

Recorded (the recording opens partway down deck 00 p. 12; the course-overview pages shown before it (pp. 2–11) are restated from the slides and the syllabus under a Gap (§1)) · **Midterm 20 Oct:** in — Block 1 (21 pp. 5–6). Arbitrage will not be asked as a direct question (10/15 τ 58:38) · **P9:** Passing — last confirming re-check 22 Sep. Edited after it — 22 Sep: the quotation round corrected quotations and citations against their sources; 29 Sep: the merge annotated its audit block (superseded figures marked); 16 Oct: the 15 Oct review's remarks added and a forward link to the 13 Oct note; gendered pronouns for the lecturer rewritten. Those edits were checked by the editing passes' own math, quotation and leak runs, not by a new audit.

Financial Economics — Lecture 1: The Course, the Four Principles of Finance, and Financial Instruments

Thursday 3 Sep 2026 · 53:30 recorded · Eduardo Dávila · ECON 2251

Sources used. Each is restated in full below; the codes are how the note cites them.

- 00 p. N — slide deck *Course Overview* (13 pages). Pages 2–11 and the top of p. 12 were shown before the recording began; the recording opens partway down p. 12. Pages 1 and 13 carry only the course's QR code.
- 01a p. N — slide deck *Financial Instruments* (21 pages). Pages 2–20 were all taught this meeting, in order; pp. 1 and 21 are the title page and a QR code. The photographs on pp. 6, 7, 9 and 20 and the charts on pp. 16 and 18 are read from the slide images themselves.
- syl p. N — the course syllabus (6 pages, updated 26 August 2026). It is this meeting's core reading: the first item on the day's agenda is "Read the syllabus carefully" (00 p. 3). §1 covers it in full.
- WB b.s Qn, p. N — the practice workbook with solutions, Block 1 (pp. 3–9).
- notation p. 1 — the one-page course handout on summation notation, used here for one symbol, the expected value. It is covered in full in the Lecture 4 note.
- 01b p. N, 02a p. N, 05a p. N — the decks of Lectures 2 to 4 and of market efficiency, cited only where this note links forward to them.
- The lecture recording, cited by time: ⌚ 15:21 . Another meeting's time carries its date: 10/15 [τ mm:ss] is the 15 October midterm review (Dávila; τ, the stitched timeline of its recordings), quoted only for what it said about this meeting's material.

At a glance

Where this sits. This is the first meeting of the course, and it does three jobs. It sets out what the course covers and how it is assessed, most of which was presented before the recording began and reaches this note from the slides and the syllabus. It lays the conceptual foundation: a definition of financial economics, four principles that Dávila says underlie everything in the semester, and a first full example of the fourth, no

arbitrage. And it builds vocabulary that every later lecture assumes: percent against percentage points and basis points, the balance sheet, real against financial assets, what financial markets are for, and a tour of the main asset classes. There is almost no algebra yet; by Dávila's own count "two lectures from today we start with equations"  41:14. Lecture 2 turns to how markets are organised, and Lecture 3 opens Block 2 with present value.

After this lecture you must be able to:

- **State** the four principles of finance, and **say** what each of the slide's A-or-B choices reveals about the person choosing.
- **Build** the Parasol and Umbrella arbitrage: find the riskless mix, finance it with a loan, check the profit state by state, and **derive** the only risk-free rate consistent with no arbitrage.
- **Tell** a true arbitrage (identical things at different prices) from a look-alike (differentiated products), and **say** what frictions do to the trade.
- **Convert** among percent, decimals, percentage points and basis points, and **distinguish** a change in percentage points from a percent change.
- **Build** a balance sheet, **compute** net worth, and **classify** any asset as real or financial by what it is used for, not by whether it can be touched.
- **Describe** fixed income, equity and derivatives by their cash flows and by what their valuation needs (time value of money; plus risk; plus optionality), **name** the three roles of financial markets, and **sketch** from memory the two charts the class is asked to keep in their heads.

Prerequisites. None from earlier lectures: this is the first. What the course itself presupposes (introductory microeconomics, and ideally some calculus and statistics) is set out in §1.2.

Symbol table

The slides of this meeting write words and numbers, not symbols. Every letter below is this note's own, chosen to agree with the later lectures' notation; the Meaning column says so where a source prints something different. One collision is avoided on purpose: the grading slide calls the attendance grade A (00 p. 11), and this note writes Att instead, keeping A for assets.

Symbol	Meaning	Units	First used
Att	attendance grade — <i>slides and syllabus write A</i>	fraction of 1	\$1
n	number of lectures attended	lectures	\$1
M, F	midterm score; final-exam score	fraction of the maximum	\$1
S	final course score	fraction of the maximum	\$1
X_A, X_B	the payoffs of the slide's option A and option B (01a p. 3); not A and B , which mean assets and the amount borrowed	dollars	\$3
$\mathbb{E}[\cdot]$	expected value: the probability-weighted average of whatever is inside	units of its argument	\$3
p_s, x_s	probability of state s ; payoff in state s . "State" means one way the uncertainty can turn out: heads or tails, rainy or sunny	pure number; dollars	\$3
p	probability that the coin lands heads, where it is varied away from $\frac{1}{2}$	pure number	Worked problems
k	factor by which both options' stakes are scaled up	pure number	\$3
R	a rate of return or interest rate per period, net	per period	\$3
PV	present value: what a future payment is worth today	dollars today	\$3
R_P, R_U	net return of Parasol & Co and of Umbrella & Co over the period; a superscript names the state, as in R_P^{rain}	per period	\$3
w	share of the money invested that goes into Parasol & Co; $1 - w$ goes into Umbrella & Co	fraction of 1	\$3
w^*, R^*	the share that makes the mix riskless; the return that mix earns in every state	fraction of 1; per period	\$3
d_P, d_U	how much better Parasol, and Umbrella, does in rain than in sun: $R^{\text{rain}} - R^{\text{sun}}$ for each company	per period	\$3
g, b	when the two companies are mirror images, the return each earns in its good state and in its bad state	per period	\$3

Symbol	Meaning	Units	First used
B	amount borrowed to finance the trade	dollars	\$3
r_f	risk-free rate: the rate at which one can borrow and lend — <i>slides write "4% interest rate"</i>	per period	\$3
$\pi_{\text{buy}},$ π_{sell}	sure profit from borrowing to buy the riskless mix; from selling the mix short and lending	dollars	Worked problems
%	the number $1/100$ (<i>01a p. 8</i>)	pure number	\$5
pp	percentage point: the unit of a difference between two percentages	0.01	\$5
bp (bps)	basis point: one-hundredth of one percent — <i>slides also write %²</i>	0.0001	\$5
$\Delta x, x_0$	a change measured in percentage points; the level it starts from, in percent	pp; percent	Worked problems
$A, L,$ NW	assets, liabilities, net worth — <i>slides write the words</i>	dollars	\$6
TVM	time value of money, the slides' abbreviation (<i>01a p. 15</i>)	—	\$10
P/E, CAPE	price–earnings ratio; Shiller's cyclically adjusted price–earnings ratio, labelled "Smoothed Price–Earnings Ratio" on the chart's axis (<i>01a p. 18</i>)	pure number	\$12
GS1, GS10	the slide's names for the two plotted series, the 1-year and the 10-year U.S. Treasury rate (<i>01a p. 16</i>)	% per year	\$10

1. The course: what it covers, how it is assessed, and how to prepare

🕒 00:00 · 00 pp. 2–12; syl pp. 1–6

This section establishes what ECON 2251 is, what it expects of you, how the grade is computed and what the ten blocks of the semester are. Only the last of these was recorded.

GAP Not captured — the first part of the meeting

The recording opens mid-sentence, partway down the course-outline slide (00 p. 12), at Block 2. Everything before that point (00 pp. 2–11 and the top of p. 12) was presented before the recorder was started, and nothing said about it survives. That those pages were presented is clear from the recorded speech, which refers back to them: the class had already been told to read the *Wall Street Journal* 23:40, to check in for attendance 01:54, and that figures come from the lecturer's notebooks 45:23. §1.1 to §1.4 therefore restate the slides and the syllabus, which cover the same ground, and attribute nothing to Dávila's speech. §1.5 and §1.6 are from the recording.

1.1 What the course is

00 p. 4; syl p. 1

ECON 2251 is designed as the gateway to the other finance courses at Yale College, and it replaces Econ 252, which is no longer offered. It is a systematic introduction to financial economics that assumes no previous knowledge of finance; for most students it is their first formal contact with the subject. The slide's own description of the level is an "introductory course taught at intermediate level" (00 p. 4): it starts from the beginning but moves at the pace of an intermediate economics course.

DEFINITION Financial economics

Financial economics "studies the allocation of resources over time and across states" (syl p. 1; the same words are on 01a p. 2). *Over time* is the dimension of dates; *across states* is the dimension of uncertainty, a **state** being one of the ways the future can turn out. So the field bears on any economic decision that involves time or uncertainty. §2 is where the lecture itself builds this definition.

The syllabus lists nine topics: time discounting, portfolio choice, equilibrium pricing, market efficiency, equity valuation, arbitrage, fixed-income securities, derivative pricing and financial intermediation (syl p. 1). They line up one to one with Blocks 2 to 10 of the outline in §1.5, with "equilibrium pricing" being the CAPM of Block 4; Block 1, this meeting and the next, is the introduction to instruments and markets (*explanation: the pairing is this note's reading of the two lists, which the syllabus does not draw itself*).

1.2 Prerequisites, and what is actually hard

00 p. 7; syl p. 2

The only formal prerequisite is introductory microeconomics (Econ 108, 110, 115 or the equivalent). The syllabus is candid that the practical prerequisite is something else: "the most important prerequisite is some

mathematical self-confidence" (*syl p. 2*). Three things help without being required:

- **Some calculus:** differentiation, limits and basic single-variable optimization.
- **Some statistics or econometrics:** basic probability, random variables, linear regression.
- **Intermediate microeconomics** (optimization and equilibrium). Taking Econ 1121 or 1125 at the same time as this course is fine, and "may be a good idea" without being necessary.

The course is self-contained. First-year students who placed out of introductory micro are ready for it, and anyone unsure is told to talk to Dávila in the first week. The slide puts the quantitative side plainly: comfortable with quantitative courses, good; not comfortable, "perhaps more challenging", but "not impossible if you put the effort" (*00 p. 7*).

Two further lines on that slide say where the difficulty really lies. Students are told to stay up to date by reading the *Wall Street Journal*, *The Economist* and the *Financial Times*, because Dávila plans to bring articles into class. And then: "The hardest part of this course is to combine analytical thinking with real world facts and events", followed by "Not the math" (*00 p. 7*). Dávila's stated goal for this year is to make the course more accessible.

1.3 Materials, and the practice workbook that replaces homework

00 pp. 9–10; syl pp. 3–5

No textbook is required. The materials are all posted on the course website, and the slides and syllabus describe five kinds.

Material	What it is for
Slides	The lectures. Check that you have the latest version: they are updated when typos are found
Handouts	Expand on some topics
Notebooks	The code that generates most of the data and figures in the slides. They replicate many slide figures and can serve as templates for the practice problems. Not required, but working through them may help
Readings	A folder of research papers, press articles and other sources: "interesting and helpful but not required"
Practice workbook	Concept questions and practice problems for every block, with solutions

The workbook is the one that matters most. There is no graded homework this year; the grade is attendance, midterm and final, and nothing else. In place of homework, "you are expected to work through the concept questions and the practice problems every week" (*syl p. 3*). The two kinds of question are different in purpose.

- **Concept questions** test the key ideas of one day's class. There are hundreds, each with a solution, and once you have reviewed that class each should take about two minutes at most.
- **Practice problems** are numerical questions, including the questions that used to be the graded homework, for extra practice.

Solutions are included, and the instruction is to attempt each question before looking. The slide calls the workbook "the single most important resource to prepare for the exams!" (*00 p. 9*). The course may be challenging, so both sources urge finding a study group to work through the workbook with; a teaching fellow can help you find one. In this note, the workbook's questions on today's material are under Worked problems and Self-check.

Two statements fix what the exams can draw on. The slide says "Exam questions can always be answered with the material covered in lecture" (*00 p. 9*). The syllabus says all exams are based on material "explicitly covered in class, handouts, and notebooks", and that a perfect score is possible without any textbook; the books below are there for alternative viewpoints (*syl p. 5*).

Key	Book	Level, and the syllabus's comment
BKM	Bodie, Kane and Marcus, <i>Essentials of Investments</i> , 10th ed.	Introductory. The 9th, 8th or 7th edition is fine; the changes are minor
Welch	Ivo Welch, <i>Corporate Finance</i> , 3rd ed.	Introductory; free online
Luenberger	David G. Luenberger, <i>Investment Science</i>	Intermediate
Campbell	John Y. Campbell, <i>Financial Decisions and Markets</i>	Advanced. "A fantastic book": anyone interested in financial economics should get a copy and read it carefully
Cochrane	John H. Cochrane, <i>Asset Pricing</i>	Advanced. The key reference for the "SDF approach to asset pricing covered in Block 7" (the syllabus gives only the acronym)
Tuckman/Serrat	Bruce Tuckman and Angel Serrat, <i>Fixed Income Securities: Tools for Today's Markets</i> , 3rd ed.	Introductory, fixed income
Veronesi	Pietro Veronesi, <i>Fixed Income Securities: Valuation, Risk, and Risk Management</i>	Slightly more advanced, fixed income
McDonald	Robert L. McDonald, <i>Derivatives Markets</i> , 3rd ed.	Introductory, derivatives
Hull	John C. Hull, <i>Options, Futures, and Other Derivatives</i> , 10th ed.	Slightly more advanced, derivatives

1.4 Exams and the grade

00 pp. 8, 10–11; syl pp. 2–4

There are two exams. The **midterm is on Tuesday 20 October** and the **final on Friday 18 December**; classes run from Thursday 3 September to Thursday 10 December, 26 meetings in all, of which 25 are lectures and one is the midterm. Both exams are closed-book. Each is a mix of numerical questions, like the workbook's practice problems, and short questions, like its concept questions; the number of questions is announced in class. The final is cumulative (00 p. 11). You need a scientific calculator that computes exponentials and logarithms (syl p. 3).

What the midterm covers is not stated in the syllabus or on the slides. The one thing the recording settles is a rule about arbitrage, given in §3.4: no arbitrage questions on the midterm. The 15 October midterm review settled the rest — the number and form of the questions (Lecture 12 note (15 Oct) §1.2), the equations printed on the paper (§1.1) and the scope, Blocks 1 to 5 (§1.5).

The final score. Write Att for the attendance grade, M for the midterm and F for the final, each as a fraction of its maximum. The final score is the better of two weightings:

$$S = \max\left\{\underbrace{0.15 \text{Att} + 0.3 M + 0.55 F}_{\text{Formula A}}, \underbrace{0.15 \text{Att} + 0.4 M + 0.45 F}_{\text{Formula B}}\right\}$$

Attendance counts 15% under both; Formula A leans on the final, Formula B moves ten points of weight from the final to the midterm (00 p. 11; syl p. 2).

DERIVATION Which formula applies — Formula B exactly when $M > F$, so $S = \text{Formula A} + 0.1 \max\{M - F, 0\}$

$$\text{Formula B} - \text{Formula A} = (0.15 - 0.15) \text{Att} + (0.4 - 0.3) M + (0.45 - 0.55) F$$

Why this step follows: subtract the two weightings term by term.

$$\text{Formula B} - \text{Formula A} = 0.1 M - 0.1 F = 0.1 (M - F)$$

Why this step follows: the attendance terms cancel, and 0.1 factors out of what is left.

$$S = \text{Formula A} + 0.1 \max\{M - F, 0\}$$

Why this step follows: the maximum picks Formula B when the difference $0.1(M - F)$ is positive, that is when the midterm beats the final, and Formula A otherwise.

Numerical check (explanation: the numbers are this note's). With full attendance, $M = 90\%$ and $F = 80\%$: Formula A gives $0.15 + 0.27 + 0.44 = 86\%$, Formula B gives $0.15 + 0.36 + 0.36 = 87\%$, so $S = 87\%$, which is $86\% + 0.1 \times 10\%$.

So the midterm is worth 30% and rises to 40% only when it is your better exam; a bad midterm is partly forgiven, and the final outweighs the midterm under either formula. Letter grades "flexibly follow" the Economics department's guidelines for intermediate-level courses: 50% A's, 45% B's and 5% C's or below (syl p. 3), which the slide abbreviates to " $\lesssim 50\%$ A and A-" (00 p. 11). The slide adds that a no-cheating policy is strictly enforced.

The midterm is not optional. A justified absence, such as an illness certified by the college dean through a Dean's Extension, gets no make-up exam; the midterm's weight moves onto the final, 30 points joining the final's 55:

$$S = 0.15 \text{ Att} + 0.85 F$$

The justified-absence formula (00 p. 11; syl p. 3).

An unjustified absence lowers the final letter grade by two units, for example from A– to B.

Attendance. It is taken at every lecture with a short online form and a passcode written on the board. All 25 lectures count, including the two guest lectures (\$1.5); the midterm day does not. With n lectures attended,

$$\text{Att} = \begin{cases} \min\{n/15, 1\} & \text{if } n \geq 6 \\ 0 & \text{if } n \leq 5 \end{cases}$$

The slide's form (00 p. 11). The syllabus writes the same function in three cases: 1 if $n \geq 15$, $n/15$ if $6 \leq n \leq 14$, 0 if $n \leq 5$ (syl p. 3).

Because $0.15 \times n/15 = n/100$, attendance contributes exactly n percentage points of the final score for $6 \leq n \leq 15$. The schedule therefore has a cliff and a cap: five lectures or fewer earn nothing, the sixth lecture brings 6 points at once, each lecture from the seventh to the fifteenth adds one more, and lectures beyond the fifteenth add nothing.

1.5 The ten blocks

 00:00 · 00 p. 12; syl p. 6

The recording begins here, with Dávila walking down the outline. The course has ten blocks, and everything posted on the website is filed by block: a file whose name starts 02, 06 or 08 belongs to that block  01:00. The slide's examples are 02c_slides_returns.pdf, 06_handout_CAPM.pdf, 07c_yield_curve.Rmd and 09e_futures.ipynb **SLIDE ONLY**. The lecture counts are printed as tentative **SLIDE ONLY**, and the suggested readings are the syllabus's.

#	Block	Lectures	Suggested readings (<i>syl p. 6</i>)	What Dávila said about it on 3 Sep
1	Financial Instruments and Markets	2	BKM 1–4	Today and the next lecture. Its description was given before the recording began
2	Present Value and Returns	2	BKM 5; Welch 2–4	For anyone who has seen net present value before, the most repetitive part; it has to come first, and little time will be spent on it
3	Portfolio Choice	4	BKM 5–7; Luenberger 6, 9; Campbell 1–2	You have money and options for investing it: what is the best way to allocate it? "An important part of the next few weeks"
4	Capital Asset Pricing Model (CAPM)	2.5	BKM 6–10; Luenberger 7–8; Campbell 3	What happens if <i>everybody</i> allocates their money that best way. "One of the workhorse models in finance, everybody uses it all the time"; a word the class will hear over and over
5	Market Efficiency	1.5	BKM 8; Cochrane 20; Campbell 3, 5	Concludes the first part: "whether people get the right returns or not"
6	Equity Valuation	1	BKM 13; Welch 13; Campbell 5	Placed with the first part of the course
7	No Arbitrage Pricing	2.5	Campbell 4, 6; Cochrane 1–4	Blocks 7 to 10 "are about arbitrage", a word introduced today "because it's so important"
8	Fixed Income Securities	3	BKM 10–11; Campbell 8; Cochrane 19; Tuckman/Serrat 1–4, 8	Bonds, "which have become very popular in the last few days, I don't know if you've been reading the news"
9	Derivatives: Options	2.5	BKM 15–16; McDonald 2, 9–13	Options
10	Financial Intermediation	1	The course slides and the readings posted on the website	"Things like banks", in the last lecture: a way to close the course with a full overview of the area

The counts sum to 22, short of the 25 lectures the syllabus counts; it lists the two guest lectures without counts and does not say how the rest are used. Two sub-totals matter later in this note. Blocks 1 to 6 take 13 lectures and Blocks 7 to 10 take 9. Within the second part, Blocks 7 to 9 take $2.5 + 3 + 2.5 = 8$ lectures, which is the "eight lectures" behind the exam rule in §3.4.

GAP Not recoverable — 00:51

One clause about the CAPM cannot be pinned down, and what turns on it is exam scope. The recording has the CAPM as "an important part of the material before we get into it. We'll conclude talking about notions of market efficiency" (00:51). A second, rough automatic transcript of the same audio has "before the internet", which makes no sense as it stands and which one reconstruction of the lecture repairs to "before the *midterm*". No slide and nothing in the syllabus says what the midterm covers, so neither reading can be confirmed. This note therefore states nothing about the midterm's scope from this passage; the only exam rule taken from this meeting is the clearly recorded one in §3.4.

Two guest lectures, both confirmed for this year (01:54). Toby Moskowitz, of the School of Management, speaks sometime in October, with the date to be posted on the course site; Dávila says the guest will speak to "the first block". Professor John Geanakoplos comes at the end of term and will speak to "the second block". An October lecture cannot be about Block 1, so "block" here most naturally means the two parts of the course, Blocks 1 to 6 and Blocks 7 to 10, as it does in the lecturer's remark about equity valuation

EXPLANATION

They are "great speakers, really fun", they take up some of the course's issues in a more conceptual way, and attendance at both counts toward the grade. The syllabus gives their titles: Geanakoplos is the James Tobin Professor of Economics and Moskowitz the Dean Takahashi '80 B.A., '83 M.P.P.M. Professor of Finance (*syl p.* 6). The slide lists both dates as "(TBD)" and then ends the overview with "Let's start!" (SLIDE ONLY). Geanakoplos comes up once more at the end of the meeting, in connection with asset-backed securities (§13).

1.6 An aside: who is in the room

(02:53) · no slide

Before starting the first block Dávila shows a chart of who is taking the class: "I asked Claude to do this for me before, with your data." About 40% are juniors, 40% sophomores and some 20% seniors. Many are undeclared, most of the sophomores among them, and the rest are a mix that includes a lot of STEM, computer science and economics-and-mathematics. Reading the chart's labels, Dávila notes that "0.7 is one

person, 1.3 is two people". The point is that the course is not tied to a major or a year: everybody is welcome, and many seniors have taken it and enjoyed it.

The chart also splits the class by residential college, and here Dávila slips in a first piece of course content. "If it's IID", the lecturer says, the colleges should all sit near the same line, "kind of random, so it's around there"; and randomness is something the course will talk about quite a bit. IID stands for independent and identically distributed: if which college a student belongs to has nothing to do with whether the student takes this course, the colleges' shares differ only by chance **EXPLANATION**.

GAP Reconstructed from the lecture audio — 02:53

The chart is in no slide deck and is not among the course files this note was built from, so only the spoken shares survive; they are reported as said and cannot be checked against anything written. Two remarks made while the chart was up are not recoverable from the audio (03:00 , 03:38).

Course logistics and the rest of the overview slides (one line each)

The rest of the overview slides

- **The agenda** (00 p. 3): practical information about the class ("Read the syllabus carefully"), a brief outline of the course, then the first block.
- **About the instructor** (00 p. 2): Assistant Professor of Economics at Yale with a secondary appointment in finance at the School of Management (SOM); assistant professor of finance at NYU Stern, 2014–2018; PhD in economics, Harvard, 2014; BA in economics, Universitat Pompeu Fabra, Barcelona, 2008; from Spain. At Yale Dávila has also taught Econ 350 (Mathematical Economics: General Equilibrium Theory, undergraduate) and the graduate courses 500 (General Economic Theory: Microeconomics) and 531 (Mathematical Economics II: General Equilibrium Foundations of Finance and Macroeconomics). Research interests: financial economics and macroeconomics, international and public finance. The slide names a recent paper, *Normative Macro-Finance: An Agenda and Ten Rules*, by title only.
- **Yale College courses you could take after 2251** (00 p. 5): Econ 350 Mathematical Economics: General Equilibrium Theory (Geanakoplos); 361 Corporate Finance (Clayton, SOM); 363 Global Financial Crises (Metrick and Geithner, SOM); 375 Monetary Policy (English); 407 International Finance (Fieler); 419 Financial Time Series Econometrics (Chen); 424 Central Banking (English); 444 Market Inefficiencies and the Limits of Arbitrage (Pascutti); 445 The U.S. Banking System (Pascutti); 450 Investment Analysis (Takahashi); 454 Evolution of Central Banking (Mohan); 456 Private Equity Investing (Schmertzler); 476 The Theory and Application of Corporate Credit Investing (Rapaport); 480 Banking Crises and Financial Stability (Benediktsdottir).
- **SOM courses you could take after 2251** (00 p. 6): MGT 540 Personal Finance (Choi); 542 Speculation and Hedging in Financial Markets (Giglio); 544 Investment Management (Goldsmith-Pinkham); 548 Real Estate Finance (Spiegel); 595 Applied Quantitative Finance (Moskowitz); 641 Behavioral Finance (Barberis); 649 World Financial History (Goetzmann); 897 Entrepreneurial Finance (Ma).
- **QR code:** the first and last pages of each deck carry a QR code that leads to a Google form; the slides do not say which form it is (00 pp. 1, 13).

Logistics

- **Where and when:** Davies Auditorium, Becton Center, Tuesdays and Thursdays. The syllabus prints 1:05–2:20 pm (*syl p. 1*) and the slide 1:00–2:15 pm (00 p. 8). It is a lecture course, and lectures are not recorded by the course.
- **Office and contact:** 28 Hillhouse, Room A206; website eduardodavila.com; course site on Canvas. Office hours are by appointment, and questions are welcome on Thursdays after class.

- **Attendance mechanics:** a short online form at every lecture, with a passcode written on the board. Section attendance is not graded but is strongly encouraged.
- **Classroom conduct:** civility and punctuality. Laptops and other devices are not recommended because they reduce focus; sit at the back if you must use one. Students are told to read Yale's regulations on plagiarism and cheating.
- **Teaching fellows and sections:** details are on the website. Questions about the practice problems go to your teaching fellow, and questions about content are welcome too. Section times are announced in class and online, and sections first meet in the second week. There is no enrollment cap; if sections are full, wait a few days for more teaching fellows to be added. Section enrollment is run by the registrar, not by the professor or the fellows.
- **Disabilities:** contact the Resource Office on Disabilities, and the professor as needed.
- **Feedback:** an anonymous Google form stays open all semester for suggestions on improving the course "before it is too late"; feedback that is not anonymous is welcome at any time.

Self-check. A student attends 12 lectures, scores 70% on the midterm and 90% on the final. What is the final score, and which formula produced it?

$Att = 12/15 = 0.8$, so attendance contributes $0.15 \times 0.8 = 0.12$, which is 12 points, one per lecture attended. Formula A: $0.12 + 0.3 \times 0.70 + 0.55 \times 0.90 = 0.12 + 0.21 + 0.495 = 82.5\%$. Formula B: $0.12 + 0.28 + 0.405 = 80.5\%$. The final beat the midterm, so Formula A applies and $S = 82.5\%$. The gap between the two, 2 points, is $0.1 \times (0.90 - 0.70)$.

Self-check. How many points of the final score does attendance contribute for a student who attends 5 lectures? 6? 10? 20?

0, 6, 10 and 15. Five or fewer lectures earn nothing. From the sixth lecture the contribution is n points, since $0.15 \times n/15 = n/100$, and it is capped at 15 points from the fifteenth lecture on. The sixth lecture is therefore worth six points by itself.

2. What financial economics is

🕒 04:42 · 01a p. 2

This section establishes what the subject is, that it is defined by time and uncertainty and not by money, and how the field divides into four areas.

Dávila opens "part one, block one" with a definition, and builds it from the class. The first question is what economics in general is, and a student answers: "How to allocate scarce resources?" ⌚ 05:15 . Dávila accepts that as the base ("perfect") and adds what makes it *financial* economics: the allocation of scarce resources "insofar as it is related to time and uncertainty" ⌚ 05:17 . The slide says the same in the syllabus's words, "allocation of resources over time and across states", with the emphasis on time and uncertainty; the phrase "across states" was not said aloud **SLIDE ONLY**.

The point Dávila presses is what the subject is *not*: "It's not about money." Money is one piece of it, but anything that has to do with time, or with uncertainty, falls within financial economics. A decision about when to consume, how much to save, or whether to insure against a bad outcome is a financial-economics question even if no bank or stock market is in sight.

The field is usually divided into four major areas (01a p. 2):

Area	What it studies	Its place in this course
Asset pricing — the slide adds "(capital markets, investments, etc.)" SLIDE ONLY	How to value cash flows and assets	Most of what the course does
Corporate finance	What corporations do and how they fund themselves	Touched on only briefly; other courses cover it, for example at the School of Management
Financial intermediation	Banking; borrowing and lending	Covered briefly at the end (Block 10)
Household finance	How finance affects people's decisions	Mortgages, which most students or someone in their family will deal with, come up "a little bit throughout the course", mainly, the lecture says, in its final part

The first mortgage in the course is in fact early: Lecture 4 prices a 30-year fixed-rate mortgage as an annuity (Lecture 4 note). Dávila closes the slide by explaining why so much of the course is valuation: it is the foundational knowledge, and "once you know how to value things, you can start to use it for very different purposes" ⌚ 05:48 .

Self-check. A farmer decides in spring how much of the autumn harvest to sell forward at a fixed price. No money changes hands today. Is this a financial-economics decision?

Yes. The subject is defined by time and uncertainty, not by money. The decision is about resources delivered at a later date (time), and its whole purpose is to deal with not knowing what the autumn price will be (uncertainty, or in the slide's language, different states). "It's not about money" ⌚ 05:17 .

Self-check. Match each question to one of the four areas: (i) what is a ten-year bond worth today? (ii) should a firm fund a new factory with a loan or by issuing shares? (iii) how does a bank turn overnight deposits into long loans? (iv) should a family take a fixed-rate mortgage?

(i) asset pricing, the valuation of cash flows; (ii) corporate finance, how corporations fund themselves; (iii) financial intermediation, banking and borrowing and lending; (iv) household finance, how finance affects people's decisions.

3. The four principles of finance

⌚ 07:09 · 01a pp. 3–4

This section establishes the four ideas that, in Dávila's words, underlie everything the course covers: non-satiation, risk aversion, the time value of money and no arbitrage. Dávila always starts the course with them, and makes a strong claim for the slide: someone only shopping the class who understood this one slide, and who was "really, really smart", should be able to derive the rest of the course from the four principles. Each principle comes with a choice between an option A and an option B, put to the room by show of hands.

3.1 Principle 1: non-satiation

⌚ 07:36 · 01a p. 3

DEFINITION Non-satiation

Non-satiation means that investors prefer more to less (01a p. 3). To be *satiated* is to want no more, as when you cannot eat another bite; non-satiation is the opposite, never being satisfied with how much money or how many resources you have.

The slide's choice is A, \$100 now, or B, \$200 now. Dávila polls the room and says it would be "almost irrational" to pick the \$100. The principle sounds too obvious to need stating, and that is the lecturer's point about it: everybody likes more, and that simple idea yields extremely powerful results. The most important of them is the fourth principle, which, Dávila says, builds on this one (§3.4).

3.2 Principle 2: risk aversion

🕒 08:35 · 01a p. 3

DEFINITION Risk aversion

Risk aversion means that investors dislike risk (01a p. 3): they prefer sure things to uncertain things.

This one Dávila calls "a little bit more subtle". Option A is \$100 in cash now. Option B is a coin flip: heads pays \$200 now, tails pays nothing (the slide words it as "\$200 now with 50% chance, nothing otherwise"). The average payoff of B is computed aloud, "50% times 200 is 100, plus zero":

$$\mathbb{E}[X_B] = \frac{1}{2} \times 200 + \frac{1}{2} \times 0 = \$100$$

The expected value weights each payoff by its probability and adds; with a fair coin it is the midpoint of \$0 and \$200, and equals option A's sure \$100.

Dávila polls the room. A few hands go up for B, and the lecturer calls the split "very, very normal". Then: "Is there a right answer? There's no right answer here." The choice is a measurement of the chooser. If you pick A you are risk averse, and if you pick B "you are what we call risk-loving" 🕒 09:35 .

INTUITION Why the two averages are made equal

The example is built so that the only difference between A and B is risk. Both pay \$100 on average. Someone who takes A gives up nothing on average and gets certainty, so the choice can only be expressing a dislike of risk. If B's average were higher, taking A would mix two motives, and the choice would reveal much less.

Strictly, equal averages leave one more possibility, a person who does not care about risk at all and is indifferent between the two; the worked problem on this example spells that out in a Warning (Worked problems).

Dávila then turns to the students who chose B and raises the stakes: what if it is \$1,000 against \$2,000? What if a zero is added, and another, and another? Who takes one billion dollars for sure, and who gambles for two billion? "That takes a lot of guts to do" 🕒 09:35 . The averages remain equal at every scale, since

both options are multiplied by the same factor k and $\mathbb{E}[kX_B] = 100k = kX_A$. So anyone who switches from B to A as the stakes grow is reacting to risk alone, which is exactly what the lecture predicts the risk-lovers will do.

