Strategic Asset Allocation for Large End-Investors: Endowments, Insurers, Pensions and Sovereign Wealth Funds

FRE-GY 6921

NYU Tandon Program in Financial Engineering

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Spring 2025

Week 1: Course Overview

Admin:

- We will make slides available Wednesdays after class
- Attendance and participation are mandatory and important: students' questions are a public good
- There will be 2 problem sets; these are generally computational in nature and are intended to make principles in lectures more concrete and provide mechanical illustrations
- There will be 2 quizzes; quizzes generally are discipline devices for readings
- Team projects
  - In the third week of the course students will form teams and select topic specializations
  - Project topic choices and task outlines will be due Monday, Apr 21st; drafts will be due Mon, Apr 28th. Final write-ups will be due Monday, May 5th; students will present projects in the final class on Tuesday, May 6th
  - A list of suggested projects will be presented during the third week's class

Week 1: Course Overview

We will model large end-investors' portfolio choice problems as constrained optimization problems

These constrained optimization set-ups will reflect these institutions' objectives and business contexts and regulatory constraints they face

To pose differentiated optimization set-ups, we need to characterize:

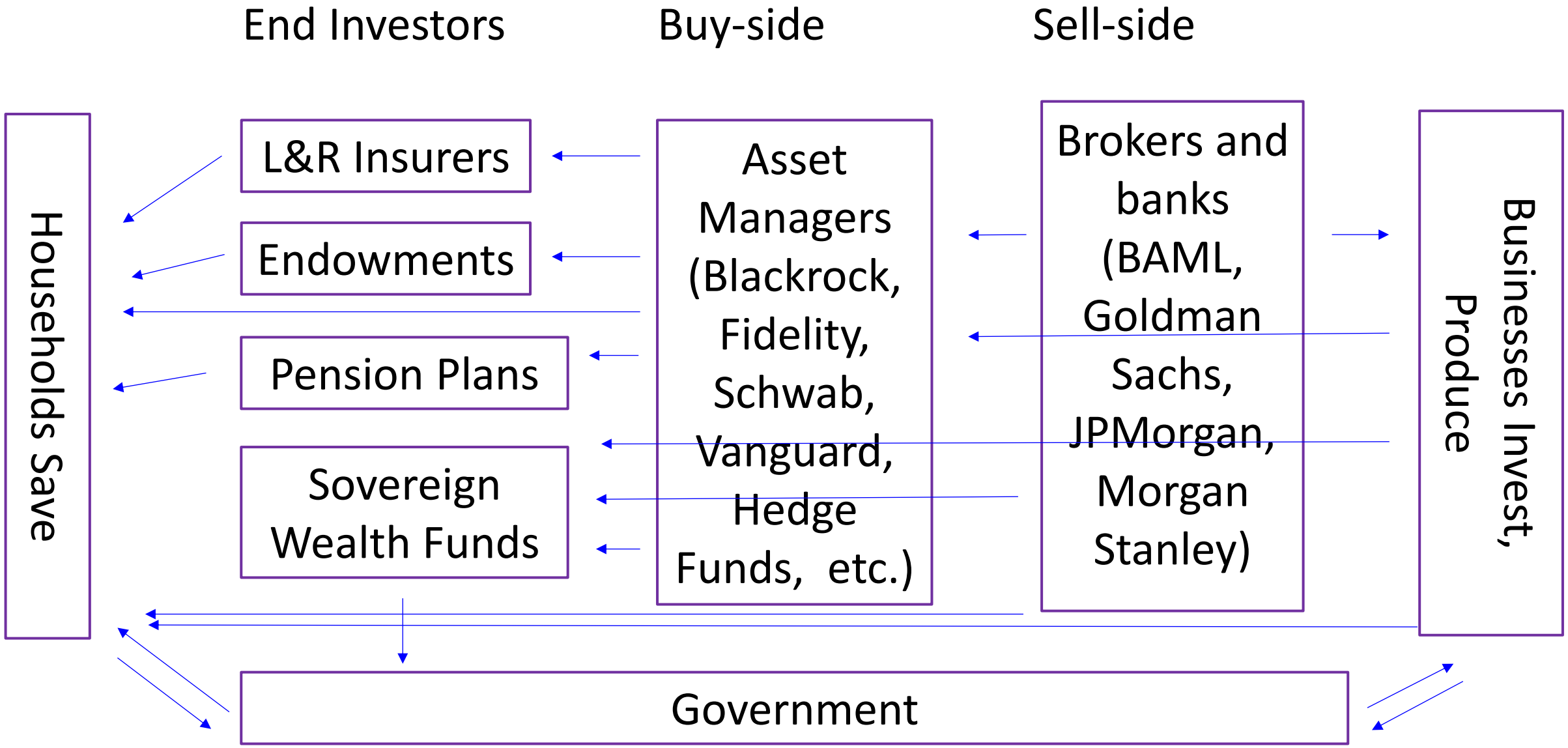
- Who are the end-investors in terms of their institutional features?
- What are their objectives, how are they organized?
- What assets do they hold?

Week 1: Endowments/SWFs, Pensions and Life Insurance Companies

Course themes

- The four types of end-investors have similar beneficiaries, objectives
- The four types of end-investors have very different asset allocations and there are even large allocational differences among end-investors within institution classes: why these differences, if they have similar objectives?
- Explanations: Risk/preferences; regulatory/institutional constraints; different beliefs/information sets; different institutional skills; (arbitrary) historical evolution?
- Portfolio size, security selection and factors: seemingly different assets or even asset classes have common exposures; “beta factors” predominate, “alpha” becomes secondary

Week 1: Endowments/SWFs, Pensions and Life Insurance Companies



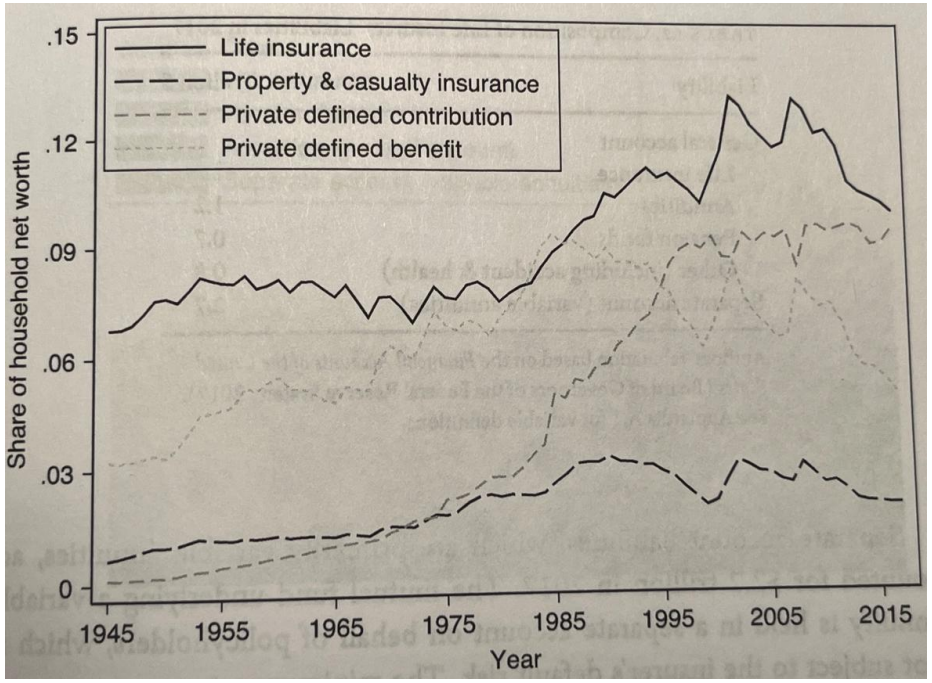
Week 1: Endowments/SWFs, Pensions and Life Insurance Companies

How big are these entities? In 2020 US Endowments held $1.5trn in assets; adding Life insurance and Private DB Pension (appreciated) we get about $11tn in the US alone, excluding public pensions:

TABLE 1.1. Liabilities of Financial Institutions in 2017

Sector	Trillion $
Life insurance	6.5
Property and casualty insurance	1.2
Banks	16.9
Private defined contribution	6.2
Private defined benefit	3.2

Authors' tabulation based on the *Financial Accounts of the United States* (Board of Governors of the Federal Reserve System, 2017). See Appendix A.1 for variable definitions.

