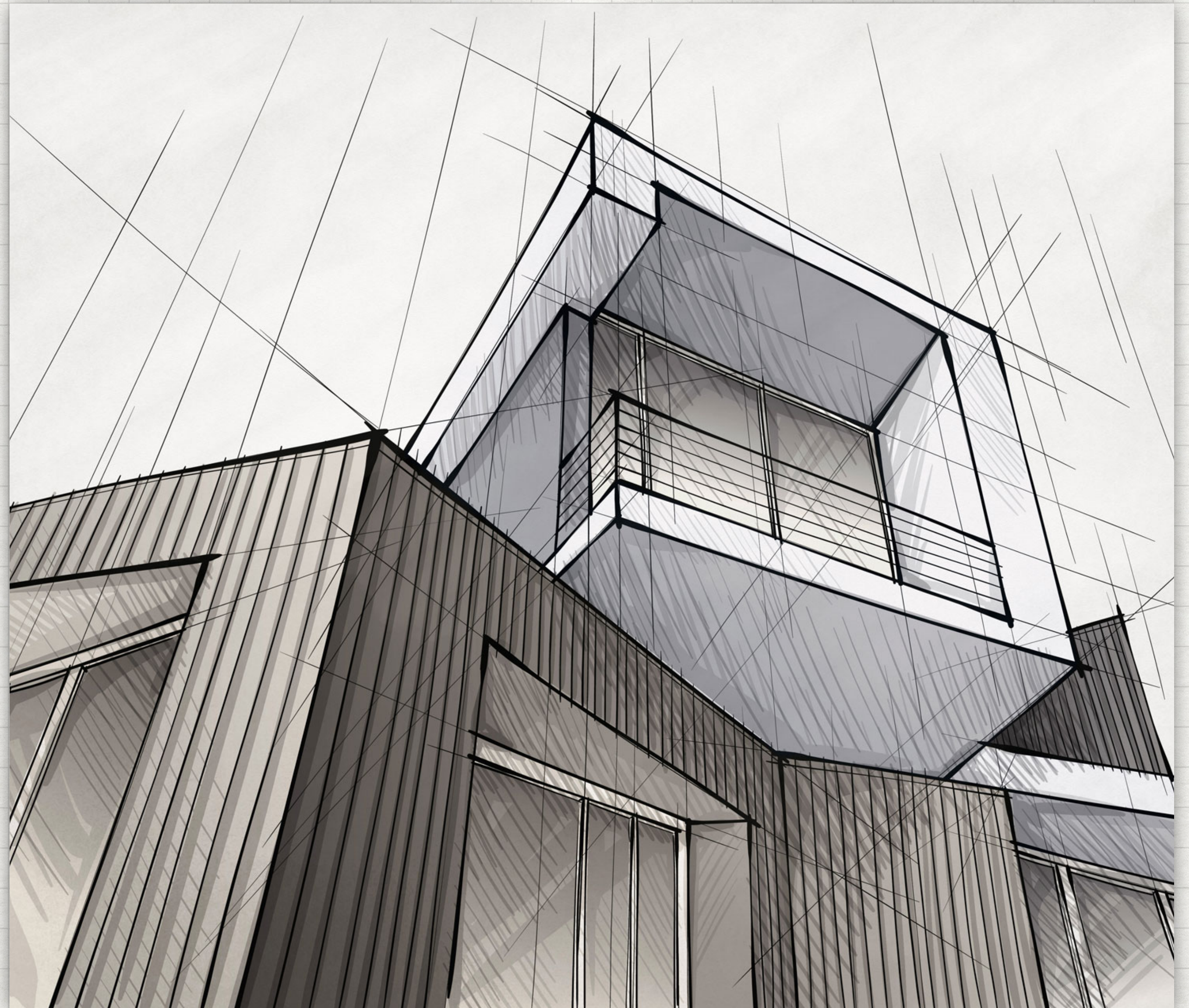


CS 007: SESSION 7

PERSONAL FINANCE FOR ENGINEERS



CS 007

GOOD
INVESTING
IS BORING

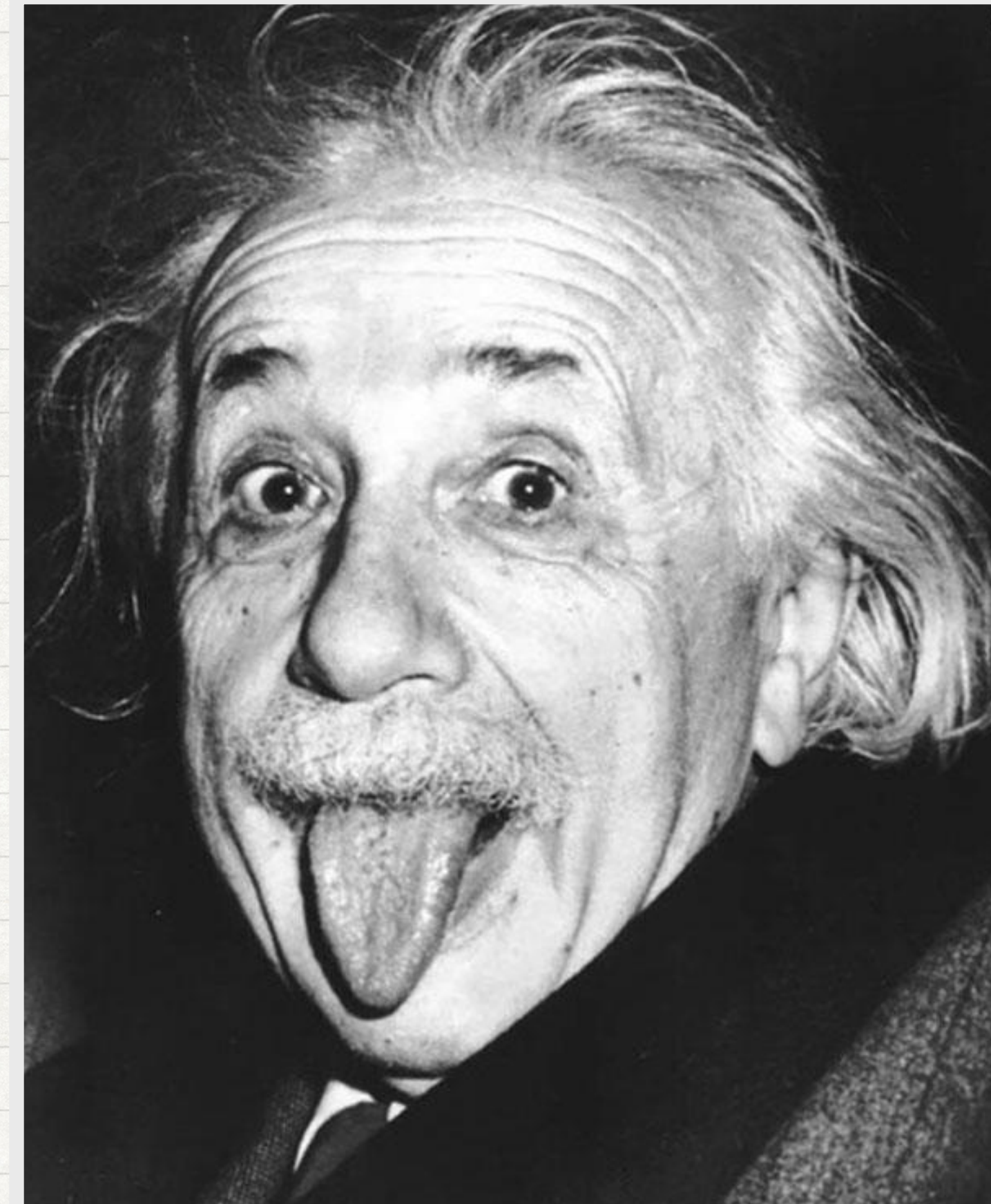


COMPOUNDING

good for savings. bad for debt.

THE MAGIC OF COMPOUNDING

- Not convinced that Albert Einstein said it was the greatest force in the universe.
- It's the key to almost all long term financial planning.
- Exponentials are bad in algorithmic cost, good for savings returns.
- The problem is that financial rates of return seem small, particularly in the early years.
- The key is to stick with it.



