities	

- Cash flows
  - Assets are purchased with funds from the right-hand side
  - Cash from assets on the left-hand side flows to claimants on the right-hand side

What Does Finance Study?

The general problems in finance

- Asset valuation
- Portfolio choice problems
- Corporate finance

Understanding discounting is critical

- Prices at different dates (today, tomorrow, ...) are related
  - The value of a stock today depends on its expected cash flows
- Time and risk determine the relationship
  - How much would you pay to get $100 in a year for sure?
  - How much would you pay if you get $200 with probability 0.5 and nothing with probability 0.5?

Financial Market Participants

1. **Households**
   - Want to invest funds; save to defer consumption
2. **Corporations**
   - Want to obtain external funds for its projects
   - Want to invest accumulated profits
3. **Government**
   - Wants to obtain funds for its projects
4. **Financial Sector (intermediaries)**
   - Role of an intermediary

Financial Asset Types I

Equity

- Common stocks
- Preferred stocks (promise a dividend)
- Warrants (e.g., executive stock options)

Debt

- Bonds and notes (i.e., short-term bonds)
- Bank debt
- Money market instruments (instruments for short-term borrowing and lending)

Financial Asset Types II

Derivatives

- Assets whose value is *derived* from an underlying asset
- Examples: options, futures, credit-default swaps (CDS)

- **Note:** Many assets fall into multiple categories
  - Mortgage-backed securities
  - Executive stock options

Risk and Return

Holding Period Returns

- We use returns to measure how well a security performs
- Net return r_{t+1} is the payoff tomorrow minus the price you paid, divided by the price you paid:
  - No dividends:
  $$r_{t+1} = \frac{P_{t+1} - P_t}{P_t}$$
  - With dividends:
  $$r_{t+1} = \frac{P_{t+1} + D_{t+1} - P_t}{P_t}$$

  where P_t is the price today, P_{t+1} is the price next period, and D_{t+1} is the dividend.
- D_{t+1} can be something else for assets other than stock:
  - Coupon payments (bonds), rent (real estate), etc.
- Simplifying assumption: dividend is paid at the end of the period. Alternative?
- Gross return is one plus the net return: $R_{t+1} = 1 + r_{t+1}$.

Example: Google's Initial Public Offering

- Google's initial public offering on August 19, 2004
- Offering price: \$85 per share
  - Price you paid for one share if you subscribed to IPO
- Closing price at the end of first trading day: \$100.34
- One-day return to IPO investors?

$$r_{t+1} = \frac{P_{t+1} - P_t}{P_t} = \frac{\$100.34 - \$85}{\$85} = 0.18 = 18\%$$

- The first-day return was 18%

Expected Return vs Realized Return (I)

- We do not know how much the U.S. stock market will go up or down in the next year
  - Formally: At time t, r_{t+1} is a random variable
- However, just like (most) other random variables, it has an expected value
- I'll use tildes ˜ to indicate random variables:

$$
\begin{aligned}
\tilde{r}_{t+1} &= \frac{\tilde{P}_{t+1} + \tilde{D}_{t+1} - P_t}{P_t}, \\
\text{where } \tilde{P}_{t+1} &= \text{price tomorrow (not known today)} \\
\tilde{D}_{t+1} &= \text{dividend tomorrow (not known today)} \\
P_t &= \text{price today (known)}
\end{aligned}
$$

Expected Return vs Realized Return (II)

- The expected return is:

$$\mathrm{E}[\tilde{r}_{t+1}] = \frac{\mathrm{E}[\tilde{P}_{t+1}] + \mathrm{E}[\tilde{D}_{t+1}] - P_t}{P_t}$$

- The realized return, which we can compute *after* we see P_{t+1} and D_{t+1}, is:

$$r_{t+1} = \frac{P_{t+1} + D_{t+1} - P_t}{P_t}$$

  I removed the tildes to emphasize that P_{t+1} and D_{t+1} are realized and hence now known