The lesson Dávila draws is that a person's attitude to risk depends on the level of wealth and on the size of the stakes  10:31. For \$100 the lecturer would not much care, because \$100 is "a nicer dinner"; but "if it's \$2 million, I can guarantee you I'll take the \$1 million". That is why risk aversion is the course's maintained assumption: when the amounts are really large people are risk averse, because most people do not want to risk ending up destitute. People dislike risk, "especially when the risk is large, or when the stakes are large", which Dávila calls a very human way of behaving and which will underlie many of the course's results.

3.3 Principle 3: the time value of money

 11:52 · 01a p. 3

DEFINITION Time value of money (discounting)

Time value of money, or **discounting**, is the principle that money today is worth more than money in the future (01a p. 3).

Option A is \$100 now and option B is \$100 in a year, and choosing B "makes no sense". The reasons given are practical: money in hand now can be used or spent, and the future is not guaranteed. "What if you're dead in a year", or something else happens, and you never get to spend it?

The principle does not say that future money is worthless, only that it is worth less, and how much less, Dávila says, is a matter of a rate: there will be a rate that makes a person indifferent between consuming today and consuming in the future, and that indifference is what drives discounting  11:52. No number is given; the rates come later in the course. In symbols, if R is that rate for one year, \$100 received in a year is worth the same as

$$PV = \frac{100}{1 + R}$$

dollars today, because that amount, invested at R , grows to exactly \$100 in a year (explanation: the formula is Lecture 3's, not shown at this meeting).

This is the starting point of Block 2, developed in the Lecture 3 note.

Dávila sums up the first three principles in one breath: we want stuff today rather than in the future, stuff that is safe rather than risky, and as much stuff as we can get. Those three ideas "underlie almost everything we'll be doing in the course"  12:51.

3.4 Principle 4: no arbitrage

🕒 13:15 · 01a pp. 3–4

The fourth idea, Dávila says, builds on the first: "It requires one, but it's slightly different." The link is this: a free lunch only gets eaten if people want more, so the conclusion that free lunches cannot survive rests on non-satiation (**EXPLANATION**).

DEFINITION Arbitrage, and the no-arbitrage principle

An **arbitrage** is "a sure profit with zero initial cash outlay" (01a p. 3): money made for certain without putting any money up front. The **no-arbitrage** principle says that "there are no free-lunches" (01a p. 3): such opportunities do not exist, or do not last.

"This is a bit more involved", Dávila says, and introduces it with an example.

The set-up (01a p. 3). Two companies' returns depend on the weather, in opposite directions, and there is a bank:

	If rainy	If sunny
Return of Parasol & Co, R_P	–10%	+20%
Return of Umbrella & Co, R_U	+20%	–10%
Borrowing and lending at the bank, r_f	4%	4%

The question on the slide: how can you make a sure profit with zero initial cash outlay? Dávila asks for thinking, not arithmetic: "I don't need to know the math. I want to get your thinking" 🕒 14:42 . A student volunteers the whole idea: buy equal amounts of Parasol and Umbrella, so that the outcome is the same whether it is rainy or sunny, and do it without any money of your own 🕒 14:48 . Dávila: "Very good." The student also put a figure on the return, and that figure does not match the slide; the Warning inside the worked problem on this trade gives both numbers.

EXAM SIGNAL Arbitrage: not on the midterm, on the final

"I'm going to say this many times. I will not ask any questions about arbitrage in the midterm" 🕒 14:58. It will be on the final, because the course spends the eight lectures of Blocks 7 to 9 on what lies behind this example. For now, what the lecturer wants from the class is exactly the reasoning the student had just given. Repeated at the 15 October midterm review: "As I've said many times, arbitrage won't show up explicitly in the midterms." (10/15 [τ 58:34]); "I will not ask a question like, oh, is this an arbitrage or not?" (10/15 [τ 58:38]). The gloss that followed, "arbitrage is the idea that you turn a profit, you make a profit, without putting too much effort into it" (10/15 [τ 58:45]), is looser than the definition above: an arbitrage needs no money up front and a profit that is sure, not merely easy. The definition is the slide's (Lecture 12 note (15 Oct) §16.1).

Dávila leaves the arithmetic to the class ("I'm going to let you work the math"), so the numbers on the next slide were shown but not read out SLIDE ONLY.

The trade (01a p. 4). Borrow \$200 and buy \$100 of Parasol and \$100 of Umbrella. The initial outlay is \$0. Then "wait for weather uncertainty to resolve":

	If rainy	If sunny
\$100 of Parasol becomes	\$90	\$120
\$100 of Umbrella becomes	\$120	\$90
The mix is worth	\$210	\$210
Repay the loan, 1.04×200	-\$208	-\$208
Profit	\$2	\$2

The slide writes the two lines as $90 + 120 - 208 = 210 - 208 = \$2$ and $120 + 90 - 208 = 210 - 208 = \$2$, reminds you that "you must pay back $1.04 \times 200 = 208$ ", and states the comparison that matters: the return on the investment is 5%, since $210/200 = 1.05$, and the borrowing rate is 4%. Its last remark is "You would like to scale-up this trade as much as possible!", because nothing limits the size: on any amount borrowed B the sure profit is $1.05B - 1.04B = 0.01B$.

Dávila's spoken version is the argument without the numbers 🕒 15:21. Put your money 50–50 into Parasol and Umbrella and you get the same amount no matter what, because the two fully offset each other. "That looks like a risk-free investment. That looks like putting my money in an account at a fixed rate." You have manufactured a bank account out of two risky companies, and this one pays 5%. So you can borrow from the bank at 4% and invest at 5% in the mix.

What the example assumes, all of it implicit on the slides **EXPLANATION**:

- **Two states and no probabilities.** The profit is checked state by state, and it is \$2 in both, so it does not matter how likely rain is. That is what separates an arbitrage from a good bet.
- **One period for everything.** The two returns and the loan run over the same stretch of time. The slide does not say how long it is, so the 4% and 5% should not be read as annual rates.
- **One rate for borrowing and lending, in any amount.** This is what allows the trade to be scaled up.
- **None of your own money.** The \$2 is therefore not a return on an investment. It is a pure profit, which is the definition of an arbitrage.

The step-by-step solution, and the proof that 50–50 is the *only* riskless split, are in Worked problems.

3.5 What no arbitrage pins down: the risk-free rate must be 5%

🕒 15:21 · 01a p. 4

The slide ends with a question and prints no answer: "Which risk-free rate is the only one consistent with no-arbitrage?" Dávila answers it in passing. Since the mix is a risk-free investment, "it better be that the return of my first investment and this 4% is the same", because if it is not, you borrow at the lower rate and invest at the higher one. The answer is therefore **5%**, the return of the riskless mix.

This is the step that turns the principle from a slogan into a tool. *No free lunches* sounds like a statement about luck. Used this way it is a statement about prices: once the two companies' returns are given, the interest rate is no longer free to be anything. Dávila comes back to this after the joke of §4: "You cannot have these companies with these returns and interest rate at 4%", because you would make money for sure by combining the two into something risk-free "and then doing a long-short strategy, which we'll cover in detail later in the course" 🕒 16:42 .

The argument has two directions. If the bank's rate is below 5%, borrow and buy the mix, as on the slide. If it is above 5%, do the reverse: sell the mix short and lend the proceeds at the bank. The second direction was not discussed at this meeting, and it needs the short sale that Lecture 2 introduces, selling something you do not own and buying it back later (01b p. 13); it is what "long-short" refers to. Both directions are worked line by line in Worked problems. At exactly 5% neither trade earns anything, which is why 5% is the only consistent rate.

The same logic works for any pair of returns, not only the slide's mirror images. Write $d_P = R_P^{\text{rain}} - R_P^{\text{sun}}$ and $d_U = R_U^{\text{rain}} - R_U^{\text{sun}}$ for how much better each company does in rain than in sun. Then the riskless share in Parasol, and the only risk-free rate consistent with no arbitrage, are

$$w^* = \frac{d_U}{d_U - d_P}, \quad r_f = R^* = \frac{d_U R_P^{\text{rain}} - d_P R_U^{\text{rain}}}{d_U - d_P}$$

On the slide's numbers these are ½ and 5%; the steps are in the derivation below.

DERIVATION Full derivation (not done in class) — the riskless share and the rate it pins down, for any two companies

Put a share w of the money in Parasol and $1 - w$ in Umbrella.

$$wR_P^{\text{rain}} + (1 - w)R_U^{\text{rain}} = wR_P^{\text{sun}} + (1 - w)R_U^{\text{sun}}$$

Why this step follows: a mix's return is the weighted average of its parts' returns, and the mix is riskless exactly when that return is the same in both states.

$$w(R_P^{\text{rain}} - R_P^{\text{sun}}) + (1 - w)(R_U^{\text{rain}} - R_U^{\text{sun}}) = 0$$

Why this step follows: subtract the right side from the left and group the terms company by company.

$$w d_P + (1 - w) d_U = 0$$

Why this step follows: substitute the two definitions.

$$w(d_P - d_U) = -d_U$$

Why this step follows: multiply out $(1 - w) d_U$, collect the two terms in w , and move d_U to the right.

$$w^* = \frac{d_U}{d_U - d_P}$$

Why this step follows: divide both sides by $d_P - d_U$, then multiply numerator and denominator by -1 . The share lies between 0 and 1 exactly when d_P and d_U have opposite signs, that is, when one company does better in the rain and the other in the sun; otherwise the riskless mix would need one company to be sold short.

$$1 - w^* = \frac{d_U - d_P}{d_U - d_P} - \frac{d_U}{d_U - d_P} = \frac{-d_P}{d_U - d_P}$$

Why this step follows: write 1 over the common denominator and subtract; this is Umbrella's share in the riskless mix.

$$R^* = w^* R_P^{\text{rain}} + (1 - w^*) R_U^{\text{rain}} = \frac{d_U R_P^{\text{rain}} - d_P R_U^{\text{rain}}}{d_U - d_P}$$

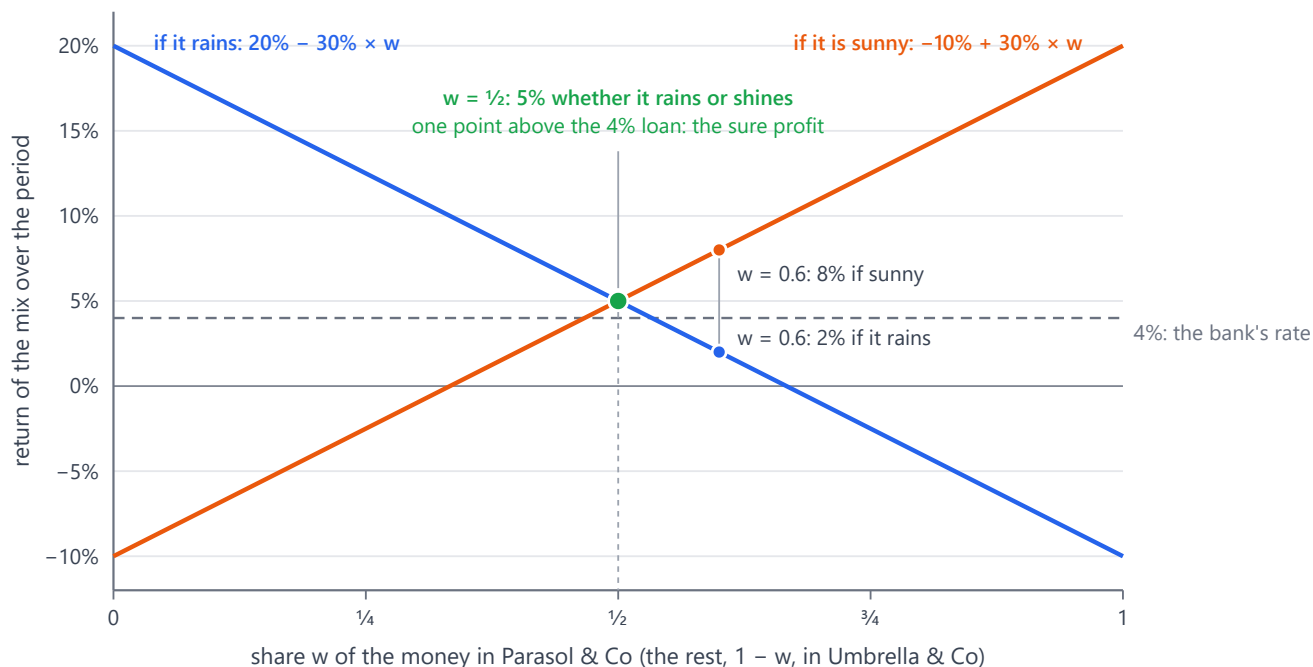
Why this step follows: evaluate the mix's return in the rainy state at the two shares just found; the sunny state gives the same number by construction.

Numerical check. On the slide $d_P = -0.10 - 0.20 = -0.30$ and $d_U = 0.20 - (-0.10) = 0.30$, so $w^* = 0.30/0.60 = \frac{1}{2}$ and $R^* = (0.30 \times (-0.10) - (-0.30) \times 0.20)/0.60 = 0.03/0.60 =$

5%. When the two companies are mirror images, each earning g in its good state and b in its bad one, the formulas collapse to $w^* = \frac{1}{2}$ and $R^* = (g + b)/2$: here $(20\% - 10\%)/2 = 5\%$.

One mix is riskless: the 50–50 split earns 5% in both states

Return of the mix if it rains and if it is sunny, against the share w of the money put in Parasol & Co



Reconstructed — no slide carries this figure. Inputs: 01a p. 3 (the four returns and the 4% rate).

Reconstructed — no slide carries this figure. The return of a mix of Parasol and Umbrella in each state, plotted against the share of the money put in Parasol, with the bank's 4% as a dashed line.

How to read this: the horizontal axis is the share w in Parasol. The blue line is the mix's return if it rains, $20\% - 30\% w$, and the orange line its return if it is sunny, $-10\% + 30\% w$. At any share other than $\frac{1}{2}$ the two lines are apart, and that vertical gap is weather risk; at $w = 0.6$ the mix earns 2% or 8%. The lines cross at $w = \frac{1}{2}$, where the mix earns 5% whatever happens. The dashed line is the bank's 4%. The one-point gap between the crossing and the dashed line is the free lunch, and no arbitrage means the dashed line must pass through the crossing.

Interactive spec — A riskless mix of two risky companies, and the rate it pins down

The sliders arrive with the site; the previewer shows the spec.

```
id: arbitrage-weights
title: A riskless mix of two risky companies, and the rate it pins down
inputs:
  - {name: RP_rain, label: "Parasol's return if rainy", min: -0.30, max: 0.30, step:
0.01, default: -0.10, format: percent}
  - {name: RP_sun, label: "Parasol's return if sunny", min: -0.30, max: 0.30, step:
0.01, default: 0.20, format: percent}
  - {name: RU_rain, label: "Umbrella's return if rainy", min: -0.30, max: 0.30, step:
0.01, default: 0.20, format: percent}
  - {name: RU_sun, label: "Umbrella's return if sunny", min: -0.30, max: 0.30, step:
0.01, default: -0.10, format: percent}
  - {name: rf, label: "Bank's borrowing and lending rate", min: 0.00, max: 0.10, step:
0.005, default: 0.04, format: percent}
series:
  - {name: "return if rainy", x: w, x_range: [0, 1], y: "w*RP_rain + (1 - w)*RU_rain"}
  - {name: "return if sunny", x: w, x_range: [0, 1], y: "w*RP_sun + (1 - w)*RU_sun"}
  - {name: "bank rate", x: w, x_range: [0, 1], y: "rf", style: dashed}
x_axis: {label: "share w of the money in Parasol & Co"}
y_axis: {label: "return of the mix", format: percent}
readout: ["(RU_rain - RU_sun)/((RU_rain - RU_sun) - (RP_rain - RP_sun))", "((RU_rain -
RU_sun)*RP_rain - (RP_rain - RP_sun)*RU_rain)/((RU_rain - RU_sun) - (RP_rain -
RP_sun))", "200*(((RU_rain - RU_sun)*RP_rain - (RP_rain - RP_sun)*RU_rain)/((RU_rain -
RU_sun) - (RP_rain - RP_sun)) - rf)"]
```

The three readouts are the riskless share w^* , the riskless return R^* , and the sure profit per \$200 borrowed, $200(R^* - r_f)$, which is \$2 at the slide's numbers and turns negative when the bank's rate is above R^* , the sign that the trade should be reversed.

"This is the deep idea", Dávila says of the whole construction, where the course will spend a lot of time, and the kind of argument it will use again and again. For today Dávila offers "three simpler examples of this idea"  15:21, which are the subject of §4.

Self-check. Suppose the bank's rate were 6% and the two companies' returns were unchanged. Does the slide's trade still make money? What does?

No. Borrowing \$200 at 6% means repaying \$212, and the mix is still worth \$210 in both states, so the slide's trade *loses* \$2 for sure. The free lunch has changed direction: sell the mix short for \$200, lend the \$200 at 6% to collect \$212, and buy the mix back for \$210 whatever the weather, keeping \$2. That trade needs a short sale, which the course introduces in Lecture 2. Only at 5% does neither direction pay.

Self-check. The example never says how likely rain is. Why does that not matter, and what would change if the mix were 60–40 instead of 50–50?

With the 50–50 mix the profit is \$2 in both states, so its probability-weighted average is \$2 whatever the probabilities are, and, more to the point, there is no state in which you lose. With 60% in Parasol the mix earns 2% if it rains and 8% if it is sunny: against a 4% loan that is a \$4 loss or an \$8 gain per \$200. That is a bet on sunshine, and whether it is a good bet depends on the probability of rain. It is no longer an arbitrage.

Self-check. Which of the first three principles does each of these choices violate, if any? (i) Taking \$100 over \$200, both today. (ii) Taking \$100 in a year over \$100 today. (iii) Taking the coin flip for \$200 over a sure \$100.

(i) Non-satiation: more is preferred to less. (ii) The time value of money: money today is worth more than the same money later. (iii) Nothing is violated in the sense of a mistake: "there's no right answer here". The choice reveals an attitude to risk. The course *assumes* people are risk averse because at large stakes nearly everyone is, but a person who takes the small gamble is not being irrational.

4. No arbitrage in action: a joke, two supermarket shelves and a bucket of popcorn

🕒 16:13 · 01a pp. 5–7

This section establishes what has to be true for a price gap to be an arbitrage: the two things must be *identical*, and you must be able to buy the cheap one and sell the dear one. Its three everyday examples each fail, or pass, a different part of that test, and together they explain why arbitrage disciplines prices in finance far more than in a supermarket.

4.1 The hundred-dollar bill

🕒 16:13 · 01a p. 5

The slide tells what it calls an old joke, widely told among economists. An economist and a companion come upon a \$100 bill lying on the street. The companion reaches down for it, and the economist says: "Don't bother — if it were a real 100 dollar bill, someone would have already picked it up" (01a p. 5). Dávila's gloss: "This is the no-free lunch idea. It's the idea that these things don't happen."

The joke is a fair picture of how the principle should be held **EXPLANATION**. Taken literally the economist is wrong, since the bill is right there. Taken as a statement about what *lasts*, the economist is right: bills do not stay on pavements, precisely because people pick them up. No arbitrage is a claim about prices that survive, and it is non-satiation, everyone wanting more, that does the clearing.

Before the photographs Dávila restates the recipe in general form 🕒 18:02. Manufacture two things that are exactly identical, as the 50–50 mix was identical to a risk-free account. If they have different prices, "I can always buy whatever is cheap and sell whatever is expensive."

4.2 Mayonnaise: an arbitrage that is not one

🕒 17:13 · 01a p. 6

"You may be thinking, wow, this seems really complicated", Dávila says, but notions of arbitrage are very natural, and many people have met them while shopping. The slide is a photograph the lecturer took in a local supermarket, named aloud as Stop & Shop.



UNIT PRICE
\$6.37
PER PINT
HLM REAL MAYO
50225.52
000034349 - 70592
11.5 FL OZ (340mL)

\$2.19

UNIT PRICE
\$6.10
PER PINT
HLMNS RL MAYO 502 11.52
032270 35366 11.500FL OZ
11.5 FL OZ (340mL)

RETAIL PRICE
\$4.39

UNIT PRICE
\$3.99
PER PINT
HLMNS RL MAYO 502 11.52
032270 35366 11.500FL OZ
11.5 FL OZ (340mL)

\$7
07/23/20 WITH CARD

SAVE 49¢



UNIT PRICE
\$3.19
PER PINT
HLMNS REAL MAYO 502 11.52
032270 35366 11.500FL OZ
11.5 FL OZ (340mL)

\$3.99

SALE
\$3.49
PER PINT
PRICE GOOD THRU: 07/02/20 WITH CARD

\$2.89



01a p. 6 — the photograph: on the upper shelf, Hellmann's 340 mL squeeze bottles labelled "Made with Cage Free Eggs", tagged 4.39; on the lower shelf, 591 mL bottles labelled "100% Recycled Bottle", tagged 3.99 with a yellow sale tag at 3.49.

How to read this: compare the two shelves. The smaller bottle on top costs more in total than the bigger bottle underneath. Then do what the slide's last line says, "Read the labels carefully": the wording on the front of the two bottles is not the same.

Dávila reads out two prices: the top bottle is 340 millilitres at \$4.39, and the bottom one is 591 millilitres at \$3.49 "if I have the coupon". The slide adds the larger bottle's regular price, \$3.99, and the shelf tags in the photograph carry the store's own unit prices **SLIDE ONLY**:

Bottle	Shelf price	Store's unit price, per pint	Per millilitre
162 mL (5.5 fl oz), also on the upper shelf	\$2.19	\$6.37	1.352¢
340 mL (11.5 fl oz)	\$4.39	\$6.10	1.291¢
591 mL (20 fl oz), regular	\$3.99	\$3.19	0.675¢
591 mL, on sale ("SAVE 50¢ EACH", price good through 07/02/20 with the store card)	\$3.49	\$2.79	0.591¢

The per-millilitre column is this note's arithmetic, price divided by volume. On sale, the big bottle is cheaper outright by \$0.90 and costs less than half as much per millilitre: $1.291/0.591 \approx 2.19$ times cheaper. (The \$6.10 tag is the store's truncation of $4.39 \div 11.5 \times 16 = 6.108$; the other three tags round correctly.)

Dávila asks the room three questions: is this an arbitrage opportunity, does it make sense for the supermarket, and what are you tempted to do when you see it?

GAP Not recoverable — 18:39

A student answered, and the answer is not in the recording: there is a gap of about seven seconds before Dávila's "Perfect." Only the lecturer's restatement of it survives, and that is what the next paragraph reports.

"You start squeezing, right? That's the natural inclination. You buy a big one" and squeeze it into small bottles to sell. "You're going to make a lot of money", though, Dávila adds, "it's not the right thing to do"

18:39. That is the arbitrage that seems to be lurking here: two identical things, mayonnaise, at different

prices, so buy the cheap one and sell the expensive one. "Now, here there's a twist", something that makes this not a true arbitrage opportunity, and the class is asked to find it.

One student suggests that the bottles are not the same size  19:27, which Dávila calls "something related". A second asks whether it is because one is gluten-free  19:34. Dávila likes the instinct, reading the label, and gives the difference meant: "It's cage-free eggs." The top bottle is made with cage-free eggs and the bottom one does not say so, and if it were, the label would say it. "The one on top is not the same as the one on the bottom", and some people really like mayonnaise made with cage-free eggs. The photograph bears this out, and shows where the second student's guess came from: the upper-shelf bottles' labels read "Made with Cage Free Eggs" and the 591 mL bottles' labels do not, and a "Gluten Free" flag hangs from the 340 mL bottle's shelf tag.

4.3 Why the twist matters: differentiated products, identical dollars

 20:00

In other parts of economics, Dávila says, international trade for example, you see that people place very different values on things that are almost identical. A dress in yellow may sell for a very different price from the same dress in black; perhaps the black one is nicer and can be worn to a ball. "It's called **product differentiation**." A seller of differentiated products can charge different prices for near-twins, and nobody can arbitrage the gap away, because the buyer of the expensive one does not regard the cheap one as the same thing.

Then the contrast that makes the whole course possible: "Finance is very special because all dollars are made the same, okay? All dollars are equally green"  20:38. That is why arbitrage is so important in finance, and so unimportant to people who sell mayonnaise. A claim that pays a dollar is the same as any other claim that pays a dollar, so two ways of getting the same dollars *must* cost the same.

GAP Not recoverable — 20:43

The sentence that follows "equally green" names the property, and the word cannot be settled. The recording has "All money is sort of tangible, and that is why arbitrage is so important for us"  20:43; a second, rough automatic transcript of the same audio has "fungible" in place of "tangible". No slide carries the point. "Tangible" would sit oddly with the lecturer's own insistence, twelve minutes later, that the distinction between kinds of asset is "not about tangibility"  32:59 (\$7), but that does not prove what was said. This note rests the point on the clearly recorded sentence, that all dollars are the same, and uses *fungible*, meaning that any unit can stand in for any other, as its own word for it.

One qualification keeps the slogan honest (**EXPLANATION**). Dollars are interchangeable only when they arrive at the same date and in the same state of the world. A dollar next year is not a dollar today (principle 3), and

a dollar paid only if it is sunny is not a sure dollar (principle 2). The Parasol and Umbrella trade works because it lines up *both*: \$210 at the same date, in every state.

So the mayonnaise pricing is "perfectly fine". In principle it looks like an arbitrage opportunity; look more carefully and the products are different, so the trade would not work. Try to sell your refilled bottle and people will tell you that theirs is the cage-free one, that it is different, and that they are happy to pay a lot for it.

4.4 Nutella: identical goods, and still no trade

🕒 21:15 · 01a p. 7

A second photograph left the lecturer "completely fascinated".



01a p. 7 — the photograph: a shelf of Nutella jars in three sizes. The left shelf tag reads "NUTELLA SPREAD 13OZ", 5.28 per pound, 4.29; the right tag reads "NUTELLA SPREAD 26.5 OZ", 5.37 per pound, 8.89.

How to read this: read the orange unit prices, not the big shelf prices. The larger jar costs more per pound than the smaller one, the reverse of what bulk buying normally looks like and the reverse of the mayonnaise shelf. The 7.7 oz jars at the far left have no visible tag.

"Nutella, same Nutella, \$5.37 per pound, \$5.28 a small bottle." The large jar costs *more* per unit. The shelf prices behind those tags are \$4.29 for 13 oz and \$8.89 for 26.5 oz **SLIDE ONLY**, so two small jars give 26 oz for \$8.58, while one large jar gives 26.5 oz for \$8.89: thirty-one cents for an extra half-ounce. The slide's only text is the question "Does this make sense?" **SLIDE ONLY**.

Dávila's trade is the mayonnaise trade run in the other direction: "I buy the small ones and then I'm going to fill the big ones", and "I should be making a profit here every time I do that." Dávila asks what could possibly explain the pricing. A student suggests that the bigger jar would expire faster than the smaller one **21:56**. The only reason Dávila can think of is a buyer who for some reason needs a lot and does not want to deal with several small jars, "but it's a really bizarre reason": "if I wanted a lot of Nutella, I'd just buy two small ones." On that logic the store should be selling zero large jars; Dávila admits never having found the time to ask the manager.

What makes this case different from the mayonnaise is that "these are the exact same products, they just sell for different prices" **21:59**. No label explains the gap away. It is the same arbitrage idea, with the first half of the test passed.

	Are the two things identical?	Can you buy the cheap one <i>and</i> sell the dear one?	Verdict
Parasol + Umbrella against the bank (\$3)	Yes: \$210 for sure is \$210 for sure	Yes, in the example: borrow and invest freely	A true arbitrage, so the prices cannot last
Mayonnaise, small against large	No: cage-free eggs on one label only	—	Not an arbitrage: product differentiation
Nutella, small against large	Yes	Only half: a shopper can buy small jars, but has nowhere to sell a refilled large one at \$8.89	A mispricing that can persist: nobody can profit from it at scale; shoppers simply should not buy the large jar

The last row's verdict is this note's summary of the lecturer's argument, and it leads directly to the lecture's next word, frictions.

4.5 Popcorn, frictions, and where this is heading

🕒 21:59

At a baseball game the gigantic popcorn is very cheap and the small one very expensive, and Dávila is sure many in the room have had the idea of buying a big bucket and selling small packets. "We have all these frictions, right? We cannot start to do it." A **friction** is anything that makes a trade costly or impossible to carry out: here, repackaging, the time it takes, and having no right to sell in the stands (*explanation: the lecture names the word and not the list*). Frictions are why grocery-shelf and stadium price gaps survive. In financial markets they are small relative to the sums involved and the goods are identical dollars, so arbitrage arguments bite hard.

How hard: "these are the kind of forces that will derive things like the Black-Scholes equation", which Dávila describes only as "a really fancy equation" built on the same ideas. No equation was shown; it belongs to Block 9. Arbitrage gets its real treatment "after the break", in the second half of the course 🕒 23:13. Today's aim was the gist.

Self-check. In one sentence each: why is the mayonnaise shelf not an arbitrage, and why does the Nutella shelf not make anyone rich even though the jars are identical?

Mayonnaise: the two bottles are different products (only the small one is made with cage-free eggs), and an arbitrage needs two *identical* things at different prices. Nutella: the goods are identical, but only the buying half of the trade is available, since a shopper can buy two small jars instead of one large one but cannot sell refilled large jars at the shelf price; frictions block the selling half, so the odd price can persist.

Self-check. Why does arbitrage matter so much in finance and so little to people who sell mayonnaise?

Because of what is being traded. Groceries are differentiated products, and buyers value near-identical items differently, so a price gap need not be an opportunity. Financial claims pay dollars, and "all dollars are equally green": two claims that deliver the same dollars at the same dates and in the same states are the same good, so they must sell for the same price, or someone buys the cheap one and sells the dear one. That is why a whole theory of pricing can be built on the absence of arbitrage.

Self-check. Using the shelf tags, check the claim that two small Nutella jars beat one large one.

Two 13 oz jars: $2 \times 13 = 26$ oz for $2 \times 4.29 = \$8.58$, which is $8.58/26 = \$0.33$ per ounce. One 26.5 oz jar: \$8.89, which is $8.89/26.5 = \$0.3355$ per ounce. Per pound, multiply by 16: \$5.28 against \$5.37, the two figures on the tags and the two read out in class. The large jar's extra half-ounce costs 31 cents, a rate of 62 cents an ounce, nearly double the 33 cents an ounce that Nutella costs in small jars, so the large jar is never the better buy.

5. The language of rates: percent, percentage points and basis points

🕒 23:13 · 01a pp. 8–9

This section establishes the three units in which rates and their changes are quoted, and the one confusion among them that Dávila flags as costly. "Now let's get into the details": basic terminology that the class half-knows and that the course will assume from here on.

5.1 Percent is a number

🕒 23:13 · 01a p. 8

The percent sign "just means 1 over 100". Wherever you see it, you may replace it with $1/100$, and everything else follows from that substitution.

Written	As a fraction	As a power of ten	As a decimal	Read as
1%	$1/10^2$	10^{-2}	0.01	"one percent"
3%	$3/10^2$	3×10^{-2}	0.03	"three percent"
$\%^2$, that is $(1\%)^2$	$1/10,000 = 1/10^4$	10^{-4}	0.0001	"one-hundredth of one percent", or "one basis point"

The last row is the slide's shorthand: a percent of a percent, $(1/100)^2$, which equals 0.01%. A percent squared, Dávila says, is quite common when you work with very small units, and it has its own name, one basis point. The reading "one-hundredth of one percent" is printed on the slide and was not said aloud **SLIDE ONLY**. Anyone reading the *Wall Street Journal*, "as I told you to do", will see basis points "left and right" 🕒 23:40 .

Dávila uses the moment to say what much of the course is for: giving you the right language, so that you can talk to people in finance and be understood. The theme returns in §9.

5.2 Percentage points against percent

🕒 24:28 · 01a p. 8

A quantity moves from 40% to 42%. There are two correct ways to describe that move, and they give different numbers:

$$42\% - 40\% = 2 \text{ percentage points}, \quad \frac{42 - 40}{40} = 0.05 = 5\%$$

The first subtracts the two levels, and its unit is the percentage point; the second divides the change by the starting level, and is a percent change. The slide's wording: "a 'two percentage point increase', but ... an actual '5 percent increase' in what is being measured" (01a p. 8).

EXAM SIGNAL Percentage points are not percent

"Very important, big confusions for doing these things wrong. I'm just sort of flagging it here so you're cautious" 🕒 24:37 . A move from 40% to 42% is **+2 percentage points** and a **5% increase**. Saying "a 2% increase" for it is the error.

What exactly Dávila said when reading this line out cannot be settled from the recording, which supports two readings; both are set out in a Warning inside the worked problem on this slide (Worked problems). The slide's wording is the one to learn either way.

