Asset and Risk Management I

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Course structure

Course content (1)

1. Institutional background
   - Liquid and illiquid asset classes
   - Major investor types / owners of assets / responsible investing
2. Market efficiency & active vs. passive investment
   - Market efficiency
   - Liquidity spirals
3. Stocks
   - Key empirical facts
   - Time varying market risk premium and predictability
   - Factor premia

Course content (2)

4. Government bonds
   - Key concepts
   - Time varying bond risk premium
5. Measurement and management of portfolio risks
   - General topics in risk management
   - Value-at-risk and Expected shortfall
   - Estimation of covariance matrices
   - Optimal hedging of FX risks
6. Parametric portfolio choice
   - The Brandt, Santa-Clara, Valkanov (2009) approach
7. Performance measurement
   - Returns-based evaluation
   - Portfolio holdings-based evaluation

Readings

- We encourage you to read all papers that we cover.
  - Ideally, before class!
  - They are also useful references for the future.
- Read (at least) the assigned sections.

Readings (2)

Topic	Papers	Sections
Asset owners	Ang (2014), Asset Management: A Systematic Approach to Factor Investing	Chapter 1: Asset Owners
Market efficiency	Grossman and Stiglitz (1980), On the Impossibility of Informationally Efficient Markets	Introduction, Section I, discussion of Figure 1, Conclusion
	Brunnermeier and Pedersen (2009), Market Liquidity and Funding Liquidity	Introduction – including Figures, Conclusion
Risk premia stocks	Cochrane (2011), Presidential Address: Discount Rates	Introduction and Section I, A-C

Readings (3)

Topic	Papers	Sections
Risk premia bonds	Cochrane and Piazzesi (2005), Bond Risk Premia	Introduction and Section I, A, B
Portfolio risk	Bräuer and Hau (2025), Do Funds Engage in Optimal FX Hedging?	Abstract and Introduction
Parametric optimization	Brandt, Santa-Clara, and Valkanov (2009), Parametric Portfolio Policies: Exploiting Characteristics in the Cross-Section of Equity Returns	Introduction, Section 1.1, 1.3.1
Performance measurement	Fischer and Wermers (2013): Performance Evaluation and Attribution of Security Portfolios	Chapter 3: Return-Based Performance Measures

Grading

- 20% group assignment
  - quality of the solution (deadline: June 7)
  - brief presentation / examination (online meeting slots will be scheduled on June 19, 08:00–18:00)
- 30% mid-term exam (closed-book exam)
- 15% in-class participation
  - 0–3 points per class for answering instructor questions, contributing to in-class discussion, and/or short closed-book quizzes.
- 35% final exam (closed-book exam)

Grading (2)

Points translate into grades as follows:

1: $[90 - 100]$

2: $[80 - 90)$

3: $[65 - 80)$

4: $[50 - 65)$

5: < 50

Tentative Course Schedule

Topic	Date and Time
Institutional background and market efficiency	**Apr. 10 — 2:30–6:00 PM**
Stocks: time-series and cross-sectional	**Apr. 17 — 2:30–6:00 PM**
Government bonds	**Apr. 24 — 2:30–6:00 PM**
Midterm exam	**May 6 — 2:30–3:30 PM**
Measuring & managing portfolio risk	**May 22 — 2:30–6:00 PM**
Parametric portfolio & performance measurement	**May 29 — 2:30–6:00 PM**
Final exam	**Jun. 12 — 2:00–4:00 PM**
Assignment presentations (online)	**Jun. 19 — 8:30 AM–4:00 PM**

Important Dates

Date	Event	Details
May 6	Midterm Exam	2:30–3:30 PM, TC.1.02
June 7	Assignment Due	Submit by 11:59 PM on Canvas Tutor: Tomáš Šamaj
June 12	Final Exam	2:00–4:00 PM, TC.2.01
June 19	Group Presentations	Online

General Information

- We have created two **Group Discussions** on **Canvas**:
  - **Assignment Discussion**: for all questions related to the group assignment.
  - **Lecture Discussion**: for general course content, lecture topics, and exam-related questions.
- Please post your questions directly in the appropriate discussion board.
- **Important:** We will not respond to questions related to lecture notes, exams, assignment via email.
- This ensures that all students benefit from shared answers.

Institutional Background

Overview

- Major assets classes
  - liquid and illiquid asset classes
- Asset owners: types and objectives
  - institutional owners
  - households
  - delegation to investment organizations
  - responsible investing – ESG

Asset Classes

Why are Asset Classes Important?

- According to the theory of portfolio optimization, there is no special role for asset classes.
  - Investors should construct a portfolio of all risky assets (and then combine it with the risk-free asset).
- In practice, investor typically decide first how to assign the wealth *among* several asset classes and then which securities to purchase *within* each asset class.
  - Advantages of a top down approach: specialization and economies of scale.
- Asset allocation is widely regarded as much more important for investment success
  - $> 90\%$ in an influential study of large pension funds.

Asset Class: Definition

An asset class consists of assets that

- exhibit similar characteristics
- behave similarly in the marketplace
- are subject to the same laws and regulations
- have a common, identifiable underlying economic driver
- are correlated highly with one another
- have together a sufficient market capitalization.

Major Asset Classes

- Bonds
  - Can be split up into government bonds (or public debt securities), financial institution bonds, and nonfinancial corporate bonds. Treasury Inflation-Protected Securities (TIPS) play a minor role. Some bonds offer high liquidity.
- Stocks (or public / listed equity)
  - U.S. investors often distinguish *domestic* and *foreign* equity. Typically high liquidity. Alternatively, split into small cap / large cap, or consider factor portfolios.
- Private equity
  - Illiquid. Only a fraction is accessible through private equity funds.
- Real estate
  - Illiquid. Only a fraction is accessible through REITs.

Other Asset Classes

- Loans
  - Illiquid. Difficult to invest in.
- Foreign Exchange (FX)
  - The largest financial market in the world in terms of daily turnover ($\sim$ 9.6 trillion USD in 2025).
- Commodities
  - It is difficult to assess the market capitalization. Commodity futures are easy to trade and liquid. But here, after netting long and short positions, the outstanding contracts have a market cap equal to zero.
- Cash
  - Most investors hold cash and money market instruments.
- Alternative investments
  - E.g., hedge funds. Sometimes considered an (illiquid) asset class, but the rationale for this is weak. Would lead to double counting as they hold other assets.

Relative Size of Stocks, Bonds, and Private Businesses

Source: Randl, Westerkamp, and Zechner (2023). Relative proportion of holdings in equities, bonds, and private businesses by U.S. households. Data source: Survey of Consumer Finances.

- In the wealth of U.S. households, stocks, bonds, and private businesses are approximately of equal importance.
- Here, *private equity* is broadly defined as all private (non publicly traded) business.
- This figure misses other asset classes and an international perspective.

The Global Market Portfolio

	ISL	DLS	GSV
Equities	21%	36%	14%
Bonds	24%	55%	16%
Securitized/Nonsecuritized loans	0%	0%	18%
Real estate and land	37%	5%	21% + 3%
Private equity	0%	4%	20%
Commodities	15%	0%	0%
Cash	4%	0%	8%

Source: Gadzinski, Schuller, and Vacchino (2021), Exhibit 6. The table compares estimates of the global capital stocks form GSV with previous estimates from Ibbotson, Siegel, and Love (ISL) and Doeswijk, Lam, and Swinkels (DLS).

Economic Magnitudes

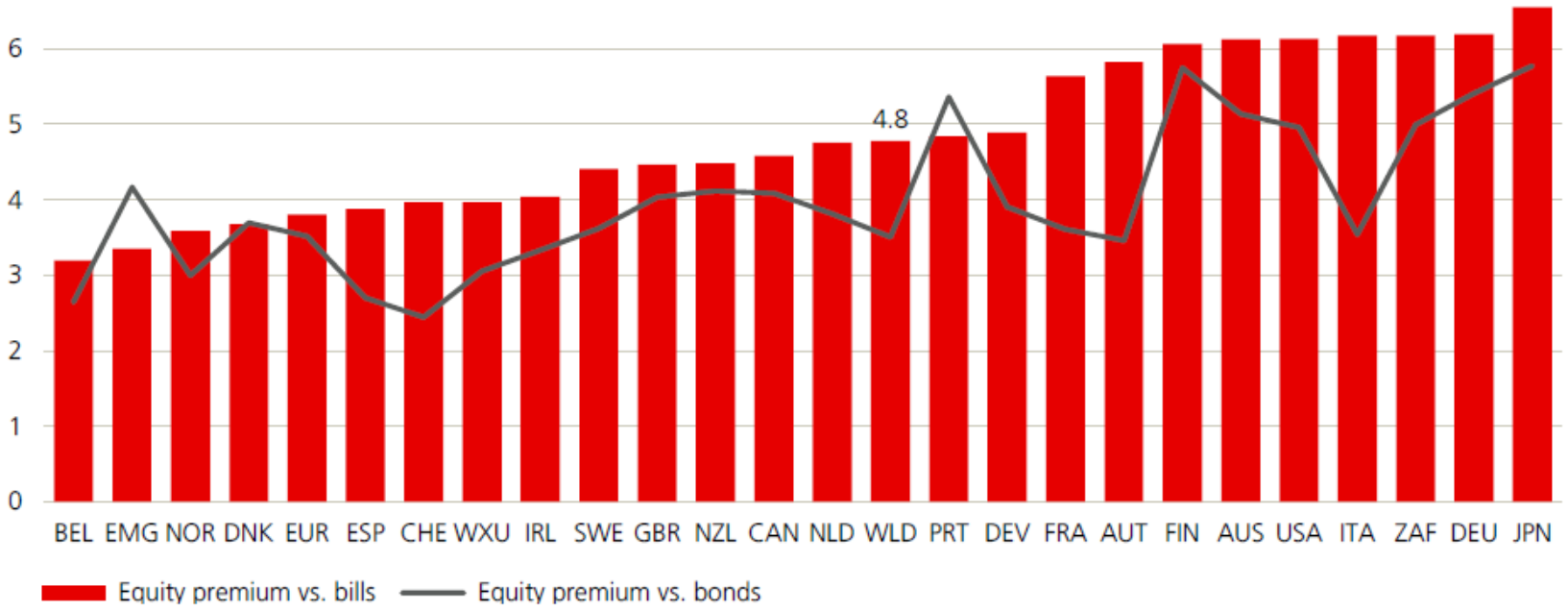
- The USD estimate for the total global capital stock equals almost 700 trillion in 2019 (corresponding to GSV on the above slide).
  - Comparison: 2019 world GDP equals $\approx$ USD 90 trillion.
- Only a fraction of this is investible.
  - Listed equities are easy to invest in (exceptions: some emerging markets). Size of the global equity market is about USD 120 trillion (as of Q4 2024).
  - Private businesses are illiquid. A small fraction is relatively easy to invest in via listed private equity funds.