- These two numbers may be very different
  - What we *expect* to happen in the next year may not come true

Multiperiod Returns and Compounding

- "Compounding" is about earning interest on interest
- An investment yields r_{t+1} at time $t+1$ and r_{t+2} at time $t+2$
- If we know r_{t+1}, we know what P_{t+1} will be

$$r_{t+1} = \frac{P_{t+1} - P_t}{P_t} \quad \Rightarrow \quad P_{t+1} = P_t(1 + r_{t+1})$$

  - The same holds for period $t+2$:

$$P_{t+2} = P_{t+1}(1 + r_{t+2})$$

- Thus, the value of the investment in two periods is

$$P_{t+2} = P_t(1 + r_{t+1})(1 + r_{t+2})$$

- The two-period return is

$$r_{t,t+2} = \frac{P_{t+2} - P_t}{P_t} = (1 + r_{t+1})(1 + r_{t+2}) - 1$$

Multiperiod Returns: Example (I)

- Suppose you earn 10% in year 1 and 20% in year 2
- What is the two-year net return?

$$r_{t,t+2} = (1 + r_{t+1})(1 + r_{t+2}) - 1 = (1 + 0.1)(1 + 0.2) - 1 = 32\%$$

- How should we think about the average (per-period) return when returns are compounded?
- The arithmetic average is the "simple" average return. Here, it is $(10\% + 20\%)/2 = 15\%$.
- However, we sometimes use geometric averages

Multiperiod Returns: Example (II)

- Geometric average is the one number that gives us the same outcome that we get from using the actual rates
- What is the geometric average in this example?
  - Formal problem: find one number r such that

$$(1+r)(1+r) = (1+0.1)(1+0.2)$$

  - Solve for r:

$$\begin{aligned} (1+r)^2 &= (1+0.1)(1+0.2) \\ 1+r &= \sqrt{(1+0.1)(1+0.2)} \\ r &= \sqrt{(1+0.1)(1+0.2)} - 1 = 0.149 = 14.9\% \end{aligned}$$

  - The geometric average is 14.9%

Geometric Average vs Arithmetic Average

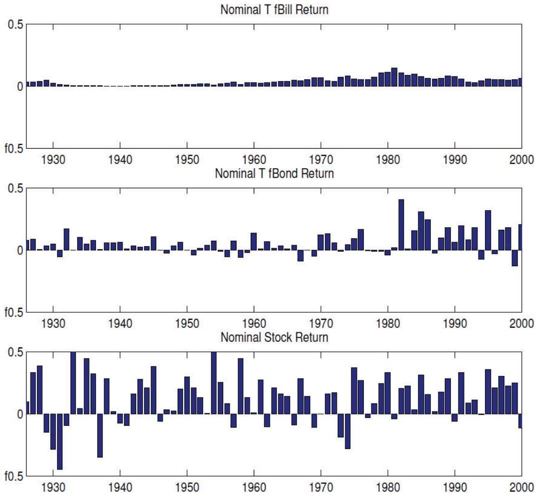
- Geometric average is always less than the arithmetic average
- Is it better to use geometric than arithmetic average?
  - The difference between the two is big if returns are very variable or the horizon long
  - Example. 5 years of returns on Dell: -20%, 35%, -25%, 40%, and 10% $\rightarrow$ Arithmetic: 8%, geometric: 4.5%
- Does geometric average make more sense?
  - Example. Suppose a stock trades at \$100 today, at \$200 one year from now, and at \$100 two years from now.
  - The per-period returns are 100% and -50%.
  - The arithmetic average return is then $\frac{100\%+-50\%}{2} = 25\%$
  - The geometric average return is (the more sensible) 0%

Geometric Average vs Arithmetic Average

- However, we still often use arithmetic returns
  - A matter of convenience
  - The difference between the two is small when returns are not too volatile
- Geometric mean: tells us average (annual) return of *n*-period investment
- Arithmetic mean: gives us measure of average ex-ante expected return if distribution has similar properties over time (technically: is stationary)
  - Example: drawing from an urn with replacement
  - Returns drawn from distribution with potential realizations: 15%, 10%, 5%, 0%, -5%
  - All realizations equally likely
  - Good measure of ex-ante expected one-period return: $\frac{1}{5}(15\% + 10\% + 5\% + 0\% + -5\%) = 5\%$

Historical Overview of Risk and Return (I)

What have **nominal, annual, realized returns** been on T-Bills, T-Bonds, and Stocks?