5.3 Basis points

🕒 24:48 · 01a p. 8

DEFINITION Basis point

One **basis point** (bp; plural bps) is one-hundredth of one percent:

$$1 \text{ bp} = 0.01\% = \frac{1}{10,000} = 0.0001 = 10^{-4}$$

So 100 bps equal 1%, 200 bps equal 2%, and 50 bps equal 0.5% (01a p. 8).

Of the slide's equalities the lecture says aloud only that a basis point is 0.01%, or ten to the minus four; the 100, 200 and 50 bp conversions and the slide's reason for the unit are **SLIDE ONLY**. That reason: basis points are "a convenient unit of measurement in contexts in which percentage differences of less than 1% are common", which describes interest rates exactly.

The lecturer's own example is not on any slide: if the interest rate is 2.25% and the Fed moves it to 2.5%, "you'll see there's 25 basis points" of change **24:48**. The unit has a second virtue, which the worked problem on basis points develops **EXPLANATION**: it cannot be misread. "Rates rose 25 basis points" can only mean an absolute move of a quarter of a percentage point, whereas "rates rose 11%" would leave the listener to guess whether the change was relative or absolute, which is the trap of \$5.2.

EXAM SIGNAL Basis points will be in the questions, and all of this is assumed

On basis points: "it's this language that you hear all the time, we'll use it in the course, I'll use it in the questions" **24:48**. And on the terminology slide as a whole: "this is an introductory course, because we're starting from the very beginning, but I will assume you know all of this" **25:16**.

One table converts everything in this section:

Decimal	Percent	Basis points	Example in this lecture
0.0001	0.01%	1 bp	the definition
0.0025	0.25%	25 bp	the Fed's move from 2.25% to 2.50%; a "quarter point"
0.005	0.5%	50 bp	the <i>Journal's</i> rate cut; "half a point"
0.01	1%	100 bp	the gap between the 5% mix and the 4% loan in §3
0.02	2%	200 bp	the move from 40% to 42%, in percentage points

5.4 The same cut, said three ways

25:16 · 01a p. 9

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<https://www.wsj.com/articles/why-is-wall-street-so-sold-on-the-50-basis-point-rate-cut-11563558992>

ECONOMY

Why Is Wall Street So Sold on the 50-Basis-Point Rate Cut?

The market was pricing in as high as a 71% chance of the Fed lowering its federal funds rate by 0.5 percentage point after its July 30-31 meeting, the highest odds this year



Will Jerome Powell and the rest of the voting members choose half a point or a quarter point? Investors love to speculate.

PHOTO: TOM WILLIAMS/CQ ROLL CALL/NEWSCOM/ZUMA PRESS

By Akane Otani

July 19, 2019 1:56 pm ET

01a p. 9 — a Wall Street Journal article headed "Why Is Wall Street So Sold on the 50-Basis-Point Rate Cut?", with a photograph of Jerome Powell at a microphone.

How to read this: find the size of the rate cut in three places. The headline says "50-Basis-Point", the line under it says "0.5 percentage point", and the photo caption says "half a point or a quarter point". "50 basis points", "0.5 percentage point" and "half a point" are one and the same number, 0.005; a quarter point is 25 bp.

Dávila reads the headline aloud and makes the point directly: "I think the journalists use all their ways to say the same thing", so it is important to understand that 50 basis points, half a point and 0.5 percentage point are all the same. The rest of the screenshot was not read out SLIDE ONLY: the article is by Akane Otani, dated 19 July 2019, in the Economy section, at [wsj.com/articles/why-is-wall-street-so-sold-on-the-50-](https://www.wsj.com/articles/why-is-wall-street-so-sold-on-the-50-)

basis-point-rate-cut-11563558992 ; its sub-headline says the market was pricing in as much as a 71% chance that the Fed would cut the federal funds rate by 0.5 percentage point after its meeting of 30–31 July, the highest odds that year; and the caption asks whether Powell and the other voting members will choose half a point or a quarter point. Of the photograph the only remark is: "Powell, of course, is not with us anymore, but he was there."

Self-check. Support for a policy rises from 20% to 25%. State the change in percentage points and in percent. Then do the same for a mortgage rate that falls from 7.0% to 6.3%, adding basis points.

Support: $25 - 20 = 5$ percentage points, and $5/20 = 25\%$. Calling it "a 5% increase" would understate the relative change fivefold. Mortgage rate: $6.3 - 7.0 = -0.7$ percentage points, which is -70 basis points; as a percent change it is $-0.7/7.0 = -10\%$. A newspaper would say "down 70 basis points", and nobody could misread it.

Self-check. Write 75 basis points as a percent and as a decimal. What is 1% of 1%?

$75 \times 0.01\% = 0.75\%$, and $75 \times 0.0001 = 0.0075$. One percent of one percent is $(1/100)^2 = 1/10,000 = 0.0001 = 0.01\%$: exactly one basis point, which is why the slide writes a basis point as $\%^2$.

6. The balance sheet

🕒 26:06 · 01a p. 10

This section establishes the balance sheet as the way to state anyone's financial position, defines net worth, and gives net worth its two everyday names, wealth for a person and book value of equity for a firm.

Dávila starts by asking who has taken an accounting course and who never has, and reassures the second group: not knowing anything is nothing to be ashamed of, and the course will give the class all it needs. For anyone who wants more, the course materials include extra slides that are taught only if time allows, one of them on the basics of financial accounting, worth "a couple hours", especially for students heading to the advanced courses.

GAP Material mentioned, not available — 26:06

The extra slides on financial accounting are not among the course files this note was built from, so nothing of their content is given here.

6.1 Assets, liabilities, net worth

⌚ 26:54 · 01a p. 10

DEFINITION Balance sheet, assets, liabilities, net worth

A **balance sheet** sets out what someone owns and how it is funded. **Assets** are the things you own. **Liabilities** are what you owe. **Net worth** is the difference:

$$\text{Net Worth} = \text{Value of Assets} - \text{Value of Liabilities}, \quad NW = A - L$$

(01a p. 10)

It applies to anyone who owns anything: "Me, you, Yale, any company." The slide's list is firms, households, banks and the central bank (the last **SLIDE ONLY**), and Dávila adds a government, and even the world ⌚ 28:10. For illustration, the lecturer's own assets are a phone, the cash in a wallet, a backpack, a house and bank and retirement accounts, and they go on the left side. Liabilities go on the right: a mortgage is long-term debt, and credit-card debt is short-term debt. Once both sides are filled in, "you put a line, and then you subtract", and that is your net worth: how much you have minus how much you owe.

The slide's example is a firm. Dávila reads out the asset side, \$100 in cash, \$50 in investments and \$30 in inventories, "the amount of product that is lying around the store"; the right-hand side was shown and not read **SLIDE ONLY**.

Assets		Liabilities	
\$100	Cash	Short-term debt	\$30
\$50	Investments	Long-term debt	\$40
\$30	Inventories		
		Net worth	\$110

$$NW = A - L = (100 + 50 + 30) - (30 + 40) = 180 - 70 = \$110$$

Total each side, then subtract; the result is the figure the slide prints.

On the slide, net worth sits on the right-hand side, under the two debts and below a double rule. That layout is itself a statement (*explanation: the slide writes only the subtraction*): the two columns add to the same total, $A = L + NW$, here $180 = 70 + 110$. Everything the firm owns was paid for either with someone else's money (liabilities) or with the owners' (net worth), which is the sense in which a balance sheet shows how it is funded.

The point of the exercise, Dávila says, is precision about three things: what you have, what it is worth, and what you owe. And the two sides interact: "I can have a lot of assets, but if everything is borrowed, my net worth is small. If I have a lot of assets and I don't borrow anything, then my net worth would be much larger" (⌚ 28:10). The worked problem on this slide puts numbers on that comparison, and on what a fall in asset values does to net worth when the debts stay put.

6.2 Two names for net worth: wealth, and book value of equity

⌚ 28:58 · 01a p. 10

For an individual, net worth is called **wealth**. "You'd be surprised" how often people confuse wealth with income. Income is something different: what arrives in your paycheck, or what your investments return. You can have high income and low wealth, or high wealth and low income. One is a stock, measured at a date; the other is a flow, measured over a period (EXPLANATION). This course talks about wealth.

For a firm, the same subtraction gives the **book value of equity**, "an important concept that we'll come back to later". The lecturer's illustration is Yale: "you can look at all the buildings, put a price on them, look at all the liabilities, Yale issues debt, you subtract it, that's the book value" (⌚ 29:38). The same goes for NVIDIA, Coca-Cola or any company. Later in the course book value will be contrasted with *market* value.

WARNING Book value is not what the assets would sell for today

Book value is computed from the values recorded in the accounts. Pricing every building at today's value is closer to **market value** (EXPLANATION).

Both names are underlined on the slide (SLIDE ONLY).

Self-check. A recent graduate has \\$2,000 in a bank account, a \\$1,500 laptop and \\$30,000 of student loans. What is the graduate's net worth? What would the lecture say is missing from the picture?

$NW = (2,000 + 1,500) - 30,000 = -\$26,500$. Net worth can be negative: the graduate owes more than the graduate owns. What the balance sheet as drawn leaves out is the asset the loans paid for, human capital, which the next section classes as a real asset. It is hard to put a dollar value on, which is why it rarely appears on a personal balance sheet, but it is the reason lending to the graduate makes sense (*explanation: the link between the two slides is this note's*).

Self-check. Give an example of high income with low wealth, and of high wealth with low income.

A newly hired banker with a large salary, no savings yet and student debt has high income and low, even negative, wealth. A retiree who owns a paid-off house and a portfolio but draws a small pension has high wealth and low income. Wealth is what you own minus what you owe at a date; income is what comes in over a period. The lecture's point is that the course's models are about wealth.

7. Real assets and financial assets

🕒 30:06 · 01a p. 11

This section establishes the distinction the whole course rests on: a real asset produces goods and services, a financial asset is a claim on what real assets produce, and the dividing line is use, not whether you can touch the thing.

DEFINITION Real asset, financial asset, capital market

Real assets are "assets used to produce goods and services": trees, factories, land, human capital, homes. **Financial assets** are contracts: "claims on the output produced by real assets", such as stocks, bonds and derivatives. **Capital markets**, also called financial markets, "are environments in which financial assets are traded" (01a p. 11).

Dávila reads out the slide's real assets except homes **SLIDE ONLY**, and dwells on the one that is not a physical thing. **Human capital**, the ideas in your head, is a real asset because you can generate knowledge and services from it. The example given is in the room: the teaching fellows have already learned finance, and they use that knowledge to help the class learn. "That's a service we're getting from them." It is not tangible, but it is an asset that produces a service.

A financial asset, by contrast, is a contract. Dávila used to describe it as a piece of paper, and now there is not even paper: it is a set of rules that determine who gets what 🕒 31:04. The example is a share of stock bought on an app such as Robinhood's. Buying NVIDIA stock does not buy a piece of NVIDIA's building, and it does not buy the human capital of the people who work there. It buys a claim to the payoffs. At the end of the year NVIDIA collects the money from the chips it sells and pays its suppliers and its employees; a share is a claim on the dollars that remain. That last clause matters later: a stockholder is paid from what is left after others have been paid, which is the idea behind two of the workbook questions in the Self-check.

The test is not tangibility, and Dávila says so twice. The share is not physical, but "it's not about tangibility": the point is that you get no claim to anything that can itself be used to produce a good or a service. You get

a promise. Dávila restates the pair once more before moving on (🕒 32:59): a real asset can be used directly to produce a good or a service, whether or not you can touch it; a financial asset produces nothing by itself and is "just a claim to money, typically, or to goods", a set of rights that you buy. Any contract whose price you want to work out is a financial asset, and stocks, bonds and derivatives are the quintessential ones. The markets where such contracts trade are what this course is about.

Tangibility and the real–financial line cut across each other (*explanation: the examples in this table are this note's, apart from the two the lecture gives*):

	Real: produces goods or services	Financial: a claim on what others produce
You can touch it	a factory, a piece of land, a tree	a bond certificate printed on paper
You cannot touch it	human capital (the lecture's example)	NVIDIA shares held in an app (the lecture's example)

The two kinds of asset also differ on the balance sheets of \$6 (EXPLANATION). A real asset appears once, on its owner's left-hand side. A financial asset appears twice: as an asset of whoever holds it, and as a liability, or as equity, of whoever issued it. A mortgage is the bank's asset and the household's liability. That is why Dávila could speak of a balance sheet for "the world": add everyone's together and the financial claims cancel, leaving the real assets, which are what ultimately produce the output that every claim is a claim on.

Self-check. Classify each as a real or a financial asset: a delivery van; a share of Coca-Cola; a nursing degree; a ten-year Treasury note; an orchard.

The van and the orchard are real: they are used to produce services and goods. The nursing degree is human capital, which the lecture classes as real even though it is intangible, because it produces a service. The share and the Treasury note are financial: each is a contract giving its holder a claim on money that someone else's real assets (or, for the Treasury, the government's tax revenue) will generate. The test in every case is whether the thing *itself* produces, not whether it can be touched.

Self-check. "When I buy NVIDIA stock I own a small piece of its factories." What would the lecture say?

It would say you own a *claim*, not a piece of a building: you are "not buying a piece of the building", and you are not buying anyone's human capital. What the share entitles you to is a slice of the dollars left over after NVIDIA has sold its chips and paid its suppliers and employees. You cannot use your share to produce anything, which is what makes it a financial asset and not a real one.

8. What financial markets are for

🕒 33:31 · 01a p. 12

This section establishes the three roles of financial markets: financing projects, allocating risk, and smoothing consumption. The slide asks why financial assets and markets are important, and Dávila answers by imagining their absence: a very primitive economy, "the Stone Age or something", with no stocks and no bonds, where people simply barter goods. The modern economy is more complicated because financial markets do three useful things.

Role 1: project financing 🕒 34:16 . Dávila's example, told in the first person: a fantastic idea, an ice cream that Yale students will love, sold outside the Commons, certain to make a lot of money — but no capital. "What can I do? I can go and ask for a loan, or ask for equity, and then start my business and make money." The slide's example is the large-scale version of the same two routes, "equity/bond issuance" **SLIDE ONLY** . Financial markets connect people who have ideas and no money with people who have money and no ideas.

Role 2: the allocation of risk, which the slide splits into two (01a p. 12).

- **Risk sharing** 🕒 34:54 spreads a risk across many people. Suppose everyone here works at the same company and one of us, it could be any of us, is going to get sick and be unable to work. If we all pay in a little, and whoever falls sick is paid out of the pot, nobody faces the full loss. The modern economy does a great deal of this: unemployment insurance and insurance contracts generally. "You shift resources to people who need it in states where they're not doing great." Buying insurance is buying a financial contract.
- **Risk transfer** 🕒 35:58 moves a risk from someone less willing to bear it to someone more willing. The earlier show of hands on the coin flip had already shown that people differ in how much risk they will tolerate, so there is room for the more tolerant to take risk off the others. One sentence of the lecturer's gloss on this is not recoverable from the audio 🕒 36:09 .

The slide gives two examples under this role: "Diversification (mutual funds)" and "Hedging (ex: currency hedging)". The hedging example is personal: Dávila goes to Spain every summer and wonders how the euro is doing, since a move in the exchange rate changes what everything there costs. "You could buy a contract to hedge that risk." Diversification, Dávila adds 🕒 36:37 , serves investment as well as insurance: should you put your money only in NVIDIA and Google, or hold a diversified portfolio, so that if those two companies do poorly the loss does not fall entirely on you? The principle of diversification arrives "in a few weeks" 🕒 34:54 , with portfolio choice; the pairing of diversification with mutual funds is on the slide only and is picked up in §13.

Role 3: consumption smoothing 🕒 37:01 . You are young and do not have much money now, but a bright future awaits, and you want something nice today: you borrow, and pay back later. Or a child is on the way,

you need a bigger house and do not have the full price: you take a mortgage and make payments over time. The slide's label for the instruments is "Saving and Borrowing" (SLIDE ONLY). This role, Dávila says in wrapping up, has not so much to do with risk: you are young today and old tomorrow, and you want to smooth over time, and across states (🕒 37:25).

Role	The problem it solves	The lecture's example	Instruments named
Project financing	Ideas and money are held by different people	The ice-cream stand outside the Commons	A loan or equity; equity and bond issuance
Risk sharing	A loss that could hit any one of us	The sick-coworker pool; unemployment insurance	Insurance contracts
Risk transfer	People differ in willingness to bear risk	The euro on the summer trip to Spain	Hedging contracts; diversified portfolios, mutual funds
Consumption smoothing	Income and needs arrive at different times	Borrowing when young; the mortgage for a bigger house	Saving and borrowing

The three roles map onto the definition of §2 (EXPLANATION). Financing and smoothing move resources *over time*; risk sharing and transfer move them *across states*. A financial market is the place where those two kinds of trade are made. The roles come back at the very end of the lecture, where Dávila uses risk sharing and risk transfer to explain why asset-backed securities exist (§13).

Self-check. What is the difference between risk sharing and risk transfer? Give the lecture's example of each.

Risk sharing spreads one risk across many people who each face it, so that no one bears the whole loss: everyone pays a little, and whoever is hit is paid. The lecture's example is the group of coworkers who pay into a pot for whichever of them falls sick, and its real-world versions are unemployment insurance and insurance contracts. Risk transfer moves a risk from a person less willing to bear it to one more willing, which is possible because, as the coin-flip poll showed, people tolerate risk differently. The lecture's example is hedging the euro before a trip to Spain by buying a contract.

Self-check. Which role of financial markets is each of these? (i) A biotech start-up sells shares to fund a drug trial. (ii) A student borrows for tuition. (iii) A homeowner buys fire insurance. (iv) An airline locks in next year's fuel price.

(i) Project financing, by issuing equity. (ii) Consumption smoothing: little money now, higher income later, so borrow now and repay later (it also finances human capital, a real asset). (iii) Risk sharing: many homeowners pay premiums, and the few whose houses burn are paid. (iv) Risk transfer by hedging: the airline passes the fuel-price risk to a counterparty more willing to bear it, exactly as the traveller to Spain could hedge the euro.

9. Three basic ideas, the language, and the Nobel prizes

🕒 38:11 · 01a pp. 13–14

This section establishes the three ideas that organise the course's models, arbitrage, optimality and equilibrium, and shows that the course's blocks are, one by one, the ideas that have won Nobel prizes in financial economics.

9.1 Arbitrage, optimality, equilibrium

🕒 38:11 · 01a p. 13

Each idea is a question on the slide (01a p. 13).

Idea	The slide's question	What Dávila said	Where it lives EXPLANATION
Arbitrage	What do we know about asset prices by just assuming that there are no risk-free profit opportunities?	If we assume there are no free lunches, we can already say interesting things about prices; more "as the semester goes"	Blocks 7–9; today's §3 and §4
Optimality	What is the best combination of financial assets, given asset returns and an investor's preferences?	The best you can do given some set of resources. In intermediate micro you maximize utility subject to a budget constraint; here you maximize utility subject to the combinations of risk and return that can be achieved by combining assets. "We're going to spend literally three weeks thinking about this idea"	Block 3, Portfolio Choice, four lectures on the printed outline
Equilibrium	What are asset prices and allocations when all investors have optimized and markets clear?	Once there is a model in which everybody behaves optimally, put everybody together and see what it predicts for prices and allocations	Block 4, the CAPM, which Dávila introduced at the start as what happens "if everybody allocates their money" the best way

The phrase "markets clear" is on the slide only **SLIDE ONLY**. The three are nested **EXPLANATION**: equilibrium presupposes optimality, since it asks what happens when every investor has optimized, while arbitrage needs neither, only that people prefer more to less. That is why arbitrage arguments are the most robust in finance and why the principle could be introduced on the first day. Dávila states the three now because they will come back throughout the semester.

9.2 Why the lecturer cares about language

🕒 39:32 · 01a p. 13

The slide's closing line is "In this course, you'll learn the language and the tools of finance"; only the first half is spoken to (*the "tools" are slide only*). Students who have taken Dávila's courses remark on how much those courses stress language, and Dávila is glad they notice. Language is what lets people communicate

quickly and get to the important things; without the right words, "we're going to be sort of talking past each other". The right language is the language the *Wall Street Journal* uses, and Dávila promises that after this course you will read the newspaper far more fluently than before. The terminology of §5 to §7 is the first instalment.

9.3 The Nobel prizes, block by block

🕒 40:09 · 01a p. 14

Dávila's "last advertisement": the slide lists the Nobel prizes in economics that belong to financial economics, and the course covers each of the ideas. The numbers in brackets are the course's blocks; Dávila reads most of them out, sometimes saying "chapter" for block.

Laureate	Insight (01a p. 14)	Blocks	Said in class
Markowitz	Optimal portfolio choice	3	
Sharpe	CAPM	4	
Tobin	Two-fund separation	3, 4	"Everything here is Tobin names, as you may have noticed by now"; "really cool result, you'll see"
Merton	Dynamic portfolio choice; option pricing	3, 7, 9	Said as "portfolio choice"; "Dynamic" is SLIDE ONLY
Scholes	Option pricing (Black–Scholes)	9	The equation Dávila had called "really fancy" in §4.5
Stiglitz	Informational efficiency	5	
Thaler	Behavioral finance	5	"A little bit of behavioral finance"
Hansen	Testing methodology	4, 5	Named only as being for testing; the slide's wording is SLIDE ONLY
Fama	Efficient markets	5	Read together with Shiller as "blocks 5 and 6", for market efficiency; the slide gives Fama block 5 alone
Shiller	Inefficient markets	5, 6	"Also a big name here at Yale"

"We're really going to go through all the big ideas", Dávila concludes, at an intermediate level. Read against the outline of §1.5, the table is a map of the first half of the course by author: Markowitz and Tobin for Block 3, Sharpe for Block 4, Fama, Shiller, Stiglitz and Thaler for Block 5; and of the second half, Merton and Scholes for options in Block 9.

Self-check. Which of the three basic ideas is each of these? (i) Deciding what share of your savings to hold in stocks. (ii) Concluding that the bank's rate in the Parasol example must be 5%. (iii) Asking what stock prices must be if every investor holds their best portfolio and all shares are held by someone.

(i) Optimality: the best combination of assets given returns and your preferences. (ii) Arbitrage: a statement about prices from nothing more than the absence of risk-free profit opportunities. (iii) Equilibrium: prices and allocations when all investors have optimized and markets clear; it is the question the CAPM answers.

Self-check. Why can an arbitrage argument be made on the first day of the course, while equilibrium has to wait for Block 4?

Because of what each assumes. An arbitrage argument needs only non-satiation: if a sure profit with no outlay existed, anyone who prefers more to less would take it, in unlimited size. It needs no model of how people feel about risk and no probabilities. Equilibrium asks what prices are "when all investors have optimized and markets clear", so it first needs a model of each investor's best choice (optimality, Block 3) and then has to put all investors together (Block 4).

10. The asset classes, I: fixed income

🕒 41:14 · 01a pp. 15–16

This section establishes what a fixed-income security is, what "fixed" does and does not promise, who the main issuers are, and what U.S. interest rates have looked like for seventy years. It opens the last part of the meeting: "In my last nine minutes", Dávila says, the important asset classes will be described at a high level. The words are defined now because they will be used as examples for the rest of the term, and "if I don't define them now, you're going to be lost".

10.1 A promise of predetermined payments

🕒 41:50 · 01a p. 15

DEFINITION Fixed-income security

A **fixed-income security** is a "promise to make fixed payments in the future". Its fixed cash flows are called **coupons** or interest payments, and its valuation needs only the time value of money (01a p. 15).

Fixed income is "the most basic, the most elementary type of security". A security is a promise: you buy a bond, and what the bond entitles you to is a set of fixed payments in the future. Dávila is careful about the word. "Fixed" really means *predetermined*: the payments do not have to be constant, and could for instance grow at some rate, but when you buy the asset you know what you are getting. Because the amounts and dates are known in advance, valuing them "connects to our principle of time value of money": it is principle 3 and nothing more. That valuation begins in the Lecture 3 note.

10.2 Treasuries, and what "safe" means

🕒 42:48 · 01a p. 15

The best example is the debt of the U.S. Treasury, which comes in three classes by maturity. Dávila names the three and gives the first maturity; the other two ranges are on the slide **SLIDE ONLY**, the spoken version of them being garbled in the recording.

Security	Maturity
Treasury bills	less than 1 year
Treasury notes	1 to 10 years
Treasury bonds	10 to 30 years

Lecture 3 prices them, starting with the bill: with less than a year to run it makes a single payment, which makes it the course's first zero-coupon bond (Lecture 3 note).

These have traditionally been considered safe investments, and the reason given is about default: "nobody could have conceived that the U.S. government would not pay back". The slide asks the question and answers it, "Why are government bonds seen as a safe investment? No default risk (at least US)", and the course works with that assumption. The slide's follow-up, "How about in Europe or other countries?"

SLIDE ONLY, Dávila answers from memory: default is very common for other countries.

GAP Not recoverable — 43:43

Dávila names three cases, and the middle one cannot be settled. The recording, in its least clearly heard passage, has "Argentina, Paris, Puerto Rico" ⌚ 43:43 ; a second, rough automatic transcript of the same audio has "argentina, anyone right here? Greece, puerto rico". The slide names no country. Argentina and Puerto Rico are common to both and are reported as said; the third is left unnamed here. One clarification on the list as said **EXPLANATION**: Puerto Rico is a U.S. territory, not a sovereign country, so it is an example of a government borrower that defaulted, not of a foreign sovereign.

The lesson Dávila draws is a caution about the word "fixed". Even though the payments are fixed in the contract, "people can always decide not to pay back, so nothing is truly fixed or predetermined". The *promises* are predetermined, and you can treat them as such, but keep default in mind; the course comes back to it briefly later.

In passing Dávila floats a name for later.

DEFINITION Yield curve

The **yield curve** is, in Dávila's words, "all these rates of different maturities put together in a picture": at one date, the interest rate on each maturity, plotted against maturity. The slide prints only the two words (*01a p. 15*).

The name is only being flagged, Dávila says, so that the class recognises it in the articles sent out; the topic belongs to Block 8, three lectures on the printed outline. On those articles: Dávila will try to send a few curated *Wall Street Journal* pieces every week, and reminds the class that every Yale student can read the *Journal* free with a Yale login ⌚ 42:48 .

10.3 Municipal and corporate bonds

⌚ 44:45 · *01a p. 15*

Municipal bonds are issued by state and local governments, and unlike Treasuries "there's a lot of default risk". The slide asks "Recent examples?" **SLIDE ONLY**; Dávila's example is Orange County, California, together with a reading recommendation.

GAP Material mentioned, not available — 44:45

"I gave you a really cool reading recommendation for Orange County, California. Really, really cool thriller on that default case." The title is never said, the syllabus does not list it, and it is not among the course files this note was built from. Nothing about its content can be given here.

Corporate bonds are fixed income too, and they also carry default risk. Dávila's bottom line for the slide: fixed-income securities have predetermined payments; if there is default risk you may not get the money back; and these are "the simplest types of financial securities".

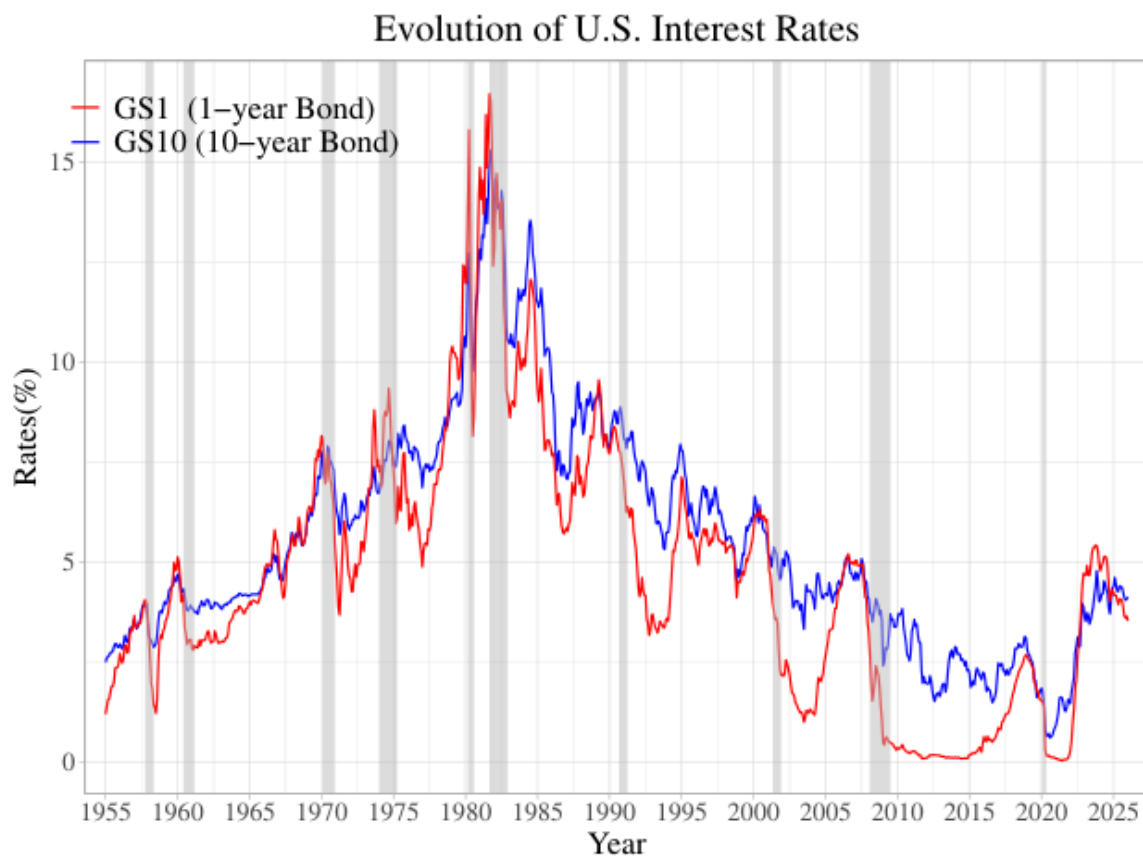
Note what the lecture does *not* do: it never ranks municipal against corporate bonds by riskiness. A workbook question asks for exactly that ranking, and its answer rests on the workbook's own claim; the Self-check says so where it matters.

10.4 Seventy years of U.S. interest rates

🕒 45:23 · 01a p. 16

"I love this picture." It is drawn by the code in one of Dávila's notebooks, so anyone can run it again.

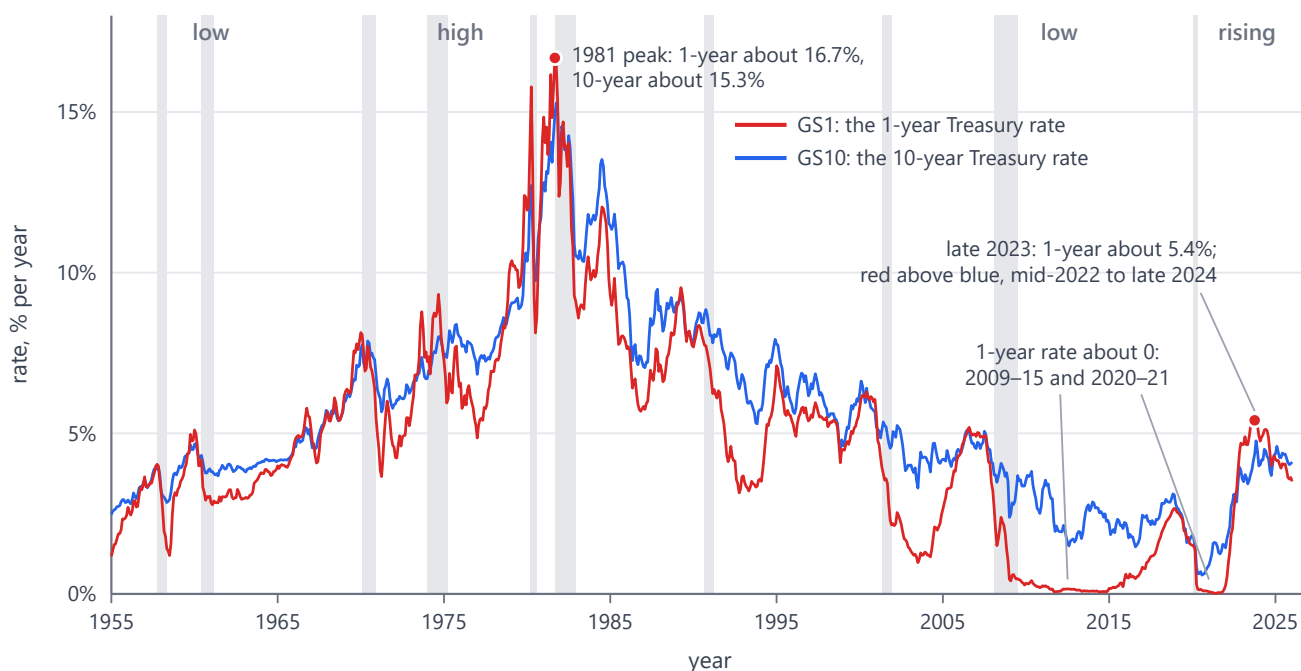
Interest Rates



01a p. 16 — original slide: "Evolution of U.S. Interest Rates", the 1-year rate (GS1, red) and the 10-year rate (GS10, blue) from 1955, in percent, with ten unlabelled grey vertical bands.