COMPOUNDING MADE EASY

- Rule of 72
- For each year, just use
`=POWER(1+rate, year)`
- 4% over 20 years is 2.19x
- 8% over 20 years is 4.66x
- Careful: it works on debt just as well as savings... in reverse!

$$A = P \left(1 + \frac{r}{n} \right)^{nt}$$

Where,

- P = principal amount (initial investment)
- r = annual nominal interest rate (as a decimal)
- n = number of times the interest is compounded per year
- t = number of years

ANNUAL PERCENTAGE RATE (APR)

- Standardized measure of how expensive a loan is, or the expected return of an investment
- Needed because of the wide variety of fees and interest-rate structures possible.
- Does not include compounding
- Tends to be higher than nominal interest rate due to fees or related payment requirements.
- **APR = simple interest**
APY = compound interest

1% monthly = 12% APR = 12.68% APY

APR $\neq$ APY

APR = Periodic Rate x Number of Periods in a Year

APY = $(1 + \text{Periodic Rate})^{\text{Number of Periods}} - 1$

THE BENEFITS OF AN EARLY START

- Compounding really takes off over long time periods
- Exponential functions are non-linear. Every time period builds on the previous one.
- In most retirement planning models, money saved between ages 25 - 35 produces more assets in retirement than all savings between 35 – 65!

Years	Return at 8%
10	2.16x
20	4.66x
30	10.06x
40	21.72x
50	46.9x

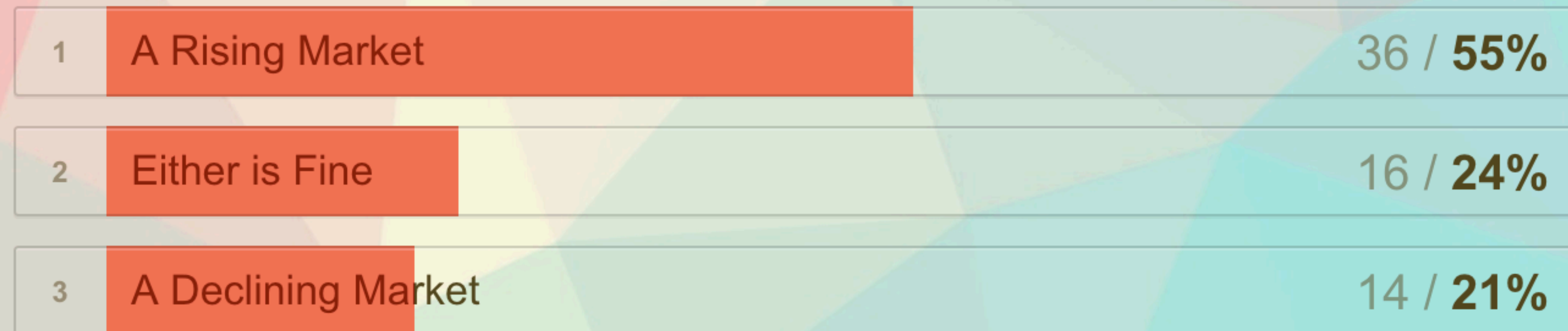
CLASS SURVEY

how do we feel about investing?

IN WHICH TYPE OF MARKET WOULD YOU PREFER TO INVEST?

In which type of market would you prefer to invest?

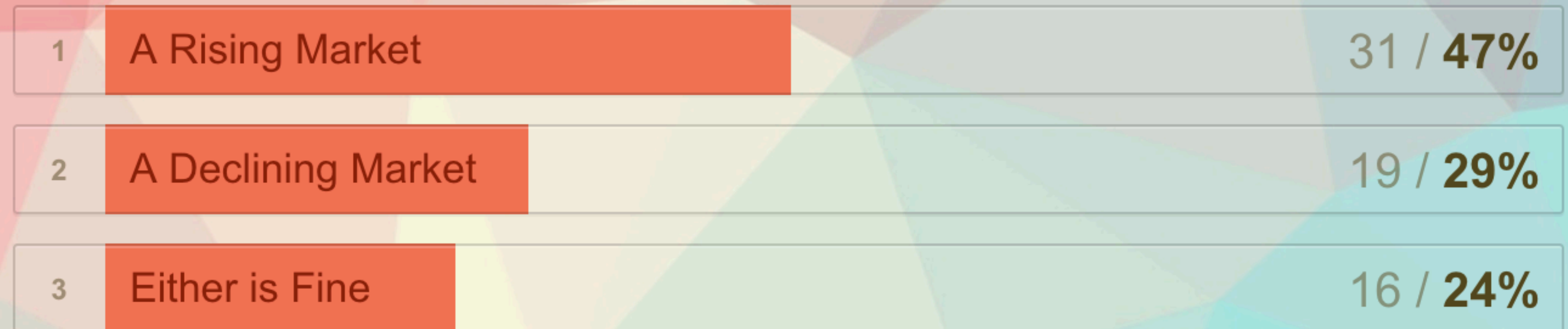
66 out of 66 people answered this question



IN WHICH TYPE OF MARKET WOULD YOU PREFER TO SELL?

In which type of market would you prefer to sell your investments?

66 out of 66 people answered this question



IN WHICH TYPE OF MARKET WOULD YOU PREFER TO SELL?

Which investment would you prefer?

66 out of 66 people answered this question

1

The one that previously performed the best

37 / **56%**

2

It doesn't matter

24 / **36%**

3

The one that previously performed the worst

5 / **8%**

HOW DO YOU MAINTAIN THE RIGHT RISK/REWARD BALANCE?

How do you maintain your ideal risk / reward balance?

66 out of 66 people answered this question

1

Buy more of the winners

37 / **56%**

2

Do nothing

23 / **35%**

3

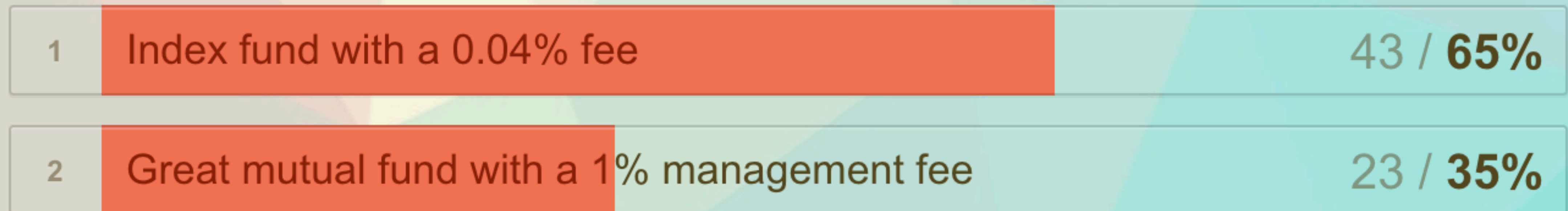
Buy more of the losers

6 / **9%**

WHICH INVESTMENT WOULD YOU PREFER?

Which investment would you prefer?