Risk and Expected Return

- Riskier asset classes tend to have higher *average* returns.
- They earn risk premia:
  - Equity risk premium: stocks outperform bonds.
  - Term premium: long term bonds outperform bills and cash.
  - Credit premium: bonds with default risk outperform AAA debt.
  - Illiquidity premium: Illiquid assets outperform liquid ones.
    E.g., private equity vs. listed equity; loans vs. bonds.
  - Style premia:
    size: small stocks outperform.
    value: assets with low market valuation outperform.
    carry: assets with high current income outperform.
- Realized risk premia (i.e., outperformance) have been recorded *on average.* Underperformance, especially in bad times, and sometimes for multi-year horizons, is possible.

The Historical Geometric Equity Premium

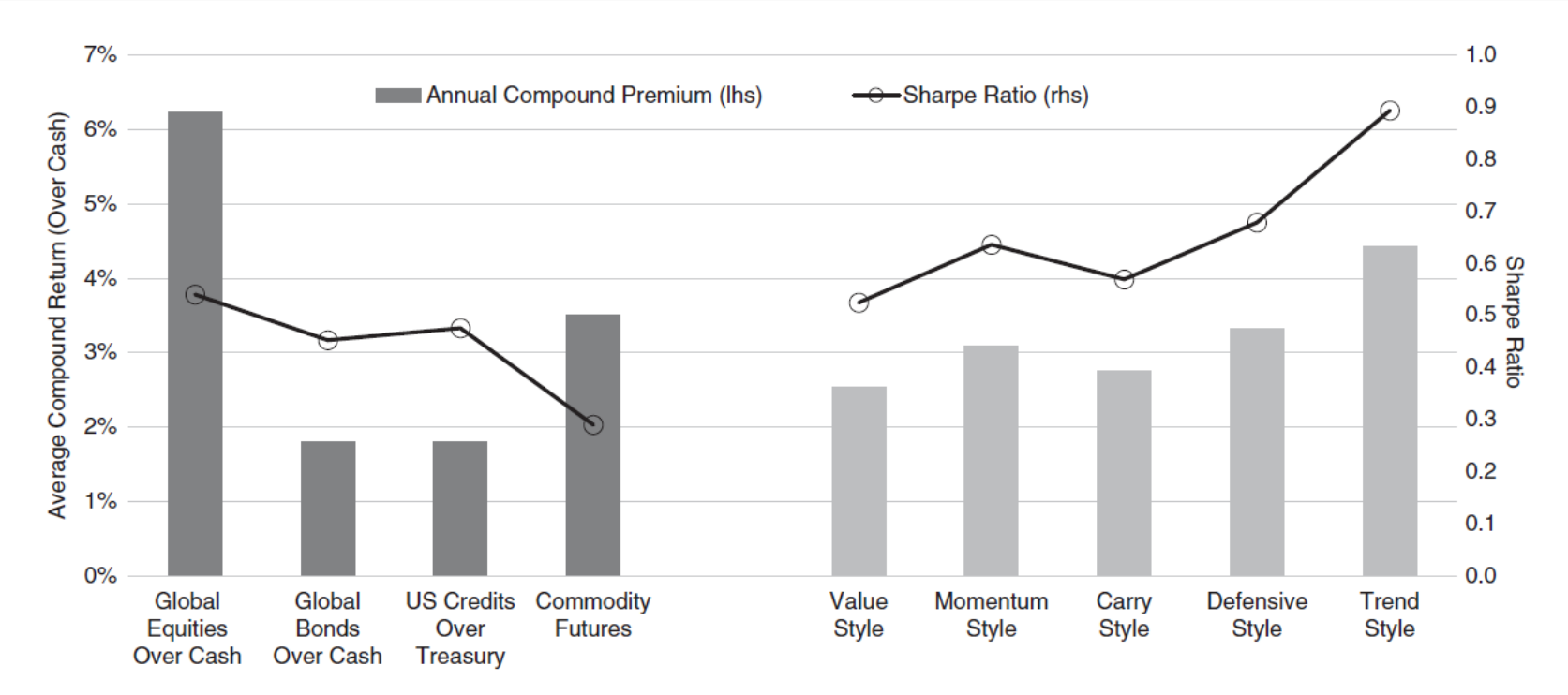
Figure 55: Worldwide annualized equity risk premium (%) relative to bills and bonds, 1900–2025



Sources: Elroy Dimson, Paul Marsh and Mike Staunton, DMS Database 2026. Not to be reproduced without express written permission from the authors.

Other Premia

Annual Excess Returns and Sharpe Ratios of Main Asset Class Premia and Alternative Risk Premia, 1926–2020.