U.S. interest rates: low, high, low, and rising again

Traced from the slide's own drawing (01a p. 16). The slide prints no values: every number here is a reading.



Redrawn by tracing the slide. The grey bands are on the slide without a label, and are left unlabelled here.

Redrawn by tracing the slide's own lines, with the features named in the lecture and in this note marked. Every number is a reading of the drawing; the slide prints no values.

How to read this: time runs along the bottom, from 1955 to the start of 2026, and the vertical axis is the rate in percent. Red is the interest rate on a 1-year Treasury and blue the rate on a 10-year Treasury. Read the shape before anything else: a long climb to a peak around 1981, a forty-year decline to roughly zero, and a sharp rise from 2022. Then compare the two lines: blue is usually on top, and the stretches where red crosses above it are the unusual ones.

Dávila's own description is brief. The horizontal axis is time, the red line is the rate on the one-year bond and the blue line the rate on the ten-year bond, and the course will explain why the two differ and what it means when the curves come together or move apart. The recent history is what Dávila wants noticed: post-COVID there has been an increasing trend in interest rates, "and it happened in the last few weeks" as well; Japan's rates have also started to move up, which was in the news. The rest of that remark is not recoverable
 ⌚ 46:08 . It is the same news alluded to at the start of the meeting, when Dávila called bonds "very popular in the last few days" ⌚ 01:00 (\$1.5).

EXAM SIGNAL Know what this picture looks like

"These pictures that I'll show you in class" are worth knowing, what they look like and what they mean, because they give context. Dávila's one-line summary of this one: "low rates, high rates, low rates, increase in rates over the last five years, and that's a very good summary" to keep in your head

⌚ 45:23

What the chart shows, read off the drawing, all values approximate because the slide prints none

SLIDE ONLY:

- Both rates start low in 1955, about 1% for the 1-year and about 2.5% for the 10-year, and peak in 1981, the 1-year at about 16.7% and the 10-year at about 15.3%.
- The 1-year rate is close to zero in 2009–2015 and again in 2020–2021. The 10-year rate's low is about 0.6%, in 2020.
- Both rise steeply from 2022. The 1-year rate peaks at about 5.4% in late 2023, the 10-year at about 4.8%. At the right-hand edge they are about 3.5% and 4.1%.
- The 10-year rate is above the 1-year rate most of the time. The 1-year rate is on top for a little under one month in five, most recently from mid-2022 to late 2024.

WARNING This chart is not a yield curve

The yield curve was named on the slide just before this one, and both are about rates at different maturities, so the two are easy to run together (**EXPLANATION**). A yield curve is a snapshot: *one date*, rates plotted against *maturity*. This chart is a history: *two maturities*, rates plotted against *time*. Each date on this chart supplies just two points of that date's yield curve, and the episodes where red is above blue are dates on which the yield curve sloped down between one and ten years.

GAP Features the slide does not explain, and material not available — 45:23

The ten grey vertical bands are drawn on the slide with no legend, caption or spoken explanation, so this note does not say what they mark, and the redrawn figure leaves them unlabelled. The notebook that draws the chart, the weekly *Journal* articles, "the article I sent", and the article on interest rates promised here ("I'll give you an article for you to read on some of this") are not among the course files this note was built from.

Dávila closes the slide by saying the class will spend "three, four lectures" understanding what is behind these two series; that is Block 8.

Self-check. A bond's payments rise by 3% every year, on a schedule printed in the contract. Is it a fixed-income security? And in what sense does the lecture's caution that "nothing is truly fixed" reach even a Treasury bond's payment?

Yes. "Fixed" means predetermined, not constant: the payments "could grow at some rate", and what matters is that when you buy the asset you know what you are getting. The second part is the lecture's caution about default (§10.2): the *promise* is fixed, but the borrower can choose not to keep it. For U.S. Treasuries the course assumes that does not happen, which is what "safe" means here; for other governments, municipalities and corporations it can.

Self-check. Without looking: sketch the chart of U.S. 1-year and 10-year rates since 1955, and say in ten words what it shows.

Low in the 1950s and 1960s, rising to a peak around 1981 (roughly 15 to 17%), falling for four decades to about zero after 2008 and again in 2020–21, then rising sharply from 2022 to around 4 to 5%. Dávila's own summary, in the Exam signal above: low, then high, then low again, and rising over the last five years. The 10-year line is usually above the 1-year line; from mid-2022 to late 2024 it was below.

11. The asset classes, II: equity and derivatives

🕒 46:52 · 01a p. 17

This section establishes what distinguishes stocks from bonds, payments that are not predetermined, and derivatives from both, payments that depend on other assets' values, and summarises the three classes by what their valuation requires.

11.1 Equity

🕒 46:52 · 01a p. 17

Most students, Dávila guesses, have had more exposure to stocks, or **equity**, than to bonds, because that is what the news reports: the S&P 500 going up or down on the day, and companies such as Coca-Cola, Google (Alphabet) or NVIDIA. The slide defines equity in four lines (01a p. 17):

- "Claims to a share of the profit of a corporation + Ownership". The "+ Ownership" was not said aloud **SLIDE ONLY**; the claim to profit is §7's NVIDIA example.
- "Future cash-flows (dividends) are uncertain".

- "Maturity is indefinite" **SLIDE ONLY**. A bond ends on a stated date; a share has no such date and lasts as long as the company does. One of the workbook questions in the Self-check turns on this line, and the Lecture 3 deck makes the same point by calling a stock's horizon infinite (*02a p. 23*).
- "Valuation: Time Value of Money + Risk".

What Dávila stresses is the second line. When you buy a stock "you don't get a predetermined payment. You don't know how much you're going to get." The range of outcomes is wide in both directions: "If you buy a stock in a company and the company goes bankrupt, you get zero", whereas a little money put into NVIDIA about ten years ago would have made you "like a millionaire"  46:52 .

WARNING Said in class vs written — 47:39

The sentence that compares stocks with fixed income is recorded in two incompatible ways, and the sources cannot settle which was said. **Reading A** (the recording): "the important thing about stocks compared to fixed income is that now, you'll get money in the future so you don't have to discount it"

 47:39 . **Reading B** (a second, rough automatic transcript of the same audio): "now you get money in the future, so you have to discount it". The slide is unambiguous, and so is principle 3: equity is valued by "Time Value of Money + Risk". A stock's cash flows arrive in the future, so they *are* discounted, and because they are uncertain, risk has to be accounted for on top. Reading A, if it is what was said, was a slip; do not learn it.

Risk is therefore the new ingredient, and Dávila poses the questions the course will have to answer  47:49 . What is risky? Is NVIDIA risky? Is Coca-Cola? How is risk priced, and what compensation should risky things earn? "And I promise you, you'll find that what you thought was risky, maybe it's not", which is why these notions will have to be defined with care. That is the work of Blocks 3 and 4.

11.2 Derivatives

 48:14 · *01a p. 17*

DEFINITION Derivative

Derivatives "are securities whose payments depend on the values of other assets. That's the name, derivatives, derived from something." The slide's examples are options, futures and swaps, and their valuation needs "Time Value of Money + Risk + Optionality" (*01a p. 17*).

The name "sounds fancy, complicated", Dávila concedes. The course will talk briefly about futures and swaps and mostly about options. What characterises an option is that everything is conditional. The example is an

option on Apple stock: if Apple's price is sufficiently high, "I have the right to buy a stock"; "if the price is sufficiently low, I may not have the right to do it. It depends on the option that you buy." Options come at the end of the semester, and Dávila promises that once this conditionality is brought in, "really exciting and interesting things are going to happen". No payoff formula was given today; that is Block 9.

WARNING An option's right does not disappear when the price is low

Taken literally, "I may not have the right to do it" misdescribes the contract **EXPLANATION**. With the kind of option in the lecture's example, a right to buy at a price fixed in advance, the holder has that right whatever the stock price turns out to be. What changes with the price is whether using the right is *worth it*: if the stock can be bought more cheaply in the market, the holder simply lets the right go unused. The payoff is conditional on the price; the right is not.

11.3 The valuation ladder

The two asset-class slides, put side by side, say what each class adds to the valuation problem (01a pp. 15, 17). It is the closest thing to a map of the course's tools, and the "+ Optionality" rung was shown and not said **SLIDE ONLY**.

Asset class	Its cash flows	Valuation needs	Principles of §3 involved	Where the course builds the tool
Fixed income	Predetermined	Time value of money	3	Block 2, then Block 8
Equity	Uncertain dividends; no maturity	Time value of money + <i>risk</i>	3 and 2	Blocks 3 to 6
Derivatives	Depend on other assets' values	Time value of money + <i>risk</i> + <i>optionality</i>	3, 2 and 4	Blocks 7 and 9

The last two columns are this note's reading **EXPLANATION**; pairing options with principle 4 follows Dávila's remark in §4.5 that arbitrage forces are what deliver the Black–Scholes equation.

Self-check. For each asset class, say what its valuation requires and why.

Fixed income needs only the time value of money, because its payments are predetermined: the one thing to do is convert known future dollars into today's dollars. Equity needs the time value of money plus risk: the dividends also lie in the future, so they are discounted, and they are uncertain, so the discounting has to reflect how risk is priced. Derivatives need both of those plus optionality: their payments depend on the value of another asset, often conditionally, as with a right to buy that is used only if the price is high enough.

Self-check. A friend says: "Stocks pay out in the future, and the future is uncertain anyway, so there is no point discounting them." What is wrong with this?

It drops principle 3. A dollar of dividends next year is worth less than a dollar today whether or not it is certain, so equity cash flows are discounted exactly as a bond's are. Uncertainty does not replace discounting; it is a *second* adjustment on top of it. The slide's summary is "Time Value of Money + Risk", with a plus sign.

12. The stock market in one picture: Shiller's CAPE

🕒 49:31 · 01a p. 18

This section establishes what a price–earnings ratio measures, how Shiller's version is read, and what the chart has looked like since 1881.

EXAM SIGNAL A figure to keep in your head

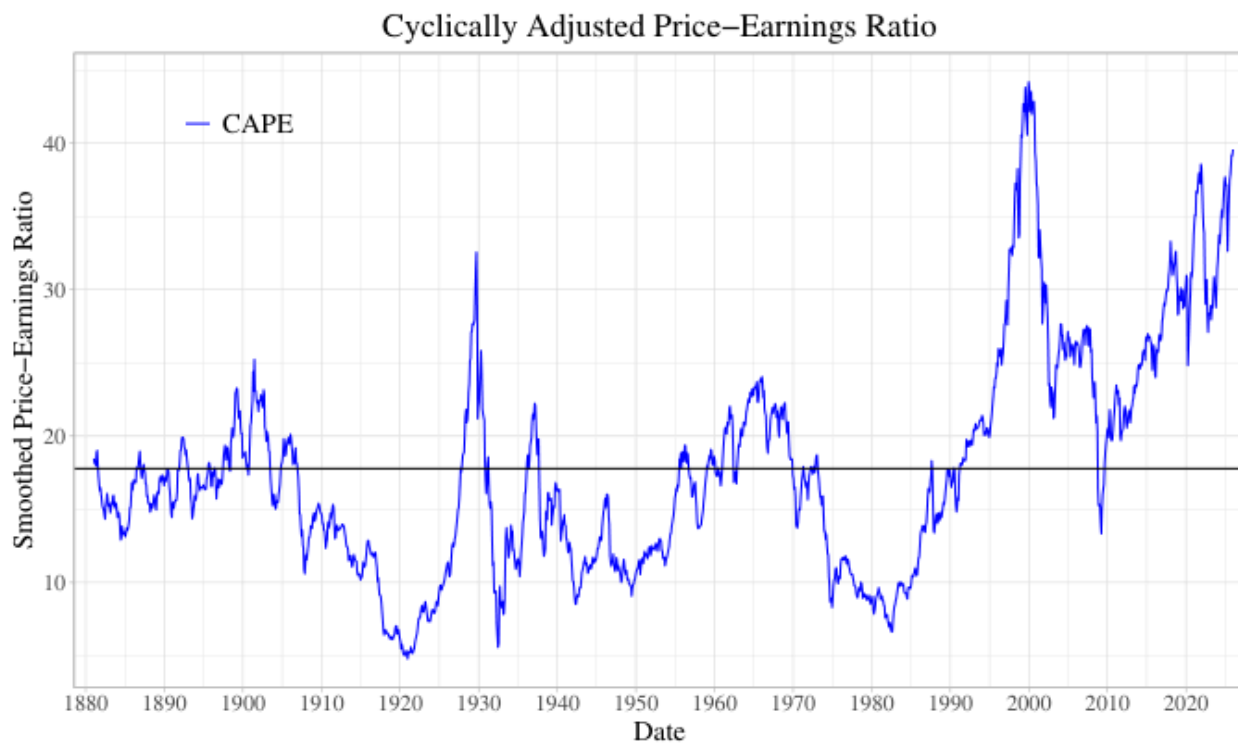
"This is one of those other figures that I hope you guys sort of keep in your head before the end of the semester. This is the famous Shiller cyclically adjusted price-earnings ratio" 🕒 49:31 .

DEFINITION Price–earnings ratio, and the CAPE

A **price–earnings ratio** (P/E) divides a price by earnings. For the market as a whole, in Dávila's words, "price is the value of the stock market, earnings is how much are the earnings of different companies"

🕒 49:59 . **Shiller's CAPE** is the "Cyclically Adjusted Price-to-Earnings ratio"; the chart's axis calls it a "Smoothed Price–Earnings Ratio" (01a p. 18), meaning that the earnings in the denominator are smoothed. Neither the slide nor the lecture says how the smoothing is done.

Stock Market



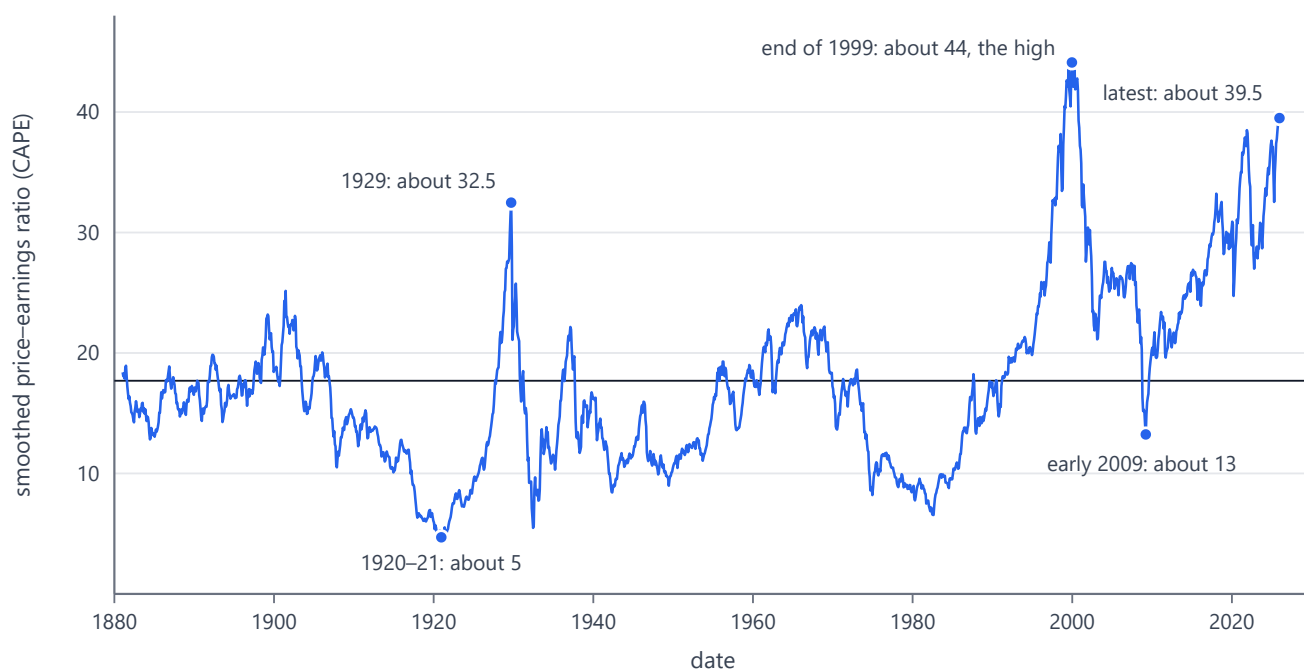
► Shiller's CAPE: Cyclically Adjusted Price-to-Earnings ratio

18 / 21

01a p. 18 — original slide: "Cyclically Adjusted Price–Earnings Ratio", one blue series from about 1881, with an unlabelled horizontal black line.

Shiller's CAPE: the stock market's price relative to smoothed earnings

Traced from the slide's own drawing (01a p. 18). The slide prints no values: every number here is a reading.



Redrawn by tracing the slide. The horizontal line is on the slide without a label, and is left unlabelled here.

Redrawn by tracing the slide's own line, with its main peaks and troughs marked. Every number is a reading of the drawing; the slide prints no values.

How to read this: time runs along the bottom, from about 1881 to the start of 2026 ("up to last week", Dávila says), and the vertical axis is the ratio itself, a pure number. A high value means the market's price is high relative to what companies have been earning. Look for the two great spikes, 1929 and the end of 1999, the trough of early 2009, and where the line ends.

How Dávila reads it  49:59 : if the price of the stock market is very high relative to earnings, "it kind of means that it's overvalued, and you would expect a correction"; that, Dávila says, is Shiller's reading. If instead there are a lot of earnings and the price is low, it is a good time to buy. And the recent history: "the last 15 years, the market keeps looking overvalued". Someone reasoning as Shiller does would have been telling you all that time that prices are too high. "We'll go back to this picture. We'll try to understand how do we rationalize this pattern."

What the chart shows, read off the drawing, all values approximate **SLIDE ONLY**:

- It starts at about 18 in 1881. Its lows are about 5 in 1920–21, about 5.5 in 1932 and about 6.5 around 1980.
- It spikes to about 32.5 in 1929, reaches about 24 in the mid-1960s, and hits its all-time high of about 44 at the end of 1999.

- It falls to about 13 in early 2009, climbs to about 38.5 in late 2021, and ends at about 39.5, close to the 1999 record.
- Its lowest value since 2011 is about 19.6, which is what "the last 15 years" of looking expensive means on the chart.

WARNING A high CAPE is not a forecast with a date on it

"You would expect a correction" is the *reading* Dávila attributes to Shiller, not a law **EXPLANATION**. The chart itself is the counter-evidence Dávila points to: the ratio has looked high for about fifteen years, and an investor who sold on that signal would have waited a long time. A high ratio says the price is large relative to past earnings; it does not say when, or whether, the price will fall, and earnings can also rise. That tension is why Dávila says the class will come back to the picture to "rationalize this pattern", in Blocks 5 and 6. The plot returns as 05a p. 8, in the Lecture 11 note (13 Oct) §3.2.

GAP A feature the slide does not explain — 49:59

A horizontal black line is drawn across the whole chart at a value of about 17.7, with no label, legend or spoken explanation. This note does not say what it marks, and the redrawn figure leaves it unlabelled. For orientation only: the series has been above that line at every point since 2011.

Self-check. Without looking: what is on each axis of the CAPE chart, where are its two highest peaks, and where does it stand now?

Horizontal: time, from about 1881 to today. Vertical: the cyclically adjusted (smoothed) price–earnings ratio of the stock market, the market's price divided by smoothed earnings. The two great peaks are 1929, at about 32, and the end of 1999, the record at about 44. It fell to about 13 in early 2009 and now stands at about 39 to 40, higher than at any time other than the 1999–2000 peak.

Self-check. In Shiller's reading, what does a very low CAPE suggest, and why?

That it is a good time to buy. A low ratio means the price is small relative to earnings: you pay little for each dollar the companies have been earning, so, on this reading, stocks are cheap and future returns should be good. The mirror image is the high-ratio case, where the reading expects a correction. That is where the market has been for fifteen years, as it "keeps looking overvalued"; the Warning above gives the caveat about timing.

13. Other institutions and assets, and two films

🕒 51:09 · 01a pp. 19–20

This section establishes, in a line or two each, the four remaining items on Block 1's list: banks, mutual funds, asset-backed securities and money markets. "In my last two minutes", Dávila says, these are things the course will not talk much about, together with something to do over the weekend.

Banks are "super important", and the course reaches them only briefly at the end (Block 10). What they do is **maturity transformation**: "You borrow short maturity, you lend money." The slide completes the sentence: they "borrow short maturities, lend long maturities" (*the second half is slide only*). A deposit can be withdrawn tomorrow; the mortgage it funds runs for decades **EXPLANATION**.

Mutual funds are financial intermediaries that pool funds. Instead of having to buy every single stock yourself, you put your money into a fund that "mutualizes" the investment across many assets, and the rationale is the diversification and risk sharing of §8. The slide's fuller wording is that they "pool funds from small investors and invest in a diversified portfolio of stocks and/or bonds", for "diversification, lower transaction costs" (*the small investors, the bonds and the transaction costs are slide only*).

Asset-backed securities (ABS) 🕒 52:02 . Dávila asks who is familiar with them and who is not, and the show of hands is a surprise: "Oh, wow, okay." "These are very popular in 2008", Dávila says, before the class's time. They are "bundling of securities"; the slide lists what gets bundled, "mortgages, auto loans, student loans", calls securitization an "example of financial engineering", names the two techniques involved, "Pooling" and "Tranching", and adds "Many acronyms: CDO, CDO², CMO, CLO, RMBS, CMBS, etc." (*all slide only except the two techniques*). The course defines neither word. In brief **EXPLANATION**: **pooling** puts many individual loans into one portfolio, so that the default of any single borrower matters little; **tranching** divides the claims on that portfolio's cash flows into slices ranked by priority, so that senior slices are paid first and junior slices absorb the first losses.

That gloss is what makes sense of the one substantive thing said about ABS. Dávila recommends *The Big Short* (watch it, and if you have seen it, watch it again) "because they explain very well what the ABSs are". What the film does not explain is *why* such securities exist, and the answer is the roles of §8: risk sharing and risk transfer "are the economic mechanisms behind the pooling and the tranching". Pooling shares each loan's risk across the whole portfolio; tranching transfers the portfolio's risk to the investors most willing to hold it (*explanation: the matching of the two techniques to the two roles is this note's*). The course will not say much more, but Dávila expects Professor Geanakoplos to give "a quick glimpse into some of these ideas" in the guest lecture. It is, Dávila adds, the material of a more advanced course on structured finance 🕒 53:00 .

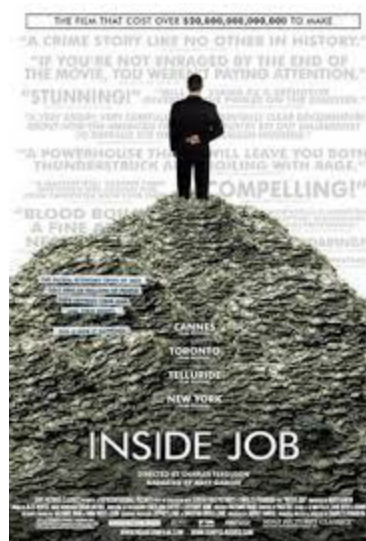
Money markets, in Dávila's words, "are overnight markets". The slide: "Short term (overnight) borrowing/saving: FFR, Repo, Commercial Paper, etc.", and "Connected with monetary policy" **SLIDE ONLY**. The slide gives the three names without explanation. For orientation **EXPLANATION**: FFR is the federal funds

rate, the rate in the *Journal* headline of \$5.4; a repo, or repurchase agreement, is a very short loan made by selling a security and agreeing to buy it back; commercial paper is short-term debt issued by corporations.

The two films (01a p. 20).



01a p. 20 — film poster: The Big Short, with the line "This is a true story".



01a p. 20 — film poster: Inside Job.

How to read this: the slide, headed "Movie Suggestions", is only these two posters. They are recommendations, not required material.

"If you have a bit of time, watch these two over the weekend, and you're going to be excited about what we're going to see in the rest of the semester" ⌚ 53:14 . Only *The Big Short* is named aloud, and the lecturer's framing of it is the one above: it shows what asset-backed securities are, and the course supplies why they exist. Its poster describes it as a true story from the author of *Moneyball* and *The Blind Side*. *Inside Job* appears only as a poster **SLIDE ONLY**; it is a documentary about the 2008 financial crisis (*explanation: the slide does not say so*). Then: "Have a great weekend. See you on Tuesday."

Self-check. What is maturity transformation, and which institution does it?

Banks. They borrow at short maturities, for instance deposits that can be withdrawn at any time, and lend at long maturities, for instance mortgages. They transform short-term funding into long-term loans, which is useful to both sides and is also what makes banks fragile, a theme the course reaches in Block 10.

Self-check. According to the lecture, why do asset-backed securities exist?

For the reasons financial markets exist at all (§8): risk sharing and risk transfer. Pooling and tranching rest on those two. Bundling many loans together shares each loan's risk, and slicing the bundle into claims of different priority moves the risk to those most willing to bear it. Dávila's point about *The Big Short* is that the film explains what ABS are very well, and does not explain this.

Continues in

The deck *Financial Instruments* is finished, and with it the first half of Block 1. The next meeting turns to how these instruments are actually traded: primary and secondary markets, brokers and dealers, bid and ask prices, the types of order, trading costs and the short sale that §3.5's reverse trade needs. That is the Lecture 2 note (8 Sep). The equations begin "two lectures from today" ⌚ 41:14 , when the Lecture 3 note (10 Sep) opens Block 2 with present value, turning principle 3 into formulas.

Worked problems

This meeting has no numerical, homework or past-exam item in the practice workbook: Block 1's questions on today's material are all multiple-choice concept questions, and they are under Self-check at the end. The worked problems here are therefore the lecture's own eight examples, each taken from the slide it was taught on and set out in full, with every step and every number machine-checked. The lecture sections above carry each example's argument and result; these carry the arithmetic, the checks and the "what if"

that the lecture left to the class. That is the use the course asks for: "There are no graded homeworks, but you are expected to work through the concept questions and the practice problems every week" (*syl p. 3*). Nothing here is submitted for credit, and no exam question is involved.

Three of the problems carry a callout that the lecture sections point to: the Warning on what choosing the gamble reveals (A), the Warning on the figure a student gave for the trade's return (B), and the Warning that gives both readings of what was said about the move from 40% to 42% (D).

A. Expected value and what a choice reveals about risk

This trains §3.2. It computes an expected value as a probability-weighted sum, uses the *equality* of the two options' averages to isolate risk, and then scales both options to show that the averages stay equal at any stake, so that drifting toward the sure thing as the stakes grow is risk aversion and nothing else.

01A P. 3 — \$100 FOR SURE OR A COIN FLIP FOR \$200: RISK AVERSION

Source: *Lecture 1 deck, 01a p. 3*. The two options are the slide's illustration of principle 2; the coin flip, the expected value and the classroom poll were done aloud at 08:35 – 09:35, and the larger stakes at 09:35 – 10:31.

SETUP

Option A pays \$100 now for sure and option B pays \$200 now with a 50% chance and nothing otherwise: what is B's expected value, and what does choosing A or B reveal about a person's attitude to risk, at the slide's stakes and at much larger ones?

GIVEN

Input	Value	Units	Source
Option A's payoff X_A	100	dollars, now, for sure	01a p. 3
Option B's payoff X_B if the coin lands heads	200	dollars, now	01a p. 3
Option B's payoff X_B if it lands tails	0	dollars ("nothing otherwise")	01a p. 3
Probability of each outcome of B	0.5	— (a fair coin)	01a p. 3 ("50% chance"); ⌚ 08:35
Larger stakes named in class	\$1,000 vs \$2,000; \$1 million vs \$2 million; \$1 billion vs \$2 billion	dollars	⌚ 09:35 , ⌚ 10:31 , spoken only

STRATEGY

Compute B's expected value, the probability-weighted average of its payoffs, and compare it with A's sure \$100. If the two averages are equal, the only thing that separates the options is risk, so a choice between them reveals the chooser's attitude to risk. Then scale both options up by the same factor and check that the averages stay equal, so that any change in people's choices as the stakes grow is about risk alone.

SOLUTION

Step 1. The expected value.

$$\mathbb{E}[X] = \sum_s p_s x_s$$

Why this step follows: the expected value weights each possible payoff x_s by its probability p_s and adds the results; this is the course's notation for an average over states, which the slide leaves implicit.

Step 2. Option B's expected value.

$$\mathbb{E}[X_B] = 0.5 \times 200 + 0.5 \times 0$$

Why this step follows: B has two states, heads and tails, each with probability 0.5, paying \$200 and \$0; substitute them into Step 1's sum.

$$\mathbb{E}[X_B] = 100 + 0 = \$100$$

Why this step follows: multiply out each product, $0.5 \times 200 = 100$ and $0.5 \times 0 = 0$, then add. In class: "50% times 200 is 100, plus zero".

Step 3. Option A's expected value.

$$\mathbb{E}[X_A] = 1 \times 100 = \$100$$

Why this step follows: A pays \$100 with probability 1, so the sum in Step 1 has a single term.

$$\mathbb{E}[X_A] = \mathbb{E}[X_B]$$

Why this step follows: compare Steps 2 and 3; both equal \$100.

Step 4. What the choice reveals. The two options pay the same on average, but B is risky and A is not. So a person who takes A gives up nothing on average in exchange for certainty: in class, "if you pick A, you are risk averse". A person who takes B accepts risk for no gain in the average: in class, "you are what we call risk-loving" (🕒 09:35). There is no right answer; the choice measures a preference.

Step 5. Scale the stakes up. Multiply every payoff of both options by the same factor $k > 0$.

$$\mathbb{E}[kX_B] = 0.5 \times 200k + 0.5 \times 0$$

Why this step follows: the scaled gamble pays 200k or 0 with the same two probabilities.

$$\mathbb{E}[kX_B] = 100k$$

Why this step follows: multiply out $0.5 \times 200k = 100k$; the second term is 0.

$$\mathbb{E}[kX_B] = k \times 100 = kX_A$$

Why this step follows: rewrite 100k as k times A's sure \$100, which is exactly the scaled option A. The averages stay equal at every scale.

The stakes named in class:

Scale k	Option A (sure)	Option B (coin flip)	$\mathbb{E}[kX_B]$
1	\$100	\$200 or \$0	\$100
10	\$1,000	\$2,000 or \$0	\$1,000
10,000	\$1 million	\$2 million or \$0	\$1 million
10,000,000	\$1 billion	\$2 billion or \$0	\$1 billion

GAP Reconstructed from the lecture audio — 09:35

The larger stakes were spoken only; no slide carries them. He moved from \$100 and \$200 to \$1,000 and \$2,000, asked "What if you ... put a zero? ... two zeros? ... three zeros?", then jumped to one billion for sure against a gamble for two billion (🕒 09:35), and closed with "if it's \$2 million, I can guarantee you I'll take the \$1 million" (🕒 10:31). The ladder is illustrative — \$100 to \$1 billion is seven added zeros, not three — so the table lists only the rungs he named. The expected values are the note's computation.

Step 6. What the larger stakes show. Because Step 5 keeps the two averages equal at every scale, anyone who switches from B to A as the stakes grow is reacting to risk alone. That is what he predicted: "once I start to add the stakes, they're going to become less risk-loving" (🕒 09:35). Attitudes to risk depend on wealth and on the size of the stakes: \$100 is "a nicer dinner", \$1 million is not. Hence the course's working assumption, principle 2: people dislike risk, "especially when the risk is large, or when the stakes are large" (🕒 10:31).

ANSWER

$$\mathbb{E}[X_B] = 0.5 \times \$200 + 0.5 \times \$0 = \$100 = X_A: \text{choosing A reveals risk aversion, strictly preferring B reveals risk-loving}$$

At every scale k the averages stay equal,

$$\mathbb{E}[kX_B] = \$100k = kX_A,$$

so a switch to A as the stakes grow is pure risk aversion.

SANITY CHECK

Magnitude. An expected value must lie between the smallest and largest payoffs, here \$0 and \$200. With a fair coin it is exactly the midpoint, \$100. ✓

No utility function is needed. The comparison uses only averages and the fact that A is certain. Nothing about how much a person values each dollar enters until Step 4 reads the choice.

WARNING Choosing B does not by itself mean risk-loving

In class, picking B was called risk-loving (🕒 09:35). Strictly, because the two options have the same expected value, a person who does not care about risk at all (risk-neutral) is *indifferent* between them and might pick either. Only a strict preference for B reveals a taste for risk; a strict preference for A reveals risk aversion (EXPLANATION).