Historical Overview of Risk and Return (II)

Some averages:

Period	T-Bills	T-Bonds	Stocks
1802–1870	5.2%	4.9%	7.1%
1871–1925	3.8%	4.3%	7.2%
1926–1992	3.8%	4.8%	9.9%
1993–2008	2.9%	3.5%	12.5%

Historical breakdown of stock returns into capital gains (change in security price) **and income yield** (cash payouts received by the investor):

Period	Stock Returns	Capital Gain	Income Yield
1802–1870	7.1%	0.7%	6.4%
1871–1925	7.2%	1.9%	5.2%
1926–1992	9.9%	5.2%	4.8%
1993–2008	12.5%	10.85%	1.7%

Nominal vs Real Returns

- We have calculated nominal returns but real returns are more relevant
- Real returns allow investors to take investment decisions when they are interested in the real purchasing power of their wealth
- Example: let's assume the price of one unit of the consumption good is \$1 and the annual inflation rate is 4%
- Then, the amount of goods that the investors will be able to buy with one dollar in a year will be $\frac{1}{1+0.04} = 0.962$
- Let π be the inflation rate; then, adjust the nominal return for inflation:

$$
\begin{aligned}
1 + r_{\text{real}} &= \frac{1 + r_{\text{nominal}}}{1 + \pi} \\
r_{\text{real}} &\approx r_{\text{nominal}} - \pi
\end{aligned}
$$

Historical Overview of Risk and Return (III)

What have the **real, annual, realized returns** on the securities been historically?

Some averages:

Period	T-Bills	T-Bonds	Stocks
1802–1870	5.1%	4.8%	7.0%
1871–1925	3.2%	3.7%	6.6%
1926–1992	0.5%	1.7%	6.6%
1993–2008	1.5%	2.8%	11.5%

- Real returns are what determines how much we can consume in different points in time
- Stocks have offered comparably stable returns throughout long periods of time
- Bonds and bills have performed poorly in second half of 20^{th} century in *real terms*. Unexpected inflation?

Risk

- Risk is our lack of knowledge of a random variable:

  "What will Microsoft's stock price be in one year?"

- How do we measure risk?
  - Most common measure is standard deviation, σ, which measures dispersion around the mean
    - Well-suited for diversified portfolio of stocks
    - For individual stocks only the incremental risk when added to a portfolio matters
    - More on this later
  - Other possibilities:
    - Range of the variable: maximum and minimum of possible values
    - Value-at-risk: the amount of money we may lose under the worst case scenario (with some confidence level)
    - Downside Risk: covariance conditional on a negative realization of a threshold variable

Risk: Example (I)

- Suppose Intel trades at $P_t = \$100$, and plans to build a new 22 mn chip plant
- The price in one year depends on the project's success:
  - Successful (40% chance): $P_{t+1} = \$135$
  - Neutral (30% chance): $P_{t+1} = \$105$
  - Failure (30% chance): $P_{t+1} = \$75$
- Calculate the expected return, return variance, and return standard deviation for Intel