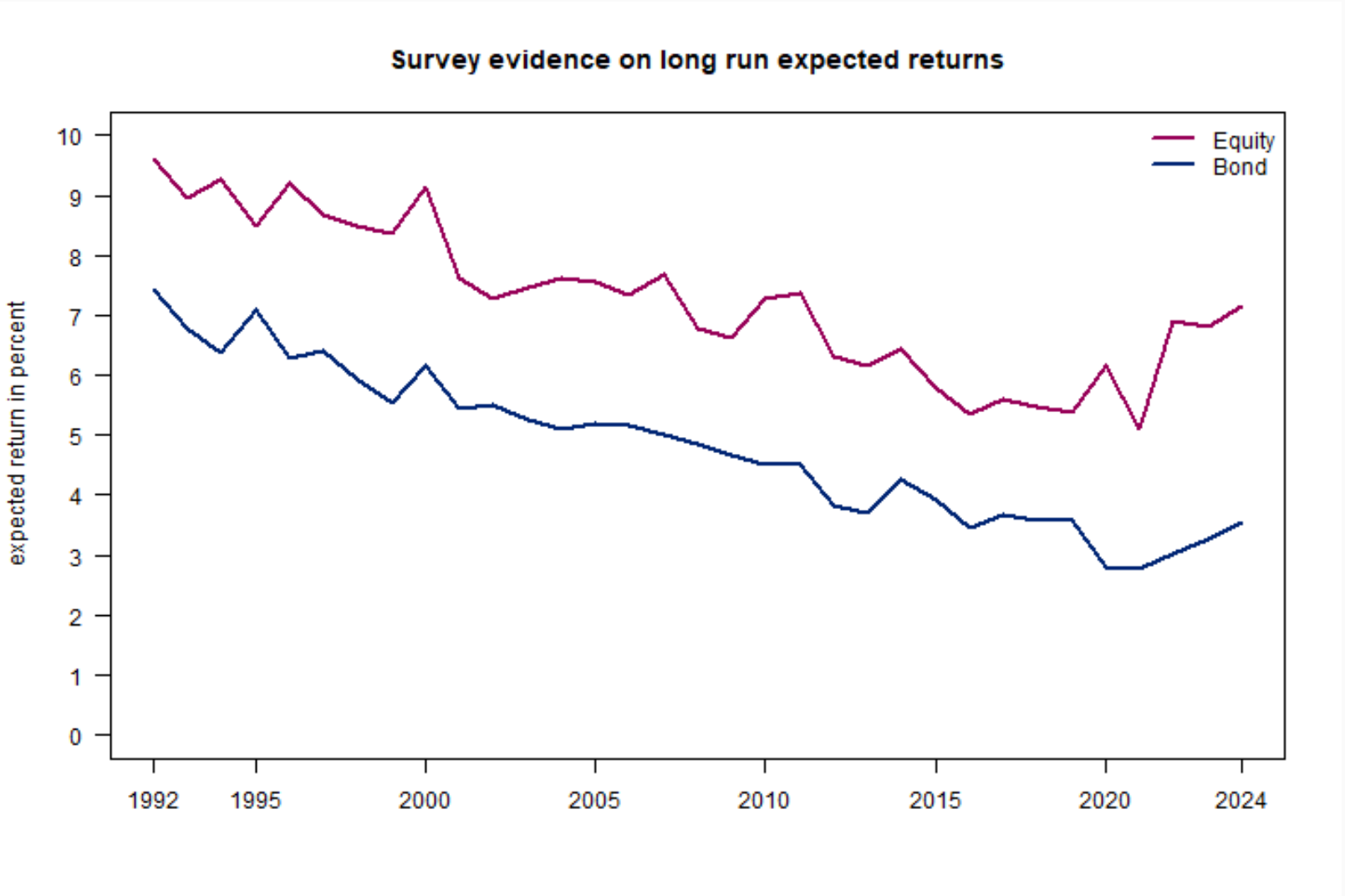
Source: Ilmanen (2022), Figure 1.2

Annual Returns in Percent, U.S. Data, 1972–2020

	Geom. Avg.	Arithm. Avg.	Std. dev.
Small cap stocks	12.7	14.9	22.2
Equity REITs	11.4	12.9	17.7
Large cap stocks	10.8	12.3	17.2
Long-term corp bonds	8.5	9.0	10.1
Long-term gov bonds	8.2	8.8	12.0
Intermediate gov bonds	6.8	7.0	6.4
T-bills	4.5	4.6	3.5
Inflation	3.8	3.9	3.0

Source: Ibbotson, R. and J. Harrington, Source: Stocks, Bonds, Bills, and Inflation (SBBI) 2021 Summary Edition

Expected Returns



Data: Survey of Professional Forecasters, Philadelphia Fed

Equity: forecasts for the annual-average rate of return to equities (S&P 500) over the next 10 years

Bond: forecasts for 10-year annual-average yield on 10-year constant maturity Treasury bonds

Precision of Expected Returns Estimates

- Let us take Dimson et al. (2026) data on the *arithmetic* world equity risk premium over bonds.
  - Average return difference: $\bar{r}^e \approx 4.7\%$
  - Standard deviation: $\sigma(r^e) \approx 14.9\%$
  - Since we have 126 years of data, the standard error of the average excess return $\bar{r}^e$ is

$$\sigma\left(\bar{r}^e\right) = \frac{\sigma(r^e)}{\sqrt{n}} \approx \frac{15.1\%}{11} \approx 1.33\%$$

  - What is the 95% confidence interval for the equity risk premium? Approximate.
  - But knowing this number is critical for asset allocation!

Asset Owners

Asset Owners

- Individuals, collective owners (e.g. pension funds), endowments, foundations, corporations, nations.
- Asset owners have different characteristics:
  - Risk preferences regarding bad times
  - Liabilities (contractual or consumption needs)
  - Income (can also be zero or negative)
  - Preferences (e.g., ESG criteria)
  - Sophistication, tax status etc.
- Asset allocation has to be specific to the characteristics of the asset owner.
- Often the asset allocation decision is delegated to managers.

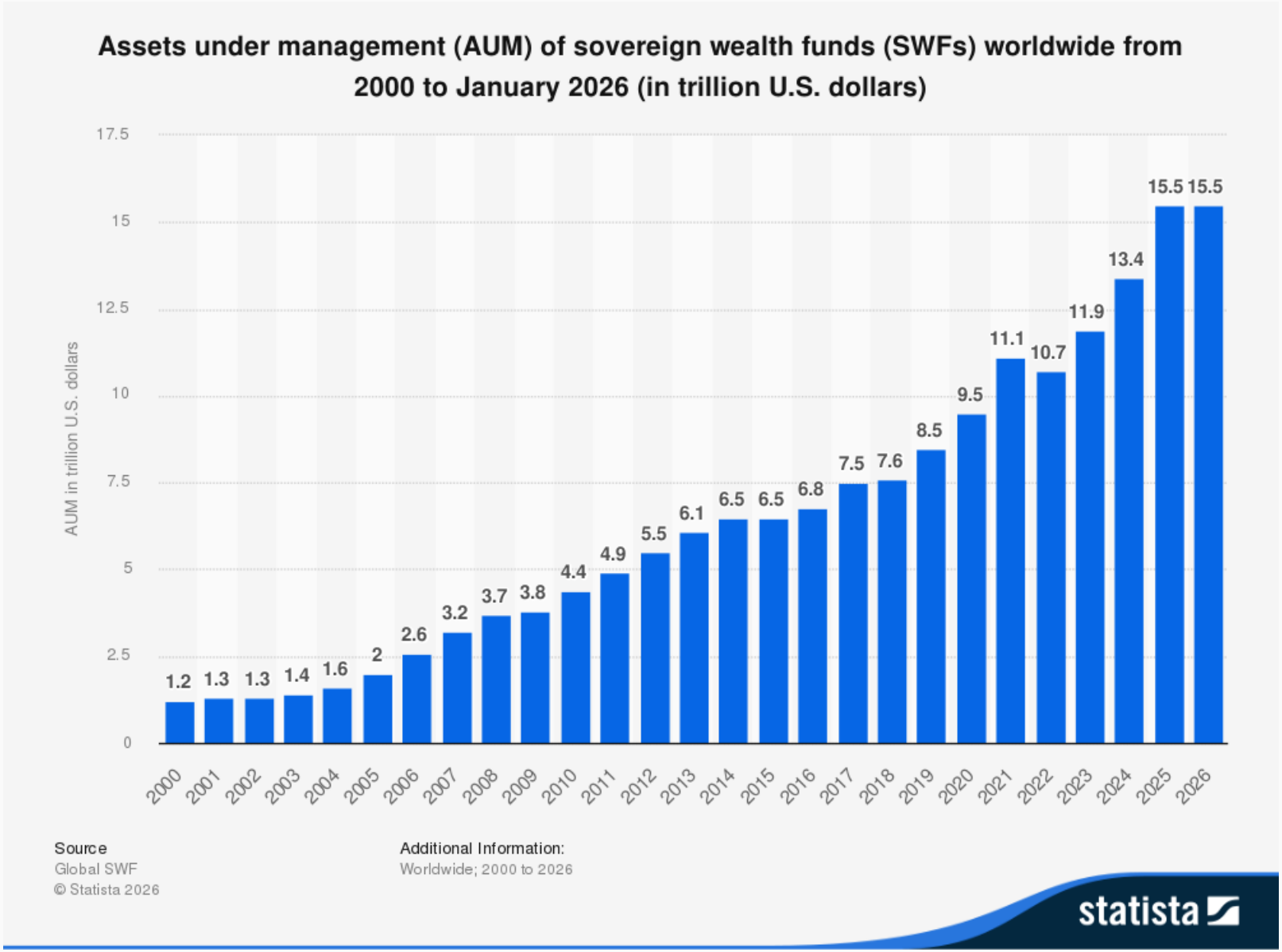
Sovereign Wealth Funds (SWF)

- Definition (Ang, 2014): An SWF is an investment fund controlled by a government and invested at least partly in foreign assets.
- SWFs are part of overall sovereign reserves (which include also central bank reserves, state owned enterprises etc.)

Largest Sovereign Wealth Funds (USD billion) (2025)		
Norway	Government Pension Fund Global	2117
China	SAFE Investment Company	1952
China	China Investment Corporation (CIC)	1567
UAE Abu Dhabi	Abu Dhabi Investment Authority	1129
Kuwait	Kuwait Investment Authority	1029

Source: www.swfinstitute.org

Estimated Assets under Management



Objectives and Management Implications

- Various objectives:
  - Smooth spending over time
  - Manage exchange rates. International liquidity protects against becoming the object of a currency attack.
  - Combat the resource curse (*Dutch disease)*
- Implications of these objectives:
  - Setting spending rules
  - Choosing the liquidity and riskiness of assets
- Agency issues
  - Role of public support
  - Accountability of decision makers