WHAT VARIES

Input	Direction	Size of the effect
The stakes k	averages stay equal; choices shift toward A	The lecture's own point (Steps 5–6): the higher the stakes, the fewer people take the gamble.
The probability of heads p	$\mathbb{E}[X_B] = 200p$: above $p = 0.5$ the gamble has the higher average, below it the lower	At $p = 0.6$, $\mathbb{E}[X_B] = \$120$. A person may then take B and still be risk-averse, trading \$20 of expected value against the risk (EXPLANATION). Only at $p = 0.5$ does the choice isolate risk.
Wealth	the richer the chooser, the less a given stake matters	Said in class (🕒 10:31); no numbers were given.

B. Building an arbitrage, and reading a price off it

These two train §3.4 and §3.5, and together they are the template for every arbitrage argument in the second half of the course. The first builds a riskless payoff out of two risky assets that move in opposite directions, finances it entirely with debt, checks it state by state, and derives that 50–50 is the only riskless split. The second turns "no free lunch" into a pricing statement by writing the sure profit in each direction, borrowing to buy below 5% and selling short to lend above it, and solving for the one rate that kills both.

01A PP. 3–4 — PARASOL AND UMBRELLA: A SURE PROFIT WITH ZERO OUTLAY

Source: Lecture 1 deck, 01a pp. 3–4. The two companies and the 4% rate are principle 4 on p. 3; the trade and all its cash flows are printed on p. 4, which was shown but not worked aloud ("I'm going to let you work the math", 🕒 14:58). A student proposed the trade at 🕒 14:48 and the professor restated it at 🕒 15:21.

SETUP

Parasol & Co returns –10% if it rains and +20% if it is sunny, Umbrella & Co returns +20% if it rains and –10% if it is sunny, and you can borrow and lend at 4%: how can you make a sure profit with zero initial cash outlay, and how large is it?

GIVEN

Input	Value	Units	Source
Return on Parasol & Co, R_P	−10% if rainy; +20% if sunny	net return over the period	01a p. 3
Return on Umbrella & Co, R_U	+20% if rainy; −10% if sunny	net return over the period	01a p. 3
Borrowing and lending rate	4%	over the same period	01a p. 3
Amount borrowed B	200	dollars	01a p. 4
Amount put in each company	100	dollars	01a p. 4

The slide gives no length for the period. The returns and the loan run over the same stretch of time, "wait for weather uncertainty to resolve" (p. 4), so the note does not call them annual rates. No probability of rain is given, and none is needed.

STRATEGY

Look for a mix of the two companies whose payoff is the same whether it rains or shines: a payoff that does not depend on the weather is risk-free, like money in the bank. Pay for the whole mix with borrowed money, so that nothing of your own goes in, and compare the mix's sure return with the 4% owed on the loan. Finally, show why the 50–50 split is the mix that works.

SOLUTION

Step 1. The initial outlay.

$$100 + 100 - 200 = \$0$$

Why this step follows: you spend \$100 on each company and pay for both with the \$200 you borrowed, so none of your own money goes in ("Initial outlay: \$0", p. 4).

Step 2. Each holding's value if it rains.

$$100 \times (1 - 0.10) = \$90$$

Why this step follows: a holding's end value is the amount invested times one plus its return, and Parasol returns −10% when it rains.

$$100 \times (1 + 0.20) = \$120$$

Why this step follows: the same rule for Umbrella, which returns +20% when it rains.

Step 3. Each holding's value if it is sunny.

$$100 \times (1 + 0.20) = \$120$$

Why this step follows: Parasol returns +20% when it is sunny.

$$100 \times (1 - 0.10) = \$90$$

Why this step follows: Umbrella returns -10% when it is sunny.

Step 4. The mix is worth the same in both states.

$$\text{rainy: } 90 + 120 = \$210$$

Why this step follows: add the two holdings' rainy values from Step 2; the parasol's payoff is written first, the order p. 4 uses.

$$\text{sunny: } 120 + 90 = \$210$$

Why this step follows: add the two holdings' sunny values from Step 3. The loss on one company is exactly offset by the gain on the other, so the weather no longer matters.

Step 5. What you owe on the loan.

$$1.04 \times 200 = \$208$$

Why this step follows: the \$200 loan must be repaid with 4% interest at the end of the period ("Remember you must pay back $1.04 \times 200 = 208$ ", p. 4).

Step 6. The profit in each state.

$$210 - 208 = \$2$$

Why this step follows: subtract the repayment from the mix's value; Step 4 gives \$210 in both states, so the \$2 arrives whether it rains or not.

Step 7. The mix's return.

$$\frac{210}{200} = 1.05$$

Why this step follows: divide the mix's end value by the \$200 put in; the gross return is 1.05, a net return of 5% in every state (p. 4: "Return on investment: 5%").

The whole trade is therefore borrowing at 4% and investing at 5% without risk: "borrow money from my bank at 4% and invest my money at 5% in this mix" (⌚ 15:21).

Step 8. The profit scales with the amount borrowed. Borrow any amount B and put half in each company.

$$1.05B - 1.04B = 0.01B$$

Why this step follows: the mix returns 1.05 per dollar in both states and the loan costs 1.04 per dollar; subtract the two, factoring out B .

At $B = \$200$ this is \$2, matching Step 6. Nothing in the model limits B , which is why p. 4 adds "You would like to scale-up this trade as much as possible!"

Step 9. Why the split must be 50–50 — Full derivation (not done in class). Put a share w of the borrowed money in Parasol and $1 - w$ in Umbrella.

$$\text{rainy return} = w(-0.10) + (1 - w)(0.20)$$

Why this step follows: a mix's return is the weighted average of its parts' returns, with the rainy-state returns from p. 3.

$$\text{rainy return} = -0.10w + 0.20 - 0.20w$$

Why this step follows: distribute the second product, $(1 - w) \times 0.20$.

$$\text{rainy return} = 0.20 - 0.30w$$

Why this step follows: collect the two terms in w .

$$\text{sunny return} = w(0.20) + (1 - w)(-0.10)$$

Why this step follows: the same weighted average with the sunny-state returns.

$$\text{sunny return} = 0.20w - 0.10 + 0.10w$$

Why this step follows: distribute the second product, $(1 - w) \times (-0.10)$.

$$\text{sunny return} = -0.10 + 0.30w$$

Why this step follows: collect the two terms in w .

$$0.20 - 0.30w = -0.10 + 0.30w$$

Why this step follows: the mix is risk-free exactly when its return is the same in both states, so set the two expressions equal.

$$0.30 = 0.60w$$

Why this step follows: add $0.30w$ and 0.10 to both sides.

$$w = \frac{1}{2}$$

Why this step follows: divide both sides by 0.60 .

$$0.20 - 0.30 \times 0.5 = 0.05$$

Why this step follows: substitute $w = \frac{1}{2}$ into the rainy return; the sunny return gives $-0.10 + 0.15 = 0.05$ as well, so the riskless mix earns 5% in both states.

Any other split leaves weather risk. At $w = 0.6$ the mix returns 2% if it rains and 8% if it is sunny; on \$200 borrowed that is \$204 or \$216 against the \$208 owed, a \$4 loss or an \$8 gain. Only the 50–50 mix turns two risky companies into a risk-free investment.

ANSWER

Borrow \$200 at 4%, put \$100 in each company: the mix is worth \$210 whatever the weather, you owe \$208, so the sure profit is \$2 on a \$0 outlay

The mix earns **5%** without risk against **4%** on the loan, a profit of $0.01B$ on any amount B borrowed; only the 50–50 split is riskless.

SANITY CHECK

Size. The \$2 is 1% of the \$200 borrowed, exactly the gap between the 5% the mix earns and the 4% the loan costs. ✓

WARNING Said in class vs written — 14:48

The student who proposed the trade said that with equal amounts in the two companies "you're going to make 10%" whether it rains or shines, and the professor answered "Very good" to the reasoning (14:58). Every copy of the recording has "10%". The slide's numbers give **5%** on the mix — \$10 on \$200 before the \$8 of interest — and a sure profit of **\$2** once the loan is repaid (Steps 6–7).

No probabilities. The check is made state by state, and the \$2 arrives in both states, so the answer is the same whether rain is likely or unlikely. That is what makes it an arbitrage rather than a good bet

EXPLANATION.

No capital of your own. The \$2 is not a return on anything you put in, because you put in nothing; it is a pure profit. That is the p. 3 definition, "a sure profit with zero initial cash outlay" **EXPLANATION**.

WHAT VARIES

Input	Direction	Size of the effect
The borrowing rate	profit per \$200 is \$210 minus $\$200 \times (1 + \text{rate})$	At 4%, \$2. At 5%, \$0. Above 5% this trade loses in both states and the opposite trade makes the sure profit — the next worked problem.
The amount borrowed B	profit $0.01B$, proportional	\$20,000 borrowed would give \$200. Because nothing caps B , prices like these cannot last: "these things don't happen" (🕒 16:13).
The split w	only $w = \frac{1}{2}$ removes the weather risk	$w = 0.6$ gives 2% or 8% (Step 9).
The two companies' returns	move the riskless split and the riskless return	Any pair where one company does better in the rain and the other in the sun can be mixed into a riskless holding; the split is $\frac{1}{2}$ here only because the two returns are mirror images (EXPLANATION).

01A P. 4 — WHICH RISK-FREE RATE IS CONSISTENT WITH NO ARBITRAGE?

Source: Lecture 1 deck, 01a p. 4. The page closes with the question "Which risk-free rate is the only one consistent with no-arbitrage?" and prints no answer. The lecture answered it in spirit at 🕒 15:21 (\$3.5), and the argument in both directions below is a *Full derivation (not done in class)*.

SETUP

Keeping the two companies' returns fixed at their p. 3 values, find the only risk-free rate r_f at which neither the p. 4 trade nor its reverse makes a sure profit with zero outlay.

GIVEN

Input	Value	Units	Source
Returns of Parasol & Co and Umbrella & Co	−10% / +20% and +20% / −10% (rainy / sunny)	net, over the period	01a p. 3
The 50–50 mix's end value per \$200	210 in both states	dollars	the previous worked problem, from 01a p. 4
Risk-free rate r_f	unknown	net, over the same period	01a p. 4's question
Short sale	sell a borrowed share now, buy it back later to return it	—	Lecture 2 deck, 01b p. 13
Dividends, borrowing fees	none	—	01a p. 4 has none

STRATEGY

The 50–50 mix is a risk-free investment that earns 5%, and a bank account is another that earns r_f . Two risk-free investments that pay different returns can be played against each other: borrow through the cheaper one and invest in the dearer one. So check both directions, r_f below 5% and r_f above 5%, and find the rate at which both trades earn nothing.

SOLUTION

Step 1. The mix is a risk-free investment at 5%.

$$200 \times 1.05 = \$210$$

Why this step follows: the previous worked problem showed that \$100 in each company is worth \$210 whether it rains or shines, a gross return of 1.05 on \$200.

Step 2. If the rate is below 5%: borrow and buy the mix. Borrow \$200 at r_f and put \$100 in each company; the outlay is \$0.

$$\pi_{\text{buy}} = 210 - 200(1 + r_f)$$

Why this step follows: at the end you hold the mix, worth \$210 in both states, and repay the loan with interest, $200(1 + r_f)$.

$$\pi_{\text{buy}} > 0 \iff 200(1 + r_f) < 210$$

Why this step follows: the profit is positive exactly when the repayment is smaller than \$210; add $200(1 + r_f)$ to both sides of the inequality.

$$200(1 + r_f) < 210 \iff r_f < 0.05$$

Why this step follows: divide both sides by 200 to get $1 + r_f < 1.05$, then subtract 1.

At the slide's 4% the profit is $210 - 208 = \$2$: the p. 4 trade.

Step 3. If the rate is above 5%: sell the mix short and lend. Borrow \$100 of each company's shares, sell them for \$200, and lend the \$200 at r_f ; the outlay is again \$0. This is the "long-short strategy" promised for later in the course (⌚ 16:42), and it needs the short sale of Lecture 2: sell something you do not own, buy it back later to return it (Lecture 2 note (8 Sep)). The lecture did not discuss this direction.

$$\pi_{\text{sell}} = 200(1 + r_f) - 210$$

Why this step follows: at the end you collect the loan with interest, $200(1 + r_f)$, and buy the shares back to return them; they cost 90 + 120 if it rains and 120 + 90 if it is sunny, \$210 either way.

$$\pi_{\text{sell}} > 0 \iff r_f > 0.05$$

Why this step follows: the profit is positive exactly when $200(1 + r_f)$ exceeds 210; divide by 200 and subtract 1, the same two moves used in Step 2.

Step 4. At exactly 5%, both trades earn nothing.

$$210 - 200 \times 1.05 = 0$$

Why this step follows: substitute $r_f = 0.05$ into Step 2's profit; Step 3's profit is the same number with the sign reversed, so it is 0 too.

Step 5. Conclusion. Every rate below 5% leaves Step 2's free lunch, every rate above 5% leaves Step 3's, and 5% leaves neither. The risk-free rate must equal the return of the risk-free mix. That is the no-arbitrage principle doing its work: "you cannot have these companies with these returns and interest rate at 4%" (⌚ 16:42).

ANSWER

$r_f = 5\%$, the riskless 50–50 mix's return; any other rate allows a sure profit with zero outlay

SANITY CHECK

Symmetry. At 4%, borrowing to buy the mix earns \$2 per \$200 (Step 2). At 6%, selling the mix short and lending earns

$$200 \times 1.06 - 210 = 212 - 210 = \$2$$

per \$200 **EXPLANATION**: the two trades are mirror images around 5%, as they should be.

It matches what was said. The lecture's answer at 15:21 was that the rate on the bank account must equal the return on the mix that replicates a bank account; Step 5 reaches the same rate from both directions.

WHAT VARIES

Input	Direction	Size of the effect
The gap between r_f and 5%	the sure profit per \$200 is \$200 times the gap, in whichever direction it points	1 point of gap gives \$2 per \$200; the sign of the gap decides whether you buy the mix or sell it short.
The companies' good-weather return	raises the riskless return by half of any change	If each company returned +30% in its good state instead of +20%, the 50–50 mix would earn $(30\% - 10\%) \div 2 = 10\%$, and 10% would be the only consistent rate EXPLANATION .
The companies' bad-weather return	a deeper loss lowers the riskless return by half of the change	With –20% instead of –10% in the bad state, the mix would earn $(20\% - 20\%) \div 2 = 0\%$ EXPLANATION .

C. Is it really an arbitrage? Unit prices, identical goods and frictions

These two train \$4. Both start the same way, by putting two package sizes on a common unit price, and then apply the test that decides the matter. The mayonnaise fails it at the first hurdle, because the two bottles are not identical. The Nutella passes that hurdle and fails the second: the goods are identical, a shopper can take the buying side, and frictions block the selling side.

01A P. 6 — HELLMANN'S MAYONNAISE: AN ARBITRAGE OPPORTUNITY?

Source: Lecture 1 deck, 01a p. 6, including the shelf photo on the slide. "I found these prices in my local supermarket": the professor's own photo, discussed at 17:13 – 21:15.

SETUP

A 340 mL bottle of Hellmann's mayonnaise costs \$4.39 and a 591 mL bottle \$3.99, or \$3.49 on sale: compare the prices per unit, say what trade they seem to invite, and decide whether it is an arbitrage.

GIVEN

Input	Value	Units	Source
Small bottle, 340 mL (11.5 fl oz)	4.39	dollars	01a p. 6
Big bottle, 591 mL (20 fl oz), regular price	3.99	dollars	01a p. 6 (slide only)
Big bottle, sale price	3.49	dollars, with the store card, "SAVE 50¢ EACH", good through 07/02/20	01a p. 6 and its photo; said as "\$3.49 if I have the coupon" (🕒 17:13)
Smallest bottle, 162 mL (5.5 fl oz)	2.19	dollars	01a p. 6 photo (slide only)
Unit prices printed on the shelf tags	6.37 (162 mL), 6.10 (340 mL), 3.19 (591 mL), 2.79 (591 mL on sale)	dollars per pint	01a p. 6 photo (slide only)
Labels	340 mL and 162 mL: "Made with Cage Free Eggs"; 591 mL: "100% Recycled Bottle", no cage-free line	—	01a p. 6 photo

STRATEGY

Put the bottles on a common unit, cents per millilitre, so that size no longer matters. If the same thing sells at two different unit prices, the arbitrage recipe is to buy where it is cheap and sell where it is dear. Then apply the test the whole lecture rests on: an arbitrage needs two things that are *exactly* identical.

SOLUTION

Step 1. Unit price of the small bottle.

$$\frac{439}{340} = 1.291 \text{ cents per mL}$$

Why this step follows: divide the price in cents, 439, by the volume in millilitres, 340.

Step 2. Unit price of the big bottle at the regular price.

$$\frac{399}{591} = 0.675 \text{ cents per mL}$$

Why this step follows: the same division with 399 cents and 591 mL.

Step 3. Unit price of the big bottle on sale.

$$\frac{349}{591} = 0.591 \text{ cents per mL}$$

Why this step follows: the same division with the sale price, 349 cents.

Step 4. How much cheaper the big bottle is.

$$\frac{439/340}{349/591} = 2.19$$

Why this step follows: divide the small bottle's unit price by the big bottle's sale unit price, using the exact fractions of Steps 1 and 3 rather than their rounded values; on sale the big bottle is about 2.19 times cheaper per mL, and about 1.91 times at the regular price.

$$4.39 - 3.49 = \$0.90$$

Why this step follows: subtract the two shelf prices. The bigger bottle is not only cheaper per mL but cheaper outright, by \$0.90 on sale and by \$0.40 at the regular \$3.99.

Step 5. The store's own unit prices agree. The tags quote dollars per pint (16 fl oz), so each is the shelf price divided by the fluid ounces, times 16.

Bottle	Shelf price ÷ fl oz × 16	Computed	Tag
162 mL	$2.19 \div 5.5 \times 16$	6.371	\$6.37
340 mL	$4.39 \div 11.5 \times 16$	6.108	\$6.10
591 mL	$3.99 \div 20 \times 16$	3.192	\$3.19
591 mL, sale	$3.49 \div 20 \times 16$	2.792	\$2.79

Why each row is its own calculation: the tag converts one bottle's price to a common unit, the same idea as Steps 1–3 in different units. The 340 mL tag shows \$6.10 where 6.108 rounds to 6.11; the store truncates, and the slide is not in error.

Step 6. The trade the prices seem to invite (EXPLANATION). "You buy a big one ... You start squeezing" (⌚ 18:39): buy the 591 mL bottle and squeeze it into small bottles.

$$\frac{591}{340} = 1.738$$

Why this step follows: divide the big bottle's volume by the small bottle's; one big bottle fills 1.738 small ones.

$$1.738 \times 4.39 = \$7.63$$

Why this step follows: value that much mayonnaise at the small bottle's price of \$4.39. No figure was given in class; this is the note's illustration.

$$7.63 - 3.49 = \$4.14$$

Why this step follows: subtract the \$3.49 the big bottle costs on sale; on paper, each big bottle turns into about \$4 of profit.

Step 7. Why it is not an arbitrage. A student pointed to the labels, and the professor agreed: "It's cage-free eggs ... The one on top is not the same as the one on the bottom" (⌚ 19:36). The 340 mL label says "Made with Cage Free Eggs"; the 591 mL label does not. So the two bottles are different products, and a shopper who values cage-free eggs may rationally pay more per millilitre for them. Different prices for different products is **product differentiation**, the same reason a yellow dress and a black one can sell at different prices (⌚ 20:00). The recipe of Step 6 needs two identical things, and these are not.

Finance is different because its goods are identical by construction: "all dollars are equally green" (⌚ 20:00). That is why arbitrage is central in finance and unimportant for "people who sell mayo".

ANSWER

Not an arbitrage: the 591 mL bottle is about 2.19 times cheaper per mL on sale (0.591 against 1.291 cents), but it is a different product (no cage-free eggs)

SANITY CHECK

The store's arithmetic confirms ours. All four shelf tags reproduce from the shelf prices (Step 5), with the one-cent truncation on the 340 mL tag.

The volumes match. One US fluid ounce is 29.5735 mL, so 11.5 fl oz is 340 mL and 20 fl oz is 591 mL, as the labels say (EXPLANATION).

The size of the gap is what makes it look like a free lunch. Bulk sizes are normally somewhat cheaper per unit; a bottle that is cheaper outright *and*, on sale, less than half the price per unit invites the squeeze trade. The labels, not the arithmetic, stop it.

WHAT VARIES

Input	Direction	Size of the effect
The sale	widens the gap	2.19 times cheaper per mL on sale, 1.91 at the regular price; the big bottle is cheaper outright either way (\$0.90 or \$0.40).
Whether the products are identical	decides the question	With identical labels, this would be two identical things at different prices — the case the next slide, Nutella, presents.
Frictions	block the trade even for identical goods	Bottles, the mess of squeezing, and the fact that a shopper cannot sell to other shoppers at the shelf price. The lecture raised such frictions for stadium popcorn (🕒 21:59).

01A P. 7 — NUTELLA: THE BIG JAR COSTS MORE PER POUND

Source: *Lecture 1 deck, 01a p. 7, including the shelf photo on the slide.* The slide asks only "Does this make sense?"; the unit prices were read out and discussed at 🕒 21:15 — 🕒 23:13 .

SETUP

A 13 oz jar of Nutella costs \$4.29 and a 26.5 oz jar \$8.89: compare the prices per pound, find the cheaper way to buy about 26 ounces, and answer the slide's question of whether the pricing makes sense.

GIVEN

Input	Value	Units	Source
Small jar, 13 oz, shelf price	4.29	dollars	01a p. 7 photo (slide only)
Big jar, 26.5 oz, shelf price	8.89	dollars	01a p. 7 photo (slide only)
Unit prices printed on the two tags	5.28 (13 oz) and 5.37 (26.5 oz)	dollars per pound	01a p. 7 photo; said at  21:15
Ounces per pound	16	oz	the tags' own conversion
Product	both tags read "NUTELLA SPREAD"	—	01a p. 7 photo

STRATEGY

Convert both jars to dollars per pound, the tags' unit, then compare the big jar with the obvious alternative: two small jars. Unlike the mayonnaise, the two jars hold the same product, so a price gap cannot be explained by product differentiation; ask what else could explain it and what trade it invites.

SOLUTION

Step 1. The small jar's price per ounce and per pound.

$$\frac{4.29}{13} = \$0.33 \text{ per oz}$$

Why this step follows: divide the shelf price by the ounces in the jar.

$$0.33 \times 16 = \$5.28 \text{ per lb}$$

Why this step follows: a pound is 16 ounces, so multiply the price per ounce by 16; this is the tag's \$5.28.

Step 2. The big jar's price per ounce and per pound.

$$\frac{8.89}{26.5} = \$0.3355 \text{ per oz}$$

Why this step follows: divide the shelf price by 26.5 ounces.

$$0.3355 \times 16 = \$5.37 \text{ per lb}$$

Why this step follows: multiply by 16 ounces per pound; unrounded the figure is \$5.3675, which the tag prints as \$5.37.

Step 3. The big jar is dearer per pound.

$$5.3675 - 5.28 = \$0.0875 \text{ per lb}$$

Why this step follows: subtract the small jar's unit price from the big jar's; on the tags, $\$5.37 - \$5.28 = \$0.09$. The larger size costs about 1.7% more per pound, the reverse of the usual bulk discount.

Step 4. Two small jars instead of one big one.

$$2 \times 13 = 26 \text{ oz}$$

Why this step follows: two small jars hold twice 13 ounces.

$$2 \times 4.29 = \$8.58$$

Why this step follows: they cost twice the shelf price.

$$8.89 - 8.58 = \$0.31$$

Why this step follows: subtract the cost of two small jars from the big jar's price. The big jar costs \$0.31 more for only half an ounce more Nutella.

Step 5. The big jar's premium over the small-jar price EXPLANATION.

$$26.5 \times 0.33 = \$8.745$$

Why this step follows: price the big jar's 26.5 ounces at the small jar's \$0.33 per ounce from Step 1.

$$8.89 - 8.745 = \$0.145$$

Why this step follows: subtract that value from the big jar's actual price; the big jar carries a premium of about 15 cents over the same amount bought at the small-jar rate.

Step 6. Does it make sense? In class the trade was put this way: "I buy the small ones and then I'm going to fill the big ones ... I should be making a profit here every time" (⌚ 21:15). A student suggested the bigger jar expires faster (⌚ 21:56). The professor's view: the only reason he could think of is that someone "for whatever reason, need[s] a lot of it" and would rather not handle small jars, "a really bizarre reason" — "if I wanted a lot of Nutella, I'd just buy two small ones" (⌚ 21:59). Unlike the mayonnaise, "these are the exact same products, they just sell for different prices".

What stops anyone from profiting is **frictions**: a shopper cannot sell a refilled jar to other shoppers at the shelf price, any more than a fan can buy the cheap giant popcorn at a stadium and resell it in small bags ( 21:59). The same forces, in markets without such frictions, are what the course later uses to price options (Black–Scholes, named in class without an equation).

ANSWER

Big jar \$5.37 per lb (5.3675) against the small jar’s \$5.28: two 13 oz jars give 26 oz for \$8.58 against 26.5 oz for \$8.89

It does not make sense for an identical product. The shopper's version of the arbitrage is simply to buy two small jars; the trader's version, buying small and selling big, is blocked by frictions.

SANITY CHECK

The tags confirm the arithmetic. $\$4.29 \div 13 \times 16 = \$5.28$ and $\$8.89 \div 26.5 \times 16 = \$5.3675$, printed as \$5.37. ✓

The two views of the premium agree. \$0.145 on \$8.745 is 1.66%, the same as \$0.0875 on \$5.28 per pound: both compare the big jar with the small-jar rate, one per jar and one per pound ().

The size is small. A 1.7% gap is a few cents a jar, far less than the mayonnaise gap of more than 2 to 1. It is striking for its sign, not its size.

WHAT VARIES

Input	Direction	Size of the effect
The big jar's price	below \$8.745 the big jar is no longer dearer per ounce than the small jar	That is 14.5 cents below the shelf price ().
The amount you need	two small jars give 26 oz, half an ounce short of the big jar	For anyone who does not need the last half ounce, two small jars dominate.
Frictions	decide whether a price gap between identical goods can be traded away	In a supermarket they are large; in financial markets, where "all dollars are equally green" ( 20:00), they are small, which is why arbitrage matters so much there.

D. Percent, percentage points and basis points

These two train \$5, which Dávila said will be assumed and used in exam questions. The first replaces the percent sign by 1/100 to write percentages as powers of ten, and keeps apart the two descriptions of a

move between percentages. The second converts among basis points, percentage points, percent and decimals, measures the Fed's move and the *Journal's* rate cut, and shows why a change quoted in basis points cannot be misread.

01A P. 8 — PERCENT, AND PERCENTAGE POINTS AGAINST PERCENT CHANGE

Source: *Lecture 1 deck, 01a p. 8*. "Basic terminology", taught at  23:13 —  24:48 . The slide's fractions and exponents are read from the slide as typeset.

SETUP

Write 1%, 3% and "%²" as powers of ten, and say by how much a quantity rises when it moves from 40% to 42%, in percentage points and in percent.

GIVEN

Input	Value	Units	Source
The symbol %	1/100	—	01a p. 8 ("The symbol % means 1/100")
Starting level	40	percent	01a p. 8
New level	42	percent	01a p. 8

STRATEGY

Replace the % sign by 1/100 wherever it appears; that is all it means. Then keep apart the two ways of describing a move between two percentages: the difference of the two numbers is a change in **percentage points**, while a **percent change** divides that difference by the starting level.

SOLUTION

Step 1. One percent.

$$1\% = 1 \times \frac{1}{100}$$

Why this step follows: replace the % sign by 1/100.

$$1\% = \frac{1}{10^2}$$

Why this step follows: write 100 as 10 squared, 10×10 .

$$1\% = 10^{-2} = 0.01$$

Why this step follows: one over ten to a power is ten to the negative power, and ten to the minus 2 is two places after the decimal point.

Step 2. Three percent.

$$3\% = 3 \times \frac{1}{10^2} = 3 \times 10^{-2} = 0.03$$

Why this step follows: the same substitution as Step 1, with 3 in front.

Step 3. "Percent squared".

$$(1\%)^2 = \left(\frac{1}{100}\right)^2$$

Why this step follows: the slide's "%²" means one percent times one percent; replace each % by 1/100.

$$\left(\frac{1}{100}\right)^2 = \frac{1}{10,000}$$

Why this step follows: square the numerator and the denominator; $1 \times 1 = 1$ and $100 \times 100 = 10,000$.

$$\frac{1}{10,000} = \frac{1}{10^4} = 10^{-4}$$

Why this step follows: write 10,000 as 10 to the fourth, then use the negative-power rule of Step 1.

$$10^{-4} = 0.0001 = \frac{0.01}{100} = 0.01\%$$

Why this step follows: 0.0001 is 0.01 hundredths, and a hundredth is what % means; so a percent of a percent is one-hundredth of one percent, which is called one basis point (the next worked problem).

Step 4. The move from 40% to 42%, in percentage points.

$$42\% - 40\% = 2 \text{ percentage points}$$

Why this step follows: subtract the old level from the new; the difference of two percentages is measured in percentage points ("a two percentage point increase", p. 8).

Step 5. The same move as a percent change.

$$\frac{42 - 40}{40} = \frac{2}{40}$$

Why this step follows: a percent change is the change divided by the starting level, 40.

$$\frac{2}{40} = 0.05 = 5\%$$

Why this step follows: divide, then write 0.05 as 5 hundredths. The quantity being measured rose by "an actual 5 percent" (p. 8).

In decimals the same two numbers are $0.42 - 0.40 = 0.02$ and $0.02 \div 0.40 = 0.05$: two hundredths of the whole in absolute terms, five hundredths of the starting level in relative terms.

WARNING Said in class vs written — 24:28

The recording is split on the very distinction being taught, and the sources cannot settle what was said.

Reading A (the transcript): "moving from 40% of something to 42% is a 2% increase, but as you know, it's a 5% increase". **Reading B** (a second, rough transcript): "a 2 percentage of increase", in which "of" may be a garbled "point". The slide prints "a 'two percentage point increase', but ... an actual '5 percent increase'". Whichever was said, the correct usage is the slide's: **+2 percentage points, a 5% increase**. Calling the move "a 2% increase" is exactly the confusion the slide warns against.

ANSWER

$$1\% = 10^{-2}, \quad 3\% = 3 \times 10^{-2}, \quad (1\%)^2 = 10^{-4} = 0.01\%; \quad 40\% \rightarrow 42\% \text{ is } +2 \text{ percentage points, a } 5\% \text{ increase}$$

SANITY CHECK

Why the percent change is bigger than the point change here. A move of Δx percentage points from a starting level of x_0 percent is a percent change of

$$\frac{\Delta x}{x_0} \times 100\%.$$

With $\Delta x = 2$ and $x_0 = 40$ that is $2 \div 40 \times 100\% = 5\%$. The two numbers coincide only when the starting level is 100% (**EXPLANATION**).

Units. Percentage points compare two percentages by subtraction, percent compares them by division; mixing the two up is what was flagged in class as "very important, big confusions" (🕒 23:40).

WHAT VARIES

Input	Direction	Size of the effect
The starting level	the lower it is, the larger the percent change for the same point change	+2 points from 2% to 4% is a 100% increase; from 40% to 42%, 5%; from 80% to 82%, 2.5% EXPLANATION .
The size of the move	the point change is the move itself; the percent change is proportional to it at a given starting level	+4 points from 40% is a 10% increase.

01A PP. 8–9 — BASIS POINTS: THE FED'S 25 AND THE JOURNAL'S 50

Source: *Lecture 1 deck, 01a pp. 8–9*. Basis points are defined on p. 8; the Fed example was given aloud at 24:48, and p. 9's *Wall Street Journal* screenshot was read out at 25:16.

SETUP

Convert basis points to percent and to decimals, measure an interest-rate move from 2.25% to 2.50% in basis points, and show that the *Journal*'s "50-basis-point" cut, "0.5 percentage point" and "half a point" are the same number.

GIVEN

Input	Value	Units	Source
One basis point (bp)	one-hundredth of one percent	—	01a p. 8
The interest rate the Fed sets, before and after	2.25 and 2.50	percent	24:48, spoken only
The <i>Journal</i> 's three names for the cut	"50-Basis-Point", "0.5 percentage point", "half a point" (and "a quarter point" as the alternative)	—	01a p. 9 screenshot: headline, subheadline, photo caption

STRATEGY

A basis point is a hundredth of a percentage point, so a change in percentage points times 100 is the same change in basis points, and basis points times 0.0001 is the change as a decimal. Apply that one conversion to each figure.

SOLUTION

Step 1. One basis point in percent and in decimals.

$$1 \text{ bp} = \frac{1}{100} \times 1\% = 0.01\%$$

Why this step follows: the definition, one-hundredth of one percent.

$$0.01\% = 0.01 \times \frac{1}{100} = 0.0001 = 10^{-4}$$

Why this step follows: replace the % sign by 1/100 and multiply; this is the "percent squared" of the previous worked problem.