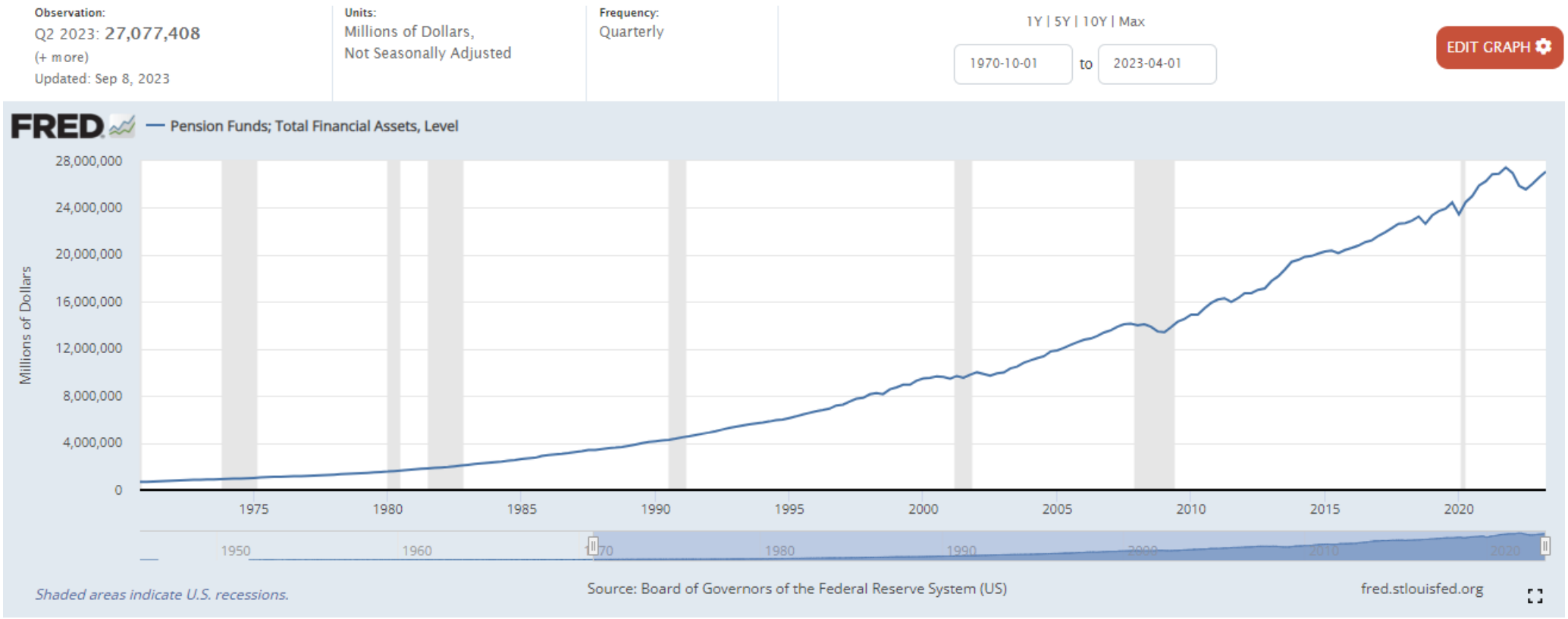


For scale:

- US GDP in 2024 is $28.3tn; Global GDP is estimated to be $109tn
- Russell 3000 market cap = $59.7tn; US residential real estate market cap = $49.6tn, commercial = $20.7tn

Week 1: Endowments/SWFs, Pensions and Life Insurance Companies

Including Public Pensions, Pensions amount to about 100% of US GDP:



Week 1: Endowments/SWFs, Pensions and Life Insurance Companies

Public Pensions (DB)

Overview

According to the U.S. Census Bureau, over 5,000 public sector retirement systems exist in the U.S. Some of the roughly 300 state-administered plans and 5,000 locally-administered plans date back to the 19th century and each has evolved independently. Collectively, these plans have:

- $5.3 trillion in assets
- 14.9 million active (working) members and 12.0 million retirees
- $334 billion in benefit distributions annually

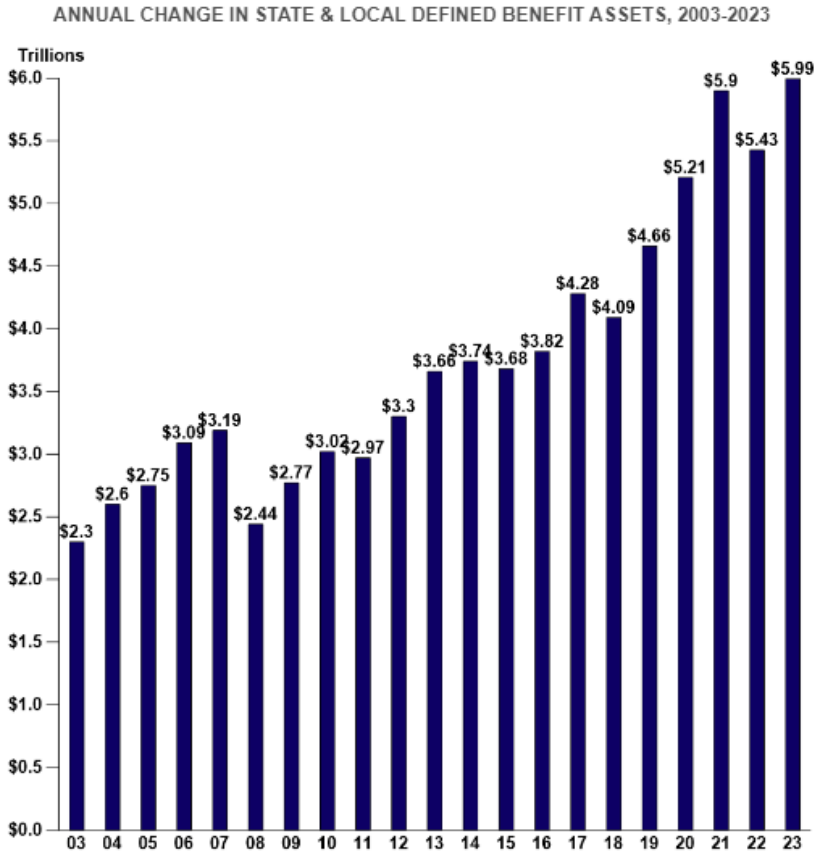
Most public pension plans release financial reports with information on pension trust cash flows and plan membership as well as actuarial data on plan assets, liabilities, and annual costs. These financial reports are prepared in compliance with the accounting standards set by the Governmental Accounting Standards Board (GASB) and can be found on most plans' websites. Significant differences exist among plans: the benefit design of their plans, manner in which plans are funded, membership composition, and investment policy. This quick-fact page highlights the aggregate status of public pension plans across the nation, as reported in their own financial documents.

Assets, Participants and Benefits

State and local government pension benefits are paid from trust funds to which public employees and their employers contributed while they were working, not from general operating revenues. Trust fund assets are invested and grow over time. The combined value of defined benefit plan assets held by state and local governments as of Q2 2022 decreased to $5.3 trillion, from $5.7 trillion as of Q2 2021 (Federal Reserve Flow of Funds, June 2023). PPD data covers the period from 2001 to the most recently available plan reports, and the historical charts presented in this page mirror the period for which PPD data are available.

ANNUAL UPDATE

The Federal Reserve reported in March 2024 that the combined value of defined benefit plan assets held by state and local governments as of Q4 2023 increased by 10.5 percent, to $5.99 trillion, from $5.43 trillion as of Q4 2022.



https://publicplansdata.org/quick-facts/national/

Week 1: Endowments, L&R Insurers, Pensions and SWFs

Differences between SWF, Endowments, L&R Insurers and Pensions

- SWFs provide benefits in many forms to the broad population (not only retirement for a qualified group, or for the benefit of a specific cause or institution)
- SWF sources of revenues come from national wealth (mineral wealth, CB surplus, privatization proceeds, etc.)
- SWFs May Have a policy angle: avoiding 'Dutch' Disease, domestic industry development
- Endowments have donors, targeted beneficiaries, and charters (governing documents) that delineate the benefits these recipients should receive
- Pensions have a targeted pool of employee beneficiaries, with defined benefits
- Insurers have policy holders, with contractually defined benefits

Do these differences imply different choices for asset allocation, or are all institutional goals satisfied the same way – just maximize wealth s.t. to risk?

Week 1: SWFs

Why should sovereigns accumulate assets in a SWF?