Risk: Example (II), Solution

- The realized return could be: 35%, 5%, and -25%
- The expected return is then
  $0.4(35\%) + 0.3(5\%) + 0.3(-25\%) = 8\%$
- Variance is the expected squared deviation around the mean:

$$
\begin{aligned}
\sigma^2 &= \mathrm{E}\left[(\tilde{r} - \mathrm{E}[\tilde{r}])^2\right] \\
&= p_1(r_1 - \mathrm{E}[\tilde{r}])^2 + \cdots + p_n(r_n - \mathrm{E}[\tilde{r}])^2 \\
&= 0.4(0.35 - 0.08)^2 + \cdots + 0.3(-0.25 - 0.08)^2 = 0.0621
\end{aligned}
$$

- Standard deviation is the square root of variance

$$
\sigma = \sqrt{0.0621} = 0.249 = 24.9\%
$$

- We usually express standard deviation in percentages (the unit is the same as returns)

Historical Estimates of Returns and Risk

- Estimated real returns and standard deviations of T-Bills, T-Bonds, and Stocks:

1926–2008	Average Real Return	Standard Deviation
T-Bills	0.5%	4.3%
T-Bonds	1.8%	10.1%
Stocks	7.0%	21.2%

- **Note:** We use sample estimates as approximations for true ex-ante means and variances, since we cannot see into the future
- **Question:** Is using past data to forecast the future the best method? (We will discuss later in more detail.)

Risk and Return

- How do people react to risk? They demand compensation!
  - Example: A lottery in which you either receive \$20,000 if a coin lands heads and lose \$10,000 if it lands tails
  - Compare this with getting \$15,000 for sure
    - Most people would prefer the sure \$15,000: both choices offer an *expected* reward of \$15,000 but one of them also has risk, which we dislike
    - If the sure thing reward was only \$12,500, you *might* choose the lottery instead
- Stocks offer higher average returns than bonds because:

  People are risk averse (they dislike risk).
  To be willing to hold a risky security they must receive higher expected return as a reward for doing so.

- The additional average returns from stocks should reflect the greater riskiness of stocks

“Explaining” Historical Stock Returns

- The high stock returns in the decades after the crash of 1929
  - the crash made stocks appear more risky than before
- By mid-1998, the perception was that stocks have become less risky
  - predicted that stock returns will be lower on average since 1999
  - this seems to have been the case
  - however, we could have predicted the same thing in 1992, and the opposite occurred
- What about now?
  - Stock returns may be higher on average in the future(?)

Finance Theory

What does Finance theory have to say about all of this?

Finance Theory

Average returns over long periods of time are determined by risk

Two Fundamental Questions of Finance

1. What is risk and how should we measure it?
2. How much extra expected return do we need to be compensated for the additional risk?

Asset Pricing and Present Value Formula

Present Value Formula (I)

- How do we compute the "present value" of a future cash-flow?
  - This is the most important question when pricing anything
- Let's start from the definition of returns:

$$\tilde{r}_{t+1} = \frac{\tilde{P}_{t+1} + \tilde{D}_{t+1} - P_t}{P_t}$$

- We can reorganize this for price, P_t:

$$P_t = \frac{\tilde{P}_{t+1} + \tilde{D}_{t+1}}{1 + \tilde{r}_{t+1}}$$

- If we take expectations, we get

$$P_t = \mathrm{E}\left[\frac{\tilde{P}_{t+1} + \tilde{D}_{t+1}}{1 + \tilde{r}_{t+1}}\right]$$

Present Value Formula (II)

- The price today is the expected payoff divided by $1 + \tilde{r}$:

$$P_t = \mathrm{E}\left[\frac{\tilde{P}_{t+1} + \tilde{D}_{t+1}}{1 + \tilde{r}_{t+1}}\right]$$

- I'll use r to denote $\tilde{r}_{t+1}$ from now on
- r is the **discount rate** $r = r_f + r^e =$ riskless interest rate $+$ risk premium
  - r_f compensates for the time value of money: consumption today vs consumption tomorrow
  - r^e for the riskiness of the future cash flows: ex-ante known vs ex-ante risky cash flow

Asset Pricing (I)

1. How do we price an asset that makes multiple payments in the future?
2. What determines the asset's price?
3. Why do prices move?