Pension Funds

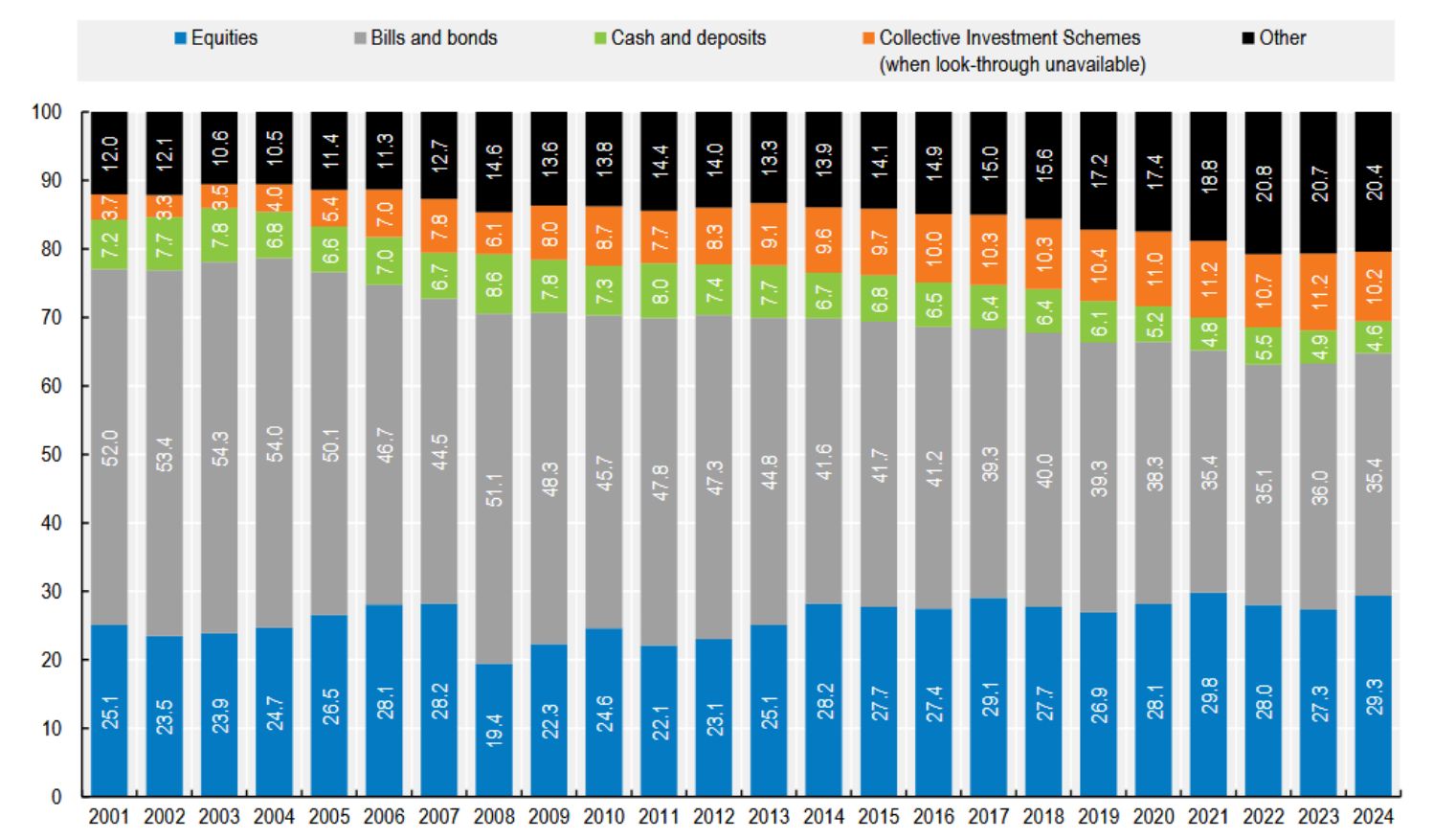
- Main types of retirement savings:
  - National pension plans like social security, sometimes the line to SWFs is blurry.
  - Private defined benefit plans. Pre-determined future benefits.
  - Private defined contribution plans. Future benefits are not fixed.
  - Funds privately managed by individuals, sometimes with advantageous tax treatments.
- Vast sums. Pension assets amount to $> 100\%$ of GDP in the OECD area. Denmark 230%, U.S. 170%, Austria 7%.

Pension Funds

- Social security and many defined benefit plans are underfunded. In the long run, assets and liabilities must be equal.
  - A method to manage pension funds is liability-driven investment (LDI): Maximize the surplus returns (difference between the pension fund's asset values and liabilities).
  - Issues: uncertainty about (actuarial) liabilities, appropriate discount rate to calculate present values of (nearly guaranteed) payouts, duration matching of assets and liabilities.
  - Governance issues: asset allocation decisions often made by board (not necessarily highly paid and qualified), while highly paid fund managers search (often elusive) alpha.
- Asset allocation. Generally, bonds are most important. Equities second. Allocation to stocks varies across countries from almost 0% to almost 100%.

Pension Funds – Asset Allocation

Average allocation of pension plan assets in selected asset classes and investment vehicles in a selection of 14 jurisdictions



Source: OECD (2025) Pension Markets in Focus 2025, Figure 2.6

Foundations and Endowments

- Charitable (cultural, environment, university,. . .)
- Or used by individuals / families to control wealth (partly exempt from tax)
- Family offices often work like foundations
- Some university endowments are investing pioneers

Endowments

- What are endowments?
  - Harvard university defines an endowment as

    a dedicated source of long-term funding, made up of donated gifts, that supports the mission and work of a philanthropic organization like a university.
- Why are university endowments special?
  - Long-term nature
  - Specific donation flows and payout needs
  - Access to expertise: alumni and faculty
- This has implications on
  - Asset allocation
  - Understanding endowment performance
  - Spending policy
- We focus on asset allocation and use this to review basic concepts.

Review: Static Asset Allocation

- *Static* means that the asset allocation is constant over time.
  - We can thus analyze a one-period model.
- The simplest case is to decide on the optimal allocation between two assets:
  - a risk free asset B with return r_f
  - a risky asset S with expected return $r = r_f + \mu$ and variance σ^2
- To obtain an analytical solution, we assume that the investor has utility with constant absolute risk aversion (CARA), where A is the coefficient of absolute risk aversion.
- What is the risky asset's share w in the optimal portfolio P?

Static Asset Allocation – Solution

- Maximize mean-variance utility as a function of w.

$$U(w) = E(r_p) - \frac{1}{2} A \sigma_p^2$$

Static Asset Allocation – Solution

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$$\begin{aligned} U(w) &= E(r_p) - \frac{1}{2} A \sigma_p^2 \\ &= (1-w) r_f + w(r_f + \mu) - \frac{1}{2} A (0 + w^2 \sigma^2) \end{aligned}$$

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- First order condition (FOC):

$$0 = \frac{\partial U(w)}{\partial w}$$

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$$0 = \frac{\partial U(w)}{\partial w} = \mu - A w \sigma^2$$

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- First order condition (FOC):

$$0 = \frac{\partial U(w)}{\partial w} = \mu - A w \sigma^2$$

- Solution: risky share: $w = \dfrac{\mu}{A\sigma^2}$

$\rightarrow$ Endowments with low risk aversion have risky portfolios.

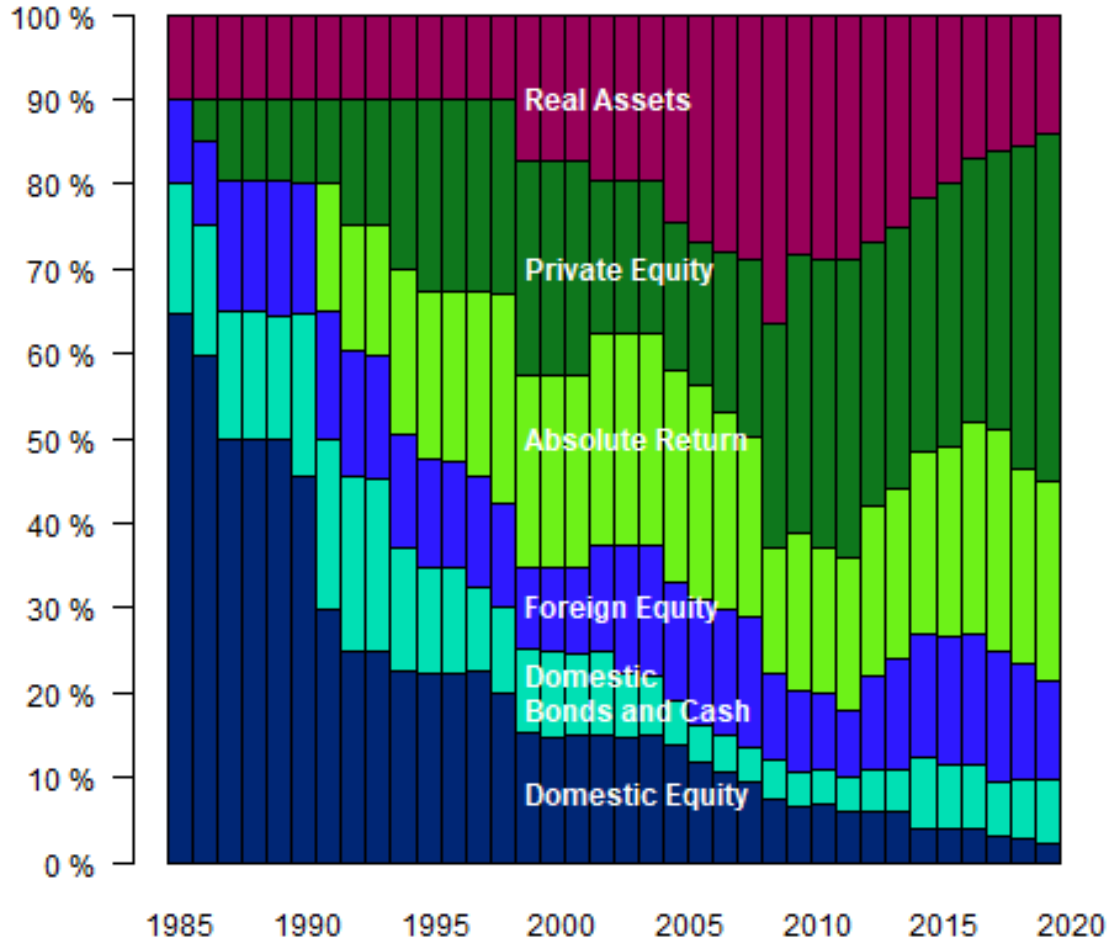
Dynamic Asset Allocation

- Multiple periods. Allow asset allocation to change over time.
- First analyzed by Merton (1969, 1971)
- Surprising result: Under the assumptions
  - constant relative risk aversion (CRRA) ρ
  - infinite horizon
  - constant risk premium $\mu_t = \mu$

  the optimal asset allocation turns out to be constant!
  - risky share: $w_t = w = \dfrac{\mu}{\rho\sigma^2}$

- How does this compare to the empirical evidence?