- Capacity-constrained efficient gov't spending (rate of return on assets * future social rate of return on gov't expenditure > current social rate of return of gov't expenditure): East Timor example
- Agency problems in gov't: political temptation to fund consumption rather than investments + distribution across generations
- A country's asset/capital markets are small relative to the pool of savings it needs to invest in foreign capital markets
- Convex utility 1: smooth consumption over time ➔ higher marginal utility
- If government is credit constrained in bad states of the world, must smooth aggregate consumption through precautionary savings
- Government can be a very large actor: its policies can create large balance of payments imbalances; a surge in consumption and capital good imports (expenditure produced by the rest of the world) can create problems for many industries and be unsustainable… leading the government to need to draw-down savings over time
- Currency Board / Monetary Policies can lead to the accumulation of large international reserves – why wouldn't a country want to do better than the return on cash?

Week 1: SWFs

Dutch Disease

- Named after problems the Dutch had after the discovery of offshore natural gas in the 1960s and 70s by (*The Economist* coined the phrase)
- Go back to Open Economy Macro: a positive resource 'shock' leads a country to begin to run persistent balance of payments surpluses
- If the firms or government managing this resource seek to convert the proceeds of these export earnings into domestic consumption, they will sell foreign exchange (say US$s) and purchase domestic currency
- This will drive up the real exchange rate
- This will make foreign goods cheaper relative to domestic goods
- This will make domestic industries – including services like hospitality and leisure – that compete with foreign industries shrink
- Generally, manufacturing and service industries are far more labor intensive than mineral extraction… meaning the resource windfall, over time, hurts the non-resource sector labor
- Avoid this by *not* converting resource revenues into domestic currency or spending the proceeds immediately: build of savings of foreign assets during the resource boom, and spend the proceeds of that pool of resources in a sustainable way from a Balance of Payments perspective

Week 1: SWFs

Largest Sovereign Wealth Funds: 2/3rds natural resource-funded

Abu Dhabi Investment Authority (ADIA)
Government Pension Fund (Norway)
Government of Singapore Investment Corporation (GIC)
Saudi Arabia Monetary Authority (SAMA)
Kuwait Investment Authority (KIA)
China Investment Corporation (CIC)
Hong Kong Exchange Fund
Temasek (Singapore)
Oil & Gas Fund (Russia)
Queensland Investment Corporation (QIC)
Qatar Investment Authority (QIA)
Future Fund (Australia)
Pension Reserve Fund (France)
Libyan Investment Authority (LIA)
Algeria Fonds de Régulation des Recettes (FRR)
Alaska Permanent Reserve Fund
Victorian Funds Management Corporation (VFMC)
Brunei Investment Authority
National Pension Reserve Fund (Ireland)
Khazanah Nasional BHD (Malaysia)
Kingdom Holding Company (Saudi Arabia)
National Oil Fund (Kazakhstan)
Korea Investment Corporation (KIC)
National Development Fund (Venezuela)
Alberta Heritage Fund
New Mexico Permanent Trust Funds
Economic and Social Stabilization Fund (Chile)
National Stabilization Fund (Taiwan)

Public Investment Fund (Saudi Arabia)
Dubai International Capital
Excess Crude Fund (Nigeria)
Reserve Fund for Oil (Angola)
Fund for Future Generations (Gabon)
National Hydrocarbon Revenue Fund (Mauritania)
New Zealand Superannuation Fund
Oil Stabilization Fund (Iran)
Mubadala (United Arab Emirates)
Development Fund for Iraq (DFI)
Pula Fund (Botswana)
State General Reserve Fund (Oman)
Istithmar World (United Arab Emirates)
Permanent Wyoming Mineral Trust Fund
Oil Stabilization Fund (Mexico)
Timor-Leste Petroleum Fund
State Oil Fund (Azerbaijan)
Heritage and Stabilization Fund (Trinidad & Tobago)
Oil Stabilization Fund (Colombia)
State Capital Investment Corporation (Vietnam)
Chile Pension Reserve Fund
Investment Fund for Macroeconomic Stabilization (Venezuela)
Revenue Equalization Reserve Fund (Kiribati)
National Fund for Hydrocarbon Reserves (Mauritania)
Emirates Investment Authority
Investment Corp of Dubai

Week 1: SWFs

SWFs: Examples

Purposes/sources	Commodity revenues	Fiscal sources	Foreign reserves
Revenue stabilization	Russia: Reserve Fund Kuwait: Reserve Fund Mexico: Oil Stabilization Fund		
Future generations / public pensions	Russia: National Prosperity Fund Kuwait: Future Generation Fund Norway: Government Pension Fund	Australia: Future Fund New Zealand: Super Fund	
Management of government holdings	Mubadala Saudi Arabia: Public Investment Fund	Singapore: Temasek Malaysia: Khazanah Vietnam: State Capital Investment Corporation	China: Bank holdings managed by CIC
Wealth or risk/return optimization	Abu Dhabi Investment Authority (ADIA) Brunei Investment Authority (BIA) Qatar Investment Authority (QIA)	Singapore: Government Investment Corporation (GIC)	Singapore: Foreign reserves managed by GIC Korea: Foreign reserves managed by KIC China: Foreign reserves managed by CIC

Week 1: Endowments

Endowments

- Include University endowments, charitable foundations, family offices
- Beneficiaries are a specific pool of individuals or enterprises, including current and future generations
- Membership criterion is determined by founding donors or the beneficiary institution
- For individuals there is compelling experimental evidence for discounted future utility (impatience)
- For many settings/institutions we may need to value the utility of future generations just as highly as the current generation
- In the US, Endowments are tax-exempt whereas often, large donors are not (e.g., Ford Foundation, Eli Lilly, etc.). To prevent tax avoidance for family dynasties, Endowments must disperse a minimum of 5% of AUM per year

Week 1: Endowments

Endowments

- University endowments are not subject to the 5% rule; they may draw-down expenditures at a lower rate
- University endowments have non-financial / non-fungible assets: University of Texas has large oil reserves; Stanford University has a large portfolio of patents (as do others); etc. Should the financial portions of these institutions' portfolios take the correlation of those non-fungible assets into account?
- University endowments have a big problem: restrictions. What is the name of the NYU Engineering School? School of Arts? School of Business? It happens everywhere. Consequently, University Endowments may target different pay-out rates on segregated pools of assets
- NACUBO (National Association of College and University Business Officers)

Week 1: Endowments & SWFs

Holdings of Important SWFs and Endowments (as of 2021)

Endowment Asset Allocations	Average (CambAssoc)	Norwegian Gov't Pension Plan	GIC	Yale	Princeton	Ford Foundation
AUM	N/A	$1,246bn	$690bn	$42.3bn	$37bn	$18.9bn
Public Equity	40.45%	71.95%	30.0%	14.0%	22.0%	2.0%
PE / VC	19.70%		17.0%	41.0%	30.0%	35.0%
Hedge Funds	17.10%			23.5%	24.0%	46.0%
Real Assets	6.70%	2.64%	16.0%	14.0%	18.0%	8.6%
Fixed Income	9.60%	25.41%	37.0%	7.5%	6.0%	8.4%
Private Credit	1.80%					
Cash and Other	4.65%					
	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

Week 1: Modelling Endowments and SWFs

- Like any commercial entity, end-investors have both liability and asset sides to their balance sheets:

Assets		Liabilities
Public Equities	33%	
Private Equity	17%	
Real Assets	14%	NPV of future flows needed
Fixed Income Corp Credit	9%	by constituents, benficiaries,
Fixed Income Govts	4%	or policy holders
Fixed Income Sov Credit	6%	
Structured Products	12%	
Commodities	5%	

- There is a vast literature on Asset Liability Management (ALM); idiosyncrasies in liabilities across end-investors make it difficult to summarize different features
- Since we cannot treat A+L jointly, liability funding requirements we will model liabilities through constraints on asset side optimization problems

Week 1: Modelling Endowments & SWFs

Modelling liabilities through beneficiary preferences

- For individuals there is compelling experimental evidence for discounted future utility (impatience)
- For many settings/institutions we may need to value the utility of future generations just as highly as the current generation
- We will still impose a time preference factor $\beta < 1$ so that our sums converge… each generation will have impatience… over-lapping generations will imply convergent (though higher) discount factors