Step 2. Round numbers of basis points.

$$100 \text{ bp} = 100 \times 0.01\% = 1\%$$

Why this step follows: multiply Step 1 by 100.

$$200 \text{ bp} = 2\%, \quad 50 \text{ bp} = 0.5\%$$

Why this step follows: the same multiplication with 200 and with 50 (both printed on p. 8).

Step 3. The Fed's move, in percentage points.

$$2.50\% - 2.25\% = 0.25 \text{ percentage point}$$

Why this step follows: subtract the old rate from the new; the difference of two rates is a change in percentage points.

Step 4. The same move in basis points.

$$0.25 \times 100 = 25 \text{ bp}$$

Why this step follows: each percentage point is 100 basis points (Step 2), so multiply by 100. In class: "you'll see there's 25 basis points changed".

GAP Reconstructed from the lecture audio — 24:48

The 2.25% and 2.5% were spoken only; no slide carries them. The 25 basis points were said and are re-derived above.

Step 5. The *Journal's* cut, three ways.

$$50 \text{ bp} = 50 \times 0.01\% = 0.5\%$$

Why this step follows: multiply one basis point by 50 — the headline's "50-Basis-Point" cut.

$$0.5\% = 0.5 \text{ percentage point} = 0.005$$

Why this step follows: a cut in a rate is the difference of two rates, so 0.5% here is 0.5 percentage point, the subheadline's wording; as a decimal, $0.5 \times 0.01 = 0.005$.

"Half a point" in the caption is the same thing, with "point" short for percentage point; the caption's alternative, "a quarter point", is 0.25 percentage point, 25 basis points, the size of the Fed move in Step 4. "They're all used to the same thing" (🕒 25:16).

Step 6. Why the Fed's move is not "11%" EXPLANATION.

$$\frac{2.50 - 2.25}{2.25} = 0.111$$

Why this step follows: the percent change divides the change by the starting level, the same rule that turned 40% to 42% into a 5% increase; the rate rose by about 11.1% of itself.

Saying "the Fed raised rates 11%" would be true only in that relative sense and would mislead almost every reader. Basis points avoid the ambiguity: "25 basis points" can only mean the difference.

ANSWER

$1 \text{ bp} = 0.01\% = 0.0001; \quad 2.25\% \rightarrow 2.50\% \text{ is } 25 \text{ bp}; \quad 50 \text{ bp} = 0.5 \text{ percentage point} = \text{half a point} = 0.005$

SANITY CHECK

Round trip. $25 \text{ bp} \times 0.0001 = 0.0025 = 0.25\%$, back to Step 3's difference. ✓

Scale. Basis points are "a convenient unit ... in contexts in which percentage differences of less than 1% are common" (p. 8): both moves here are below one percentage point, so both read naturally as whole numbers of basis points (25 and 50) rather than as fractions of a percent.

WHAT VARIES

Input	Direction	Size of the effect
The size of the move	basis points = $100 \times$ the change in percentage points	A tenth of a point is 10 bp; a full point, 100 bp.
The starting level	changes the relative (percent) change, never the basis points	25 bp from 2.25% is 11.1% of the rate; the same 25 bp from 5% would be 5% of it EXPLANATION .

E. The balance sheet

This trains §6. It totals both sides of the slide's balance sheet, computes net worth, reads the layout as the identity $A = L + NW$, and then does what the lecture only described in words: it varies how much of the assets is borrowed, and lets asset values fall, to show how borrowing magnifies the effect on net worth.

01A P. 10 — THE BALANCE SHEET: \$180 OF ASSETS, \$70 OF DEBT, \$110 OF NET WORTH

Source: *Lecture 1 deck, 01a p. 10, read as laid out on the slide.* Taught at 26:54 – 30:06; the asset figures were read out, the liabilities and the net worth were shown but not said.

SETUP

A firm holds cash, investments and inventories and owes short-term and long-term debt: compute its net worth, check the balance-sheet identity, and say how net worth changes with how much of the assets is borrowed.

GIVEN

Input	Value	Units	Source
Cash	100	dollars	01a p. 10; said at ⌚ 26:54
Investments	50	dollars	01a p. 10; said
Inventories	30	dollars ("the amount of product that is lying around the store")	01a p. 10; said
Short-term debt	30	dollars	01a p. 10 (slide only)
Long-term debt	40	dollars	01a p. 10 (slide only)
Definition	Net Worth = Value of Assets – Value of Liabilities	—	01a p. 10

STRATEGY

Add up each side of the balance sheet, then apply the slide's definition: net worth is what you have minus what you owe. The slide's layout, with net worth written under the liabilities on the right-hand side, says the same thing the other way round: the two sides balance.

SOLUTION

Step 1. Total assets.

$$A = 100 + 50 + 30 = \$180$$

Why this step follows: assets are everything the firm owns, the left-hand column, so add cash, investments and inventories.

Step 2. Total liabilities.

$$L = 30 + 40 = \$70$$

Why this step follows: liabilities are everything it owes, so add the short-term and the long-term debt.

Step 3. Net worth.

$$NW = A - L$$

Why this step follows: the slide's definition, "Net Worth = Value of Assets – Value of Liabilities"; in class, "how much do you have minus how much do you owe" (🕒 26:54).

$$NW = 180 - 70 = \$110$$

Why this step follows: substitute Steps 1 and 2 and subtract; this is the \$110 printed on the slide.

Step 4. The balance-sheet identity.

$$A = L + NW$$

Why this step follows: add L to both sides of Step 3's definition. This is the slide's layout read as an equation: net worth sits on the right, under the debts, so the right-hand column adds up to the left.

$$180 = 70 + 110$$

Why this step follows: substitute the three totals; both sides are \$180, so the sheet balances.

Step 5. How much of the assets is borrowed. The lecture made this comparison in words only: the more of the assets is borrowed, the smaller the net worth (\$6.1, 🕒 28:10). With the same \$180 of assets

EXPLANATION:

$$\text{all borrowed: } NW = 180 - 180 = \$0$$

Why this step follows: if every asset was bought with debt, liabilities equal assets, and Step 3 gives zero.

$$\text{nothing borrowed: } NW = 180 - 0 = \$180$$

Why this step follows: with no liabilities, net worth is the whole value of the assets.

The slide's firm sits between the two, with \$70 of its \$180 borrowed.

Step 6. Names for net worth. For an individual, net worth is **wealth** — not income, which is what you are paid in a period (🕒 28:58). For a firm, net worth is the **book value of equity**. So this firm's book value of equity is \$110.

ANSWER

$A = \$180, \quad L = \$70, \quad NW = A - L = \$110$ (the firm's book value of equity)

SANITY CHECK

The identity holds. $\$70 + \$110 = \$180$, the total of the assets. ✓

Range. Liabilities here lie between zero and total assets, so net worth must lie between \$0 and \$180; \$110 does. A firm whose debts exceed its assets would have negative net worth (**EXPLANATION**); what its stockholders can lose then is the question of the workbook's limited-liability item (WB 1.1 Q3).

Book value and market value. The caution on the Yale illustration is the Warning in §6.2 (🕒 29:38).

WHAT VARIES

Input	Direction	Size of the effect
The value of an asset	net worth moves one-for-one with it	If the investments fell 20%, from \$50 to \$40, assets would fall to \$170 and net worth to \$100: a 5.6% fall in assets but a 9.1% fall in net worth, because the \$70 of debt does not shrink (EXPLANATION).
The amount borrowed	net worth falls one-for-one with debt, for the same assets	From \$180 (nothing borrowed) to \$0 (everything borrowed), Step 5.
Whose balance sheet	the same arithmetic	Any "individual/entity who owns something": firms, households, banks, a central bank (01a p. 10), and, as said in class, "a government, the world" (🕒 28:10).

Common mistakes

Each item is a trap that this meeting flagged, that one of its examples is built around, or that the recording itself fell into.

The principles

- **Treating a choice under risk as right or wrong.** Taking the coin flip over the sure \$100 is not a mistake: "there's no right answer here". The choice measures a preference. Risk aversion is the course's *assumption*, justified by how people behave at large stakes, not a rule of rationality (§3.2).
- **Reading "risk-loving" into every choice of the gamble.** With equal averages, a person indifferent to risk could pick either option. Only a strict preference reveals an attitude (Worked problems, A).
- **Thinking discounting is only for safe cash flows.** Money later is worth less than money now whether or not it is certain. Risky cash flows are discounted *and* adjusted for risk: "Time Value of Money + Risk", with a plus sign (§11.1).

The Parasol and Umbrella argument

- **Calling a good bet an arbitrage.** An arbitrage needs zero outlay and a profit in *every* state. A 60–40 mix of Parasol and Umbrella financed at 4% makes \$8 in the sun and loses \$4 in the rain; however likely sunshine is, that is a bet (\$3.5).
- **Bringing probabilities into an arbitrage argument.** None are given in the Parasol example and none are needed. If you find yourself needing the probability of rain, you have not found an arbitrage.
- **Confusing the mix's return with the profit.** The 50–50 mix returns 5%. The profit is the gap between that and the 4% loan: 1% of the amount borrowed, \$2 on \$200. A student's figure for the return, given in class, matches neither (Worked problems, B).
- **Calling the 4% and 5% annual rates.** The slide states no period. All that matters is that the two returns and the loan cover the *same* period.
- **Proving only half of "the rate must be 5%".** Showing that 4% allows a free lunch does not show that 5% is the only consistent rate. You also need the reverse trade for rates above 5%, which requires a short sale (\$3.5).

Arbitrage in the wild

- **Treating every price gap as an arbitrage.** Ask two questions. Are the two things identical? (The mayonnaise bottles are not.) Can you buy the cheap one *and sell the dear one*? (With Nutella and stadium popcorn you cannot.) Only two yeses make an arbitrage (\$4.4).
- **Stretching "all dollars are equally green" too far.** Dollars are interchangeable only at the same date and in the same state. A dollar next year, or a dollar paid only if it is sunny, is a different good; that is what principles 3 and 2 say (\$4.3).

Units

- **Saying "percent" for "percentage points".** From 40% to 42% is +2 percentage points and a 5% increase. "Very important, big confusions" (\$5.2).
- **Misplacing the decimal in a basis point.** One basis point is 0.01%, which is 0.0001, not 0.01. Fifty basis points is half a percent, not five percent (\$5.3).

Balance sheets and assets

- **Confusing wealth with income.** Wealth is net worth at a date; income is what arrives over a period. High income can go with low wealth and the reverse (\$6.2).
- **Treating book value as what the firm is worth in the market.** Book value of equity is assets minus liabilities as recorded; market value is a different number, to be contrasted with it later in the course

(\$6.2).

- **Sorting assets by whether you can touch them.** Human capital is intangible and real; a paper bond certificate is tangible and financial. The test is whether the thing itself produces goods or services (§7).
- **Thinking a share is a piece of the company's buildings.** It is a claim on the dollars left after suppliers and employees are paid (§7).

Asset classes and charts

- **Reading "fixed" as constant, or as guaranteed.** It means predetermined: the payments may grow on a schedule, and the promise can still be broken by default (§10.1, §10.2).
- **Reading "safe" as "the price never moves".** For Treasuries, safe means no default risk, which the course assumes for the U.S. A Treasury bond sold before maturity can still gain or lose value when interest rates move, as the Lecture 4 note shows (EXPLANATION).
- **Calling the two-line rates chart a yield curve.** A yield curve is one date across maturities; the chart is two maturities across time (§10.4).
- **Treating a high CAPE as a timed forecast.** The ratio has looked high for fifteen years (§12).
- **Thinking an option's right vanishes when the price is low.** The right remains; using it is just not worthwhile (§11.2).

Key takeaways

Foundations

1. Financial economics is the allocation of scarce resources over time and across states. It is defined by time and uncertainty, not by money.
2. Four principles underlie the course: people prefer more to less (non-satiation), dislike risk (risk aversion), value money today above money later (time value of money), and cannot find sure profits with zero outlay (no arbitrage). The first three are about preferences; the fourth is about prices, and rests on the first.
3. An equal-average choice isolates risk: \$100 for sure against a coin flip for \$200 or nothing, both worth \$100 on average. Attitudes to risk depend on wealth and stakes, and at large stakes nearly everyone is risk averse.
4. A riskless asset can be manufactured from risky ones. Half in Parasol and half in Umbrella is worth \$210 per \$200 whatever the weather, a sure 5%. With a bank at 4%, borrowing to buy the mix makes $0.01B$ on any amount B with no money down.
5. No arbitrage turns that into a price: the risk-free rate *must* be 5%, because any other rate allows a sure profit in one direction or the other. Arbitrage questions are not on the midterm; they are on the

final.

6. A price gap is an arbitrage only if the goods are identical and both sides of the trade can be done. Product differentiation explains the mayonnaise, and frictions protect the Nutella and the popcorn. Finance is different because identical dollars are identical.

Vocabulary and instruments

7. Percent means 1/100. A difference between two percentages is in percentage points; a percent change divides by the starting level. One basis point is 0.01%, or 0.0001, and "50 basis points", "half a point" and "0.5 percentage point" are the same thing.
8. Net worth is assets minus liabilities, so $A = L + NW$. It is called wealth for a person and book value of equity for a firm. The slide's firm has \$180 of assets, \$70 of debt and \$110 of net worth.
9. Real assets produce goods and services; financial assets are claims on that output. Financial markets exist to finance projects, to allocate risk by sharing and transferring it, and to smooth consumption.
10. Three ideas organise the models: arbitrage (Blocks 7–9), optimality (Block 3) and equilibrium (Block 4). Fixed income is valued by the time value of money; equity adds risk; derivatives add optionality.
11. Two pictures to carry: U.S. rates since 1955, which climbed to a peak, fell for four decades and have risen again since COVID (\$10.4), and Shiller's CAPE, with its peaks in 1929 and 1999 and a market that has looked expensive for fifteen years.

The workbook closes Block 1 with a checklist of seventeen key concepts. The five that this meeting covers follow, each with the statement that makes it usable; the other twelve belong to Lecture 2.

WB 1.4 — the Block 1 key concepts this meeting covers

Source: Workbook Block 1.4, p. 9. The workbook closes Block 1 with a seventeen-item checklist and no definitions. **The first five are this meeting's**, two of them with sub-items. Each is printed below with the statement that makes it usable and where the course gives it.

#	Key concept	The statement that makes it usable	Source
1	Principles of finance	the four ideas the rest of the course is built on:	01a p. 3
	– Non-satiation	investors prefer more to less: \$200 beats \$100	01a p. 3
	– Risk aversion	investors dislike risk: \$100 for sure is preferred to a coin flip for \$200 or \$0, although both average \$100; the more so, the larger the stakes	01a p. 3
	– Time value of money	money today is worth more than money in the future: \$100 now beats \$100 in a year, and some rate makes a person indifferent between the two	01a p. 3
	– No arbitrage	there are no free lunches: no sure profit with zero initial cash outlay. With Parasol (–10% / +20%) and Umbrella (+20% / –10%), a 50–50 mix earns 5% in every state, so 5% is the only risk-free rate consistent with no arbitrage; at 4%, borrowing \$200 to buy the mix makes \$2 for sure	01a pp. 3–4
2	Real vs. financial assets	real assets are used to produce goods and services (trees, factories, land, human capital, homes); financial assets are contracts, claims on the output of real assets (stocks, bonds, derivatives). The test is use, not tangibility	01a p. 11
3	Balance sheet terminology	assets (what you own) against liabilities (what you owe); net worth = $A - L$, so $A = L + NW$. Net worth is wealth for a person and the book value of equity for a firm. Slide example: \$180 – \$70 = \$110	01a p. 10
4	Role of financial markets	project financing (equity or bond issuance); allocation of risk — risk sharing and risk transfer, through diversification (mutual funds) and hedging (currency hedging); consumption smoothing, by saving and borrowing	01a p. 12
5	Financial instruments/institutions	the asset classes and the institutions that hold or create them:	01a pp. 15–19
	– Fixed income securities	a promise of fixed (predetermined) payments, valued by the time value of money. Treasury bills under 1	01a p. 15

#	Key concept	The statement that makes it usable	Source
		year, notes 1–10 years, bonds 10–30 years, with no default risk (at least in the US); municipal and corporate bonds carry default risk	
	– Equity	a claim to a share of a corporation's profit, plus ownership; dividends are uncertain; maturity is indefinite; valued by time value of money + risk	01a p. 17
	– Derivatives	payments depend on the values of other assets (options, futures, swaps); valued by time value of money + risk + optionality	01a p. 17
	– Banks	engage in maturity transformation: borrow short maturities, lend long	01a p. 19
	– Mutual funds	intermediaries that pool many small investors' money and invest it in one diversified portfolio of stocks, bonds or both; the reasons to use one are diversification and lower transaction costs	01a p. 19
	– Asset-backed securities (ABS): securitization with pooling + tranching	bundles of loans (mortgages, auto loans, student loans) turned into securities; the slide calls securitization an example of financial engineering. Pooling and tranching rest on risk sharing and risk transfer (the Gap below)	01a p. 19
	– Money markets	short-term (overnight) borrowing and saving — the federal funds rate, repo, commercial paper — connected with monetary policy	01a p. 19

GAP "Pooling" and "tranching" — named, not defined

Block 1.4 lists "securitization with pooling + tranching" (*workbook p. 9*), and 01a p. 19 prints the two words, but no slide, handout or lecture defines them. In class the professor said only that asset-backed securities are "bundling of securities" and that risk sharing and risk transfer are what lie behind pooling and tranching (🕒 52:02); he recommended the film *The Big Short* because "they explain very well what the ABSs are", and left the subject to a guest lecture and to advanced courses. "Securitization" itself is on the slide only. The one-line explanation of each word in §13 of this note is the note's own, labelled as explanation there; it is not course material.

WHERE EACH OF THE FIVE IS PRACTISED

- **1, principles of finance:** the lecture's own worked examples — the \$100 / \$200 coin flip; the Parasol and Umbrella trade and the risk-free rate it pins down; the mayonnaise and Nutella shelves. Time value of money is practised with numbers from the Lecture 3 note (10 Sep) on, in Block 2.
- **2, real vs. financial assets:** WB 1.1 Q13.
- **3, balance sheet terminology:** the 01a p. 10 example worked in this note; the limited-liability item, WB 1.1 Q3, uses it.
- **4, role of financial markets:** no workbook item; the lecture's examples (the ice-cream start-up, the sick-coworker pool, the euro hedge, the mortgage for a bigger house).
- **5, financial instruments/institutions:** WB 1.1 Q1 (default risk), Q2 (the residual claim), Q3 (limited liability), Q4 (maturity).

THE TWELVE ITEMS THIS MEETING DOES NOT COVER

#	Bullet	Owner
6–17	liquidity · primary vs. secondary markets · auctions vs. underwriting · primary dealers · secondary markets · brokers vs. dealers · exchanges vs. OTC markets · market making · bid-ask spread and its determinants · types of orders · trading costs · short selling	Lecture 2 note (8 Sep)

The full seventeen-item checklist is assembled once, on the course review page, from the per-meeting subsets.

Connections

Backward. There is nothing before this meeting. What the course presupposes, introductory microeconomics and ideally some calculus and statistics, is in §1.2; the one idea from intermediate micro that the lecture invokes, maximizing utility subject to a constraint, is explained where it appears (§9.1).

Forward, within Blocks 1 and 2.

- The Lecture 2 note (8 Sep) begins by recapping this deck, then covers how the instruments of §10 to §13 are issued and traded. It introduces the short sale, which completes §3.5's argument for rates above 5%, and contrasts the most a buyer can lose, the price paid, with a short seller's unlimited loss, which the limited-liability question in the Self-check links to.
- The Section 1 note (11 Sep) restates the four principles and the balance sheet from the section handout, using this lecture's numbers: the \$100 expected value, the \$210, \$208 and \$2 of the trade,

and the \$180, \$70 and \$110 of the balance sheet.

- The Lecture 3 note (10 Sep) turns principle 3 into formulas: present value, annuities, perpetuities and bond prices. It also reuses this lecture's method, arguing that only one price for a future payment is consistent with no arbitrage, recalls the mayonnaise shelf while doing so, and repeats the rule that arbitrage is not on the midterm.
- The Lecture 4 note (17 Sep) supplies the first piece of household finance, the 30-year mortgage, and shows that a default-free bond can still lose value if sold before maturity.

Forward, to the rest of the course. Risk aversion (§3.2) is the preference behind portfolio choice and the CAPM, Blocks 3 and 4, where "what is risky" and "how do we price the risk" (§11.1) finally get definitions. The CAPE chart (§12) and the question of whether the market is overvalued return with market efficiency, Block 5 — Shiller's CAPE plot is on the market-efficiency deck, read with long-run predictability in the Lecture 11 note (13 Oct) §3.2 — and with equity valuation, Block 6. The Parasol and Umbrella construction (§3.4 and §3.5) is the prototype for Blocks 7 to 9: no-arbitrage pricing, the yield curve and the rates chart of §10, and options, where the same forces deliver the Black–Scholes equation. Banks and maturity transformation (§13) are Block 10, and asset-backed securities are promised a glimpse in Professor Geanakoplos's guest lecture.

Across this lecture. The pieces fit together more tightly than a first-day tour suggests. The definition of §2 names two dimensions, time and states. The principles of §3 say how people feel about each (principles 3 and 2) and what prices must therefore satisfy (principle 4, resting on principle 1). The roles of §8 are trades along those same two dimensions, and the valuation ladder of §11.3 adds one principle per rung. Even the last slide's acronyms come back to §8: pooling and tranching are risk sharing and risk transfer.

Beyond the course materials. The syllabus suggests Bodie, Kane and Marcus, *Essentials of Investments*, chapters 1 to 4, for Block 1, without saying how those chapters divide between this meeting and the next, and it requires no textbook: all exams are based on material "explicitly covered in class, handouts, and notebooks" (*syl pp. 5–6*).

GAP The suggested textbook was not available

The book is not among the files this note was built from, so no comparison with its chapters has been made and no list of what they add can be given. The workbook's own pointers to end-of-chapter problems in that book, for Blocks 1 and 2, cannot be restated for the same reason.

Self-check

The workbook's five concept questions on this meeting's material, grouped by the skill they test, in lecture order. Each answer is hidden until revealed, and each explanation says why every wrong option is wrong.

Three of them lean on something the lecture did not say aloud, and their explanations say so: a slide-only line (Q4), the workbook's own ranking (Q1) and an explanation that is this note's (Q13).

Real against financial assets (§7)

Self-check — WB 1.1 Q13: which of these is not a real asset?

Source: *Workbook Block 1.1 Q13, pp. 5–6*. Real against financial assets, 01a p. 11 (taught at 30:06 – 33:31).

QUESTION

Which of the following is **not** a real asset?

- (a) Human capital.
 - (b) The software behind Google's search engine.
 - (c) A dollar bill.
 - (d) A gold coin.
-

ANSWER

Reveal the answer

(c) A dollar bill

Why

The test is what the thing *does*. A **real asset** is used to produce goods and services — trees, factories, land, human capital, homes. A **financial asset** is a contract: a claim on the output that real assets produce (01a p. 11). The lecture was emphatic that touching it has nothing to do with it: "It's not about tangibility. It's not about that you can't touch it. It's about where you can use it to produce a good or a service directly" (🕒 32:59).

A dollar bill produces nothing. Nobody makes a good or delivers a service *with* it; its value lies entirely in what others will give you for it. That makes it a claim, which is what a financial asset is. The workbook gives the answer, (c), but its printed reason explains only option (b); why the dollar bill fails the test, and why the gold coin passes it, is explained in no course material, and the reasoning in this reveal is the note's own **EXPLANATION**.

Options (b) and (c) together make the lecture's point from both sides: Google's software is intangible and still a real asset, while a dollar bill is a physical object and still a financial one. Tangibility decides neither.

A second test that sorts all four **EXPLANATION**. A financial asset always sits on two balance sheets at once: it is an asset of its holder and a liability of whoever issued it. A bond is its buyer's asset and the company's debt; a dollar bill is its holder's asset and a liability of the central bank that issues it (01a p. 10 lists a central bank among the entities that keep a balance sheet). A real asset is nobody's liability. Human capital, Google's software and a gold coin owe their holder nothing and are owed by no one; the dollar bill is the only option that is someone else's promise.

Why each other option is wrong

Option	Why it is a real asset
(a) Human capital	On the slide's own list (01a p. 11). The knowledge in a person's head is used to produce services: in class, the teaching fellows "can use all the knowledge they have to help you learn in this course ... that's a service we're getting from them. It's not tangible ... but it's an asset you can use to produce a service" (🕒 30:06).
(b) Google's software	The workbook's own reason: the software "is non-tangible but it allows to produce goods and services" — here, search. Being intangible does not make it financial.
(d) A gold coin	EXPLANATION Gold is a physical commodity with productive uses — jewellery, electronics, dentistry — and a coin's value rests on the metal itself, not on anyone's promise to pay. If every bank and government defaulted, a gold coin would still be gold. People often <i>hold</i> gold coins as a store of value, which is what makes this option tempting, but no one owes the holder anything, so the coin is a real asset.

Equity as the residual claim (§7, §11.1)

Self-check — WB 1.1 Q2: who is last in line when a firm is liquidated?

Source: Workbook Block 1.1 Q2, p. 3. Equity as the residual claim, 01a pp. 11 and 17 (taught at 🕒 31:04 and 🕒 46:52).

QUESTION

If a firm is liquidated, who are the last in line to be paid after all those who have a claim on the income and assets of the corporation?

- (a) The government.
- (b) The suppliers.
- (c) The stock holders.
- (d) The bond holders.

ANSWER

Reveal the answer

(c) The stockholders

Why

A share of stock is a claim to a share of the firm's profit, plus ownership (01a p. 17) — to what is *left* once everyone else has been paid. The lecture made this concrete with NVIDIA: at the end of the year it collects the money from the chips it sells and pays its suppliers and its employees, and a shareholder holds "a claim on those dollars" that remain (🕒 31:04). Nobody promises the shareholder a fixed amount; the dividends are uncertain (01a p. 17). That is what makes equity the **residual claim**.

Liquidation applies the same order to the firm's assets instead of its yearly income. The assets are sold, and the proceeds go first to everyone holding a fixed claim; stockholders receive whatever is left, often nothing, which is why a bankrupt company's stock pays its holders zero (§11.1).

The workbook states the legal order in full: government, then employees, then bondholders, then preferred stockholders, then common stockholders. This ranking is the workbook's; no lecture or slide gives it. Preferred stock is a class of share the course has not defined; the workbook ranks it ahead of common stock, and either way the last in line are stockholders.

The order on the 01a p. 10 firm (EXPLANATION). The firm has \$180 of assets and \$70 of debt. If its assets were sold for \$180, the creditors would take \$70 and the stockholders the remaining \$110, its book value of equity. At a sale price of \$100, creditors still take \$70 and stockholders get \$30. At \$60, the creditors take all \$60 and are still \$10 short, and the stockholders get nothing. Every fall in the sale price hits the stockholders first.

Why each other option is wrong

Option	Why it is not last
(a) The government	First in the workbook's order, ahead of every other claimant — the opposite end of the line.
(b) The suppliers	They are owed a fixed amount for what they delivered, and in the lecture's own example the firm pays its suppliers before shareholders get "those dollars" (🕒 31:04). The workbook's list does not name suppliers, but a claim for a fixed sum owed ranks ahead of the residual claim (EXPLANATION).
(d) The bondholders	A bond is a promise of fixed payments (01a p. 15), so bondholders are creditors and are paid before any stockholder — third in the workbook's order.

Self-check — WB 1.1 Q3: the most a stockholder can lose

Source: *Workbook Block 1.1 Q3, p. 3*. Equity in bankruptcy (taught at  46:52) and the workbook's principle of limited liability.

QUESTION

If you own a stock of a firm, and if this firm is liquidated, what is the most you can lose?

- **(a)** Nothing.
 - **(b)** Your original investment.
 - **(c)** Only 50% of your original investment.
 - **(d)** Your original investment and some other asset (for example your house).
-

ANSWER

Reveal the answer

(b) Your original investment

Why

The answer has two halves, and they come from different places.

The stock can go all the way to zero. Stockholders are paid last, from whatever is left after every creditor (WB 1.1 Q2), so in a liquidation there is often nothing left for them and the shares pay zero (§11.1). Everything you paid for the shares can be lost.

It cannot go below zero. The workbook supplies the second half, which no lecture states: creditors can never "go after stockholders and demand them to pay for remaining debt." If the firm's assets do not cover its debts, the creditors bear the shortfall, not the owners. This protection is called **limited liability**: the most a stockholder can lose is what the shares cost.

EXPLANATION On the 01a p. 10 firm, with \$70 of debt: if its assets fetched only \$60 in a liquidation, the creditors would receive \$60 and lose \$10, and the stockholders would receive nothing — but no creditor could ask them for the missing \$10. Someone who had paid \$1,000 for shares in that firm loses the \$1,000 and not a cent more.

This is the stock-market case of a rule the next lecture states for any purchase: when you buy something, the most you can lose is what you paid, because a price cannot fall below zero ("when you buy something, you're always protecting the downside by how much you pay", Lecture 2 at 62:49). A short seller has no such floor, which is why the Lecture 2 note (8 Sep) contrasts the two.

Why each other option is wrong

Option	Why it is wrong
(a) Nothing	The share price can fall to zero in a liquidation (⌚ 46:52), so the whole investment can be lost.
(c) Only 50%	No rule stops the loss halfway. Stockholders are last in line, and if nothing is left after the creditors, the shares are worth nothing.
(d) Your investment and your house	This is exactly what limited liability rules out: the firm's creditors have no claim on the owners' other assets.

The asset classes: default risk and maturity (§10, §11.1, §13)

Self-check — WB 1.1 Q1: rank three kinds of bond by risk

Source: *Workbook Block 1.1 Q1, p. 3*. Fixed-income securities, 01a p. 15 (taught at 41:50 – 45:23).

QUESTION

Rank the following bonds from the most risky to the least risky:

- **(a)** Treasury bonds, Corporate bonds, Municipal bonds.
 - **(b)** Municipal bonds, Corporate bonds, Treasury bonds.
 - **(c)** Corporate bonds, Treasury bonds, Municipal bonds.
 - **(d)** Corporate bonds, Municipal bonds, Treasury bonds.
-

ANSWER

Reveal the answer

(d) Corporate, then municipal, then Treasury

Why

All three are fixed-income securities: each is a promise of fixed, predetermined payments in the future (01a p. 15). The risk that separates them is **default risk**, the chance that the promise is not kept: an issuer can choose not to pay (§10.2,  42:48).

- **Treasury bonds** are the safe end: "No default risk (at least US)" (01a p. 15). They "have been traditionally considered safe investments" because nobody could conceive of the US government not paying back, and the course works with that assumption ( 42:48). The "at least US" matters: defaults by other countries' governments are common, and Argentina was named in class.
- **Municipal bonds**, issued by state and local governments, and **corporate bonds** both carry default risk (01a p. 15;  44:45).

That fixes Treasuries as the least risky. The workbook then ranks the other two: corporations are the most likely to default on their bond payments, followed by state and local governments, while US Treasury debt is very safe. Hence corporate, municipal, Treasury.

WARNING The municipal-versus-corporate ranking is the workbook's, not the lecture's

The lecture never compared the two. In fact it described municipal bonds as carrying "a lot of default risk" and, right after it, recommended a reading on "that default case" in Orange County, California ( 44:45). The order corporate > municipal comes from the workbook's own statement that corporations default more often than state and local governments; it is the answer the course's materials expect.

Why each other option is wrong

Option	Why it is wrong
(a) Treasury, corporate, municipal	Puts Treasury bonds at the <i>risky</i> end, reversing the lecture's one firm point: US Treasuries have no default risk.
(b) Municipal, corporate, Treasury	Gets the safe end right but swaps the other two, against the workbook's ranking of corporations as the likelier defaulters.
(c) Corporate, Treasury, municipal	Ranks a bond with no default risk (Treasury) as riskier than one with default risk (municipal).

Self-check — WB 1.1 Q4: which instrument has the longest maturity?

Source: *Workbook Block 1.1 Q4, p. 3*. Equity, 01a p. 17, against the fixed-income and money-market instruments of 01a pp. 15 and 19.

QUESTION

Of the following financial instruments, which one has the longest maturity?

- (a) A Treasury Bond.
- (b) Commercial Paper.
- (c) A Stock.
- (d) Mortgage Backed Security.

ANSWER

Reveal the answer

(c) A stock

Why

This answer rests on a line that was on the slide but was never said in class. Under "Equity (stocks)", 01a p. 17 lists "Maturity is indefinite". The lecture's words on equity (⌚ 46:52) were about uncertain payments — a stock can pay a fortune or nothing — not about maturity. The Lecture 3 deck makes the same point in passing, also without saying it aloud: stocks, like the perpetuity, have an "infinite horizon" (02a p. 23; Lecture 3 note (10 Sep)).