66 out of 66 people answered this question

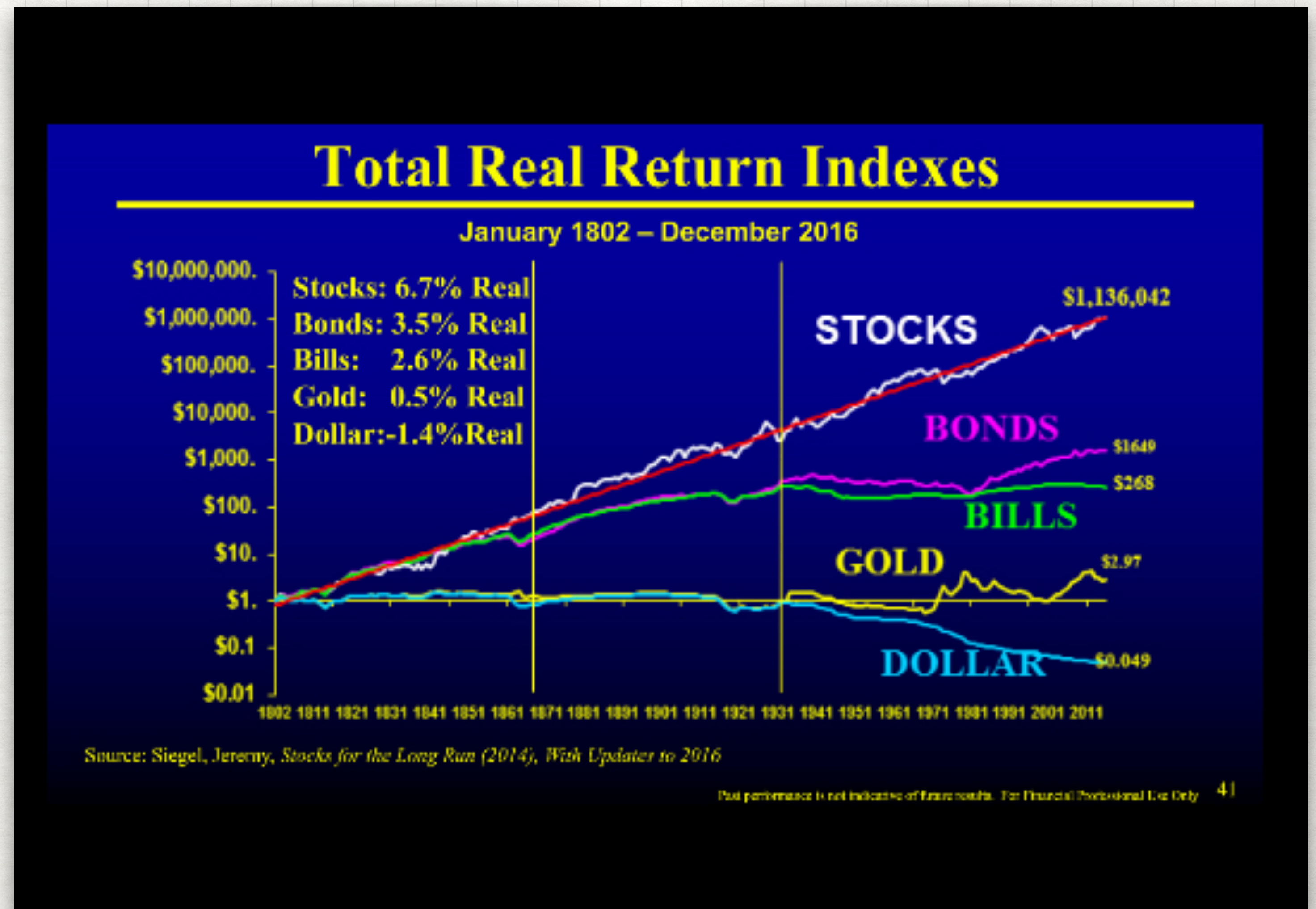


TYPES OF INVESTMENTS

stocks, bonds, commodities, real estate

COMMON WAYS TO INVEST

- We have aggregated over 200 years of data on the primary ways that people invest their money.
- Real return is return net of inflation, which measures how money devalues over time. (in this chart, dollars)
- Stocks have the highest annualized return over long time periods, but also higher volatility.



STOCKS / EQUITIES

- Stock is a security that represents ownership in a corporation.
- There are over 4,000 publicly traded stocks in the US alone.
- Returns based on capital appreciation & dividends.
- Businesses over time grow with the economy & adjust for inflation
- Many ways to sub-divide stocks:
 - Large cap vs. Small cap
 - US vs. Developed Markets vs. Emerging Markets
 - Growth vs. Value



BONDS

- A bond is a debt investment representing a portion of a loan.
- Maturity date, coupon rate & market price all matter. Typically issued at \$1000 per bond, but then trade at any price.
- Higher credit quality, the lower the rate.
- Returns based on capital appreciation & interest income.
- U.S. Treasuries = key benchmark
- Many ways to sub-divide bonds:
 - Government vs. Corporate
 - Domestic vs. International
- Municipal bonds have special tax treatment



COMMODITIES

- A commodity is a basic good used in commerce.
- Renewable (e.g. agriculture, lumber)
- Non-renewable (e.g. iron, oil, gold)
- Returns based on appreciation only.
- Simon-Ehrlich wager from 1980, scarcity vs. tech. Pick commodities non-government controlled, will they rise or fall in price?

(Simon won in 1990, but there is quite a bit of debate about alternate time periods)



REAL ESTATE

- Real estate is a combination of land & facilities that occupy that land.
- Investment real estate excludes your primary residence.
- Returns based both on rental income & capital appreciation.
- Real Estate Investment Trusts (REITs) trade on the public markets w/ special tax treatment.



DIVERSIFICATION

don't turn down a free lunch

ASSET CLASSES: VOLATILITY & CORRELATION

- Asset classes vary in terms of historical return, but also vary in volatility
- Movements of different asset classes vary in correlation
- Asset class correlation has been increasing over time, but still varies.

Table 4: Asset Class Volatility Assumptions

Asset Class	Volatility (Annualized)
US Stocks	16%
Foreign Developed Stocks	17%
Emerging Market Stocks	23%
Dividend Stocks	13%
Commodities	24%
Real Estate	20%
US Bonds	4%
TIPS	5%
Municipal Bonds	5%
US Corporate Bonds	7%
Emerging Market Bonds	14%

Table 5: Asset class correlation assumptions

	US Stocks	Foreign Developed Stocks	Emerging Markets Stocks	Dividend Stocks	Commodities	Real Estate	U.S. Bonds	TIPS	Municipal Bonds	US Corporate Bonds	Emerging Markets Bonds
US Stocks	1.00	0.85	0.77	0.82	0.65	0.60	0.02	0.09	0.06	0.23	0.57
Foreign Developed Stocks	0.85	1.00	0.81	0.73	0.64	0.59	0.06	0.13	0.13	0.30	0.57
Emerging Markets Stocks	0.77	0.81	1.00	0.58	0.60	0.52	0.03	0.13	0.07	0.24	0.68
Dividend Stocks	0.82	0.73	0.58	1.00	0.64	0.60	0.06	0.12	0.08	0.22	0.40
Commodities	0.65	0.64	0.60	0.64	1.00	0.42	-0.02	0.11	-0.06	0.16	0.40
Real Estate	0.60	0.59	0.52	0.60	0.42	1.00	0.24	0.21	0.33	0.40	0.47
U.S. Bonds	0.02	0.06	0.03	0.06	-0.02	0.24	1.00	0.66	0.63	0.69	0.39
TIPS	0.09	0.13	0.13	0.12	0.11	0.21	0.66	1.00	0.45	0.56	0.32
Municipal Bonds	0.06	0.13	0.07	0.08	-0.06	0.33	0.63	0.45	1.00	0.54	0.36
US Corporate Bonds	0.23	0.30	0.24	0.22	0.16	0.40	0.69	0.56	0.54	1.00	0.53
Emerging Markets Bonds	0.57	0.57	0.68	0.40	0.40	0.47	0.39	0.32	0.36	0.53	1.00

Correlation



RISK-ADJUSTED RETURN

- Absolute return of an asset class isn't the only thing that matters. Volatility also matters.
- Bill Sharpe developed the Sharpe Ratio in 1966, revised in 1994.

The Sharpe Ratio

$$= \frac{\bar{r}_p - r_f}{\sigma_p}$$

Where:

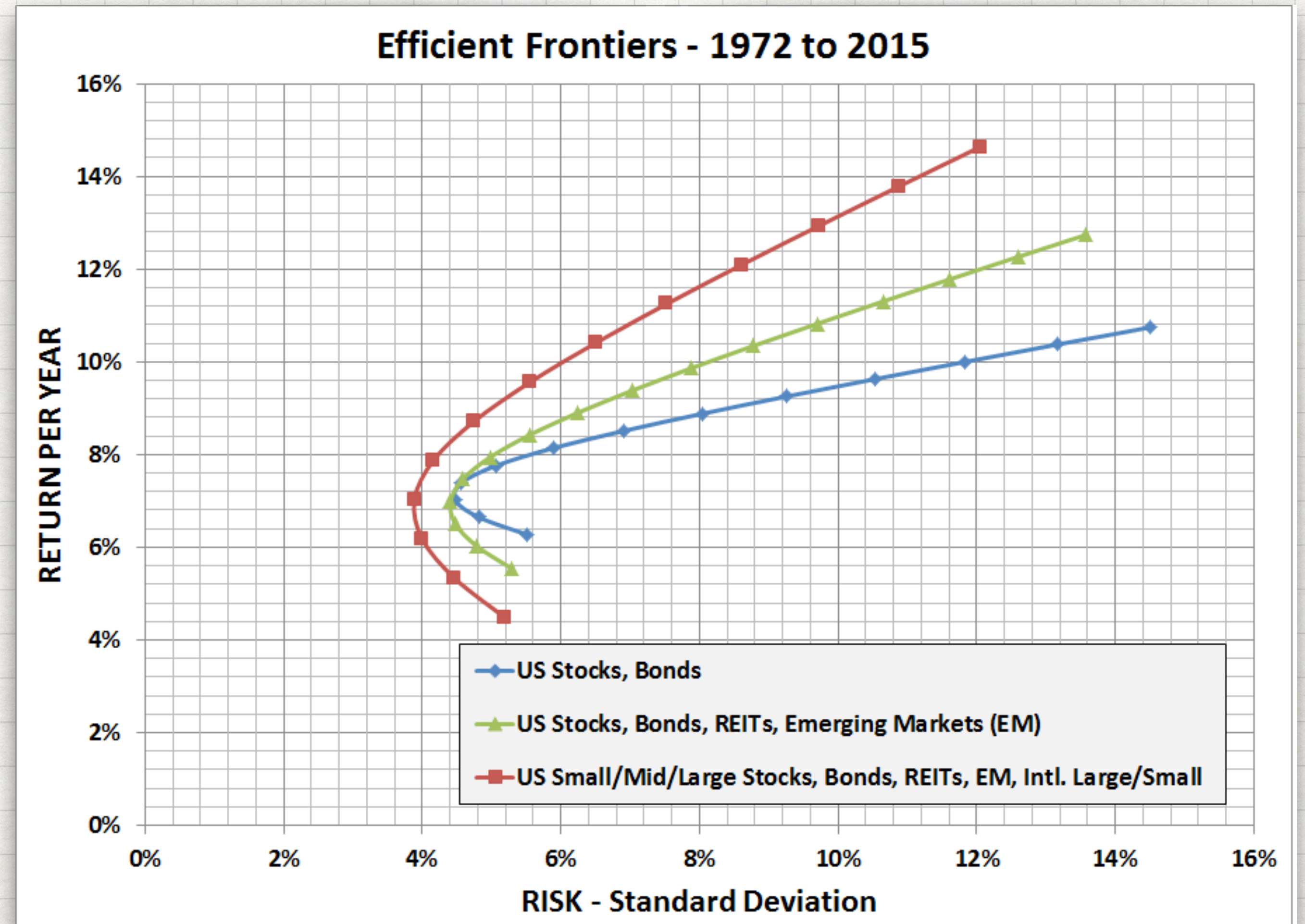
$\bar{r}_p$ = Expected portfolio return

r_f = Risk free rate

σ_p = Portfolio standard deviation

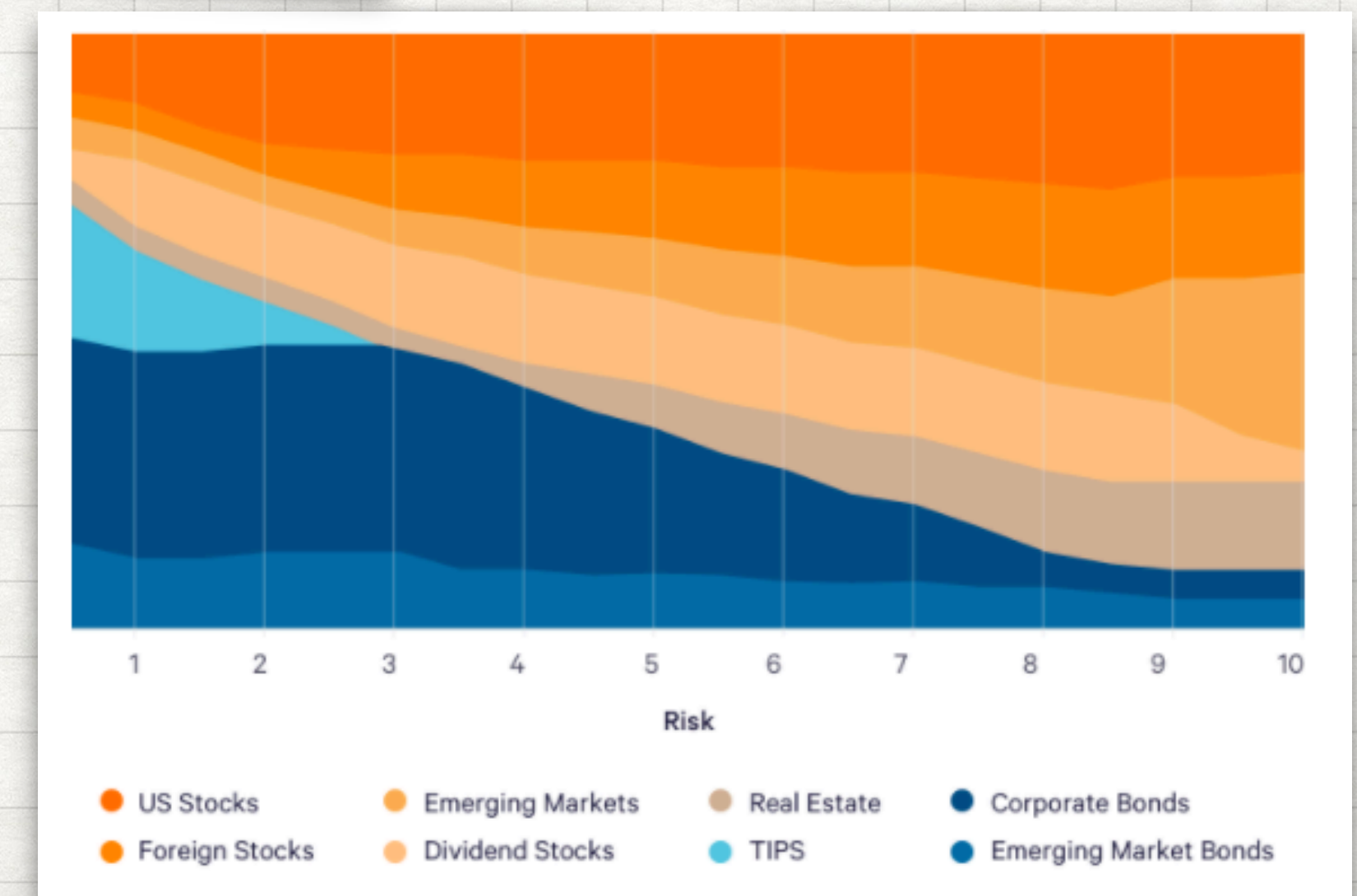
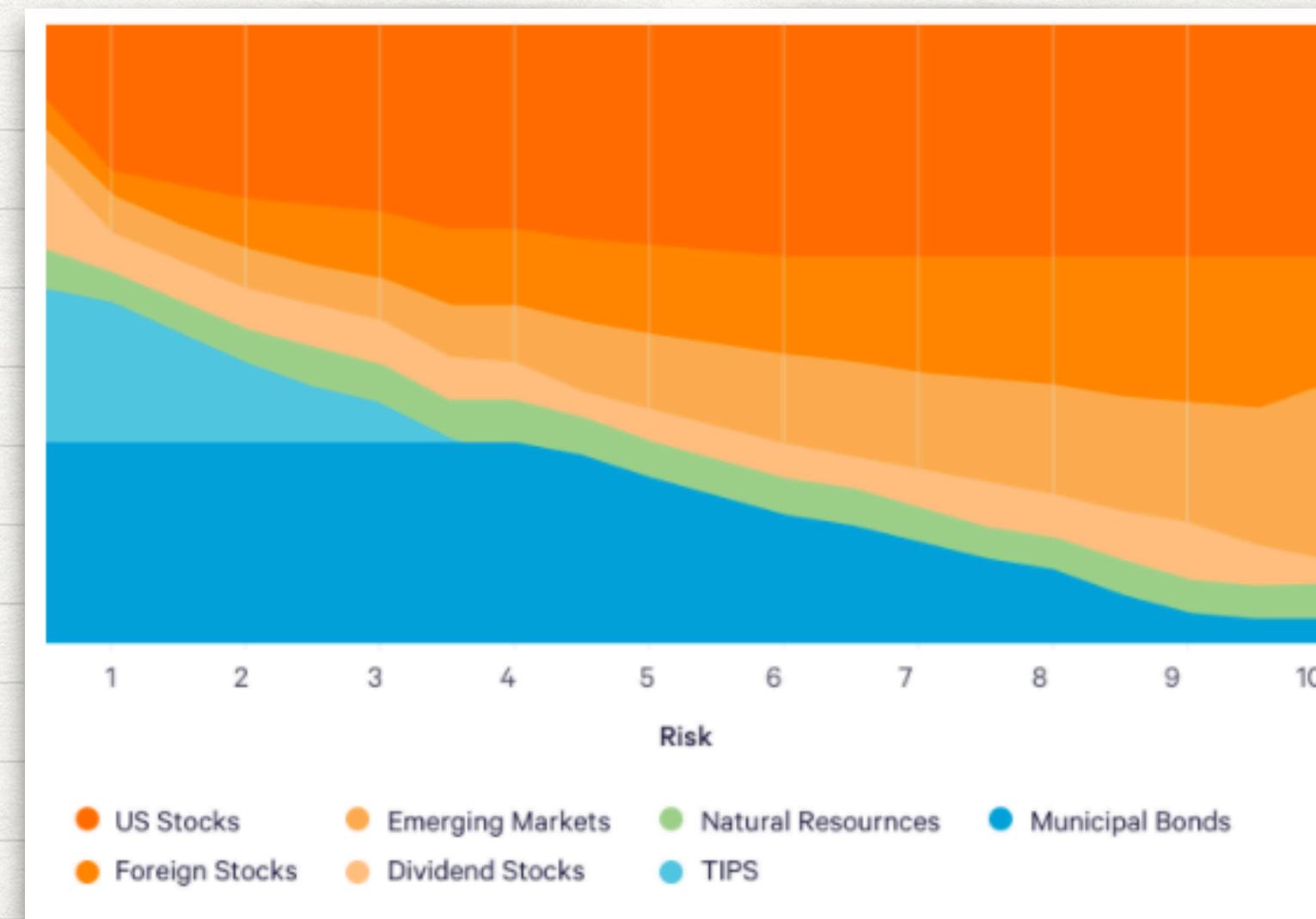
MODERN PORTFOLIO THEORY