Week 1: Consumption, Savings and Utility Theory

An interlude: Utility Theory

- People generally prefer smooth consumption
- The wealthier you get, the less difference “more stuff” makes to you
- Losing something you possess (or consumption you are accustomed to) has a larger negative impact than the same magnitude gain of new consumption (or a new possession)
- Consumption vs. Wealth: formally, utility comes from consumption
- A common functional form:

$$U(W) = \frac{W^{1-\gamma}}{1-\gamma}, \qquad (2.1)$$

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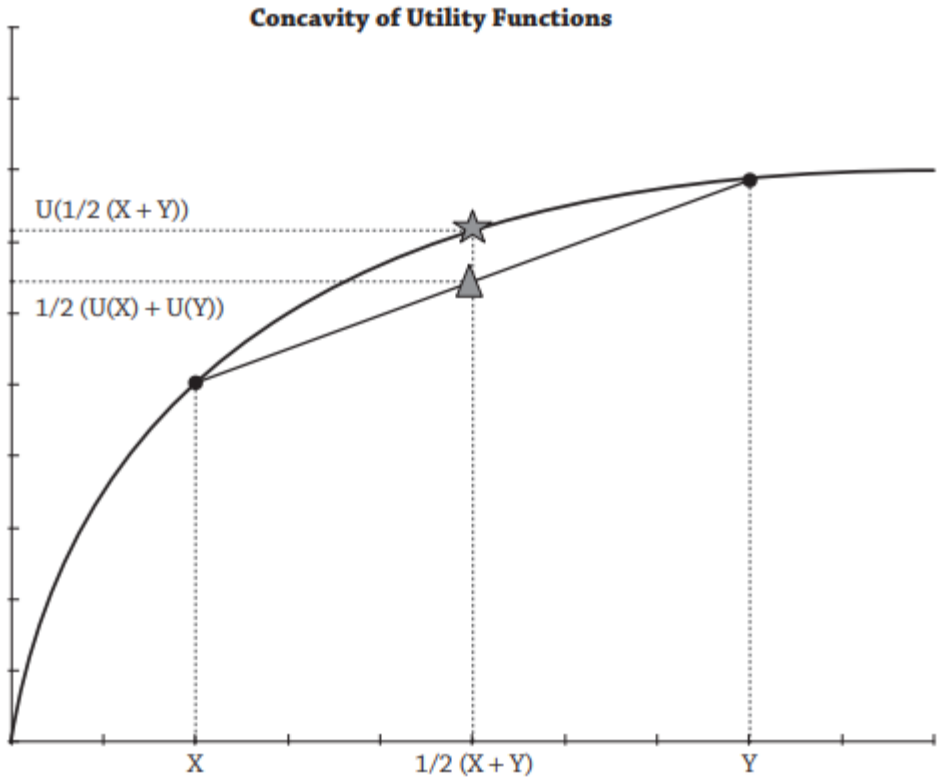
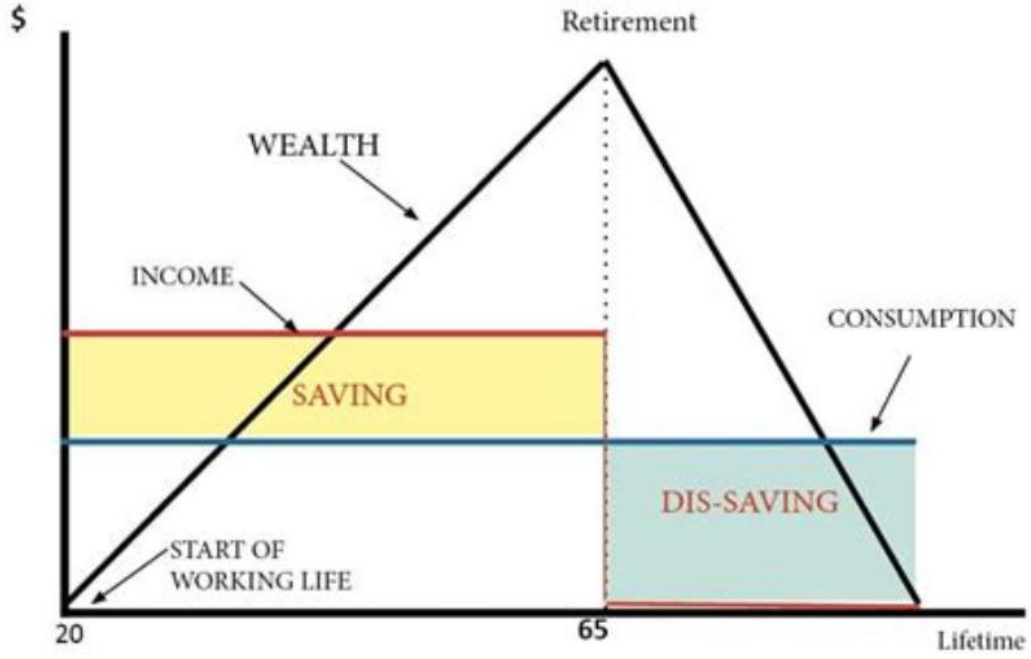


Figure 2.4

Week 1: Consumption, Savings and Utility Theory

Lifetime income

- This chart assumes $c_t = \bar{c}$ is the optimal solution (consumption smoothing)
- It doesn't model how wealth accumulates exponentially or uncertain death
- It doesn't incorporate rising income during one's career (most saving happens when one is 40-65) and the impact that has on early consumption (consumption grows from years 20-40)
- It doesn't incorporate uncertain timing of death
- But the general idea is you work (and save) from 20-65, then you retire (and draw down savings) after about 65



Week 1: Endowments

Problem the CIO of the endowment faces.

Define the sequences $\{W_{t+i}, CF_{t+i}\}_{i=0}^{\infty}$ as the value of the endowment fund and the cash flow it generates each period.

$$max_{CF} \sum_{i=0}^{\infty} \beta^i \, U(CF_{t+i})$$

$$s.t.$$

$$x_{t+1} = (1 + q_t)(x_t - z_t)$$

$$W_t = \sum_{n=1}^{N} x_t$$

$$CF_t = \sum_{n=1}^{N} z_t$$

$U(\cdot)$ is concave and standard all other respects

The stochastic total returns vector is denoted q_t, x_t is the vector of value of asset holdings, and z_t is the vector of net current income, additions to holdings, and proceeds from sales of assets

Week 1: Endowments

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$$CF_t = \sum_{n=1}^{N} z_t$$

Asset	x(t)	z(t)	q(t)	x(t+1)
Public Equity	$ 6.60	$ 0.33	22.00%	$ 7.65
Private Equity	$ 3.40	$ 0.17	8.00%	$ 3.49
Real Assets	$ 2.80	$ 0.14	14.00%	$ 3.03
Fixed Income Corp Credit	$ 1.80	$ 0.09	5.80%	$ 1.81
Fixed Income Govts	$ 0.80	$ 0.04	4.90%	$ 0.80
Fixed Income Sov Credit	$ 1.20	$ 0.06	5.20%	$ 1.20
Structured Products	$ 2.40	$ 0.12	6.10%	$ 2.42
Commodities	$ 1.00	$ 0.05	-2.00%	$ 0.93
W(t), CF(t), W(t+1)	$ 20.00	$ 1.00		$ 21.33

Week 1: Endowments

Characterize the solution of this problem using dynamic programming. First simplify to:

$$max_{CF} \sum_{i=0}^{\infty} \beta^i \, U(CF_{t+i})$$

$$s.t.$$

$$W_{t+1} = (1 + q_t^*)W_t - CF_t$$

Now define a function $V(W_t)$ as:

$$V(W_t) = max_{\{CF_t, CF_{t+1}, \dots\}}\{U(CF_t) + \beta U(CF_{t+1}) + \beta^2 U(CF_{t+2}) + \cdots + \beta^k U(CF_{t+k}) + \cdots\}$$

We map the infinite horizon utility maximization problem into a recursive functional equation in the state variable W_t, where we try to solve for the function $V(W_t)$

$$V(W_t) = max_{CF}\{U(CF_t) + \beta V(W_{t+1})\}$$

$$s.t.$$

$$W_{t+1} = (1 + q_t^*)W_t - CF_t$$

Week 1: Endowments

How does this work? If $V(W_t)$ is defined as

$$V(W_t) = max_{\{CF_t, CF_{t+1}, \dots\}}\{U(CF_t) + \beta U(CF_{t+1}) + \beta^2 U(CF_{t+2}) + \cdots + \beta^k U(CF_{t+k}) + \cdots\}$$

by extension, the definition of $\beta^k V(W_{t+k})$ is

$$max_{\{CF_{t+k}, CF_{t+k+1}, \dots, CF_{t+k+2}\}}\{\beta^k U(CF_{t+k}) + \beta^{k+1} U(CF_{t+k+1}) + \beta^{k+2} U(CF_{t+k+2}) + \cdots\}$$

Substitution yields

$$V(W_t) = max_{\{CF_t, CF_{t+1}, \dots\}}\{U(CF_t) + \beta U(CF_{t+1}) + \beta^2 U(CF_{t+2}) + \cdots + \beta^k V(W_{t+k})\}$$

or

$$V(W_t) = max_{CF}\{U(CF_t) + \beta V(W_{t+1})\}$$

Week 1: Endowments

First order conditions the optimal functional equation V() has to fulfill is

$$U'(CF_{t+i}) = E[\beta(1 + q^*_{t+i})U'(CF_{t+i+1})] \; \forall \; i$$

Suppose the average expected return on the portfolio is q^*_{port}, and $q^*_{port} > (\beta^{-1} - 1)$, the rate of time preference

Rule-of-thumb: for an endowment consumption policy consume a constant fraction of total wealth each period, call it θ:

$$CF_t = \theta W_t$$

$$\theta = q^*_{port} - (\beta^{-1} - 1) \gg 0$$

i.e., $W_{t+1} = W_t(1 + q^*_t) - \theta W_t = W_t(1 + q^*_t) - \left(q^*_{port} - (\beta^{-1} - 1)\right) W_t = W_t\left(1 + (\beta^{-1} - 1)\right)$

In this case, the approximate optimal endowment policy would be to spend the fraction θ of W_t, and allow W_t to grow at the rate $(\beta^{-1} - 1)$, which implies that CF_t would also grow at the rate $(\beta^{-1} - 1)$ over time.