Target Asset Allocation of the Yale Endowment



Source: Randl, Westerkamp, and Zechner (2022), Fig. 1

Explanations

- Why should an endowment deviate from a static asset allocation rule?
  - time-varying investment opportunities
  - constraints on spending
  - expertise in specific asset classes or lower barriers to invest
  - correlation of returns with other streams of income or liabilities

Time-varying Investment Opportunities

- Intuitively, an investor with a long horizon can exploit return predictability.
  - Example: With mean reversion, expected stock returns are high after a market crash. Knowing this, long-term investors can invest more in stocks.
- Formally, investors should add hedge portfolios to take into account how returns correlate with future investment opportunities (Merton).
  - These hedge portfolios are very hard to derive. But the theory is a good justification for dynamic portfolios.

$\rightarrow$ Unconstrained endowments tend to invest counter-cyclically.

Constraints on Spending

- Most endowments have smoothing constraints on spending.
- Problem: The value of the portfolio might fall but spending cannot be reduced fast.
  - This necessitates procyclical investing (Dybvig, 1999) and a low spending rate to begin with (Dybvig and Qin, 2022).
- Spending the entire expected return leads to reaching for yield when interest rates decline (Campbell and Sigalov, 2021).
  - Without spending constraints, investors would reduce consumption. But a minimum spending rule forces investors to increase risk instead.

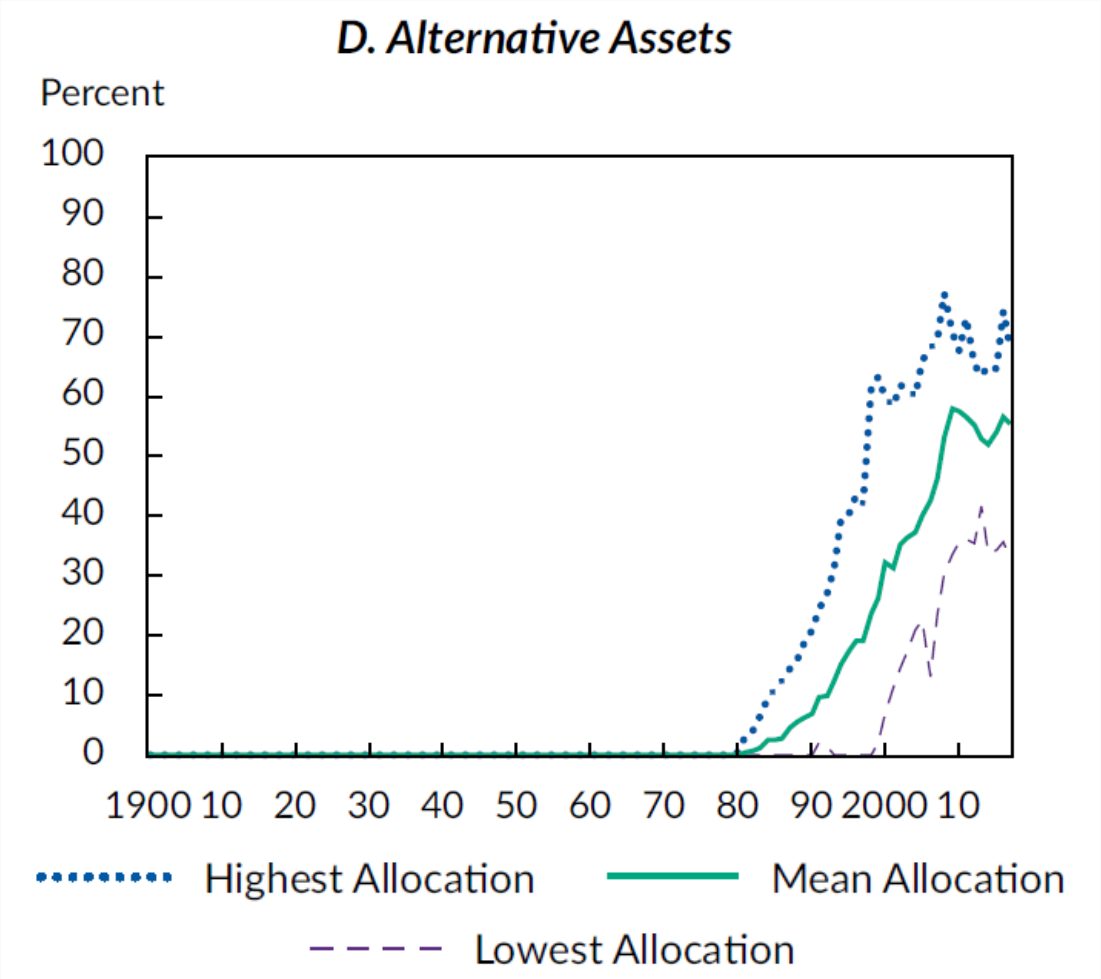
$\rightarrow$ With a long horizon, spending rates should be low.

Expertise in Specific Asset Classes

- Through alumni (and perhaps faculty) some universities have access to superior investment skills.
  - This is valuable for asset classes where there is a high dispersion of returns across managers – such as hedge funds.
  - For some assets, other market participants face higher barriers to entry – e.g., private equity.
- In portfolio optimization, a positive alpha leads to a higher weight of an asset class.

$\rightarrow$ Top universities hold more hedge funds and private equity.

Empirical Evidence



Source: Chambers et al. (2020), Fig. 1. The graph shows the allocation to hedge funds and private equity for 12 U.S. university endowments.

Other Streams of Income

- An investor should optimize over its entire wealth, not just a subset of assets.
- Non-endowment income can change the risk of a university's total portfolio.
  - Positive correlation of donation flows and tuition income with stock returns leads to a lower optimal allocation to stocks.
  - This can be interpreted as a shadow holding of the risky asset.
  - Empirically, higher non-endowment income risk leads to a significantly higher proportion allocated to fixed income.
- Similar argument for liabilities.

$\rightarrow$ Heterogeneity across university endowments.

Endowments – Summary and Takeaways

- Static asset allocation shows that endowments with low risk aversion should have risky portfolios.
- Their long horizon allows endowments to exploit time-varying investment opportunities and invest counter-cyclically.
- Low spending rates reduce the need for pro-cyclical investing arising from spending constraints.
- Superior investment skills explain high allocations to hedge funds and private equity.
- Taking into account other streams of income and liabilities leads to heterogeneity across endowments.

High Net Worth Individuals

- Ultra-high net worth $>$ 10 million
- High net worth $>$ 1 million
- Families generally do not preserve wealth well over generations. Often the bulk is spent in two generations. 1877 Cornelius Vanderbilt, the richest person in the world, died. At a family reunion less than 100 years later, not a single millionaire was among them.

Problems with Family Wealth

- Family fights
  problems with succession planning, managing a business or family office
- Nepotism
  Often families are better off using professional management instead of a unskilled family member
- Lack of diversification
  Preserving wealth requires well-diversified portfolios. This is typically not how wealth has been made.
- Spending too much
  Spending habits make it difficult to set reasonable payout rules

Middle Class Individuals

- Labor income
  - Biggest asset is not financial wealth, but human capital
  - Life-cycle considerations
- Leverage
  - Housing is a very levered, illiquid asset for most people
  - Leverage is a short position in bonds. Depending on the loan type, there is considerable interest rate risk.
- Personal risk
  - Divorce, health, care for elderly.
  - This type of background risk typically increases risk aversion.
- Note: Our discussion of investor types stops with so-called middle class individuals. Asset management is typically not of first order importance for poor households.