The reason is what a stock is. A bond is a promise of fixed payments up to a stated date, its maturity, when the last payment is made (01a p. 15). A stock is a claim to a share of the firm's profits plus ownership (01a p. 17), and nothing in that claim ever falls due: the firm never repays the shareholder, so the claim lasts as long as the firm does. In the workbook's words, a stock's life "can be arbitrarily long unless the firm gets liquidated". Every other option has a date on which it ends.

Why each other option is wrong

Option	Its maturity	Why it is shorter
(a) A Treasury bond	10 to 30 years (01a p. 15, slide only; bills are under a year and notes 1 to 10 years)	Long, but finite: the government repays the bond on a fixed date. The workbook gives the same range.
(b) Commercial paper	short-term	A money-market instrument: the money market is "short term (overnight) borrowing/saving", and 01a p. 19 lists commercial paper there (slide only); in class, "money markets, which are overnight markets" (🕒 53:00). The workbook: "commercial paper is short-term".
(d) A mortgage-backed security	at most the term of its mortgages	An asset-backed security bundles loans — mortgages first on 01a p. 19's list (slide only) — and pays out as the borrowers pay. The course's mortgage is a 30-year loan of 360 monthly payments that comes with a prepayment option (02a p. 30, taught in the Lecture 4 note (17 Sep)), so a pool of such mortgages stops paying within 30 years, and sooner when borrowers prepay. The workbook's solution does not discuss this option (EXPLANATION).

Coverage audit

PIPELINE P9 / NOTE_SPEC Stage 4, run 2026-09-21 in a fresh prep-model session against the assembled note `notes/fin/fin-2026-09-03-L1.md` (9 parts + 14 included P8a drafts, 36,669 words). Audited against `work/beats/fin-2026-09-03-L1.md` (143 beats), `work/maps/fin-2026-09-03-L1.md` (§1 beat→source map, §2 deck coverage and the 67 shown-not-said items, §3 math inventory M01–M23 with warnings W1–W10 and gaps G1–G12, §4 problem map, §5 reading map with beats R01–R25, §7 notation), `work/xref/fin-2026-09-03-L1.md` (listen list, 5 items), `work/problems/fin-2026-09-03-L1/_index.md` and all 14 drafts, `work/readings/fin-2026-09-03-L1/`, `work/problems/fin.yaml`, `config/problem_policy.yaml` and `notes/_CONVENTIONS.md`. Pipeline ids are used in this block only; they appear nowhere else in the note.

Verdict: PASS (9/21), **confirmed by the 9/22 re-check (§9)**: fix items 1, 2, 3(a) and 4 are closed.

143/143 beats covered, 0 MISSING, 0 THIN. Math check **3,888 checks, 0 failing** across the three scripts for this session after the re-check (3,392 at this audit, 862 of them added by it; the re-check's quotation check P9Q adds 498, and 436/436 quotations match their cited sources). *[Superseded 2026-09-29 (merge M2): after the 9/22 final round's quotation fixes, P9Q counts 430 pairs, all passing (final-report.md §3).]* 6/6 problem-map items present exactly once; 14/14 drafts included and each conforming; 25/25 reading beats covered; 67/67 shown-not-said slide items present and flagged; 23/23 math-inventory items present and fully derived; 0 pointer defects; 0 unmarked copy defects. **Four non-blocking conformance items** are listed at the end; none blocks *done*.

1. Beat audit — `work/beats/fin-2026-09-03-L1.md` , 143 beats

§n.m is the note's own section number. Status `ok` = covered in substance; `THIN` = present but shrunk; `MISSING` = absent.

Course roadmap, recorded mid-overview (beats 1–9)

#	Beat, in short	Where in the note	Status
1	NPV is the most repetitive part but has to come first	§1.5 table, Block 2 row	ok
2	portfolio choice defined; "important part of the next few weeks"	§1.5 table, Block 3 row	ok
3	CAPM, "one of the workhorse models" (<i>listen item 1</i>)	§1.5 table, Block 4 row + Gap <i>Not recoverable</i> — 00:51	ok
4	market efficiency: "whether people get the right returns"	§1.5 table, Block 5 row	ok
5	equity valuation belongs with the first part; blocks 7–10 are arbitrage	§1.5 table, Blocks 6 and 7 rows	ok
6	bonds "very popular in the last few days"	§1.5 table, Block 8 row (paired with beat 123 in §10.4)	ok
7	options; intermediation closes the course	§1.5 table, Blocks 9 and 10 rows	ok
8	materials are filed by block number	§1.5 opening ¶ + the four file names SLIDE ONLY	ok
9	two guest lectures, October and end of term, attendance counts	§1.5 <i>Two guest lectures</i>	ok

Aside: who is taking the class (beat 10)

#	Beat, in short	Where in the note	Status
10	the class-composition chart: 40/40/20, "0.7 is one person", IID	§1.6 + Gap <i>Reconstructed from the lecture audio</i> — 02:53	ok

What financial economics is (beats 11–19)

#	Beat, in short	Where in the note	Status
11	opens block one; asks the class what economics is	§2 ¶1	ok
12	STUDENT: "how to allocate scarce resources" — accepted	§2 ¶1	ok
13	financial economics = that, plus time and uncertainty	§2 ¶1; Definition in §1.1	ok
14	"It's not about money"	§2 ¶2	ok
15	area 1, asset pricing	§2 table row 1	ok
16	area 2, corporate finance; other courses, SOM	§2 table row 2	ok
17	area 3, financial intermediation	§2 table row 3	ok
18	area 4, household finance; mortgages	§2 table row 4 + the forward link to Lecture 4	ok
19	valuation is the foundational knowledge	§2 last ¶	ok

The four principles (beats 20–43)

#	Beat, in short	Where in the note	Status
20	four principles; a smart student could derive the rest	§3 opener	ok
21	principle 1, non-satiation, defined	§3.1 Definition	ok
22	\$100 or \$200; the poll; "almost irrational"	§3.1 ¶2	ok
23	everybody likes more; a very simple idea with powerful results	§3.1 ¶2	ok
24	principle 2, risk aversion; the coin flip	§3.2 Definition + ¶1	ok
25	$E[B] = 50\% \times 200 + 0 = \$100$	§3.2 display; <i>Worked problems A</i> Steps 1–3	ok
26	no right answer; $A \Rightarrow$ risk averse, $B \Rightarrow$ risk-loving	§3.2 ¶2 + Warning in A's SANITY CHECK	ok
27	scaling the stakes: \$1,000/\$2,000 ... \$1bn/\$2bn	§3.2 ¶4; A Step 5 table + Gap — 09:35	ok
28	attitude depends on wealth and stakes; the maintained assumption	§3.2 last ¶	ok
29	principle 2 restated, "a very human way of behaving"	§3.2 last ¶	ok
30	\$100 is "a nicer dinner"; at \$2m "I'll take the \$1 million"	§3.2 last ¶; A Step 6	ok
31	principle 3, time value; \$100 now vs \$100 in a year	§3.3 Definition + ¶1	ok
32	why: spend it now; "what if you're dead in a year"	§3.3 ¶1	ok
33	a rate makes you indifferent; no number given	§3.3 ¶2 + the symbolic PV	ok
34	summary of the first three	§3.3 last ¶	ok
35	the fourth builds on the first	§3.4 ¶1	ok
36	principle 4, no arbitrage; no free lunches	§3.4 Definition	ok
37	Parasol/Umbrella/4% set-up	§3.4 state table	ok

#	Beat, in short	Where in the note	Status
38	STUDENT proposes the trade; the student's "10%"	§3.4 ¶ after the table + Warning in B's SANITY CHECK	ok
39	EXAM: not on the midterm, on the final; eight lectures	§3.4 Exam signal	ok
40	"I'm going to let you work the math"; p. 4 shown, not read	§3.4 ¶ + SLIDE ONLY	ok
41	the 50–50 replication argument; "looks like a risk-free investment"	§3.4 ¶ after the cash-flow table	ok
42	the mix's return and the 4% "better be" the same; borrow 4, invest 5	§3.4 last ¶ and §3.5 ¶1	ok
43	"this is the deep idea"; three simpler examples follow	§3.5 last ¶	ok

No arbitrage in action (beats 44–63)

#	Beat, in short	Where in the note	Status
44	the \$100-bill joke	§4.1 ¶1	ok
45	those returns cannot coexist with 4%	§3.5 ¶3	ok
46	exploiting it is a long-short strategy, covered later	§3.5 ¶3–4	ok
47	arbitrage is natural; the Stop & Shop photo	§4.2 ¶1	ok
48	mayo: 340 mL \$4.39; 591 mL \$3.49 with the coupon	§4.2 price table; C1 Steps 1–5	ok
49	the general recipe: identical things, buy cheap, sell dear	§4.1 last ¶	ok
50	"you start squeezing"; "not the right thing to do"	§4.2 ¶ after the Gap; C1 Step 6	ok
51	the arbitrage that seems to lurk; "here there's a twist"	§4.2 same ¶	ok
52	STUDENT: not the same size — "something related"	§4.2 last ¶	ok
53	STUDENT: gluten-free? — no, cage-free eggs	§4.2 last ¶ + the photo caption	ok
54	product differentiation; the yellow and black dress	§4.3 ¶1	ok
55	"all dollars are equally green" (<i>listen item 2</i>)	§4.3 ¶2 + Gap <i>Not recoverable</i> — 20:43	ok
56	so the mayo pricing is "perfectly fine"	§4.3 last ¶	ok
57	Nutella: \$5.37/lb large against \$5.28/lb small	§4.4 ¶2; C2 Steps 1–3	ok
58	buy the small ones and fill the big ones	§4.4 ¶3; C2 Step 6	ok
59	STUDENT: expiry — "a really bizarre reason"; "buy two small ones"	§4.4 ¶3	ok
60	unlike the mayo, "the exact same products"	§4.4 ¶4 + the two-test table	ok
61	stadium popcorn; frictions stop us	§4.5 ¶1	ok
62	the same forces derive Black–Scholes, "a really fancy equation"	§4.5 ¶2	ok
63	arbitrage gets its treatment "after the break"	§4.5 ¶2	ok

Percent and basis points (beats 64–74)

#	Beat, in short	Where in the note	Status
64	% just means 1/100	§5.1 ¶1	ok
65	$1\% = 10^{-2}$, $3\% = 3 \times 10^{-2}$	§5.1 table; D1 Steps 1–2	ok
66	a percent squared = 10^{-4} = one basis point; the WSJ	§5.1 table + ¶2; D1 Step 3	ok
67	the right language is much of what the course gives you	§5.1 last ¶	ok
68	EXAM: 40% → 42% (<i>listen item 3</i>); "big confusions"	§5.2 + Exam signal + Warning in D1	ok
69	one basis point is 0.01%, or 10^{-4}	§5.3 Definition; D2 Step 1	ok
70	2.25% → 2.5% is 25 basis points (<i>spoken only</i>)	§5.3 ¶2; D2 Steps 3–4 + Gap — 24:48	ok
71	EXAM: "I'll use it in the questions"	§5.3 Exam signal	ok
72	the WSJ headline: 50 bp = half a point = 0.5 pp	§5.4 ¶2; D2 Step 5	ok
73	"Powell, of course, is not with us anymore"	§5.4 last sentence	ok
74	EXAM: "I will assume you know all of this"	§5.3 Exam signal (second half)	ok

Balance sheets (beats 75–85)

#	Beat, in short	Where in the note	Status
75	introduces the terminology; the accounting poll	§6 ¶1	ok
76	extra slides on financial accounting, "a couple hours"	§6 ¶1 + Gap <i>Material mentioned, not available</i> — 26:06	ok
77	a balance sheet: who owns something and how it is funded	§6.1 Definition + ¶1	ok
78	assets are what you own; phone, wallet, backpack, house, accounts	§6.1 ¶1	ok
79	the firm: \$100 cash, \$50 investments, \$30 inventories	§6.1 table; E Steps 1–3	ok
80	liabilities: mortgage is long-term, credit card short-term	§6.1 ¶1	ok
81	net worth: "put a line, and then you subtract"	§6.1 Definition + display; E Step 3	ok
82	it works for a person, firm, bank, government, the world	§6.1 ¶1	ok
83	all borrowed $\Rightarrow$ small net worth; nothing borrowed $\Rightarrow$ larger	§6.1 last ¶; E Step 5	ok
84	for a person, net worth is wealth, not income	§6.2 ¶1	ok
85	for a firm, the book value of equity; Yale, NVIDIA, Coca-Cola	§6.2 ¶2 + Warning in E's SANITY CHECK	ok

Types of assets (beats 86–92)

#	Beat, in short	Where in the note	Status
86	real assets produce goods and services; trees, factories, land	§7 Definition	ok
87	human capital is real; the teaching fellows	§7 ¶2	ok
88	a financial asset is a contract, a set of rules	§7 ¶3	ok
89	NVIDIA on Robinhood: a claim on the dollars that remain	§7 ¶3	ok
90	"it's not about tangibility"; only a promise	§7 ¶4 + the two-by-two table	ok
91	capital markets are where financial assets trade	§7 Definition	ok
92	the distinction restated	§7 ¶4	ok

Roles of financial markets (beats 93–100)

#	Beat, in short	Where in the note	Status
93	why markets at all; the Stone-Age barter economy	§8 ¶1	ok
94	role 1, project financing; the ice cream outside the Commons	§8 <i>Role 1</i>	ok
95	role 2a, risk sharing; the sick-coworker pool	§8 <i>Risk sharing</i>	ok
96	unemployment insurance; buying insurance is a financial contract	§8 <i>Risk sharing</i>	ok
97	risk transfer; the euro on the summer trip to Spain	§8 <i>Risk transfer</i> (with the 36:09 unrecoverable note)	ok
98	diversification also serves investment; NVIDIA and Google	§8 ¶ after the two bullets	ok
99	role 3, consumption smoothing; borrow young; the mortgage	§8 <i>Role 3</i>	ok
100	wrap-up: financing, risk allocation, smoothing over time and states	§8 table + the closing ¶	ok

Three ideas, the language, the Nobel prizes (beats 101–108)

#	Beat, in short	Where in the note	Status
101	idea 1, arbitrage	§9.1 table row 1	ok
102	idea 2, optimality; utility subject to risk-return combinations	§9.1 table row 2	ok
103	"literally three weeks" on this idea	§9.1 table row 2	ok
104	idea 3, equilibrium	§9.1 table row 3	ok
105	the language is "super important"; the WSJ; talking past each other	§9.2	ok
106	Markowitz, block 3; Sharpe, block 4	§9.3 table	ok
107	Tobin, two-fund separation; "everything here is Tobin names"	§9.3 table	ok
108	Merton, Scholes, Stiglitz, Thaler, Hansen, Fama, Shiller	§9.3 table (all ten rows, brackets verified)	ok

Fixed income (beats 109–125)

#	Beat, in short	Where in the note	Status
109	the asset-class tour; next lecture is markets; equations in two lectures	§10 opener + <i>Continues in</i>	ok
110	fixed income is the most elementary security; a promise	§10.1 Definition + ¶1	ok
111	"fixed" means predetermined, not constant	§10.1 ¶1	ok
112	coupons; valuation "connects to time value of money"	§10.1 Definition + ¶1	ok
113	curated WSJ articles weekly; free with a Yale login	§10.2 last ¶	ok
114	bills, notes, bonds by maturity	§10.2 maturity table	ok
115	Treasuries traditionally safe; nobody could conceive a default	§10.2 ¶2	ok
116	Argentina, Puerto Rico and a third name (<i>listen item 4</i>)	§10.2 Gap <i>Not recoverable — 43:43</i>	ok
117	nothing is truly fixed; keep default in mind	§10.2 ¶ after the Gap	ok
118	the yield curve, flagged as a name for later	§10.2 Definition + ¶	ok
119	municipal bonds; "a lot of default risk"; the Orange County reading	§10.3 ¶1 + Gap <i>Material mentioned, not available — 44:45</i>	ok
120	corporate bonds also carry default risk	§10.3 ¶2	ok
121	bottom line: predetermined payments, default risk, the simplest securities	§10.3 ¶2	ok
122	the chart from the lecturer's notebook; axes and the two colours	§10.4 ¶1–3 + both figures	ok
123	post-COVID rise, "the last few weeks", Japan	§10.4 ¶3	ok
124	EXAM: know the pictures; "low rates, high rates, low rates ..."	§10.4 Exam signal	ok
125	an article to come; "three, four lectures" on the series	§10.4 last ¶ + the Gap	ok

Equity and derivatives (beats 126–131)

#	Beat, in short	Where in the note	Status
126	equity; the S&P; Coca-Cola, Google, NVIDIA	§11.1 ¶1	ok
127	no predetermined payment; bankrupt $\Rightarrow$ zero; the NVIDIA millionaire	§11.1 ¶3	ok
128	"so you don't have to discount it" (<i>listen item 5</i>)	§11.1 Warning <i>Said in class vs written</i> — 47:39	ok
129	what is risky? how is risk priced? what compensation?	§11.1 last ¶	ok
130	derivatives: payments derived from other assets; options, futures, swaps	§11.2 Definition	ok
131	options are conditional; the Apple example	§11.2 ¶1 + Warning on the right vs exercising it	ok

Shiller's CAPE (beats 132–135)

#	Beat, in short	Where in the note	Status
132	EXAM: a figure to keep in your head	§12 Exam signal	ok
133	the chart's axes: time against price over earnings	§12 Definition + both figures	ok
134	high P/E $\Rightarrow$ overvalued, expect a correction; low $\Rightarrow$ a good time to buy	§12 ¶ after the figures + Warning	ok
135	the last 15 years keep looking overvalued; "rationalize this pattern"	§12 same ¶ + the readings list	ok

Other institutions, and two films (beats 136–143)

#	Beat, in short	Where in the note	Status
136	banks; maturity transformation	§13 <i>Banks</i>	ok
137	mutual funds pool funds; diversification and risk sharing	§13 <i>Mutual funds</i>	ok
138	ABS; the show of hands; "very popular in 2008"; bundling	§13 <i>Asset-backed securities</i>	ok
139	<i>The Big Short</i> : watch it, and watch it again	§13 ¶ after the ABS bullet	ok
140	what the film does not explain: why ABS exist — risk sharing and transfer	§13 same ¶	ok
141	Geanakoplos will give a glimpse of these ideas	§13 same ¶	ok
142	structured finance is an advanced course; money markets are overnight	§13 <i>Money markets</i>	ok
143	watch "these two" over the weekend	§13 <i>The two films</i> + the closing line	ok

Beat totals: 143 covered · 0 THIN · 0 MISSING. No beat is discharged as [LOGISTICS – DISCHARGED] : the beat sheet already excluded logistics (its *Notes for P7* item 1), and its two borderline beats — the class chart (10) and the file-prefix rule (8) — are both written in as content.

2. Math check

Three scripts cover this session. All pass.

	9/22 re-check	9/21 audit
work\mathcheck\fin-2026-09-03-L1.py	3527 checks, 0 failures	3033
work\mathcheck\fin-2026-09-03-L1_body.py	327 checks, 0 failures	325
work\mathcheck\fin-2026-09-03-L1_readings.py	34 checks, 0 failing	34
total	3888 checks, 0 failing	3392

(9/22: the fix lane's edits moved the counts to 3,029 and 327, two 🕒 links having left the drafts and two having joined the body; the re-check's P9Q section then added 498. See §9.5.)

Section	What it covers	Result
LA–LH, K1, C1–C5, S1–S27 (P8a)	the 8 lecture-example drafts, the 1.4 checklist, the 5 concept items, and the index's own structure	pass
NB1–NB9, NBS (P8b)	the note parts' own numbers: grading, course arithmetic, both charts read from the slide PDF's vector paths, and the structural scans	pass
readings (P8a)	every number in the syllabus digest	pass
P9a–P9f (added by this audit, 862 checks)	the claims no other script touched, listed below	pass
P9Q (added by the 9/22 re-check, 498 checks)	every quotation in the assembled note, paired in order per line, against the source it is attributed to; 13 seeded misquotes	pass (§9.3)

The P9 sweep re-read the assembled note line by line and found six groups of assertions that no existing check covered. All are now checked:

- **P9a — deck 00 pp. 2, 4–7, 9, 11, 12.** The pages shown before the recorder started reach the note only through §1 and its collapsed logistics box, and none of their content had a check. Now verified against the converted deck: the biography's three years (2014–2018, 2014, 2008) and three course numbers (350, 500, 531); *Econ 252 no longer offered*; **all fourteen** Yale College courses on p. 5 with their instructors and **all eight** SOM courses on p. 6; the prerequisite line; the cumulative final; the no-cheating policy; the four file-name examples. The note restates several of these in its own words, so the checks assert the claim in the note *and* its source separately.
- **P9b — the syllabus's reference list and per-block readings.** Nine textbooks with their editions, and the *Suggested Readings* line of each of the ten blocks, checked row by row against syl p. 6 — the note's §1.5 table reproduces all ten. Plus the arithmetic the note states in prose: the counts sum to 22, blocks 1–6 take 13 and 7–10 take 9, blocks 7–9 take 8, and 25 lectures plus the midterm make 26 meetings.
- **P9c — 01a pp. 6, 7, 9, 14, the image pages.** The 7.7 oz untagged Nutella jars; the WSJ screenshot's 71% odds, 30–31 July meeting, byline and full URL; the mayo photo's sale tag, date, and both product labels; and **all ten** Nobel rows with their block brackets, cross-checked between the note's table and 01a p. 14. Also that Merton's "Dynamic", Hansen's slide wording and Fama's bracket are each flagged where the speech differed.
- **P9d — conversions and table rows the body asserts on its own.** The fluid ounce/millilitre pairings at 29.5735 mL/fl oz; the big Nutella jar's extra half ounce at 62¢ against 33¢; **every row** of §5.3's five-row conversion table, and the identification of its 100 bp row with §3's 5%-vs-4%

gap and its 200 bp row with 40% → 42%; the attendance schedule for $n = 0 \dots 25$; the justified-absence weight ($0.30 + 0.55 = 0.85$); and both \$1.4 self-checks, both \$5.2 self-checks, \$6's – \$26,500 and \$3.5's two WHAT VARIES rows.

- **P9e — index ↔ draft ↔ note agreement.** Cost fix 1 means P8b read `_index.md` and opened only three drafts, so a wrong index entry would have reached the reader unchallenged. Checked: 14 index blocks against 14 draft files; **every number the index advertises under Body numbers is present in its draft**; every draft's boxed ANSWER survives into the assembled note; every draft's `**Source:**` line is in the assembled note (so the assembler really inlined it); the eight full write-ups carry the seven headings in order; each of the five concept items has a ##### QUESTION , a hidden `<details>` answer, four lettered options, the official letter, and a *Why each other option is wrong* table; and $5 + 12 = 17$ checklist bullets. **No disagreement found between the index and any draft.**
- **P9f — mechanical conformance.** The pointer, symbol-table, why-line, copy, callout-type, timestamp, figure, bold, beat-count, reading-beat-count, textbook-gap, exam-exclusion, per-course-basis and internal-repetition scans reported below.

Math inventory M01–M23 — all present and fully derived

id	Item	Where	Status
M01	non-satiation, \$200 > \$100, ordinal only	§3.1; restated in the 1.4 checklist	present
M02	$E[X_B] = \frac{1}{2} \cdot 200 + \frac{1}{2} \cdot 0 = \$100 = X_A$	§3.2 display; <i>Worked problems A</i>	present
M03	the scaled stakes (spoken only)	A Step 5 table + Gap — 09:35	present
M04	\$100 now vs \$100 in a year; $PV = 100/(1+R)$, no rate invented	§3.3	present
M05	the two companies' returns and the 4% rate	§3.4 state table	present
M06	the p. 4 trade; 0.01B; and the general weight , a <i>Full derivation (not done in class)</i>	§3.4 cash-flow table; B Steps 1–9; §3.5 derivation	present
M07	p. 4's unanswered question: $r_f = 5\%$, both directions , a <i>Full derivation</i>	§3.5; B2 Steps 1–5	present
M08	mayonnaise unit prices, the 2.19 ratio, all four shelf tags	§4.2 table; C1	present
M09	Nutella per oz and per lb, two small jars, the premium	§4.4; C2	present
M10	$\% = 1/100$; 1%, 3%, $\%^2$ as powers of ten	§5.1 table; D1 Steps 1–3	present
M11	40% → 42%: 2 points against 5%	§5.2; D1 Steps 4–5	present
M12	1 bp = 0.01% = 10^{-4} ; 100, 200, 50 bp	§5.3 Definition; D2 Steps 1–2	present
M13	2.25% → 2.50% = 25 bp (spoken only)	§5.3; D2 Steps 3–4 + Gap	present
M14	the WSJ's three names for 50 bp	§5.4; D2 Step 5	present
M15	$A = 180$, $L = 70$, $NW = 110$, and $A = L + NW$	§6.1; E Steps 1–6	present

id	Item	Where	Status
M16	Treasury maturity classes	§10.2 table; WB 1.1 Q4	present
M17	the p. 16 rates chart, read from the vector paths	§10.4 + both figures + the traced redraw	present
M18	the p. 18 CAPE chart, read from the vector paths	§12 + both figures + the traced redraw	present
M19	the valuation ladder TVM → +Risk → +Optionality	§11.3 table	present
M20	options are conditional; no payoff formula presented as class content	§11.2 + Warning	present, correctly unformalised
M21	the class chart's shares (spoken only)	§1.6 + Gap; the 149–153 headcount inference is correctly not printed	present
M22	the course's lecture arithmetic	§1.5 table and the two sub-totals	present
M23	the grading formulas	§1.4, with the collapsed derivation of Formula B – Formula A	present

Two *Full derivation (not done in class)* labels are required (map §3) and both are there: the general riskless weight (§3.5's derivation callout) and the two-direction argument for $r_f = 5\%$ (worked problem B2). The §3.5 callout is collapsed with - and shows its result as a display equation directly above it.

Warnings W1–W10 and errata

No erratum exists in this meeting's materials (map §3's composition line and the index's *No POSSIBLE ERRATUM*), and the note correctly flags none. The one near-miss is recorded, not flagged as an error: the 340 mL shelf tag prints \$6.10 where $4.39 \div 11.5 \times 16 = 6.108$, and §4.2 and C1 Step 5 both say this is the **store's** truncation and "the slide is not in error".

#	Item	Where	Both readings where needed
W1	the student's "10%" against the slide's 5%	B SANITY CHECK, [!warning] Said in class vs written – 14:48	n/a — every witness says 10%
W2	40% → 42%, listen item 3	D1 SOLUTION, [!warning] Said in class vs written – 24:28	yes
W3	"so you don't have to discount it", listen item 5	§11.1, [!warning] Said in class vs written – 47:39	yes
W4	choosing B need not mean risk-loving	A SANITY CHECK [!warning] , once	n/a
W5	same period · no own capital · no probabilities	§3.4's assumption list and B's SANITY CHECK, labelled EXPLANATION	n/a
W6	the rates chart is not a yield curve	§10.4 [!warning]	n/a
W7	a high CAPE is not a timed forecast	§12 [!warning]	n/a
W8	an option's right does not vanish	§11.2 [!warning]	n/a
W9	book value is not today's sale value	E SANITY CHECK [!warning]	n/a
W10	the municipal-vs-corporate ranking is the workbook's	Self-check Q1 [!warning]	n/a

Each Warning the index said "should appear once" appears exactly once.

Gaps G1–G12 — all flagged, none filled

#	What	Where
G1	00 pp. 1–11 and the top of p. 12, shown before the recording	§1 [!gap] Not captured – the first part of the meeting
G2	the class-composition chart	§1.6 [!gap] Reconstructed from the lecture audio – 02:53
G3	spoken-only math: M03, M13, M21	A Step 5 Gap, D2 Step 4 Gap, §1.6 Gap
G4	listen item 1, the CAPM clause	§1.5 [!gap] Not recoverable – 00:51, both readings
G5	listen item 2, tangible/fungible	§4.3 [!gap] Not recoverable – 20:43, both readings
G6	listen item 4, the third defaulter	§10.2 [!gap] Not recoverable – 43:43, both readings
G7	the lost student reply at 18:39	§4.2 [!gap] Not recoverable – 18:39
G8	the Orange County reading's title	§10.3 [!gap] Material mentioned, not available – 44:45
G9	the notebook, the WSJ articles, the accounting slides	§6 and §10.4 Gap callouts
G10	no textbook gap list is possible	<i>Connections</i> [!gap] The suggested textbook was not available
G11	the ten unlabelled grey bands; the unlabelled CAPE line	§10.4 and §12 Gap callouts
G12	unrecoverable asides	03:00 and 03:38 (§1.6), 36:09 (§8), 46:08 (§10.4); the rest carry no content beyond their beats

Checked directly against the two traced SVGs: *rates-traced.svg* labels only the two series, the 1981 peak, the near-zero years and the 2022–24 inversion — **no band is named**; *cape-traced.svg* labels five dated points and **leaves the horizontal line unlabelled**. Nothing outside the slides was invented.

Nothing said is presented as written, and nothing written as said

All **67** shown-not-said items of map §2.3, plus deck 00 p. 12's five, are in the note, each carrying * (slide only)* or an equivalent sentence. Spot-checked group by group: p. 2 (2), p. 3 (1), p. 4 (9), p. 6

(6), p. 7 (3), p. 8 (6), p. 9 (4), p. 10 (4), p. 11 (1), p. 12 (3), p. 13 (2), p. 14 (4), p. 15 (3), p. 16 (3), p. 17 (4), p. 18 (2), p. 19 (9), p. 20 (1). No page is [SLIDE ONLY] this meeting: deck 01a is finished and every content page was taught (map §2.2, untaught: $\emptyset$).

3. Problem audit

work/problems/fin.yaml — 6 records for this session

id	page	Type	Treatment in the note	Present
WB 1.1 Q13	5–6	concept	<i>Self-check</i> , answer hidden, all three wrong options answered	1×
WB 1.1 Q2	3	concept	<i>Self-check</i> , ditto	1×
WB 1.1 Q3	3	concept	<i>Self-check</i> , ditto	1×
WB 1.1 Q1	3	concept	<i>Self-check</i> , ditto, with the W10 Warning inside the reveal	1×
WB 1.1 Q4	3	concept	<i>Self-check</i> , ditto, opening with the slide-only caveat	1×
WB 1.4 (L1 subset)	9	checklist	<i>Key takeaways</i> , bullets 1–5 with their 11 sub-items	1×

6/6 present, each exactly once, each citing its page. `fin-wb-1.4-keyconcepts-FULL` is a course-review-page record and is correctly **not** in the note; the note says so in one line. The nine workbook §11 BKM pointers are registered to no session and BKM is not in the corpus, so they are correctly absent (map §4.5).

The 14 drafts, audited as part of the note

The assembler inlines all 14 whether or not P8b opened them, so this audit applied checks 4–8 to the included text as strictly as to the body.

Group	Drafts	Conformance
8 lecture examples	risk aversion · the arbitrage trade · the risk-free rate · mayonnaise · Nutella · percentage points · basis points · the balance sheet	all seven headings, in order, in capitals ; GIVEN is the four-column table; every SOLUTION step carries its why-line; ANSWER is <code>\boxed{...}</code> ; SANITY CHECK and WHAT VARIES present
5 concept items	WB 1.1 Q13, Q2, Q3, Q1, Q4	##### QUESTION with the four options, hidden answer, official letter, every wrong option explained
1 checklist	WB 1.4 (L1 subset)	printed subset with its source line and the pooling/tranching Gap

Index-versus-draft check (the new requirement). Every ANSWER line and every number under Body numbers in `_index.md` agrees with its draft — 14 blocks, no disagreement. The index's one "not in the draft" clause (p. 9's 71%, 30–31 July, byline and date, which it hands to the body's figure caption) is correct: those figures are in §5.4, not in the basis-points draft.

The three drafts the index told P8b to open all had their rulings applied, and each Warning appears **once**: the student's "10%" in B, listen item 3 in D1, the risk-neutral guard in A. The eleven drafts P8b could include unread are conformant; the two rulings stated in their blocks are both discharged — Q1's Warning is inside its reveal, and the pooling/tranching Gap is under the checklist, with the note's own one-line definitions in §13 labelled **EXPLANATION** and cross-referenced from the Gap.

Assigned questions, exams, and the basis

- **No assigned problem set exists for this course** — `config/problem_policy.yaml` records `fin` as having no graded homework, quoting syllabus p. 3: *"There are no graded homeworks, but you are expected to work through the concept questions and the practice problems every week."* The note quotes **exactly that line**, at the head of *Worked problems* and again in §1.3, and no other instructor's statement about AI use appears anywhere in the note (checked mechanically for Jaynes, Zilibotti and Chalioti). `note_must_say` is empty for `fin`, so the note correctly carries **no** "this must be Tony's own write-up" line: nothing here is submitted for credit, and the note says so.
- **No exam question is worked ahead of its exam.** Block 1 of the workbook has no past-exam section and no numerical item on this meeting's material, so the note's worked problems are the lecture's own eight examples. The midterm (20 Oct) and final (18 Dec) are named as dates only.
- **In-class questions** (01a p. 3's "how can you make a sure profit...", p. 4's closing question, p. 6's "Can you spot an arbitrage opportunity?", p. 7's "Does this make sense?", and the A/B polls) are

lecture examples answered in class, not registry items, and all five are worked in the note.