Week 1: Endowments

We say approximate because:

- the return on the portfolio is stochastic
- We haven't checked to see if the first order conditions are fulfilled
- However, the form of $U(\cdot)$ implies we will realize higher value if the endowment's cash flow is smooth, and we also need $E\left[\frac{U'(CF_{t+i})}{U'(CF_{t+i+1})}\right] = E[\beta(1+q^*_{t+i})] \geq 1$ meaning CF must grow over time, which it does

Things to ponder:

- The higher W_t is in the future, the greater $V(W_0)$ is today, *ceteris paribus*. But the optimal path is defined by marginal variations in CF_t, CF_{t+1}, etc. How can we be sure these two things are consistent (i.e., W_t being the right magnitude in the future through perturbations in CF_t)?
- In a deterministic environment, the optimal endowment consumption/accumulation path does take the form $CF_t = \theta W_t$ where θ is a function of utility parameters, q* and possibly W_0, depending on the form of $U(\cdot)$
- How might the prior assertion vary in a stochastic environment? How might θ vary as a function of higher moments of the distribution of the vector q_t?

Week 1: Endowments, Pensions, L&Rs

General themes or rules that emerge from utility theory as we develop it in the next 3 lectures:

- Diversify widely – watch out for concentrated holdings (employer's stock? stock in founder's company? Stock in large national industry (ARAMCO)?...), home-bias, asset class concentration
- Rebalance at appropriate intervals: valuation matters and rebalancing leads to good relative timing
- Dis-save after retirement, use annuities to insure time-of-mortality risk
- Ignore asset "labels", look at the true attributes, statistical and fundamental, of the assets in your portfolio (examples: private equity is still equity; ETFs re the same as Mutual Funds, the correlation of the S&P 500 with the MSCI World is > 0.95, High Yield bonds have a higher correlation to stocks (>0.5) than they due to bonds (<0), etc.)
- Finance / investment is rife with conflicts of interest. Be skeptical of the latest thing (private credit), complexity… drill down to substance

Week 1: Pensions

There are a number of types of pension schemes:

- National public pension schemes that are partially-funded, generational transfer schemes (US Social Security)
- National or state public pension schemes that are fully funded (Australia Super, CPPIB, etc.), often for public employees, that often have defined benefits
- Private Defined Benefit (DB) pension plans (employer commits to an inflation-adjusted annuity upon retirement)
- Private Defined Contribution (pre-defined investments, non-fixed future benefits)
- Tax-advantaged, privately managed funds (IRAs, 401Ks, etc.)

Week 1: Pensions

Whether a pension is defined benefit (DB) or defined contribution (DC) makes a big difference:

DC: the amount, frequency and investment allocation that gets made on a pensioner's behalf is stipulated a head of time.

- During the future pensioner's employment, a pre-determined periodic contribution amount is transferred to the pensioner's retirement account
- Upon retirement, a portfolio or asset balance gets delivered to the pensioner
- The only asset management involved (by pension provider) is selection of a (age-conditional) benchmark by which to allocate assets
- The retiree has to figure out how to "annuitize" the asset balance upon retirement

Week 1: Pensions

Whether a pension is defined benefit (DB) or defined contribution (DC) makes a big difference:

DB: subject to meeting qualification requirements, beneficiaries are granted a pre-determined monthly disbursements for the rest of their lives

The pension fund manager serves three functions as once

- They seek the highest possible return, constrained to risk tolerances
- They pool and manage mortality rates among the group of pensioners they are serving (as a Life Insurer would do when hedging annuity obligations)
- They administer calculation, payment, withholdings of monthly payments

Week 1: Pensions

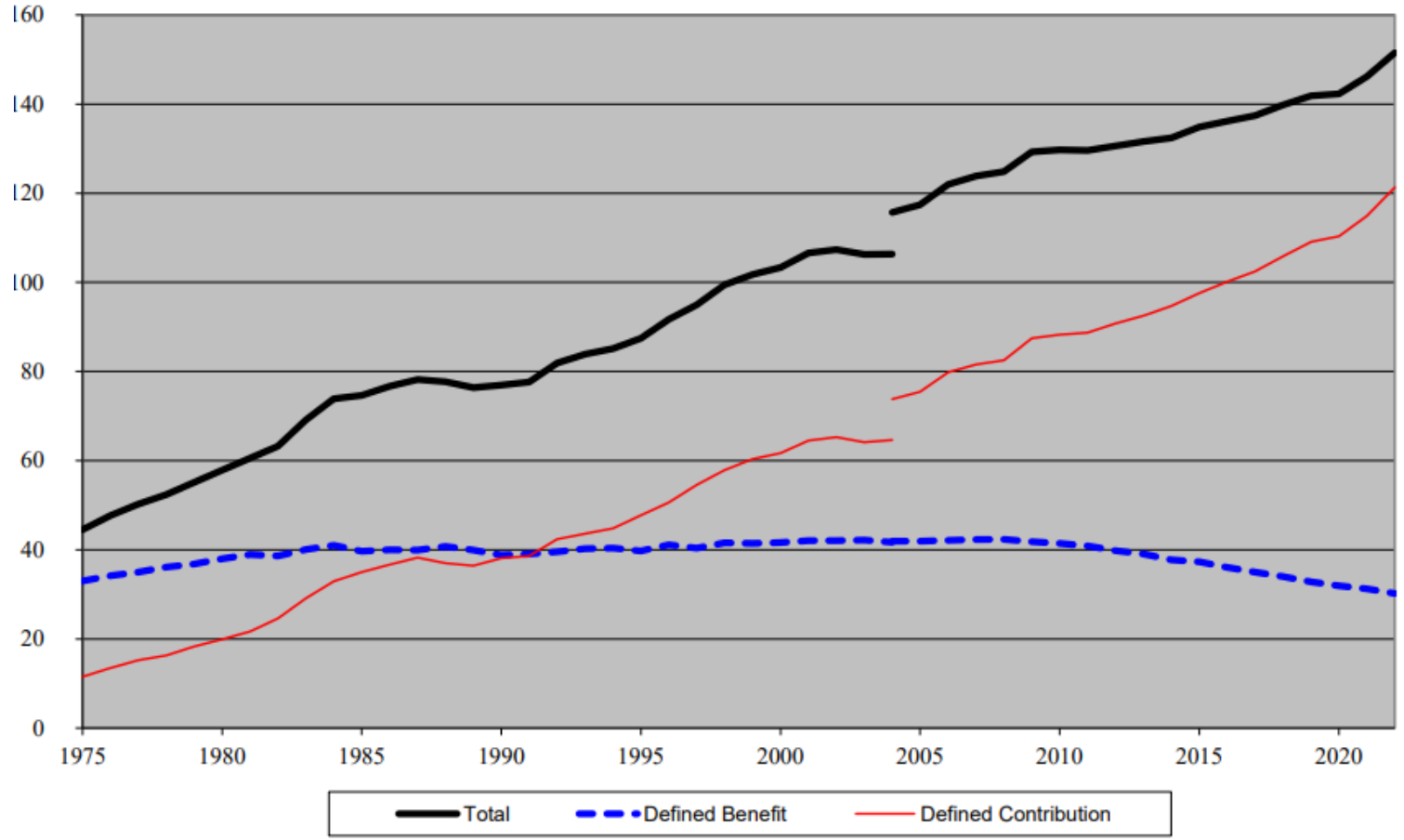
We will focus on Defined Benefit plans as they are more complex and involve substantive asset allocation decision making. However, DB schemes are becoming a decreasing portion of the pension fund universe