- Harry Markowitz introduced in 1952. Nobel Prize.
- You can reduce portfolio risk for a given expected return by combining different asset profiles
- The Markowitz Bullet



TAXES MATTER

- Tax rates vary for interest, dividends & capital gains.
- Asset classes vary in terms of the source of their historical return.
- After-tax risk-adjusted return is critical for taxable accounts.
- Before-tax risk-adjusted return is critical for tax-deferred accounts (401k, IRA)



HOW TO INVEST

what to do & why you do it

BROKERAGE ACCOUNTS

- In most countries, large banks provide brokerage services.
- In the United States, brokerages are financial firms that offer security accounts, regulated by the SEC & FINRA.
- Most large banks have acquired or built brokerages.
- These are not bank accounts, but they are institutions where you can deposit money and purchase (and sell) securities.
- Unlike bank accounts, you can lose money. Investments can and do go down, sometimes over long periods of time.
- SIPC insurance created in 1970, is currently \$500,000. Covers when brokerages inappropriately endanger customer assets.



HOW DO YOU MEASURE INVESTMENT RETURN?

- Alpha α is defined as excess return over the market rate of return.
- Beta β is defined as the measure of volatility compared to its market benchmark over time.
- Beta of 1 implies expected market performance & volatility.
- Both are derived from the Capital Asset Pricing Model (CAPM)
- The key is to achieve the best risk-adjusted return, net of fees & taxes.



TYPES OF INVESTMENT APPROACH

- **Fundamental analysis** attempts to choose securities based on the business performance & valuation.
- **Technical analysis** attempts to choose securities based on price patterns.
- Neither have demonstrated credible & repeatable above-market risk-adjusted performance net of fees in practice for the average professional.
- Fundamental analysis is very useful as a business owner & operator. Warren Buffett annual letters are famous for good reason.



THE SECULAR RISE OF INDEX FUNDS

- **A Random Walk Down Wall Street** was published in 1973.
- **Vanguard** launched the first consumer-focused index mutual fund on Dec 31, 1975.
- **Index funds** now hold almost \$6 trillion in assets, and represent the majority of new equity fund inflows.
- Large difference between broad, market based index funds (like VTI) and niche index funds based on alternate approaches or subsets of the market.
- Factor-based investing has credible academic evidence, but the primary issue in practice has been high fees.

Total Net Assets Long-Term Mutual Funds and ETFs* Billions of dollars

	Active Sep 2025	Index Sep 2025	Index as a % of Total
Equity			
Domestic equity	7,944.9	12,954.4	62.0
World equity	2,887.9	2,729.4	48.6
Hybrid	1,689.7	88.3	5.0
Bond	4,707.4	2,815.8	37.4
Total	17,229.8	18,587.8	51.9

* Data for funds that invest primarily in other mutual funds were excluded from the series.

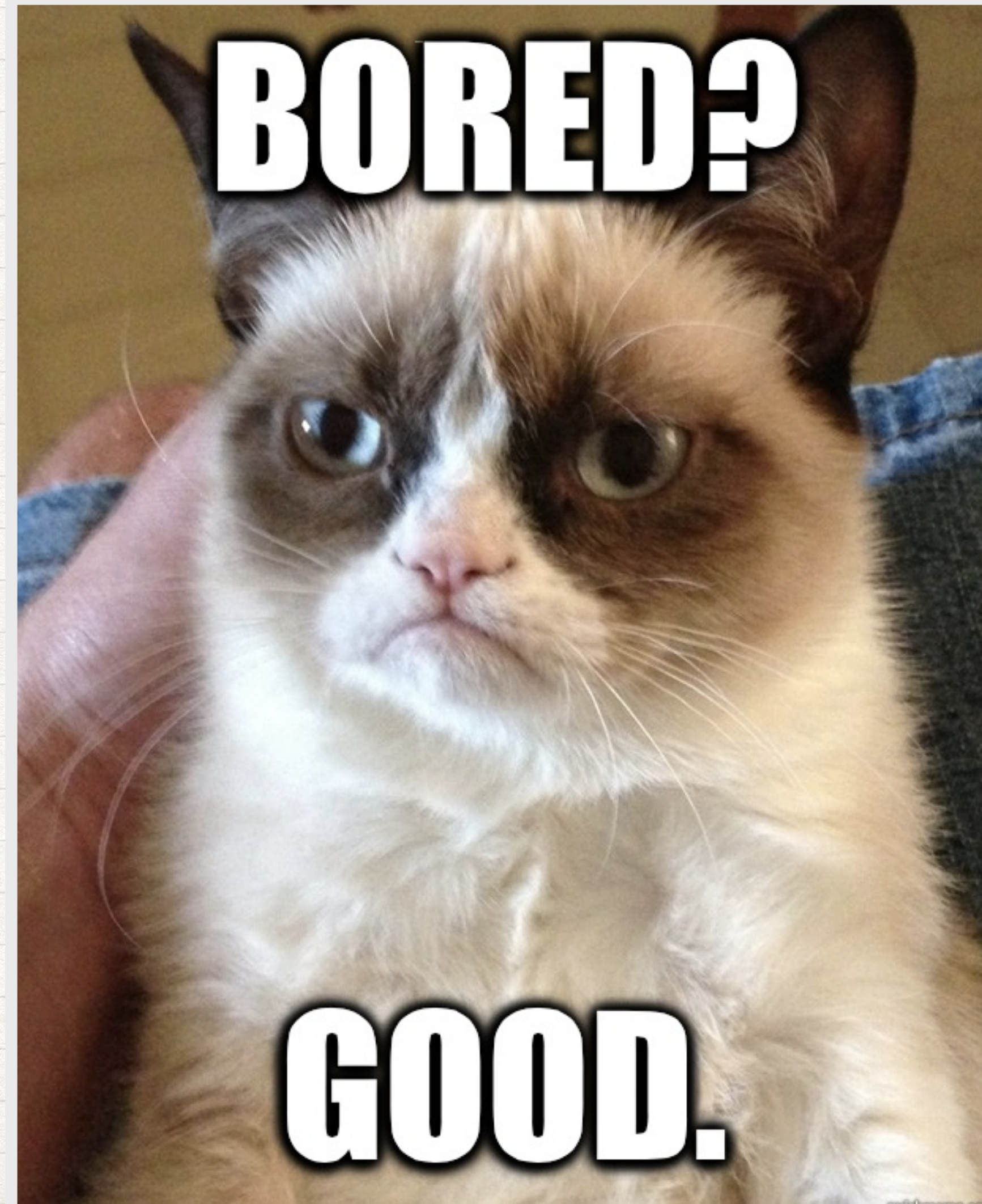
* https://www.ici.org/research/stats/combined_active_index

**GOOD INVESTING IS
BORING**

otherwise, you are doing it wrong.