4. Reading audit

The syllabus — core reading, 25 beats owed, 25 covered

Beats	Content	Where in the note	Status
R01	the gateway to Yale's other finance courses; a systematic introduction	§1.1 ¶1	ok
R02	the definition: resources over time and across states	§1.1 [!definition]	ok
R03	the nine topics	§1.1 ¶2, mapped to Blocks 2–10	ok
R04	[admin] Davies Auditorium; Tu/Th; 26 meetings = 25 + the midterm	§1.4 ¶1 and the logistics box	ok
R05	[admin] office hours, no cap, the registrar, TFs, sections in week 2	logistics box	ok
R06	first class, midterm, last class, final	§1.4 ¶1	ok
R07	prerequisites, and the "mathematical self-confidence" line	§1.2	ok
R08	the two grading formulas and the weights table	§1.4 display + derivation	ok
R09	the midterm is not optional; the absence rules; 50/45/5	§1.4	ok
R10	the attendance form and the three-case A function	§1.4 display + the prose on the cliff and the cap	ok
R11	no graded homework; work through the questions every week	§1.3 ¶3, quoted	ok
R12	[admin] study groups and the TF's help	§1.3 last ¶	ok
R13	a scientific calculator with exponentials and logarithms	§1.4 ¶1	ok
R14	[admin] conduct, integrity, mobile devices	logistics box	ok
R15	concept questions: hundreds, with solutions, about two minutes	§1.3 bullet 1	ok
R16	practice problems: extra practice	§1.3 bullet 2	ok

Beats	Content	Where in the note	Status
R17	exams: numerical plus short questions, both closed-book	§1.4 ¶1	ok
R18	notebooks: the code behind the figures	§1.3 table + §10.4	ok
R19	[admin] the Resource Office on Disabilities	logistics box	ok
R20	[admin] the anonymous feedback form	logistics box	ok
R21	no textbook required; exams rest on class, handouts, notebooks; the readings folder	§1.3 last ¶ and the table	ok
R22	BKM, Welch, Luenberger, Campbell, Cochrane, with levels and comments	§1.3 reference table, rows 1–5	ok
R23	Tuckman/Serrat, Veronesi, McDonald, Hull	§1.3 reference table, rows 6–9	ok
R24	the ten blocks with lecture counts and suggested readings	§1.5 table (all ten rows verified against syl p. 6)	ok
R25	the guest lecturers' titles	§1.5 <i>Two guest lectures</i>	ok

25/25 covered, 0 THIN. Six are [admin] , and all six sit in the one collapsed *Course logistics* box that map question Q3 defaulted to.

Textbook gap list

work/readings/fin-2026-09-03-L1/_textbook_gaps.md records **0 ADD IN FULL items and 0 one-liners**, because neither BKM nor Welch is anywhere in the corpus (map G10). Its instruction to P8b was to write one line in *Connections* and to **omit** an *Also in the textbook* block, so that an empty block would not imply a check that could not be run. Both are done: *Connections* → *Beyond the course materials* carries the line (BKM chapters 1–4 suggested for Block 1, no textbook required, exams from class, handouts and notebooks) with a Gap callout saying no comparison was possible, and the string "Also in the textbook" appears nowhere.

Other readings

Nothing else is owed. The four items P8a listed as unavailable are all Gaps in the note (§4's G8, G9, G2, G10). `00a_handout_notation` is digested under Lecture 4 and the note only *links* to it for the Σ convention, as the reading map directs; `00b_handout_statistics` belongs to Lecture 5. The two films

and the instructor's own paper carry title, subject and the instructor's framing only, per the *Fixed* treatment.

5. Pointer scan

Grepped the assembled note for *see slide*, *see the slide*, *see p.*, *see the reading*, *see the handout*, *see the syllabus*, *see the workbook*, *see the textbook*, *see the deck*, *refer to*, *as in the textbook*, *in the handout*, *look at the slide*, *consult*, *turn to page*, *see above*, *see below*, *cf.*

0 pointer defects — zero hits on every pattern. Every source in the note is an italic parenthetical citation beside restated content, an in-note cross-reference (§3.5 , [Worked problems](#worked-problems)), or a link to another note. Checked the other direction too: every source the note cites is also restated — deck 00's twelve content pages, deck 01a's nineteen, the syllabus's six, the workbook's six Block 1 items, and both charts' vector readings are all reproduced in the note's own words or as data.

One reported instruction is handled correctly rather than passed on: 00 p. 3's first agenda item is "Read the syllabus carefully", which the note quotes in its *Sources used* block as the reason the syllabus is this meeting's core reading — and then covers all 25 of its beats, so the reader never has to.

6. Copy scan

Word-level n-gram comparison of the assembled note against the cleaned transcript, both slide decks, the syllabus, the practice workbook and both visual reads, at 25 words and again at 18 words.

0 unmarked copy defects. At 25 words the sweep finds ten passages; every one is accounted for:

Source	Run	Verdict
transcript	seven runs — the bonds-in-the-news line, the CAPM clause, the arbitrage exam rule, "that looks like a risk-free investment...", the long-short line, "very important, big confusions...", "I'll use it in the questions" / "I will assume you know all of this", the balance-sheet comparison, Yale's book value, the ice-cream financing, the Orange County recommendation, the rates summary, reading A of 47:39, the derivatives definition, the Apple option, the CAPE "keep in your head", the P/E gloss, "it's not about tangibility...", and the weekend film line	all quoted , each with its [🕒 mm:ss]
01a p. 8	"a convenient unit of measurement in contexts in which percentage differences of less than 1% are common"	quoted , page cited
01a p. 13	the arbitrage question	quoted inside the §9.1 table, page cited
syllabus p. 3	the per-course basis	quoted twice, page cited both times
workbook	the four multiple-choice stems and the 1.4 bullet names	reproduced under ##### QUESTION / in the checklist table with a **Source:** line — required by §4B ("recreated in full, so the reader never needs to open it"); a paraphrased multiple-choice item would be a different item
01a p. 9 visual read	the WSJ sub-headline's 30-word content	attributed, not the note's own voice : "its sub-headline says the market was pricing in as much as a 71% chance...". It is a newspaper sub-headline reported with its source named, and it matches P7's own paraphrase of the

Source	Run	Verdict
		screenshot rather than the paper's wording

At 18 words the picture is the same: every run is inside quotation marks with a timestamp or page, or is a reproduced workbook item, with one exception noted in the fix list (01a p. 19's mutual-fund wording is quoted in §13 and then repeated unquoted in the checklist table).

Internal repetition. Two lecture quotations appear **three** times each, and one 28-word quotation appears twice in full. See fix items 1 and 2; both are §0 "no point is repeated" items, not copy defects.

7. Conformance — NOTE_SPEC §8 and notes/_CONVENTIONS.md

§8 checkbox	Evidence	Result
Every beat maps to a section	§1 above: 143/143, 0 MISSING, 0 THIN	pass
Every symbol used is defined and in the symbol table	28 rows. Mechanical scan of all 306 math expressions in the note: every single letter used inside math is declared , and the nine word-symbols (Att, pp, bp, TVM, CAPE, GS1, GS10, PV, NW) all have rows. The one collision is declared and resolved: the grading slide's $\underline{A}$ is renamed $\underline{Att}$ so $\underline{A}$ can mean assets. $\underline{X_A/X_B}$ are used instead of $\underline{A/B}$ for the p. 3 options, and the state superscripts are declared in $\underline{R_P}$'s row	pass
Every derivation step has a justification	mechanical scan: 0 display steps inside a [!derivation] callout and 0 inside a SOLUTION lack their *why this step follows: ...* line. The 11 standalone display equations with no why-line were checked by hand: 7 are $\boxed{\dots}$ ANSWERS, 4 are statements or a restated result, per conventions §3	pass
No algebra jumps more than one manipulation	checked by hand across both [!derivation] blocks and all 8 SOLUTION sequences. §3.5's general derivation takes 7 lines where the slide gives none; worked problem B's Step 9 takes 8 lines to reach $w = \frac{1}{2}$	pass
Every lecture figure present, captioned, explained	10 image files = 7 figure units (F1 mayo, F2 Nutella, F3 WSJ, F5 rates original + traced, F6 CAPE original + traced, F7 the two posters, F8 the note's own return-against- $\underline{w}$ redraw), 7 <i>How to read this</i> lines, all 10 files exist on disk. F4 (the p. 10 balance sheet) is a table, as map §3.4 directed — "no image needed" — with its layout explained beneath. F8 labels both axes, all five $\underline{w}$ ticks, both state lines, the crossing, the bank rate and the profit gap, and carries <i>Reconstructed — no slide carries this figure</i> . The interactive block gives sliders on all four returns and the bank rate, with three readouts	pass
Every worked problem follows the template	8/8 carry SETUP · GIVEN · STRATEGY · SOLUTION · ANSWER · SANITY CHECK · WHAT VARIES, in that order, in capitals	pass
Slide-only content included and	67/67 of map §2.3 plus deck 00 p. 12's five, each tagged (§2 above). No page is [SLIDE ONLY] : 01a is finished and every	pass

§8 checkbox	Evidence	Result
flagged	content page was taught	
Gaps flagged, not filled with invention	14 [!gap] callouts covering G1–G12; all five listen-list items carry both readings ; the unlabelled chart features are described as unlabelled in the prose <i>and</i> left unlabelled in the traced SVGs; the class-chart headcount inference is not printed; no payoff formula is attached to the Apple option	pass
Every math-inventory item present and fully derived	M01–M23, table in §2. Both required <i>Full derivation (not done in class)</i> labels present	pass
Every spoken-vs-written conflict and erratum flagged	W1–W10 all present, each once; 3 <i>Said in class vs written Warnings</i> ; the 14 non-math spoken-vs-written items of map §3.5 all resolved the way the map directs (states not space, 8 not "six/eight", 3 not "22", the slide's Nobel list, neither reading of "point number one/four", no photo dates from speech). No erratum exists , and none is invented; the \$6.10 tag is explained as the store's truncation	pass
The math check passes for every equation and number	3,392 checks, 0 failing; 862 added by this audit, covering every claim the earlier scripts had not reached. 9/22 : 3,888 checks, 0 failing, with P9Q checking all 436 quotations [<i>Superseded 2026-09-29 (merge M2): 430 after the 9/22 final round (final-report.md §3).</i>]	pass
Every problem-map item present, with its source cited	6/6, each once, each with its block, question and page (§3 above)	pass
Every assigned question worked, machine-checked, basis cited	this course sets no graded homework; the syllabus p. 3 line is quoted verbatim twice; every item in the note is machine-checked; no other instructor's statement is attributed	pass
No exam question worked ahead of its exam	Block 1 has no past-exam item; the midterm and final appear as dates only	pass

§8 checkbox	Evidence	Result
Nothing pasted beyond short cited quotes; no repetition; no padding	copy scan §6: 0 unmarked pastes. Repetition: two quotations appear three times and two passages twice — fix items 1–3, non-blocking. 9/22 : items 1–3(a) closed; the re-check's R1–R4 (§9.6) are non-blocking	pass <i>(with fix items R1–R4)</i>
Every core and optional reading covered in full; textbook gap list attached	the syllabus R01–R25, 25/25; the gap list is attached and is empty for a stated reason, with the required one-liner in <i>Connections</i> and no empty <i>Also in the textbook</i> block	pass
No sentence sends the reader to a source	pointer scan §5: 0 defects on 18 patterns	pass
Reading it start to finish requires opening no other file	every cited page is restated, including the eleven pre-recording overview slides and both unreadable charts; the only forward references are to content this meeting did not teach (the short sale, present value, the mortgage), each with a <i>Continues in</i> or a named link	pass

Conventions. Only the seven callout types appear — gap 14, definition 12, warning 9, exam 5, derivation 2, intuition 1; 43 in all. Both [!derivation] blocks are collapsed with - and show their result. All 13 numbered sections open with "This section establishes ..." and carry a [🕒 mm:ss](t:SSS) line directly under the heading; 27 of the 32 subsections do too (25 at this audit; fix item 4 added §9.1 and §11.1, closed 9/22). All **178** timestamp links have t:SSS equal to their own mm:ss and lie inside the 53:30 recording — 0 mismatches. Inline self-checks: §1 ×2, §2 ×2, §3 ×3, §4 ×3, §5 ×2, §6 ×2, §7 ×2, §8 ×2, §9 ×2, §10 ×2, §11 ×2, §12 ×2, §13 ×2 — every section inside the 2–3 rule. Section order is NOTE_SPEC §2's exactly. No pipeline internals appear outside this block: the mechanical scan returns 0 hits for session ids, M\d\d , G\d , W\d , NOTE_SPEC and work\... paths in prose. No escaped star inside math. Bold is **3.77%** of non-math words, inside the 5% ceiling, and every bold run is a term at first definition, a final answer, a run-in label (****Step 4.**** , ****Source: ...**** , ****Role 1:****) or a table label — with the one exception in fix item 3.

8. Fix list for the next revision — none blocks *done*

1. **The same lecture quotation is given three times.** Two passages: "*it better be that the return of my first investment and this 4% is the same*" appears in §3.5, again in worked problem B2's source line, and again in B2's SANITY CHECK; "*If you buy a stock in a company and the company goes bankrupt, you get zero*" appears in §11.1, in Self-check Q2 and in Self-check Q3. NOTE_SPEC §0 says to state each point once. Keeping it in the body and referring to it by its content in the drafts would fix both.
2. **Two quotations are repeated in full where a reference would do.** The 28-word balance-sheet comparison ("I can have a lot of assets, but if everything is borrowed...") is quoted in full in §6.1 *and* in worked problem E's Step 5; Yale's book-value sentence is quoted in full in §6.2 *and* in E's Warning. Both are P8a draft text that the body also carries.
3. **Two small conventions slips.** (a) The WB 1.4 checklist table's *Mutual funds* row reproduces 01a p. 19's bullet almost verbatim without quotation marks — "intermediaries that pool funds from small investors and invest in a diversified portfolio of stocks and/or bonds; rationale: diversification, lower transaction costs" — while §13 already quotes the same wording properly with the page. Either quote it in the table too or put it in the note's own words. (b) Self-check Q4 opens with a **bolded sentence**, "*This answer rests on a line that was on the slide but was never said in class.*" Conventions §11 and NOTE_SPEC §3 both say a sentence the note wants to stress is *italic*, never bold.
4. **Two subsections could carry the timestamp they rest on.** §9.1 and §11.1 each rest on a single lecture moment (38:11 and 46:52) but have no [🕒] line under the heading. The other five without one — §1.1 to §1.4 and §11.3 — are pre-recording or cross-slide material with no single moment to point at, so they are right as they are. This is the same open convention question the Lecture 4 audit left for a single ruling.

Observation, not a fix. The note uses one [!intuition] callout in 13 sections. Nothing requires more — the visual vocabulary is a fixed list, not a quota — but for a concepts lecture whose whole point is intuition, a second or third would fit the material (§4.3's "all dollars are equally green", §7's two-balance-sheet argument, §8's time-and-states mapping all read as Intuition content already).

9. Re-check (9/22)

A targeted P9 re-check, run 2026-09-22 in its own prep-model session. A fix lane had applied §8's items 1, 2, 3(a) and 4, plus a link-check lane item, to parts 05 and 06 and to five drafts: fin-Lec-01a-p4-riskfree-rate, fin-Lec-01a-p10-balance-sheet, fin-wb-1.1-Q02, fin-wb-1.1-Q03 and fin-wb-1.4-

keyconcepts-L1 . Item 3(b) and the intuition-callout observation were skipped by ruling, because the bolded Q4 sentence is allowed under Tony's 9/22 bold ruling. The re-check verified each item against the parts, the drafts, the Whisper record and the decks. It re-ran all three scripts and `assemble_note.py --check` , ran the pointer and copy scans on the seven changed files, and added a quotation check (P9Q). Sections 1–8 above are the 9/21 findings, unchanged apart from the counts in the summary, §2 and §7.

Verdict: PASS. Items 1, 2, 3(a) and 4 are closed. The math check passes 3,888 checks with 0 failing. --check exits 0. The seven changed files have 0 pointer defects and 0 unmarked copy runs. All 436 quotations match their cited sources; 8 of them do so through deviations registered on the fix list (R4). *[Superseded 2026-09-29 (merge M2): 430 after the 9/22 final round (final-report.md §3).]* No §8 item fails. The items in §9.6 are non-blocking or optional.

9.1 The fix items

Item	Status	Evidence
1, the two triple quotations	closed	Each quotation now appears once outside this block. "it better be that the return of my first investment and this 4% is the same" is in §3.5 only (Whisper 15:44, inside the cleaned [15:21] paragraph). B2's source line says the lecture answered the question "in spirit at 15:21" and links §3.5; its SANITY CHECK restates the answer in its own words. "If you buy a stock in a company and the company goes bankrupt, you get zero" is in §11.1 only (Whisper 47:27). Q2 now has "a bankrupt company's stock pays its holders zero (§11.1)" and Q3 "the shares pay zero (§11.1)".
2, the two double quotations	closed	E Step 5 is one sentence: "the more of the assets is borrowed, the smaller the net worth", with links to §6.1 and 28:10. The 28-word comparison is now quoted in §6.1 only (Whisper 28:42, inside the [28:10] paragraph). E's Warning paraphrases the Yale illustration and links to §6.2 and 28:58. See rulings (i) and (ii) for what that leaves.
3(a), the <i>Mutual funds</i> row	closed	The row now reads "intermediaries that pool many small investors' money and invest it in one diversified portfolio of stocks, bonds or both; the reasons to use one are diversification and lower transaction costs". The longest run it shares with 01a p. 19 is four words ("diversified portfolio of stocks").
4, §9.1 and §11.1 time lines	closed	[🕒 38:11](t:2291) · *01a p. 13* and [🕒 46:52](t:2812) · *01a p. 17*. Both t: values equal their mm:ss, and both times start a cleaned-transcript paragraph. 27 of the 32 subsections now carry a time line. The five without one (§1.1–§1.4 and §11.3) are the ones item 4 said are right without.
Lane: links	confirmed	Checked against the renderer's own slugs (tools/render_note.py collect_headings). The note has 26 in-note anchor links; the fixer's 27 counts one inside this block. It also has 18 cross-note links. All resolve. Inbound, L2 has 26 anchored links into L1 (12 distinct) and L3 has one (#102-treasuries-and-what-safe-means); all resolve. The four anchors the fix added (#35-..., #111-equity , #61-..., #62-...) all resolve. No heading was renamed.
Lane: the assembled file	confirmed	Before this block was edited, the assembled note on disk (stamped 2026-09-22T07:02:26) was byte-identical to a fresh assembly of the parts and drafts.

9.2 Rulings on the fixer's three flags

(i) §6.2's Yale sentence: a defect, non-blocking (R1). Whisper puts the sentence in the segment at 1778.12 s (29:38): "you can look at all the buildings, put a price on them, look at all the liabilities, Yale issues debt, you subtract it, that's the book value". §6.2 shares **18** consecutive words with the cleaned transcript ("look at all the buildings ... Yale issues debt"), not 16, and has no quotation marks around them. A span-level scan of the whole note (§9.4) finds no other unquoted run of 18 or more words. The run is under the ~25-word paste threshold, so it does not fail §8's paste item. It is still the lecturer's words presented as the note's own narration. The 9/21 copy scan (§6 above) listed "Yale's book value" among the quoted runs. That was true only of E's Warning. P9f6's test passes a line when a quote mark appears anywhere on it, and §6.2's line quotes "an important concept that we'll come back to later".

Fix: quote the sentence verbatim with [🕒 29:38](t:1778) . Quoting is better than rewording here because the caution attached to this illustration turns on the lecturer's words "put a price on them", so the reader should see them. Rewording is acceptable if the caution is reworded to match.

E's link to "§6.2 (28:58)" is not a wrong time. 28:58 is §6.2's heading time and the start of the cleaned paragraph that contains the sentence. The note uses that convention throughout: §6.1 cites the "I can have a lot of assets" quotation at 28:10, and it was spoken at 28:42. The link does land 40 s early, on the wealth-versus-income passage. *Optional:* once §6.2 quotes the sentence at 29:38, point E's link at 29:38 as well.

(ii) The book-value caution stated twice: yes, a §0 repetition, non-blocking (R2). §6.2 says "strictly, book value uses the values recorded in the accounts, and pricing the buildings at what they would fetch today is a step toward market value". It introduces this as "set out in a Warning inside the worked problem", then sets it out anyway. E's Warning says "Book value is computed from the values recorded in the accounts. Pricing every building at today's value is closer to market value". The two clauses are the same, twice. This is the class and scale of items 1–2, which 9/21 ruled non-blocking.

Fix: state it once, where the reader meets the Yale illustration. Move the Warning callout into §6.2 in place of the sentence (the P8a index allowed P8b to move it there) and give E a one-line link. Or keep E's Warning and cut §6.2 to the illustration plus a link.

(iii) P9f26 tightened to 0. The test was ≤ 2 ; it is now $= 0$, and P9f26b's label says so. This is sound. Fix item 1 removed both passages the old allowance covered, and nothing in NOTE_SPEC §0 owes a 15-word passage a third copy. The 15-word window cannot see shorter quotations, however. The quotation pairs P9Q collects show 10 quotations of four or more words that appear three or more times (R3). P9Q now fails if any new one is added.

9.3 The quotation check (P9Q, new)

What was there: nothing. No script for this session checked a quotation against any source. P9f6 only asks that a line carrying a 25-word source run carry a quote mark somewhere, and P9f23 checks one sentence (the syllabus basis). The re-check seeded 13 misquotes into an in-memory copy of the assembled note and of the part or draft that carries each. Every one passed: the main script 3,029/0 and the body script 327/0. The readings script reads only the syllabus digest, so no seed reaches it. L1 could not show L2's pairing failure because it had no pairing at all.

What P9Q does. It follows the S1 model (`fin-2026-09-11-S1.py` , P9Q). Every quote mark on a line of the assembled note is paired in order: 1–2, 3–4, and so on. The audit block, code fences and HTML comments are excluded. An odd count fails, and there is no length floor. Each quotation is registered with the source the note attributes it to: a time or page on its own line, else its section's /page line or its draft's **Source** line. It is then checked against that source.

- **Decks, syllabus, workbook:** the quotation must be on the named page, word for word and verbatim. **New here:** if the line cites a page of the same document, the quotation must be on one of the pages it cites. The decks' image pages are checked against their visual reads. The note's "second, rough automatic transcript" is checked against `Financial_Econ_1_9_3.md` , and its "one reconstruction" against the GPT file.
- **Lectures:** the raw Whisper record. The words must start inside the cleaned paragraph that the cited time names, or inside a range that ends at a time cited on the line. A back-reference is allowed only if the line names the section that times the moment (twice: \$7 and \$1.5).

Unregistered quotations fail, and so do unused registry entries and specs.

Results. P9Q found 436 quotation pairs (383 distinct) and 0 odd lines. *[Superseded 2026-09-29 (merge M2): after the 9/22 final round's quotation fixes, P9Q counts 430 pairs, all passing (final-report.md \$3).]* They break down as follows:

- **Whisper:** L1 244, L2 1.
- **01a:** 91 from the deck text and 39 from the visual read of its image pages.
- **00:** 12 from the deck text and 1 from the visual read.
- **Other documents:** syllabus 12, workbook 6, 02a 1, rough transcript 3, reconstruction 1.
- **Not source quotations:** 17 are the note's own words. These are mentions of a term ("percent", "State"), hypotheticals ("Rates rose 25 basis points", a friend's claim) and labels ("Percent squared"). Each is registered with its reason.
- **Registered deviations:** 8, all on the fix list (R4).

All 436 pass. *[Superseded 2026-09-29 (merge M2): 430 after the 9/22 final round (final-report.md \$3).]* Four auto-matches were right words from the wrong source and were re-pointed by hand. For example,

"10%" matched 01a p. 3's –10% when the line means the student's figure at 14:48. None of the four was a defect in the note.

What the check found:

- **12 ASR corrections, all P4's.** The note quotes the cleaned transcript. Whisper has "workforce", "risk-logging", "low-short", "fraud differentiation", "intel", "a hero of", "principal and entire value", "materials", "secretly adapted twice-square inspiration", "short monetary", "booming" and "mail". Each correction is listed in the cleaned transcript's header, and a P9Q check holds every substitution to that list. One of them is a reconstruction rather than a spelling fix: §9.3's Thaler row quotes "A little bit of behavioral finance" where the record has "a little bit of a hero of finance". P4 made that correction against 01a p. 14's "Behavioral finance". It is acceptable and is noted here.
- **8 small misquotes** (R4, table in §9.6). None changes a meaning the note relies on. Two touch the listen-list readings, and those matter most, because the reader is told what the tie-breaker transcript "has".
- **One listen-item link lands just after its words** (R5). The CAPM clause "before we get into it" ends the Whisper segment that runs from 26.92 s to 51.02 s, and the Gap's [🕒 00:51](t:51) starts the next sentence.

Seeds. Each seed was applied once to an in-memory copy of the note. Every seed must be caught by the audit, and each wording seed must also be caught by its source alone, as if the registry had been edited to match.

Every wording seed is caught twice. The audit reports it as an unregistered quotation, because the text is no longer the verified one. Its source alone also rejects it, with the message in the last column.

Seed	Existing scripts	P9Q audit	P9Q, source alone
"Future cash-flows (dividends) are uncertain" loses its hyphen	passed	caught	words on 01a p. 17 but not verbatim
Reading B turned into Reading A ("so you don't have to discount it")	passed	caught	not in the rough transcript
"Many acronyms: ..." loses "RMBS", right after the one-word "Tranching"	passed	caught	not on 01a p. 19
"Tranching" → "Trenching", a one-word quote right after the one-word "Pooling"	passed	caught	not in L1 at 52:02
"fungible" → "fungibles", one word from the rough transcript	passed	caught	not in the rough transcript
"I love this picture." → "I really love this picture."	passed	caught	not in L1 at 45:23
a syllabus quotation loses "self-"	passed	caught	not on syl p. 2
a workbook quotation altered inside the Q3 draft	passed	caught	not on WB p. 3
the photo label "NUTELLA SPREAD 13OZ" → "15OZ"	passed	caught	not in the 01a p. 7 visual read
a P4 correction stretched: "behavioral finance" → "behavioral economics"	passed	caught	not in L1 at 40:09
§13's ABS line re-timed from 52:02 to 50:02	passed	caught: "the line cites 50:02, not 52:02" (3 quotations)	—
§7's definition line re-paged from 01a p. 11 to p. 12	passed	caught: "the line cites 01a p. 12, not p. 11" (3 quotations)	—

Seed	Existing scripts	P9Q audit	P9Q, source alone
an unbalanced quote mark	passed	caught: odd count, and the pairs after it shift (8 failures)	—

The pairing test covers both of the failures found elsewhere today. A synthetic line checks that one-word quotations do not shift the pairs after them. The note's own line "... "Pooling" and "Tranching", and adds "Many acronyms: ..."" must also split into exactly those quotations.

9.4 Scans on the changed files

Pointer scan. The 18 patterns of §5, plus "on the slide", "in the reading", "listen to", "as shown on" and "see the transcript", were run over the seven changed files. There are 0 defects. The nine hits for "on the slide" are provenance tags beside restated content, such as "the other two ranges are on the slide (*slide only*)" followed by the table that gives them.

Copy scan. Two tests were run on the seven changed files, at 25 words and at 18: P9f6's line-level test, and a span-level test that requires every word of a matching run to sit inside a quotation. Both find **0 runs** in all seven files.

Over the whole note, the span-level test at 25 words finds only the WSJ sub-headline that §6 already ruled on, plus two boundary artefacts where a 🕒 label abuts a quotation. At 18 words it finds one more run: §6.2's Yale sentence, ruling (i).

9.5 Counts

	9/21 audit	after the fix lane	after this re-check
fin-2026-09-03-L1.py	3,033 / 0	3,029 / 0	3,527 / 0 (P9Q +498; P9f26 tightened)
fin-2026-09-03-L1_body.py (NB9 ran against the slide PDF)	325 / 0	327 / 0	327 / 0
fin-2026-09-03-L1_readings.py	34 / 0	34 / 0	34 / 0
total	3,392	3,390	3,888 / 0
assemble_note.py fin-2026-09-03-L1 --check	—	—	10 parts, 14 includes, 45,395 words , exit 0 (before this block grew)
timestamp links; label vs seconds mismatches	178; 0	178; 0	178; 0
subsections with a time line	25 / 32	27 / 32	27 / 32
bold share of non-math words	3.77%	—	3.78%
note words without this block	36,669	36,618	36,618

9.6 Fix list after the re-check (none blocks *done*)

- **R1 (non-blocking), §6.2.** Quote the Yale sentence verbatim with [🕒 29:38](t:1778) , or reword it together with its caution; ruling (i). *Optional:* point E's Warning link at 29:38.
- **R2 (non-blocking), §6.2 and E's Warning.** State the book-value caution once, in §6.2; ruling (ii).
- **R3 (non-blocking).** Three lecture sentences are each quoted three times, once in the body and twice in recaps. This is the class of closed item 1, below P9f26's 15-word window:
 - "people can always decide not to pay back ...": §10.2, §10.4's self-check, and WB 1.1 Q1's answer;
 - "the economic mechanisms behind the pooling and the tranching": §13, §13's self-check, and the WB 1.4 Gap;
 - "low rates, high rates, low rates, increase in rates over the last five years": §10.4's Exam signal, §10.4's self-check, and Key takeaways 11.

A recap can restate the point in its own words and link back. The other seven quotations that recur three or more times are acceptable, because each is used as a label rather than as evidence:

- slide or photo wording: "Time Value of Money + Risk" ×5, "Made with Cage Free Eggs" ×4, "a two percentage point increase" ×3, "an actual 5 percent" ×3;
 - slogans used as cross-reference names: "there's no right answer here" ×3, "Very important, big confusions" ×3, and "all dollars are equally green" ×5. Five uses of the last is at the edge; trimming them is *optional*.
- **R4 (non-blocking): eight quotations that are not verbatim.** Each is registered in P9Q as a deviation, so its verbatim form is what is checked. Fixing one means deleting its registry entry, which P9Q's unused-entry check will then require.

Where	The note quotes	The source has	Fix
§6.1, last paragraph	"how it is funded"	the note's own gloss; 26:54 has "who owns something and how this is going to fund it"	drop the quotation marks
§10.2 Gap, reading B	"Argentina, Greece, Puerto Rico"	rough: "argentina, anyone right here? Greece, puerto rico"	mark the cut ("Argentina, ... Greece, Puerto Rico") or give the names without quotation marks
§10.4 self-check question	"not truly fixed"	44:11 "nothing is truly fixed or predetermined"	quote "nothing is truly fixed"
§12 self-check answer	"looks overvalued"	50:43 "the market keeps looking overvalued"	"keeps looking overvalued"
A, SOLUTION	"what if you put a zero, ... two zeros, ... three zeros?"	10:11 "What if you multiply everything and put a zero? What if you put two zeros? What if you put three zeros?"	mark the first cut too ("what if you ... put a zero? ... two zeros? ... three zeros?")
C, Nutella SETUP	"makes sense"	01a p. 7 "Does this make sense?"	quote the slide's question
D, SOLUTION Warning, reading B	"a 2 percentage [point] increase"	rough: "a 2 percentage of increase"	give the rough's words and say that "of" may be a garbled "point"; reading B is the tie-breaker's evidence, so show what it has
<i>Connections</i>	"how risk is priced"	48:02 "how do we price the risk"	quote the words, or drop the quotation marks

- **R5 (optional), §1.5 Gap, listen item 1.** [🕒 00:51](t:51) lands just after the disputed clause. The Whisper record has no word times; by the segment's word rate, [🕒 00:47](t:47) lands on "an important part of the material before we get into it".

2026-09-22, fix lane (prep model): R1–R4 closed, R5 not applied. R1: §6.2 quotes the Yale sentence verbatim from the 29:38 segment with [🕒 29:38](t:1778) , and E's link now points at 29:38. R2: E's Warning moved into §6.2 in place of the sentence. Its Yale restatement and its repeat of the market-

value clause were dropped. E keeps a one-line link. R3: the six recap copies (§10.4's two self-checks, §13's self-check, Key takeaways 11, WB 1.1 Q1 and the WB 1.4 Gap) are paraphrased, so each sentence is quoted once, in the body, and `Q_TRIPLE_KNOWN` no longer lists the three. R4: all eight fixed, and their eight `minor` entries deleted; the deviation count is now held at 0. C's SETUP drops its quotation marks instead of quoting the slide, because a third "Does this make sense?" would be a new triple. LF's needle follows D's new wording. Checks: `fin-2026-09-03-L1.py` **3,520 / 0** (P9Q 431 pairs, 380 distinct, 0 deviations; P9f26 0), `_body.py` **328 / 0**, `_readings.py` **34 / 0**; total **3,882 / 0**. Render: 317 math spans, 0 KaTeX errors, 0 dead links.