- In DB plans the employee receives a commitment for a predetermined stream of future payments; the employer (or pension manager) bears the risk of meeting those payments
- Due to longer life expectancy, employers have found themselves on the losing end of actuarial mortality extension
- Increasing prudential regulation of private DB schemes has also increased their cost
- Consequently, companies find DC schemes cheaper and less risk to provide to employees
- DB benefits can increase non-linearly in job tenure (i.e., you have to work 20 years to qualify at all… if you work an additional 2 or 3 years, your benefits increase more than 10 or 15%)
- As job tenure has shrunk / employee mobility has increased in the private sector, employees have come to prefer DC schemes as the benefits are portable
- However, in the public sector, DB schemes are still predominant, and governments are following the example of success in delegating pension scheme management to non-politically exposed agencies

Week 1: Pensions

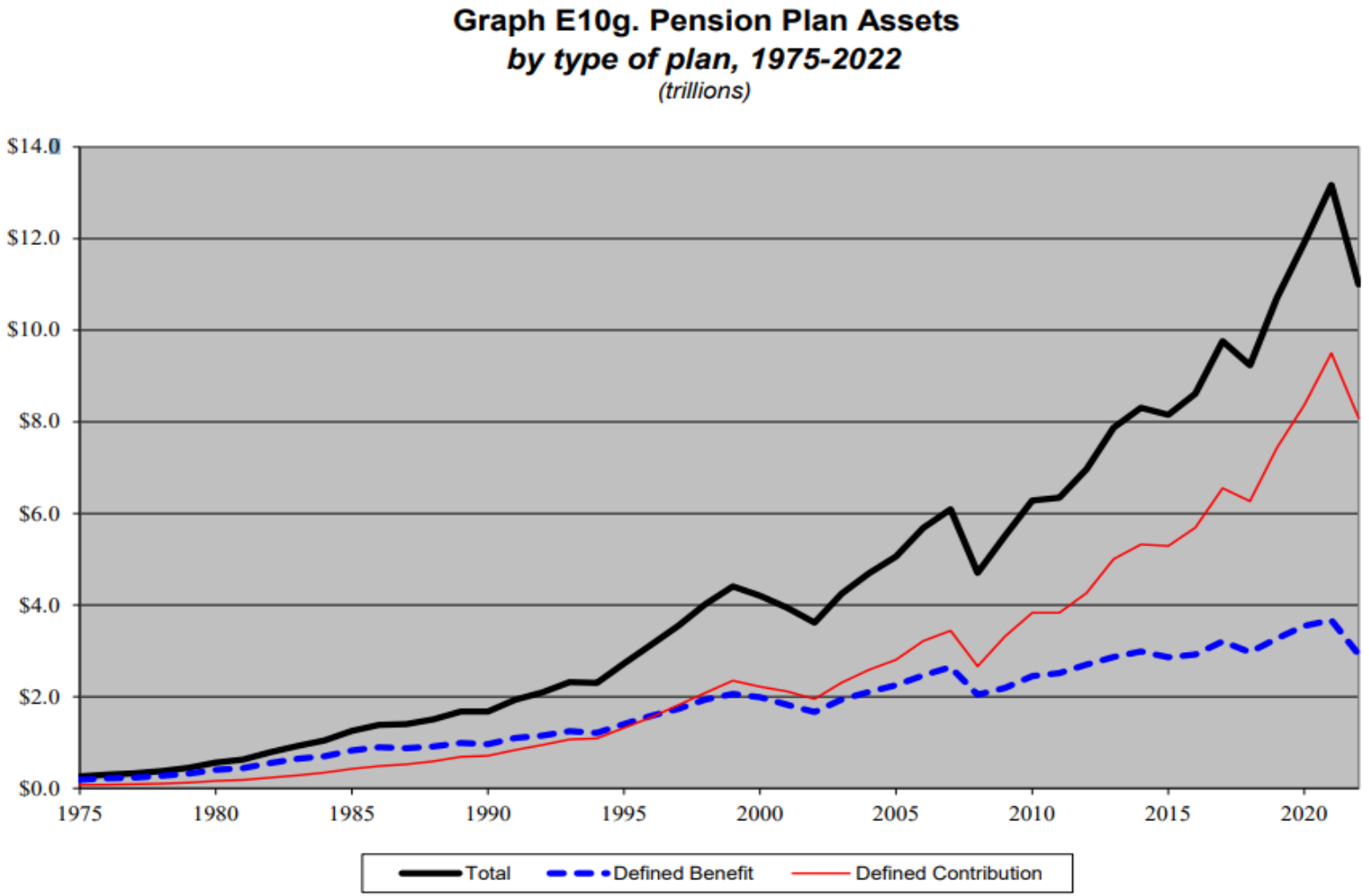
DC growing faster than DB:

Graph E4g. Number of Participants in Pension Plans
by type of plan, 1975-2022
(millions)



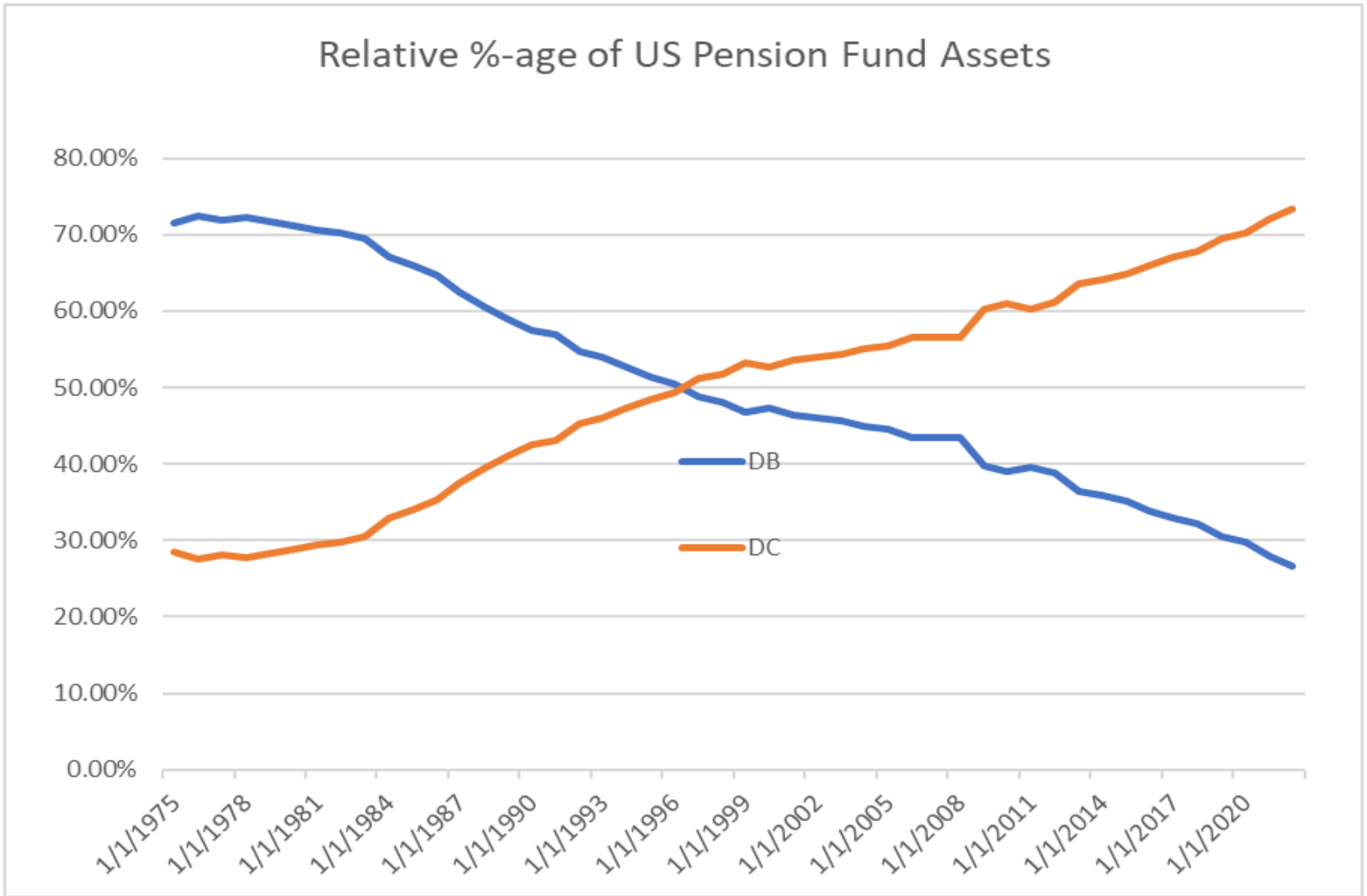
Week 1: Pensions

DC growing faster than DB:



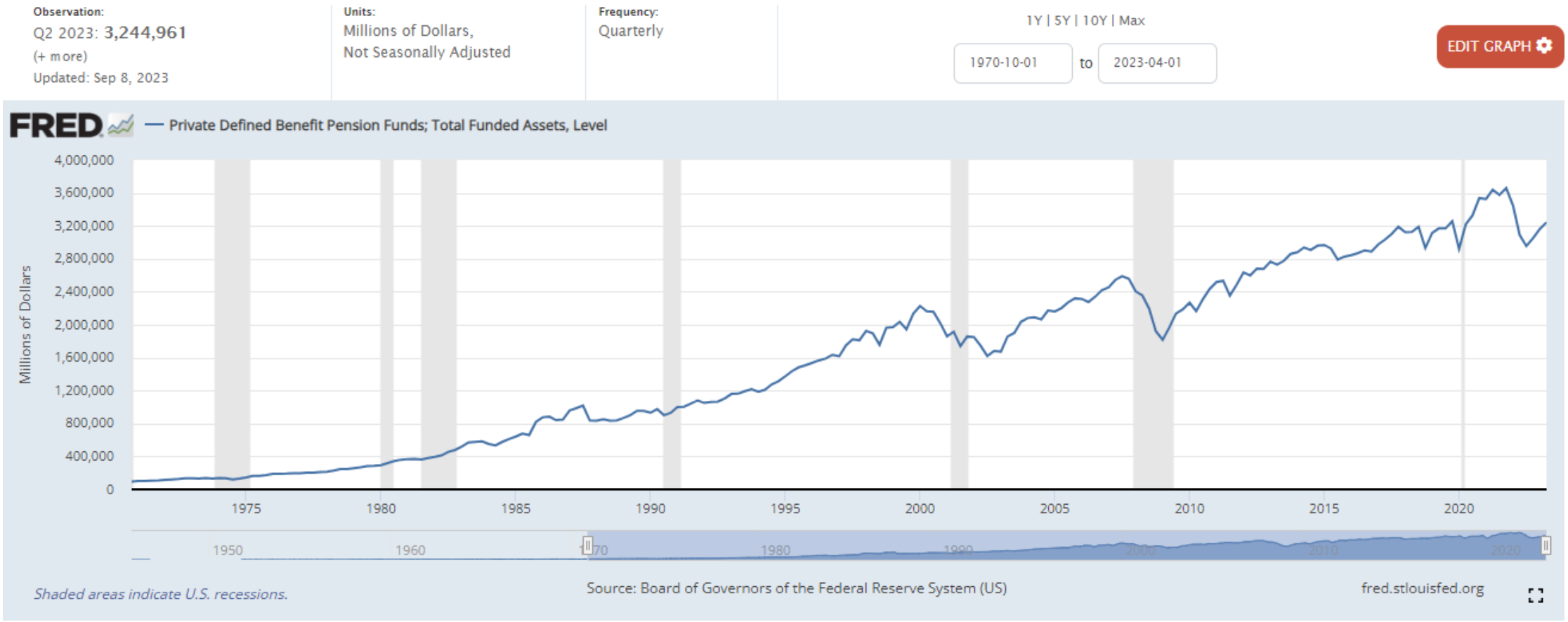
Week 1: Pensions

DC growing faster than DB:



Week 1: Pensions

Even though DC is becoming more popular than DB, DB plans continue to grow:



Week 1: Pensions

A Defined Benefit reduced balance sheet:

DB Pension Assets		DB Pension Liabilities
Public Equity	37%	NPV of projected future cash flows; DB benefit parameters + mortality tables + future CPI inflation are key inputs; summarized by required rate of return, duration, risk (e.g., CVAR)
PE / VC	6%	
Hedge Funds	5%	
Real Assets	7%	
Private & Pub Credit	23%	
Fixed Income & Cash	22%	

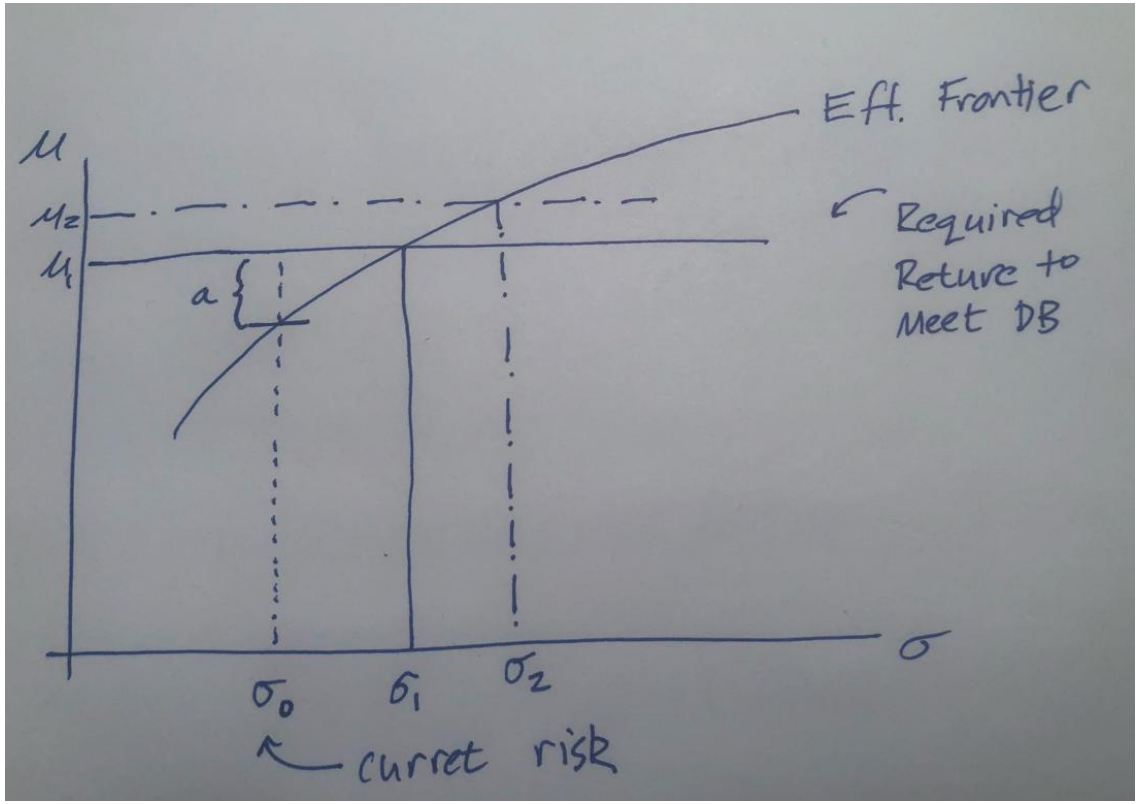
If you wanted to do the exercise of generating expected CFs for a DB plan, you'd need the age / sex composition of your retiree pool and a mortality table:

https://www.pbgc.gov/prac/mortality-retirement-and-pv-max-guarantee/erisa-mortality-tables/erisa-section-4044-mortality-table-for-2023-valuation-dates

Week 1: Pensions

Why DB plans are more challenging to manage than DC plans:

- The boards that determine eventual pension benefits are not always constrained by assets or existing flows into the program
- The managers bear the risk of achieving expected benefit requirements in the future
- Often, assets are not deemed not sufficient to meet future obligations at low-risk rates of return, meaning a plan may be "under-funded".
- The CIO must take on higher portfolio risk in hopes of catching up to the DB plans' future obligations, at the cost of going further under-funded in the event of a bad year



Week 1: Pensions

Key issue: measurement of pension fund liabilities

$$V(PensionLiab) = \sum_{i=0}^{\infty} PS(t, t+i) \cdot \left(\frac{1}{\left(1 + r(t, t+i)\right)} \right)^{i} \cdot BCF(t+i)$$

Where

$PS(t, t+i)$ = probability of survival to period t+i of projected pool of beneficiaries

$BCF(t+i)$ = expected benefits cash flow from the pension program to living beneficiaries

$r(t, t+i)$=(zero coupon) discount rate between time t and time t+i

In many contexts r is set to the expect IRR of the pool of assets. This is technically incorrect, since the sequence $\{ BCF(t+i) \}_{i=1}^{\infty}$ is generally a function of factors with no correlation to and lower volatility than expected asset rates of return. I.e., r should be closer to treasury rates, not expected rates of return on risk assets. Why do it?