Delegation to Investment Organizations

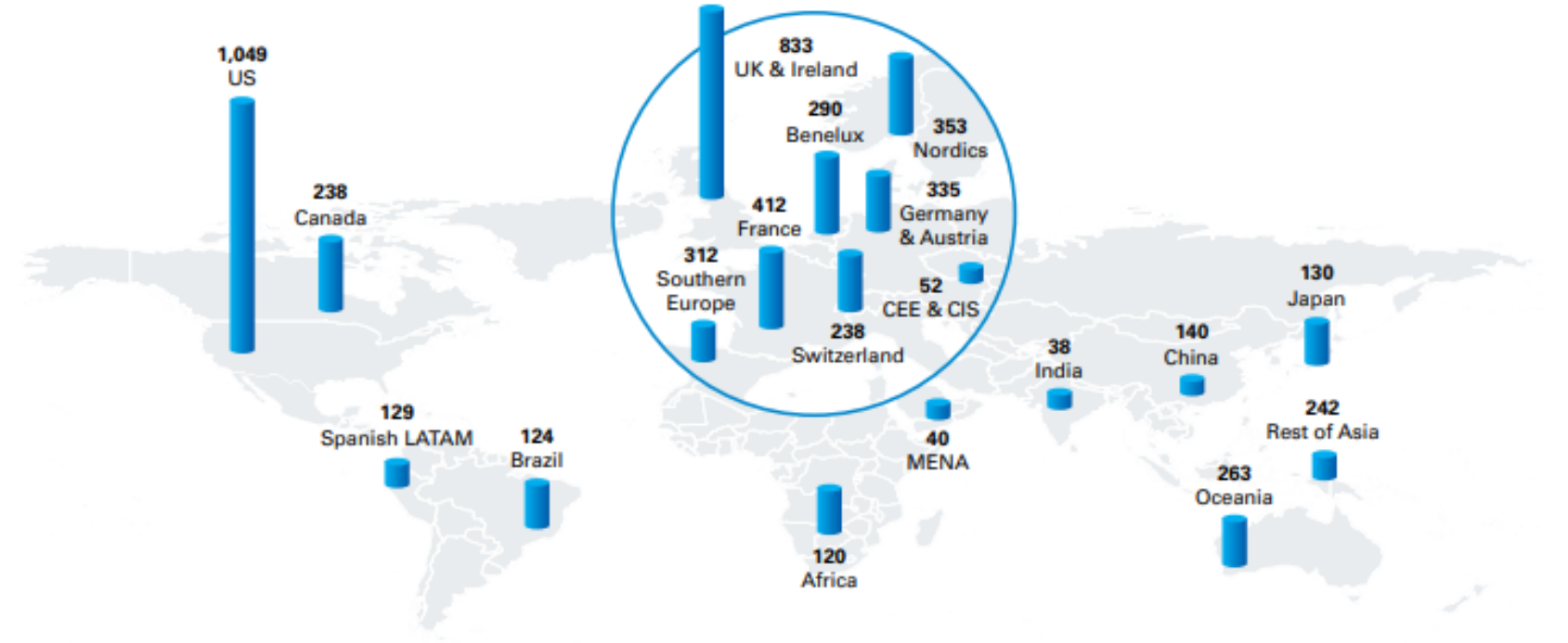
- Many investors delegate portfolio management entirely or partially to investment organizations.
  - Mutual funds, closed-end funds, ETFs, hedge funds, private equity funds, target date funds, etc.
  - Fund management by professionals can be active or passive
- We will discuss *delegated portfolio management* in more detail in ARM II.

ESG Investing

- Many investors now consider environmental (E), social (S) and governance (G) criteria in selecting their investments. Currently, the focus is on E (*green investing*).
- There is a debate on the impact of ESG investing.
  - Does it really lead to better real-world outcomes?
  - Does it impact performance (and risk)? To the better or to the worse?
- The interest of investors in ESG varies over time and across regions.
- More details will be provided in ARM II.

Interest in ESG Investing

Figure 13. Total signatories, by region (31 March 2024)



Source: PRI Annual Report 2024

Summary – Why Should we Consider Asset Owners?

- Investor-specific characteristics give rise to "bad times"
  - Bad times depend on risk aversion, liabilities, income ...
- Which assets should be held to mitigate the risk of bad times and/or to earn risk premiums?
  - An investor's bad times do not necessarily correspond to the market's (marginal investor's) set of bad times.
- Asset owners usually hire delegated managers
  - The principal-agent relation adds complexity.

Market Efficiency and Active vs. Passive Portfolio Management

Active vs. Passive Portfolio Management

- A portfolio is called *passive* if it is invested according to market capitalizations.
- Thus, if the bond market capitalization makes up 30% of the overall market and the equity market 40%, then a passive portfolio invests 30% in bonds and 40% in stocks.
- Deviating from market capitalization weights results in active portfolio management.
- Note: some people define passive much more broadly and view all 'rule-based' portfolio strategies, such as momentum strategies, as passive.

Arguments for Passive Portfolio Management

1. Under certain assumptions the value weighted market portfolio is efficient, see e.g. Sharpe, Lintner and Mossin, and the resulting CAPM literature.
2. The 'average' investor must hold the value weighted market portfolio.
3. Passive portfolios are cheap to manage.

Arguments for Active Portfolio Management

1. Existence of over- and undervalued assets: A passive portfolio overweights assets that are overvalued and underweights assets that are undervalued.
2. The investor cannot or does not wish to invest in certain assets. E.g., private equity is difficult to invest in. Alternatively, the investor may not want to invest in certain assets, due to ethical considerations. Portfolios with ethical screens are likely to be underdiversified.
3. The investor requires certain portfolio risk characteristics, such as being able to meet given liabilities.
4. More generally: In the presence of market imperfections, the passive market portfolio may not be efficient, e.g. preferences for leverage.

Active PM and Market Efficiency

- If asset prices do not reflect all available relevant information, then prices are not informationally efficient.
- This means assets can be mispriced (overvalued or undervalued).
- Such mispricing can potentially be exploited by active investors.
- We therefore discuss the concept of market efficiency in some detail, starting with definitions of market efficiency.

What is Market Efficiency?

- Markets are efficient if prices reflect all available information.
  - Then, one cannot 'beat the market', and
  - prices are 'correct'.
- Prices as discounted expected cash flows:

$$P_t^j = \sum_{\tau=1}^{\infty} \frac{1}{1 + r_{f,t,\tau} + \pi_{t,\tau}^j} \mathbb{E}\left[CF_{t+\tau}^j \mid I_t\right]$$

- The discount rate is appropriate for the risk of the cash flows.
  - Risk premium π^j depends on covariance (β^j) with variables the investor cares about, e.g. the market (CAPM) or aggregate consumption (CCAPM).

What is Market Efficiency?

- Under the efficient market hypothesis (EMH), price changes reflect
  - (objective) news about expected cash flows ...

$$\Delta P^j_{t+1} = \sum_{\tau=0}^{\infty} \frac{1}{1 + r_{f,t+1,\tau} + \pi^j_{t+1,\tau}} \left[\mathbb{E}[CF^j_{t+\tau} | I_{t+1}] - \mathbb{E}[CF^j_{t+\tau} | I_t] \right]$$

  - ... or discount rates

$$\Delta P^j_{t+1} = \sum_{\tau=0}^{\infty} \frac{\mathbb{E}[CF^j_{t+\tau}]}{1 + r_{f,t+1,\tau} + \pi^j_{t+1,\tau}} - \sum_{\tau=0}^{\infty} \frac{\mathbb{E}[CF^j_{t+\tau}]}{1 + r_{f,t,\tau} + \pi^j_{t,\tau}}$$

- Under the EMH, investors react to new information quickly and to the right extent.

No Free Lunch

- When we say 'prices are correct', we are implicitly stating what 'correct' is, i.e., we are assuming an asset pricing model.
  - Joint hypothesis problem: Any test of market efficiency is also a test of the asset-pricing model.
  - The joint hypothesis problem makes it very hard to reject the efficient market hypothesis.

Implications of the Efficient Market Hypothesis

- Expected returns are a compensation for risk
  - More generally: compensation for undesirable features.
- The only way you can get higher expected returns is by taking on more risk.
- There is no information out there that can be used to construct strategies that earn expected returns higher than required for their risk.
- Price movements are best described by a Random Walk:

$$P_{t+1} = P_t + \epsilon_{t+1}, \qquad \mathbb{E}_t[\epsilon_{t+1}] = 0$$

Information and Market Efficiency

- The EMH posits that security prices reflect all available information.
- Efficiency is relative to an information set I_t.
  - Revealing the information contained in I_t to market participants will not affect prices.
  - Consequently, one cannot make economic profits by trading on I_t.
- The three versions of the EMH differ by what is meant by *all available information*:

Type of information contained in prices	Form of efficiency
Past prices	Weak
Past prices & public information	Semi-strong
Public & private information	Strong

Market Efficiency: Examples

What form of market efficiency is violated (if any)?

- Firm A gets approval of a newly developed medication which is considered to raise firm A's earnings substantially. The CEO makes a press statement on Wednesday and on Friday the stock price rises by 5%.
- Firm B's stock price stays unchanged after news come out that firm A's CEO will join firm B next year.
- At a bar, the CEO of firm A gets drunk and tells a journalist that the new medicine is a scam. The journalist takes out his phone, short sells firm A and makes a fortune.
- In his new career as a freelance financial blogger, the former CEO of firm A posts a list of which stocks will beat the market next year. So far, he was right 100% of the time.

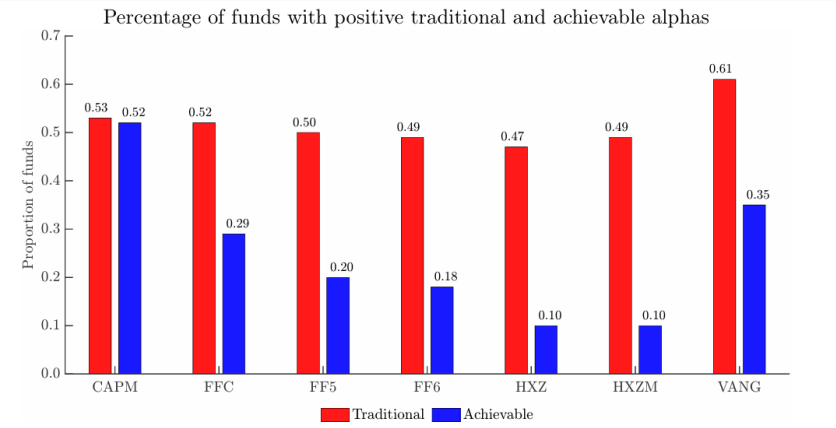
Why Should Markets be Efficient?

