Simple Personal Finance Models
Lecture 15

BSEN 5250/6250

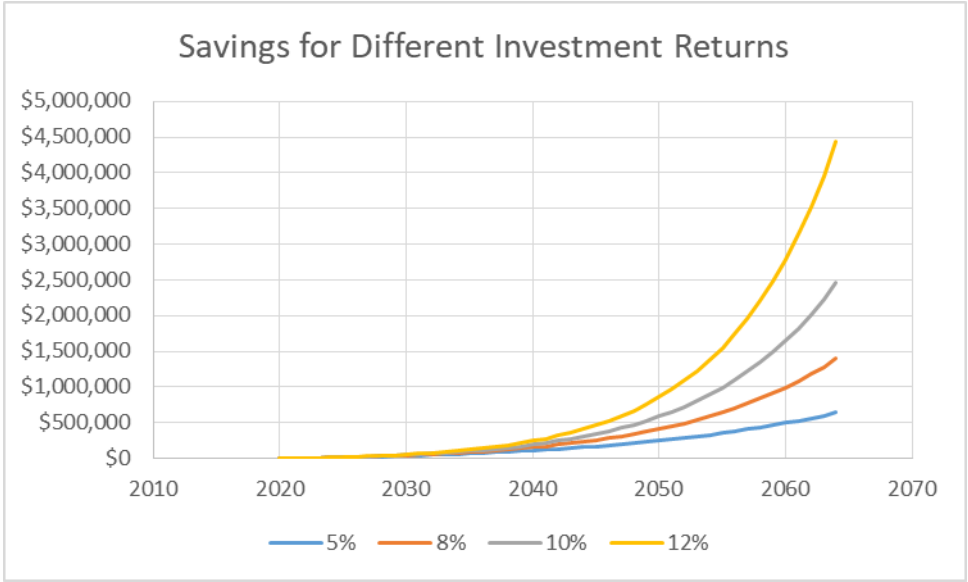
Deterministic Modeling for Biosystems

The Value of Money Grows Over Time

If $1,000 is invested for 1 year at an interest rate of 5%, what is the value of the investment at the end of a year?

Year 1 - $1,000 * (1+.05) = $1,050
Year 2 - $1,050 * (1+.05) = $1,103
Year 3 - $1,103 * (1+.05) = $1,158

Increase due to interest

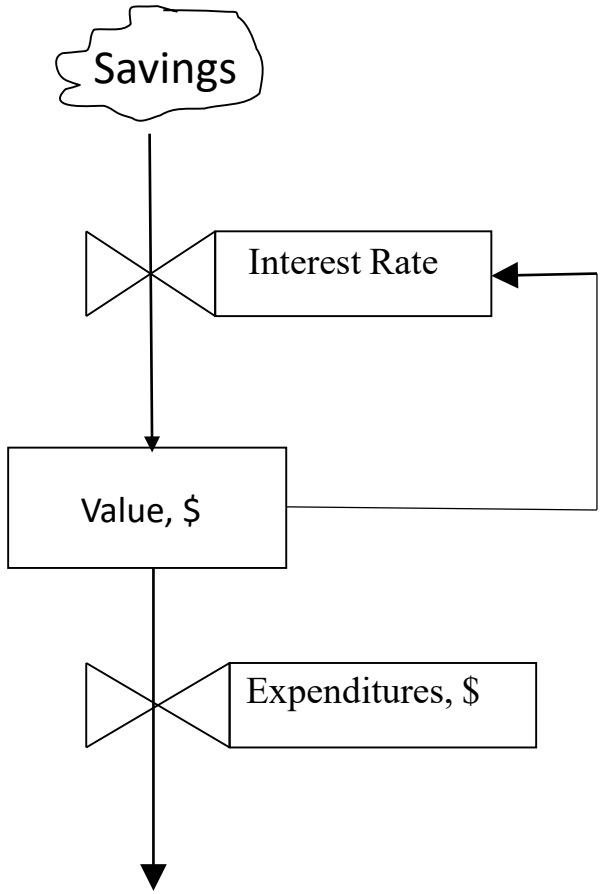


Time is your best friend for wealth accumulation!