Week 1: Pensions

Major North American pension plans and their asset allocations:

Pension Asset Allocations	Average (NAREIT)	CalPERS (DB)	CalSTRS (DB)	CPPIB (DB)	Ontario Teachers (DB)
AUM	N/A	$336.6bn	$216.19bn	C$273bn	C$154.4bn
Public Equity	36.79%	48.5%	39.5%	27.0%	17.0%
PE / VC	6.11%	11.0%	15.1%	32.0%	17.0%
Hedge Funds	5.31%	0.0%	1.3%	0.0%	6.0%
Real Assets	6.61%	16.2%	22.9%	18.0%	31.0%
Private & Pub Credit	22.94%	1.9%	9.2%	16.0%	10.0%
Fixed Income & Cash	22.24%	22.5%	12.0%	7.0%	19.0%
	100%	100%	100%	100%	100%

Week 1: Pension Regulation (US)

ERISA (1974), Employee Retirement Income Security Act. Set minimum benefits, minimum funding levels for private pension plans (DB and DC)

- Funding levels are measured as AUM's percentage of the NPV of liabilities
- 100% is considered "fully funded"
- AUM fluctuates (i.e., the volatility of the portfolio > 0), so full funding is not assured
- ERISA provides guidelines for recovering to full funding in the event of shortfalls (i.e., within 7 years, etc.)

PBGC, Pension Benefit Guarantee Corporation

- A bit like the FDIC, the PBGC is a Federal Agency that collects premiums from private pensions and funds pension "takeovers" in the event a private pension plan fails to meet its ERISA obligations (is considered failed)
- Premiums are higher for underfunded pensions
- Intervention by the PBGC often entails pensioners taking some hit (there is a maximum annual benefit that gets covered)
- Creates a problem of moral hazard (fund managers might be inclined to raise risk to become fully funded since PBGC bears some of the costs of a bad investment outcome)

Week 1: Life and Retirement Insurers

- L&R companies specialize in demographic actuarial solutions
- Life insurance if you die too soon
- Annuities if you live too long, both fixed, indexed and variable
- L&R insurers offer Pension Risk Transfer -- provide services to entities (e.g., a school district) committed to a DB plan without specialized personnel to manage it
- Regulated by the NAIC, principally through risk capital charges

Life and Retirement Asset Allocations	Average	NY Life	Northwestern	Met Life	Prudential	Lincoln
Asset AUM	N/A	$224.35bn	$284bn	$351bn	$162bn	$387bn
Public Equity	8.73%	7.93%	1.49%	1.08%	32.93%	0.23%
PE / VC	9.58%	7.26%	10.26%	0.00%	27.21%	3.16%
Hedge Funds	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Real Assets	0.45%	1.14%	1.09%	0.00%	0.00%	0.00%
Public and Private Credit	68.09%	82.28%	85.83%	68.63%	9.01%	94.68%
Fixed Income & Cash	13.16%	1.39%	1.33%	30.29%	30.84%	1.92%

Week 1: Endowments, Pensions, L&Rs

Summary

- Despite having seemingly similar objectives, SWFs, Endowments, Pensions and L&R Insurers hold very different asset allocations
- We refer to the allocation targets these institutions use as “Strategic Asset Allocations,” or SAAs, because given their size, and liquidity of their holdings relative to their positions, their allocations must be long-term and change slowly

Asset Class	**Endowments**	**Pensions**	**L&Rs**
Public Equity	40.5%	36.8%	8.7%
PE / VC	19.7%	6.1%	9.6%
Hedge Funds	17.1%	5.3%	0.0%
Real Assets	6.7%	6.6%	0.4%
Public and Private Credit	9.6%	22.9%	68.1%
Fixed Income & Cash	1.8%	22.2%	13.2%

Week 1: Resources and References

SWFs:

https://statetreasurer.wyo.gov/investments/

https://statetreasurer.wyo.gov/wp-content/uploads/2022/12/Packet-10312022.pdf

https://joi.pm-research.com/content/30/1/67

Pensions:

https://kpa-advisory.com/the-ambachtsheer-letter/view/the-canadian-pension-model-past-present-and-future

https://kpa-advisory.com/userfiles/Ambachtsheer_JPM_article_April_2021_1.pdf

https://hub.cembenchmarking.com/hubfs/PDFs/Research%20Downloads/R-40-NAREIT_CEM_ES_2022.pdf

Endowment Funds:

https://www.wsj.com/articles/yale-university-endowment-alternative-assets-b4bd3258

https://jpm.pm-research.com/content/early/2021/03/02/jpm.2021.1.227/tab-article-info

Life Insurance

https://www.guggenheiminvestments.com/GuggenheimInvestments/media/PDF/The-Life-Insurance-Industrys-Investment-Conundrums.pdf

https://www.nb.com/en/global/insights/the-solvency-sharpe-ratio-strategic-asset-allocation-for-insurers#:~:text=The%20Solvency%20Sharpe%20Ratio%20Risk,Source%3A%20Bloomberg%2C%20Neuberger%20Berman

NAIC:

https://content.naic.org/sites/default/files/inline-files/Master%20NAIC%20Designation%20and%20Category%20grid%20-%202020.pdf

Week 1: The Strategic Investment Time-Frame

Large end-investors are planning for income for horizons decades in advance

Large end-investors' portfolio allocations are large relative to available liquidity – moving an allocation even 1% might take a year

Forecasting assets at a 10-year horizons is very different than forecasting at day, week, month or even a quarter

- Factors / features are different (price trend, last quarter's company fundamental data not applicable in SAAs)
- Samples are much smaller (40 years, not 10,000 days), sampling frequencies longer (years, not days)
- The nature of asset classes change within the forecast horizon (many asset classes didn't exist 10 years ago; some that existed 10 years ago are no longer around)

The asset class allocation decision is different than the security investment decision

Week 1: Assets Held by Large End-Investors

Assets large end-investors allocate to:

Rates – cash (T-bills, deposits, CDs, etc.), government bonds, and rate derivatives (gov't bond futures, IR swaps, etc.)

Public Credit – Corporate bonds, sovereign bonds (IG, HY, EM)

Structured Credit – MBS, CMBS, ABS, CLOs, etc. Securities funded on pools of underlying loans, where each security class's payouts are determined by a hierarchy of payment-priorities (e.g., "waterfall") structured to create an array of risk profiles from that single pool

Private Credit – LPs (limited partnerships) and direct investment in whole loans from "middle market" (small cap) corporates, Private Equity investors (leveraged loans), and enterprises deemed to have steady future cash flows

Public Equity – listed stocks

Week 1: Assets Held by Large End-Investors

Assets large end-investors allocate to:

Private Equity (PE) – LPs (limited partnerships) and direct investment in firm ownership, where the firms are not publically listed (e.g., pre-IPO). Many different contexts: LBO, growth (e.g., post-VC funding rounds, anticipating an IPO exit), etc.

Private Equity Real Estate – Sub-set of PE, focused on particular collateral and cash-flow characteristics of commercial real estate firms

Venture Capital – PE for high-growth start-ups (e.g., tech)

Real Assets – Toll roads, infrastructure projects such as power plants, airports, etc. Highly predictable future cash flows; both equity and credit portions of the capital structure

Hedge Funds – LPs on managers that pursue active trading ("alpha" oriented) strategies on behalf of LP members

Week 1: Course Themes

Diversification is essential to high risk adjusted returns

$$\sigma = \frac{\sum independent\ return\ factors}{\sqrt{N}}$$

Truly independent return streams are difficult to find

- Does not come from large numbers of assets necessarily, but many independent vectors of return
- Statistically, low correlation across component or factors of returns in each asset class
- Structurally, different industries, regions, asset classes, sources of profits can also insure low correlation during periods of market stress

Hence in SAA, a large emphasis on factors, true risk premia

High return portfolios have lower Sharpe ratios... Trade-off between capital efficiency and risk adjusted returns

Modelling Risk, Returns and Constraints Is difficult: Optimization Is Not Simple

Week 1: Resources and References

Brandt, M.W. Estimating Portfolio and Consumption Choice: a Conditional Euler Approach. *Journal of Finance* (54), 1999.

Cheng, Murphy and Kolanovic (2019). Optimal Portfolio Construction: Beyond Risk Parity. Commercial Manuscript.

Idzorek, Thomas (2014). A Step-by-Step Guide to the Black-Litterman Model. Manuscript.

Markowitz, Harry M. (1952). "Portfolio Selection", *Journal of Finance* 7(1): 77-91.

Markowitz, Harry M. Portfolio Selection: Efficient Diversification of Investments, Yale University Press. 1959.

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