- We now know that

$$P_t = \mathrm{E}\left[\frac{\tilde{P}_{t+1} + \tilde{D}_{t+1}}{1+r}\right]$$

- However, time subscripts are arbitrary, so we can also write:

$$P_{t+1} = \mathrm{E}\left[\frac{\tilde{P}_{t+2} + \tilde{D}_{t+2}}{1+r}\right]$$

- Substituting the second into the first, we get:

$$P_t = \mathrm{E}\left[\frac{\tilde{D}_{t+1}}{1+r} + \frac{\tilde{D}_{t+2}}{(1+r)^2} + \frac{\tilde{P}_{t+2}}{(1+r)^2}\right]$$

Asset Pricing (II)

- If we use the same one-period formula to substitute in for P_{t+2}, P_{t+3}, etc., we get:

$$P_t = \mathrm{E}\left[\frac{\tilde{D}_{t+1}}{1+r} + \frac{\tilde{D}_{t+2}}{(1+r)^2} + \frac{\tilde{D}_{t+3}}{(1+r)^3} + \cdots\right]$$

Price = Sum of Discounted Expected Future Cash Flows

- Discount rate =
  - riskless nominal interest rate + risk premium
  - real interest rate + expected inflation + risk premium
- r can be called:
  - the discount rate
  - the expected rate of return
  - the required rate of return

Interpreting the Present Value Formula

When stock prices move, it must be due to:

1. Changes in expectations about future dividends (cash flows or the way investors form expectations)
2. ("Rational" bubble of price growing faster than discount rate)
3. Changes in the discount rate
   - Changes in the riskless interest rate
   - Changes in the risk premium

- Changes in the risk premium can arise due to
  - changes in the amount of risk (risk exposure)
  - changes in the compensation required by investors per unit of risk (risk premium)

Understanding the surge in stock prices in the 90's

1. **Rise in expected future cash flows**
   - *Rational*: we're entering a new era of computer-driven productivity
   - *Irrational*: people are extrapolating recent good earnings reports too far out, or are overly optimistic
2. **Fall in the discount rate**
   - Due to a fall in the risk premium
     - people think stocks are less risky $\rightarrow$ they don't need to be compensated so much for holding stocks
     - people are less risk-averse $\rightarrow$ need less compensation for risk
   - Due to a fall in the interest rate
     - baby boomers are putting their savings into the stock market $\rightarrow$ supply of capital is outstripping the demand for capital $\rightarrow$ the real interest rate must fall to balance the market
     - Fed has been reluctant to increase already low rates

What about the financial crisis?

Understanding the Effects of Economic Reports (I)

Bonds and inflation

- If news comes out that inflation is higher than expected, bonds fall because. . .
- discount rates are higher
  - lenders raise rates to cover the rise in inflation
  - the Fed may tighten credit to prevent overheating

Understanding the Effects of Economic Reports (II)

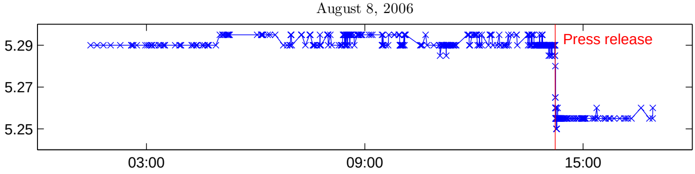
Stocks and inflation

- If inflation is higher than expected
  - just like with bonds, discount rates are higher
  - however, *cash flows* also rise with inflation
  - over the long-term, the two effects cancel out
  - over the short-term, the first effect may dominate and stock prices may fall:
    - a Fed tightening may reduce near-term cash flows or increase in risk premium (typically, we witness a stock market decline when interest rate increases are announced)
    - tax effects: less borrowing $\Rightarrow$ less tax deductible interest, therefore the government takes a bigger bite of corporate profits