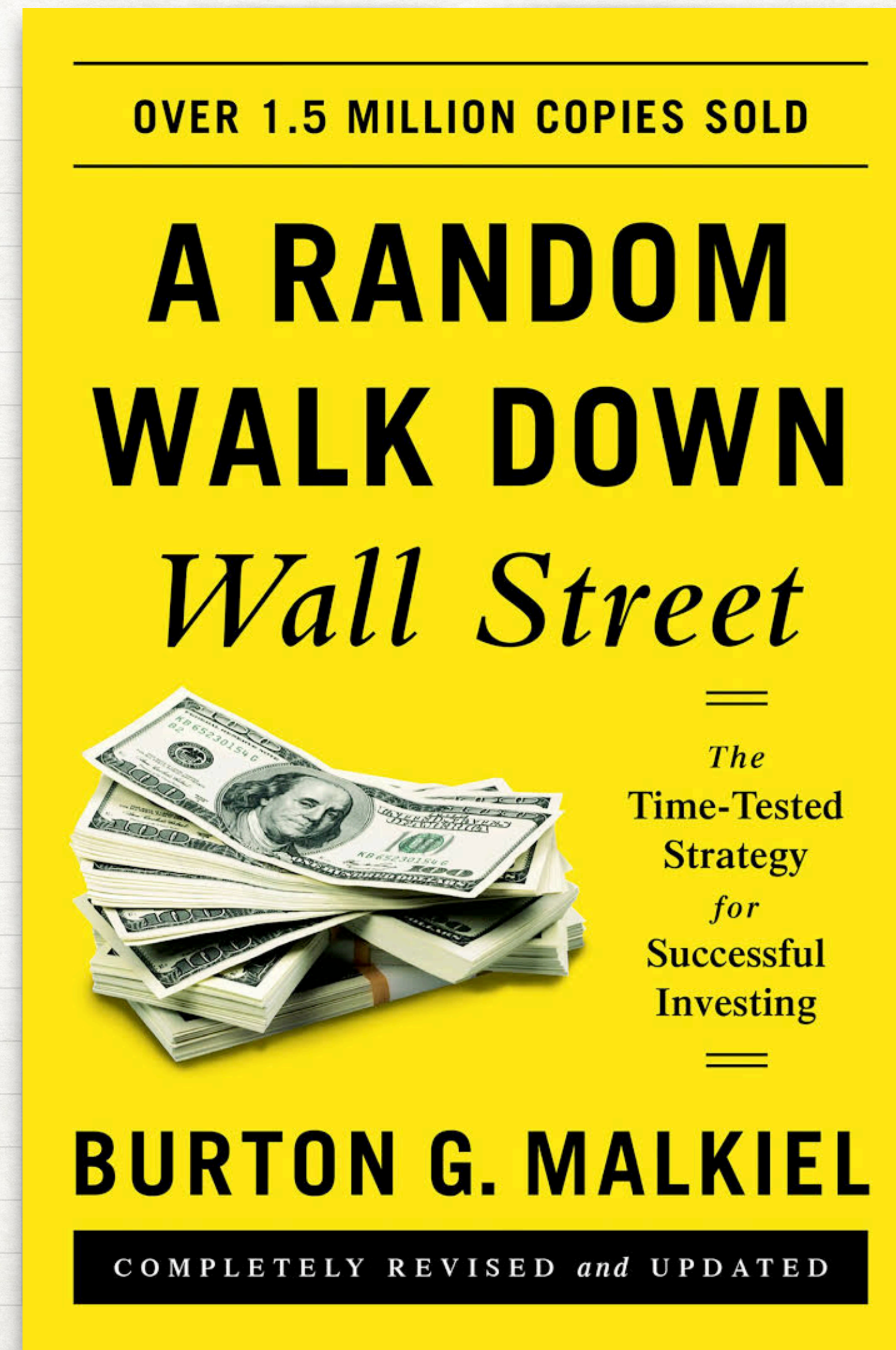
GOOD INVESTING IS BORING

- No one wants to be average, but with investing, “average” is actually well above average.
- You will beat most mutual funds, hedge funds & your peers with simple, low cost index funds.
- Asset allocation explains ~90% of the variance in manager performance



A RANDOM WALK DOWN WALL STREET

- Over 40 years old, by famous Princeton economist Burt Malkiel
- Most professionals fail to beat a simple market-weighted index, net of fees.
- The fee is the killer. It means professionals have to reliably beat the index by more than their fee.
- The ones who do, don't repeat for the next time period.
- Keep your fees low by using index funds for each asset.



RETAIL INVESTORS DO WORSE THAN THE PROS

- Dalbar publishes research annually covering 20 year periods.
- The average equity investor underperformed the S&P 500 by 4.6% over the 20 year period from 1998-2017.***
- The overall S&P 500 return over the same time period was 7.2% with dividends reinvested. *
- Biggest causes are high fees and market timing errors.