- There are a large number of competing profit-seeking investors.
  - It is not necessary that the average investor is smart, only that there are a few smart investors (with *deep pockets*).
  - Deep pockets: having access to sufficient funds in order to keep up a position for an extended period of time.
- New information about securities comes to markets in a random fashion.
- Forces of arbitrage: smart investors exploit the mispricing in securities until it disappears.

Why Should Markets Not be Efficient?

- If prices reflect 'all available information', why does anyone collect information (which is costly)?
  - How does the information get into the prices in the first place?
  - Small abnormal returns should compensate investors for collecting information.
  - Hence, prices might reflect information only up to the point where marginal benefits do not exceed marginal costs.
- Limits to arbitrage
  - Transaction costs, margins, leverage, scarce supply of stocks for borrowing.
  - Mispricing persists when it is difficult/costly/impossible to sell short.
  - No deep pockets.

Example: Evidence for Market Efficiency



Source: De Miguel, Martin-Utrera, Uppal (2025), Fig. 1

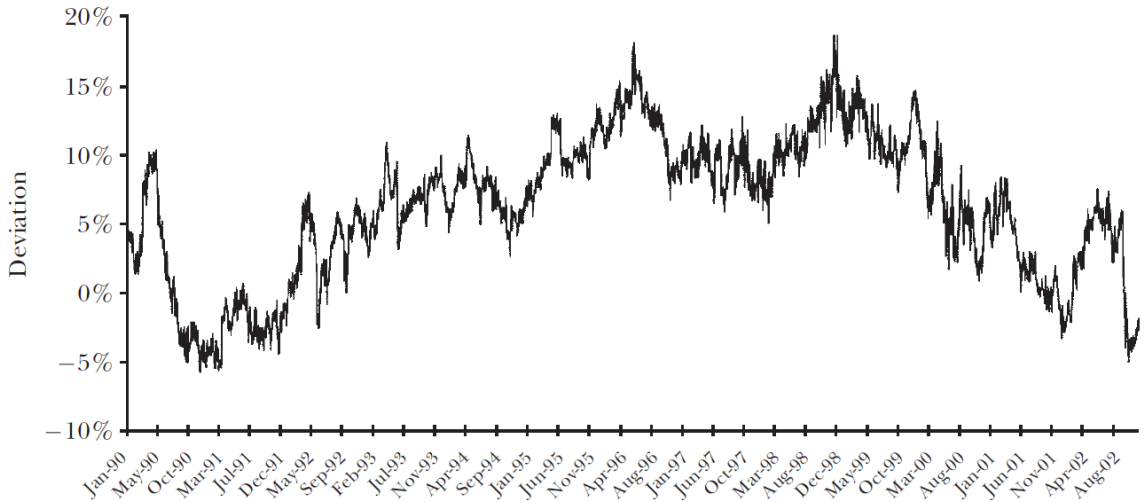
- Money managers do not beat the market on average.
- Early evidence from Malkiel (1995) shows a slightly negative mean α for the period 1971 to 1991.

- Recent evidence is broadly consistent. De Miguel et al. (2025) show that – depending on the asset pricing model used – 47% to 61% of funds have positive α.
- However, *achievable* α is harder to obtain. Here, α is measured against long-only benchmarks.

Example: Evidence against Market Efficiency

- Lamont and Thaler (2003), Anomalies: The Law of One Price in Financial Markets, *Journal of Economic Perspectives* 17(4)
- *Royal Dutch* is a claim to 60%, *Shell* to 40% of the same cash flows

Figure 1
Pricing of Royal Dutch Relative to Shell
(*deviation from parity*)

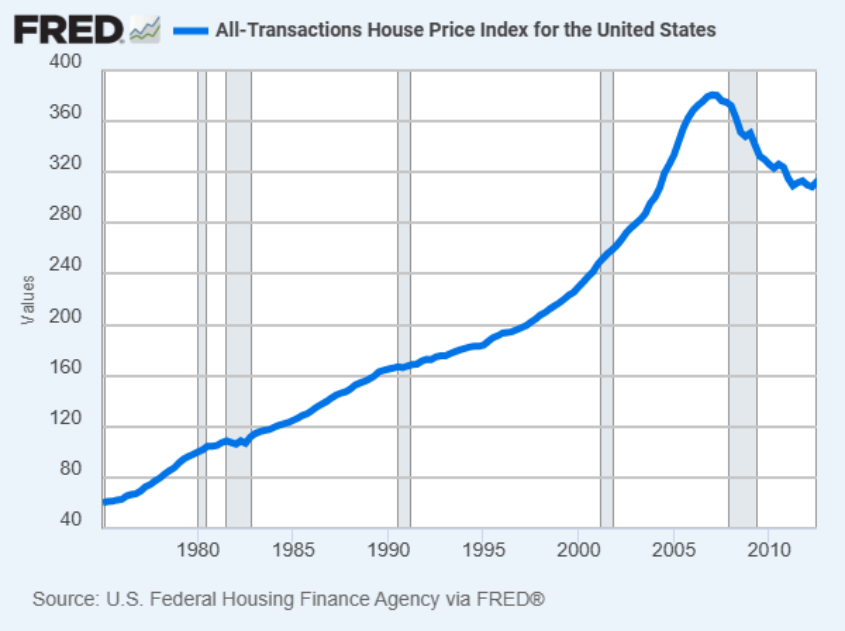


- (Partial) market-efficient explanation: *Royal Dutch* was in the S&P 500, *Shell* was not. Some investors need to hold the S&P 500.

Bubbles

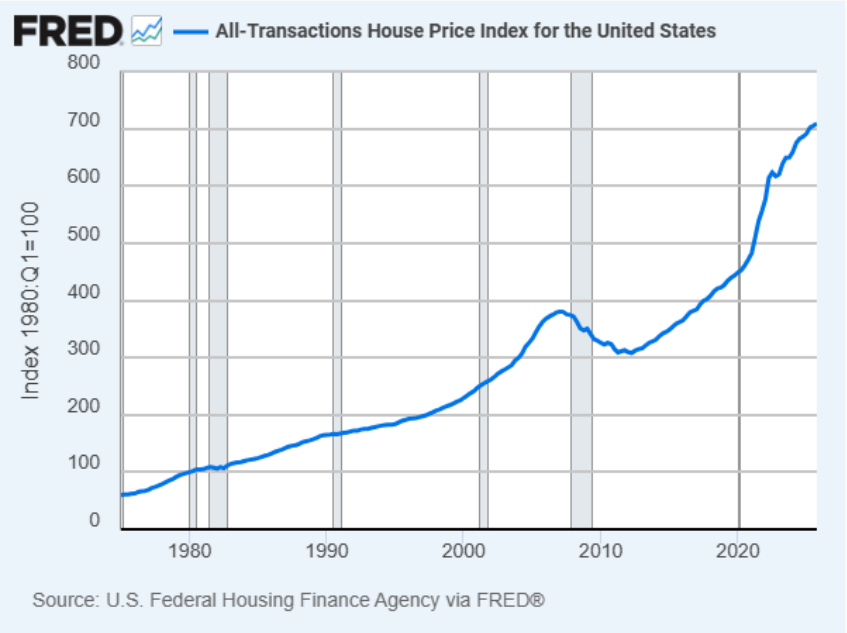
- Market prices are substantially driven by psychological factors.
- News of rising prices spur investor enthusiasm which is spread by psychological contagion.

- $\Rightarrow$ Prices are decoupled from fundamentals.
- $\Rightarrow$ Bubble bursts eventually.
- Many examples in economic history, like 2007/2008 house price bubble.
- Surely, prices were just too high, right?



Bubbles (contd.)

- Are you sure? How about now?
- What *is* the bubble?
- What about supply/demand?



Evidence on Market Efficiency – Summary

- Behavioral economists focus on
  - high volatility of prices relative to fundamentals
  - specific episodes with prices that are difficult to rationalize
- 'Classic' economists focus on
  - difficulties in beating the market on a risk-adjusted basis
  - rational explanations of seemingly strange prices
- There seem to be various degrees of market efficiency.
- Would either extreme—prices revealing all or no fundamentals—make sense?

On the Impossibility of Informationally Efficient Markets

- Title of a famous paper by Sanford J. Grossman and Joseph E. Stiglitz in *The American Economic Review*, 1980
- Paradox when information is costly:
  - If asset prices are fully informative about 'true value', there is no incentive to buy information.
  - The only possible equilibrium is with no information.
  - But if everyone is uninformed, it pays some individual to become informed.
  - No competitive equilibrium exists.

$\rightarrow$ Markets cannot be informationally efficient.