Measuring Monetary Policy Surprises

- High-frequency identification of monetary policy shocks
- Tick-by-tick federal funds futures (FFF) Globex data from CME
- FFF ff^0 settles on average effective fed funds rate: use scaled change

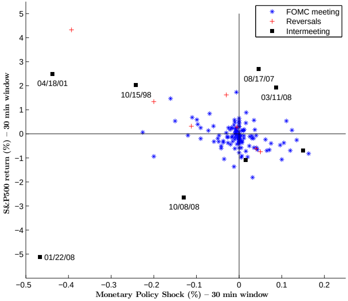
$$v_t = \frac{D}{D-t}\left(ff^0_{t+\Delta t^+} - ff^0_{t-\Delta t^-}\right) \qquad \text{where } D \text{ is \# of days in month}$$



Source: Gorodnichenko & Weber (2016): Are Sticky Prices Costly? Evidence from the Stockmarket.

- High trading activity with immediate market reaction

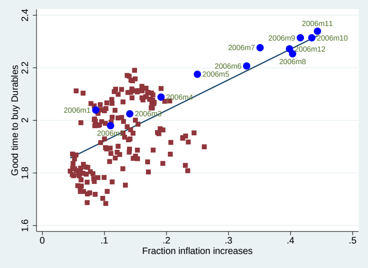
Effect of Surprise Changes in the Federal Funds Rate



Source: Gorodnichenko & Weber (2016): Are Sticky Prices Costly? Evidence from the Stockmarket.

- Higher than expected Fed funds rates lead to drop in stock market (S&P500)
- *Anything* goes on unscheduled announcements (*signalling effect*)

Inflation Expectations and Readiness to Spend



Source: D'Acunto, Hoang, & Weber (2015): Inflation Expectations and Consumption Expenditures.

- Households with higher inflation expectations more willing to buy durable consumption good
- Stocks are claims on real assets and typically benefit from inflation through higher cash flows

Motivating Asset Pricing Models

So far, we have only made general statements about risk and return

- Can we get some numbers out of this?
  - e.g., what should the value of Microsoft be?
  - e.g., is the stock market too high? Too low?
- Need to do two things:
  - need to forecast future cash flows
  - need a discount rate
    $\rightarrow$ need the riskless interest rate
    $\rightarrow$ most importantly, need a risk premium
- What is the right risk premium?
  - How risky is Microsoft? How much compensation (risk premium) should we demand in return for the risk?
  - 4%, 6%, 8%, ... per year?
- How do we measure risk?
- Asset Pricing Models like the CAPM address these points (covered later)

Compounding Frequency and Annuity

Compounding Frequency (I)

- Returns (discount rates) may be compounded annually, semi-annually, weekly, daily, ...
- Returns are usually quoted in annual terms:
  - "The return is 5% per year, compounded annually."
  - "The return is 5% per year, compounded monthly."
- The compounding frequency tells you how often returns are compounded—i.e., how often you get interest on interest
- Example. If the discount rate is said to be "12% per year, compounded monthly," it is a way of saying that the discount rate is $\frac{12\%}{12} = 1\%$ per month.

Compounding Frequency (II)

- Example. Your credit card has an APR (Annual Percentage Rate) of 20% per year, compounded monthly. If you have a balance of \$1,000 and you make no payments for a year, what will your balance be in a year?
  - The rate per month is $\frac{20\%}{12} = 1.67\%$.
  - Thus, the balance grows to $\$1{,}000(1 + 0.0167) = \$1{,}016.7$ after one month, to $\$1{,}016.7(1 + 0.0167) = \$1{,}033.6$ in two months, and so forth.
  - The credit card balance is $\$1{,}000(1 + 0.0167)^{12} = \underline{\$1{,}219.4}$ after twelve months
- Thus, the 20% rate (the APR) is not the actual rate that you end up paying
- Because of interest on interest, the actual rate—which we call the effective rate—is $(1 + 0.0167)^{12} - 1 = 21.9\%$ per year