Exhibit 2: Underperformance Rates Rise over Time

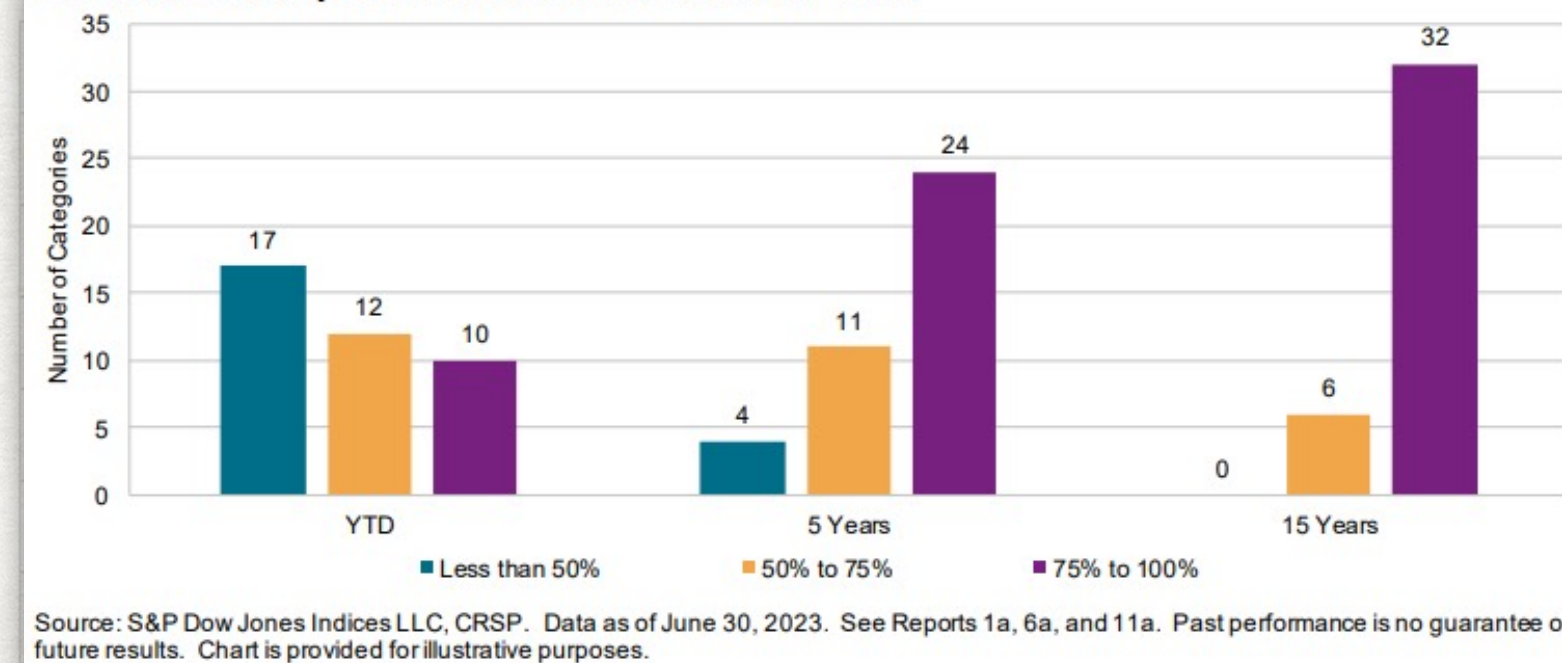
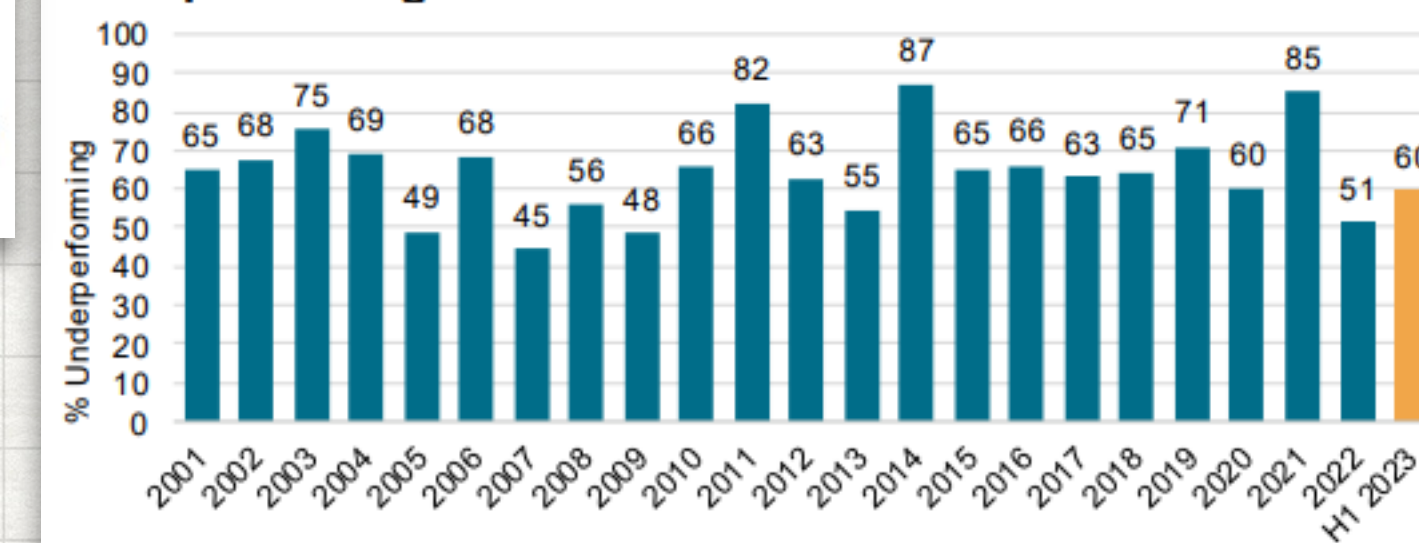
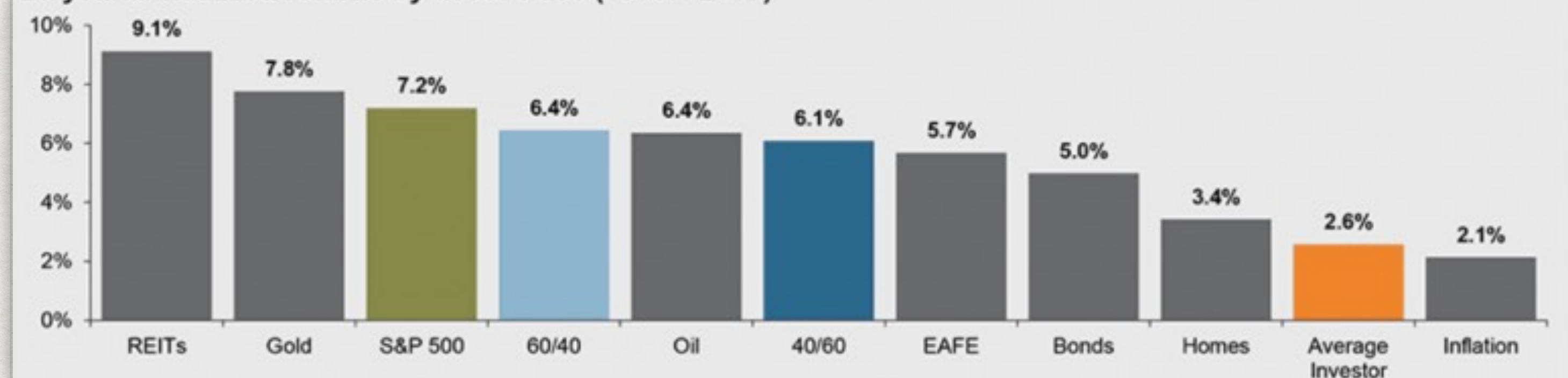


Exhibit 1: Percentage of Large-Cap Domestic Equity Funds Underperforming the S&P 500 Each Year



20-year annualized returns by asset class (1998 – 2017)



* <https://dqydj.com/sp-500-return-calculator/>

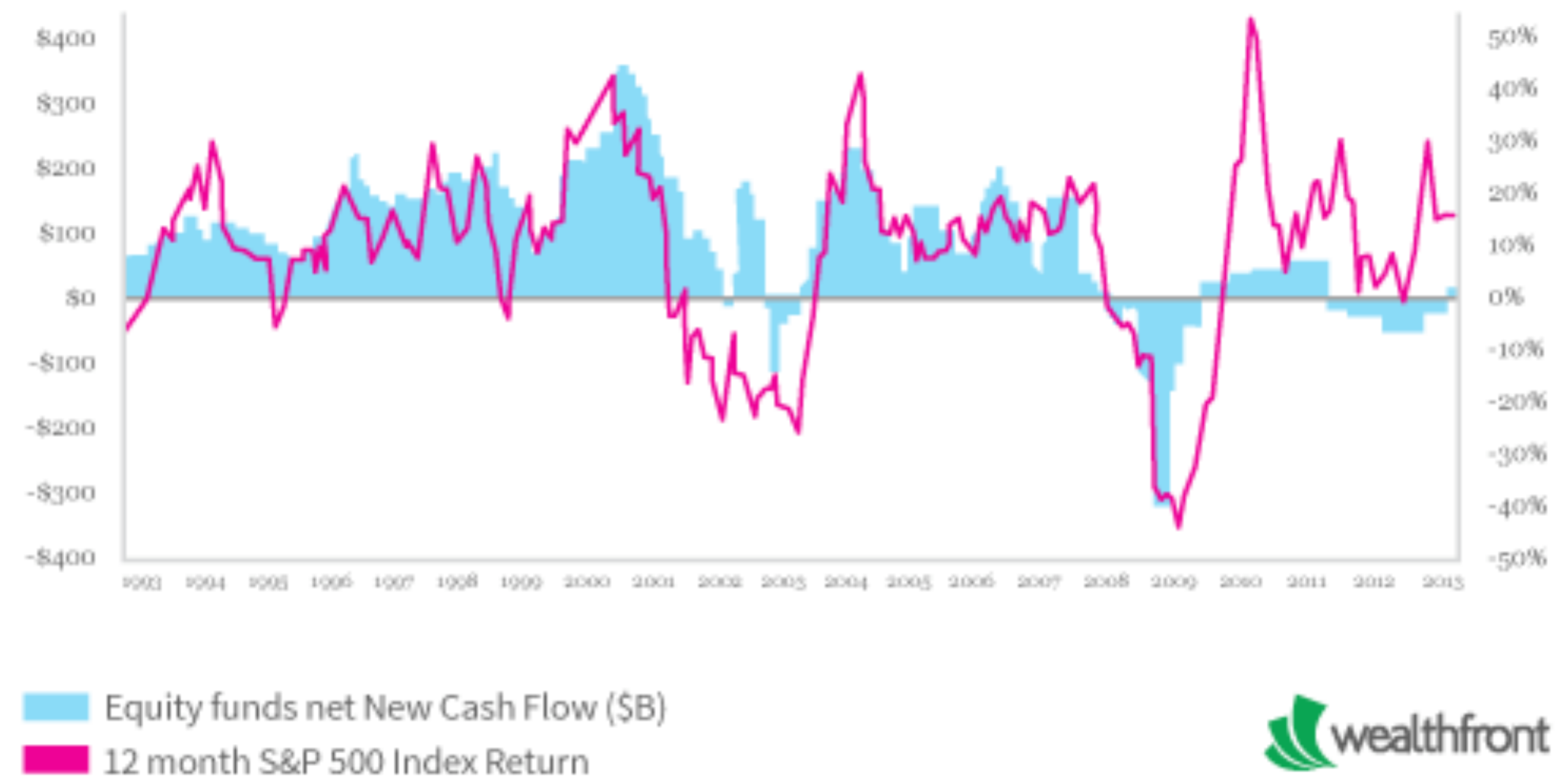
** <https://finance.yahoo.com/news/dalbars-latest-investor-behavior-research-203000780.html>

*** <https://stablebread.com/why-most-investors-underperform-the-market/>

MARKET TIMING IS TERRIBLE

- History of money flowing into equities shows how badly people do.
- Dalbar research consistently shows market timing as one of the main reason retail investors underperform the market.
- You have to be right twice.
- Just. Keep. Saving.