Setup of an Equilibrium Model

- Safe asset yields return R.
- Risky asset yields uncertain return u:

$$u = \theta + \epsilon$$

- θ is observable at cost c, ϵ is unobservable.
- Two types of ex-ante identical traders:
  - Informed traders spend c and learn θ.
  - Uninformed traders observe only the price p of the risky asset.
- Equilibrium price function depends on informed traders' information, the supply of the risky asset, and the fraction of informed traders.

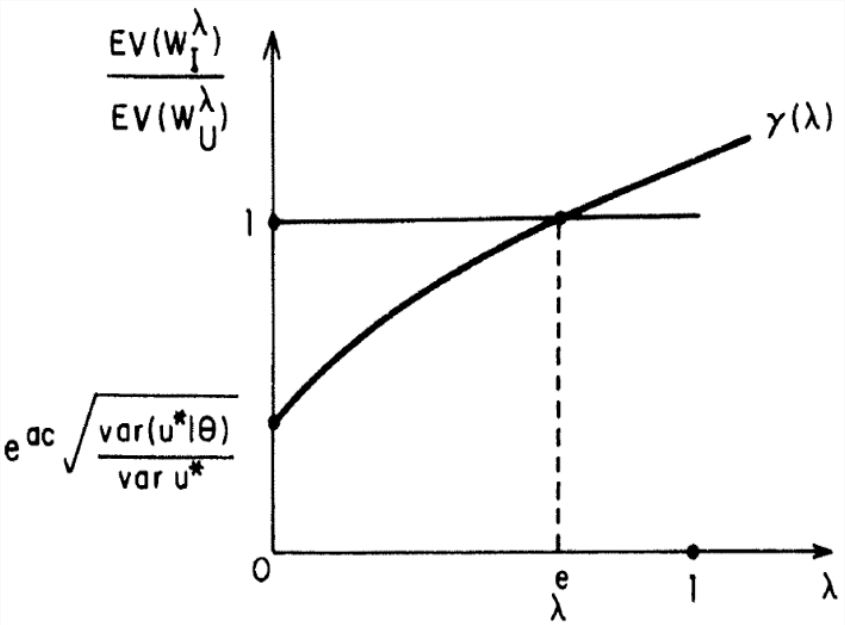
Setup of an Equilibrium Model (2)

- Individuals $i \in I, U$ maximize their utility $V(W_{1i})$.
- Both types of investors have the same utility function: exponential utility in period 1: $V(W_{1i}) = -e^{-AW_{1i}}$
  - Constant absolute risk aversion (CARA)
- In equilibrium, informed traders I and uninformed traders U must have the same expected utility.
  - Define λ as the fraction of traders becoming informed

logic

Grossman Stiglitz Equilibrium

- Higher $\lambda \longrightarrow$ expected utility of informed traders becomes more negative relative to uninformed traders.
- Higher risk aversion or higher information costs decrease the informativeness of prices.
- Higher quality of information increases informativeness.



Source: Grossman and Stiglitz (1980), Figure 1.

Market Efficiency and Cross-sectional Return Patterns

- Researchers found soon after publication of the CAPM that some return patterns remain unexplained.
  - E.g., value (stocks with high book-to-market ratios outperform on average) and size (small stocks outperform on average).
- Depending on the benchmark asset pricing model, such return patterns can be considered an anomaly (e.g., relative to the CAPM) or risk premia (e.g., relative to the Fama-French 3-factor model).
- There is a huge academic literature on cross-sectional asset pricing, and asset managers devote major effort to finding asset characteristics related to higher average returns.
- We will go into more detail when looking at factor premia of stocks.

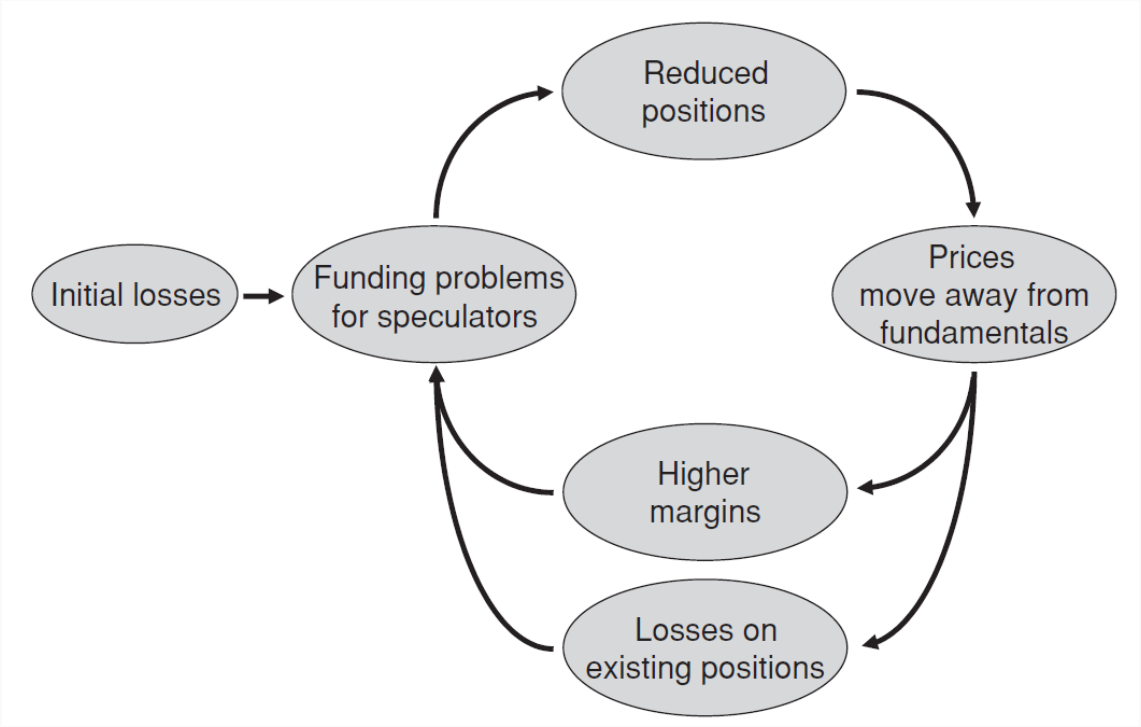
Market Efficiency and Time-varying Risk Premia

- There is increasing evidence that interest rates and risk premia are both time-varying and at least partly predictable.
- We will see later in detail that
  - aggregate dividend yields forecast stock returns,
  - rising yield curves signal higher returns for long-term bonds,
  - international interest rate spreads signal returns.
- Can this be reconciled with efficient markets?

Theories for time-varying π_t

- Excessive run-ups or crashes due to irrational investors
  - Bubbles and limits to arbitrage details
- Amplification and persistence in downturns
  - Liquidity spirals

Unstable dynamics due to Liquidity Spirals



Source: Brunnermeier and Pedersen (2009), Figure 2.

- Loss spiral (outer)
  - very pronounced in mark-to-market accounting regime
- Margin/haircut/precaution spiral (inner)
  - more pronounced in mark-to-model accounting regime

details

Punch Line (1)

- Market prices seem to reflect a lot of information.
- Strong evidence that markets are close to 'micro-efficient' (event studies).
- However, there is evidence that returns are related to 'factors', such as value, momentum etc.
- Whether these returns reflect a fair risk premium (i.e. the π in the pricing equation changes) or an anomaly (i.e. irrational investor behavior) is still debated.

Punch Line (2)

- Even if there are no simple and big 'anomalies' that are easy to exploit, this does not mean that active portfolio management is useless.
- Several arguments in favor of active portfolio management do not rest on market inefficiencies.

Appendix slides

Theory - Speculative Bubbles

- Price distortion + speculation (hold an overpriced asset in the hope to sell at an even higher price)

$$\left.\begin{array}{r}\text{No arbitrage}\\ \text{opportunity}\end{array}\right\} \begin{array}{c}\not\Rightarrow\\ \Leftarrow\end{array} \left\{\begin{array}{l}\text{'price is right' (EMH)}\\ \text{no bubble}\end{array}\right.$$

- Arbitrage is limited/risky, since
  - irrational trades might push price further away - noise trader risk
- Lean against bubble, but not enough, De Long, Shleifer, Summers and Waldmann (JPE '90)
  - Isaac Newton
    - 04/20/1720 sold shares at £7,000 profiting £3,500
    - re-entered the market later - ended up losing £20,000
    - 'I can calculate the motions of the heavenly bodies, but not the madness of people'

back

Other Theories for Time-varying π_t

- Liquidity spirals
- Markus K. Brunnermeier and Lasse Heje Pedersen (2009), Market Liquidity and Funding Liquidity, Review of Financial Studies 22(6).

back

Liquidity Mismatch

Assets

- Market Liquidity
  - can only sell assets at *fire-sale prices*

  = Ease with which one can raise money by selling the asset

Liabilities

- Funding liquidity
  - Can't roll over short term debt
  - Margin-funding is recalled

  = Ease with which one can raise money by borrowing, using the asset as collateral

back

Liquidity Squeezes and Asset Management

- Thus, financial institutions may be subject to liquidity and capital squeezes.
- In these cases their risk-taking capacities may be seriously limited
- This may trigger time-varying risk premia. I.e. during and subsequent to such squeezes, risk premia may increase.

back