Compounding Frequency (III)

- All present and future value formulas adjust accordingly
- For example, the present value of a year-T cash flow is

$$\text{Present Value} = \frac{\text{Year-}T\text{ Cash Flow}}{(1+r)^T},$$

  if the discount rate is compounded annually.
- However, if the rate is compounded m times a year, the present value is

$$\text{Present Value} = \frac{\text{Year-}T\text{ Cash Flow}}{\left(1+\frac{r}{m}\right)^{mT}}$$

- Similarly, the value of an investment T years out is

$$\text{Year-}T\text{ Value of an Investment} = \text{Today's Investment Value} \times \left(1+\frac{r}{m}\right)^{mT}$$

Note: We often assume annual compounding for simplicity.

Annuity (I)

- Annuity is an asset that pays a fixed C dollars each period for the next T periods
- Using the present value formula, the value of this asset is:

$$P = \frac{C}{1+r} + \frac{C}{(1+r)^2} + \frac{C}{(1+r)^3} + \cdots + \frac{C}{(1+r)^T}$$

- We could compute the asset's value directly from this
- However, let's derive a formula for this price
  - Multiply both sides of the pricing equation by $(1+r)$:

$$(1+r)P = C + \frac{C}{1+r} + \frac{C}{(1+r)^2} + \cdots + \frac{C}{(1+r)^{T-1}}$$

  - Now subtract the first equation from the new one:

$$rP = C - \frac{C}{(1+r)^T} = C\left(1 - \frac{1}{(1+r)^T}\right)$$

  - Thus, the price of an annuity is

$$P = \frac{C}{r}\left(1 - \frac{1}{(1+r)^T}\right)$$

Annuity (II): Example

Example

Consider an asset that pays \$1,000 a year for the next 20 years?

1. What is the price of this asset if the discount rate is 5% per year, compounded annually
2. What if the rate is compounded monthly and, instead of receiving \$1,000 a year, you receive $\frac{\$1{,}000}{12} = \$83.33$ a month?

- Answer. Using the annuity formula, the price of the asset with annual compounding is

$$P = \frac{C}{r}\left(1 - \frac{1}{(1+r)^T}\right) = \frac{\$1{,}000}{0.05}\left(1 - \frac{1}{(1+0.05)^{20}}\right) = \$12{,}462.2$$

- If the rate is compounded monthly and the monthly payment is one-twelfth of the annual payment, the price of the asset is

$$P = \frac{\$83.33}{\left(\frac{0.05}{12}\right)}\left(1 - \frac{1}{\left(1+\left(\frac{0.05}{12}\right)\right)^{12\times 20}}\right) = \$12{,}627.11$$

Annuity (III)

- Perpetuity is an asset that pays a fixed C dollars each period for ever (also knows as consols)
- Economically, an annuity is a perpetuity starting today minus a perpetuity starting in period T
- Using the present value formula, the value of a perpetuity is:

$$P = \frac{C}{1+r} + \frac{C}{(1+r)^2} + \frac{C}{(1+r)^3} + \cdots$$

- Use knowledge for sum of infinite geometric series:

$$P = \frac{C}{r}$$

- Hence, let's write the value of the annuity as the difference of two perpetuities:

$$P = \frac{C}{r} - \frac{\frac{C}{r}}{(1+r)^T}$$

$$P = \frac{C}{r}\left(1 - \frac{1}{(1+r)^T}\right)$$

What We Learned Today

- We learned about different market participants and assets
- We studied the difference between expected and realized returns and why (not) we might want to use geometric rather than arithmetic means
- We saw that stocks have outperformed bonds in the 20^{th} century: compensation for risk!
- The price of any asset is the sum of discounted future cash flows; to get the price we have to project cash flows and need an asset pricing model to get the appropriate (for the riskiness of the asset) discount rate
- We saw that an APR is NOT the actual interest rate we pay: the effect of compounding!