Do Not Try To Time The Market.
Your Emotions Are Likely To Lead You Astray.
Chart compares flows to equity funds related to 12 month S&P 500 Index Return.



ASSET CLASSES: WINNERS RARELY REPEAT

- Asset classes vary in terms of historical return, but also vary in volatility
- Movements of different asset classes vary in correlation
- Asset class correlation has been increasing over time, but still varies.
- Stay diversified.

2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	10 Years
REITs 30.4%	REITs 2.4%	Small Cap 26.6%	EM 37.3%	Cash 1.7%	Large Cap 31.2%	Large Cap 18.3%	REITs 40.5%	Comdty 17.5%	Large Cap 26.2%	Large Cap 11.9%
Large Cap 13.5%	Large Cap 1.3%	Mid Cap 20.5%	Int'l Stocks 25.1%	Bonds 0.1%	REITs 28.9%	EM 17.0%	Comdty 31.1%	Cash 1.4%	Int'l Stocks 18.4%	Mid Cap 9.0%
Mid Cap 9.4%	Bonds 0.5%	Comdty 12.9%	Large Cap 21.7%	TIPS -1.4%	Mid Cap 25.8%	Mid Cap 13.5%	Large Cap 28.8%	EW -11.5%	Mid Cap 16.1%	Small Cap 8.6%
Bonds 6.0%	Cash -0.1%	Large Cap 12.0%	Mid Cap 15.9%	Large Cap -4.6%	Small Cap 22.6%	Small Cap 11.4%	Small Cap 26.8%	TIPS -12.2%	Small Cap 16.1%	REITs 7.4%
Small Cap 5.5%	Int'l Stocks -1.0%	EM 10.9%	Small Cap 13.1%	REITs -6.0%	Int'l Stocks 22.0%	TIPS 10.8%	Mid Cap 24.5%	Bonds -13.0%	REITs 11.8%	EW 5.0%
EW 4.0%	TIPS -1.8%	EW 10.0%	EW 12.6%	EW -7.2%	EM 18.2%	EW 7.8%	EW 16.3%	Mid Cap -13.3%	EW 10.2%	Int'l Stocks 4.2%
TIPS 3.6%	Small Cap -1.8%	REITs 8.6%	REITs 4.9%	Small Cap -8.6%	EW 17.5%	Int'l Stocks 7.6%	Int'l Stocks 11.5%	Int'l Stocks -14.4%	EM 9.0%	TIPS 2.3%
Cash -0.1%	Mid Cap -2.5%	TIPS 4.7%	Bonds 3.6%	Mid Cap -11.3%	Bonds 8.5%	Bonds 7.5%	TIPS 5.7%	Small Cap -16.1%	Bonds 5.7%	EM 1.8%
EM -3.9%	EW -4.7%	Bonds 2.4%	TIPS 2.9%	Comdty -13.1%	TIPS 8.4%	Cash 0.4%	Cash -0.1%	Large Cap -18.2%	Cash 4.9%	Bonds 1.8%
Int'l Stocks -6.2%	EM -16.2%	Int'l Stocks 1.4%	Comdty 0.7%	Int'l Stocks -13.8%	Comdty 7.6%	Comdty -4.1%	Bonds -1.8%	EM -20.6%	TIPS 3.8%	Cash 1.1%
Comdty -18.6%	Comdty -28.2%	Cash 0.1%	Cash 0.7%	EM -15.3%	Cash 2.0%	REITs -4.6%	EM -3.6%	REITs -26.2%	Comdty -9.9%	Comdty -1.9%

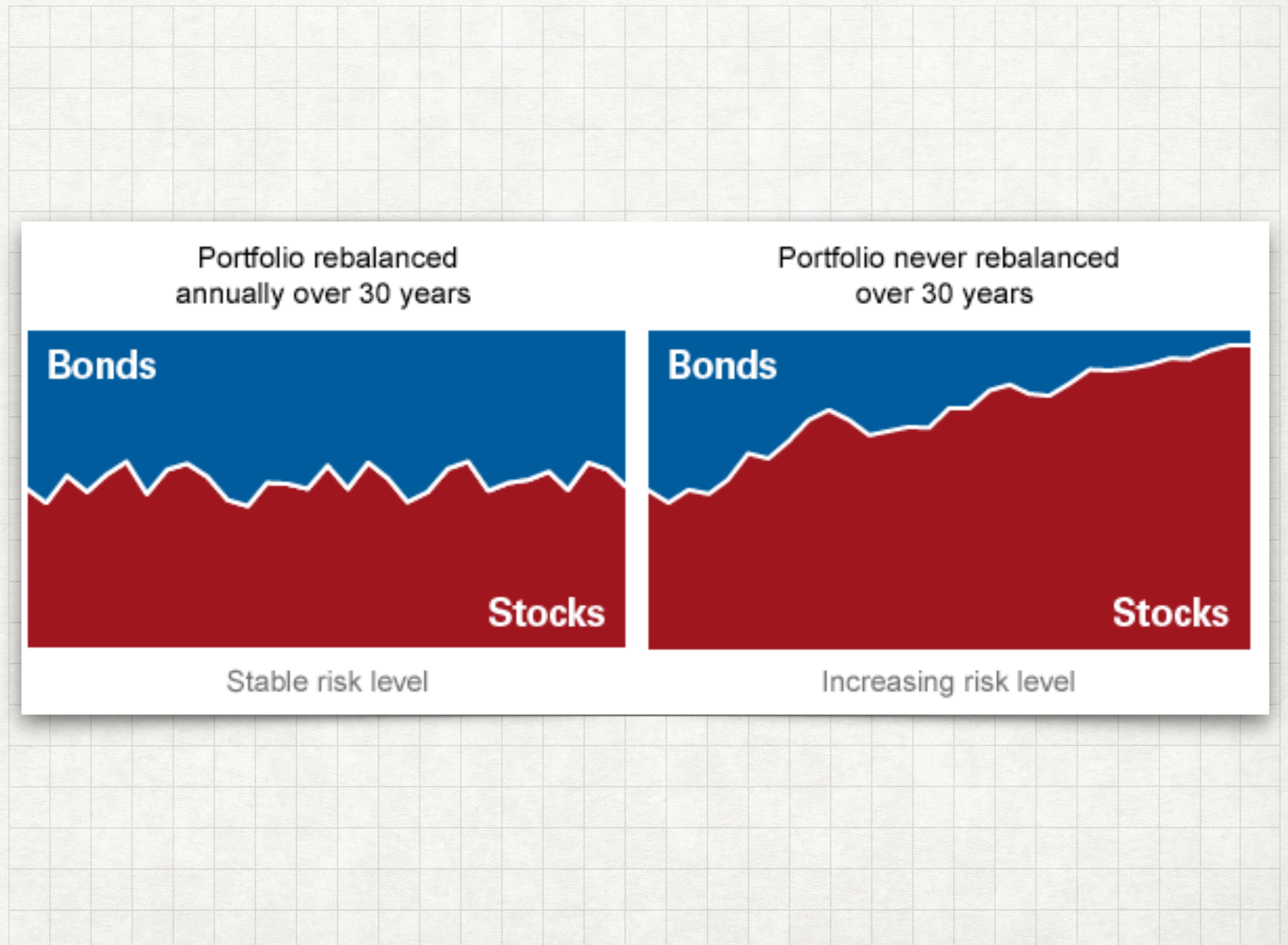
Funds: EEM, VNQ, MDY, SPSM, SPY, EFA, TIP, AGG, DJP, BIL

* <https://blog.wealthfront.com/why-you-shouldnt-just-invest-in-the-s-p-500/>

* <https://awealthofcommonsense.com/2024/01/updating-my-favorite-performance-chart-for-2023/>

REBALANCING

- Over long time periods, asset allocation will drift due to varied performance.
- Tax efficient methods: intelligent dividend reinvestment, deposits, withdrawals.
- Trigger-based rebalancing occurs only after a certain % drift from the ideal allocation.
- Reduces risk over time, does not necessarily improve returns.



FOUR KEYS TO GOOD INVESTING

1

Keep Saving

3

Stay Diversified

2

Low Fees

4

Minimize Taxes

IT'S A MARATHON, NOT A SPRINT.



Investing is
simple, but
not easy.

- Warren Buffett

CS 007

QUESTIONS



WEEK 8: FINANCIAL GOALS

- How to Plan for Financial Goals
- Different Types of Goals:
Travel, Marriage, House, Children,
College, Starting a Business,
Retirement
- Life Insurance
- Couples & Financial Decisions