Money Balance Equation (Euler Integration)

$$V^{t+dt} = V^{t} + (\text{gains} - \text{losses})\, dt$$

Where
V = value, $
Gains = rate of increase during time step, $
Losses = expenditures during time step, $



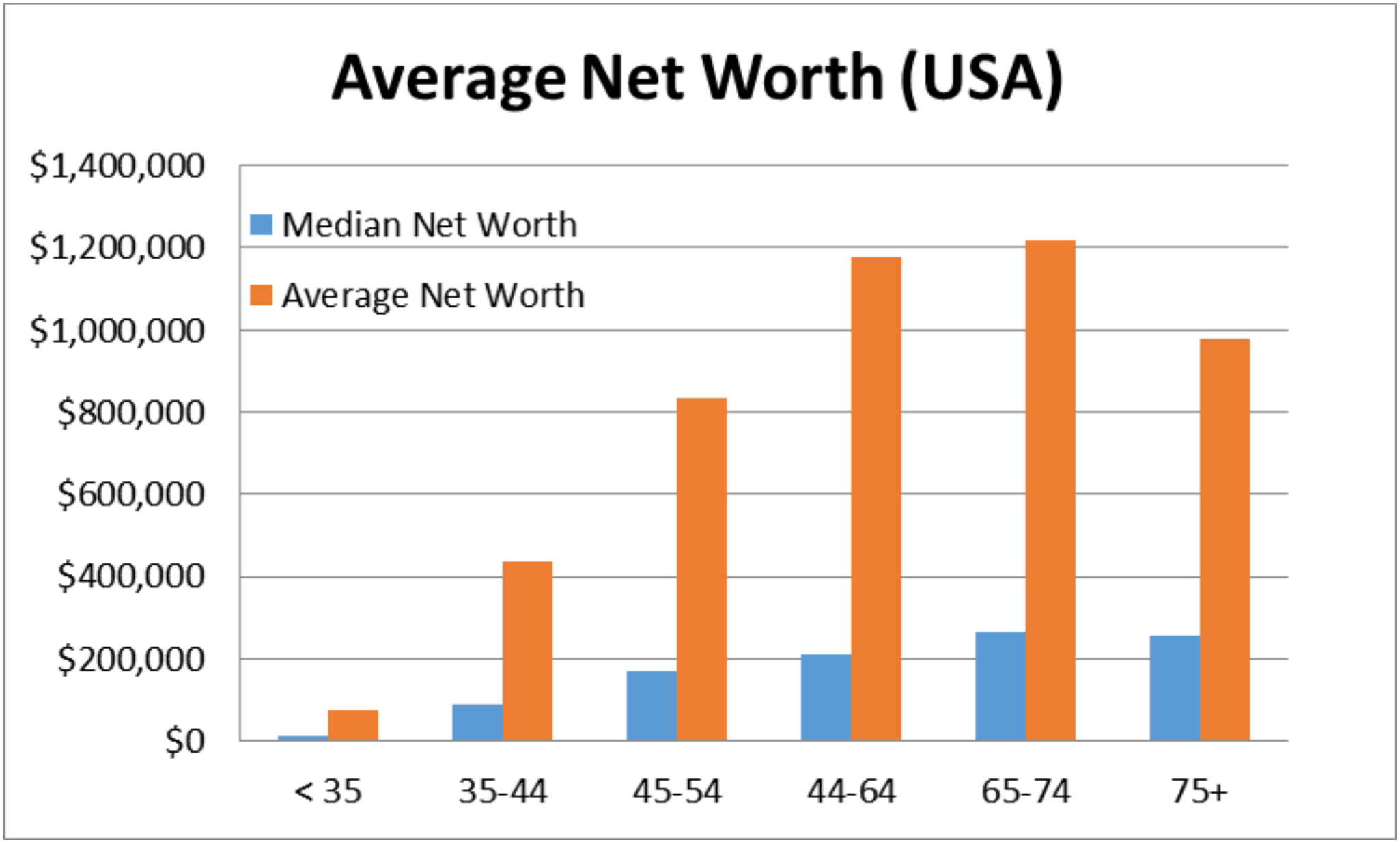
State variable is the Value of money!

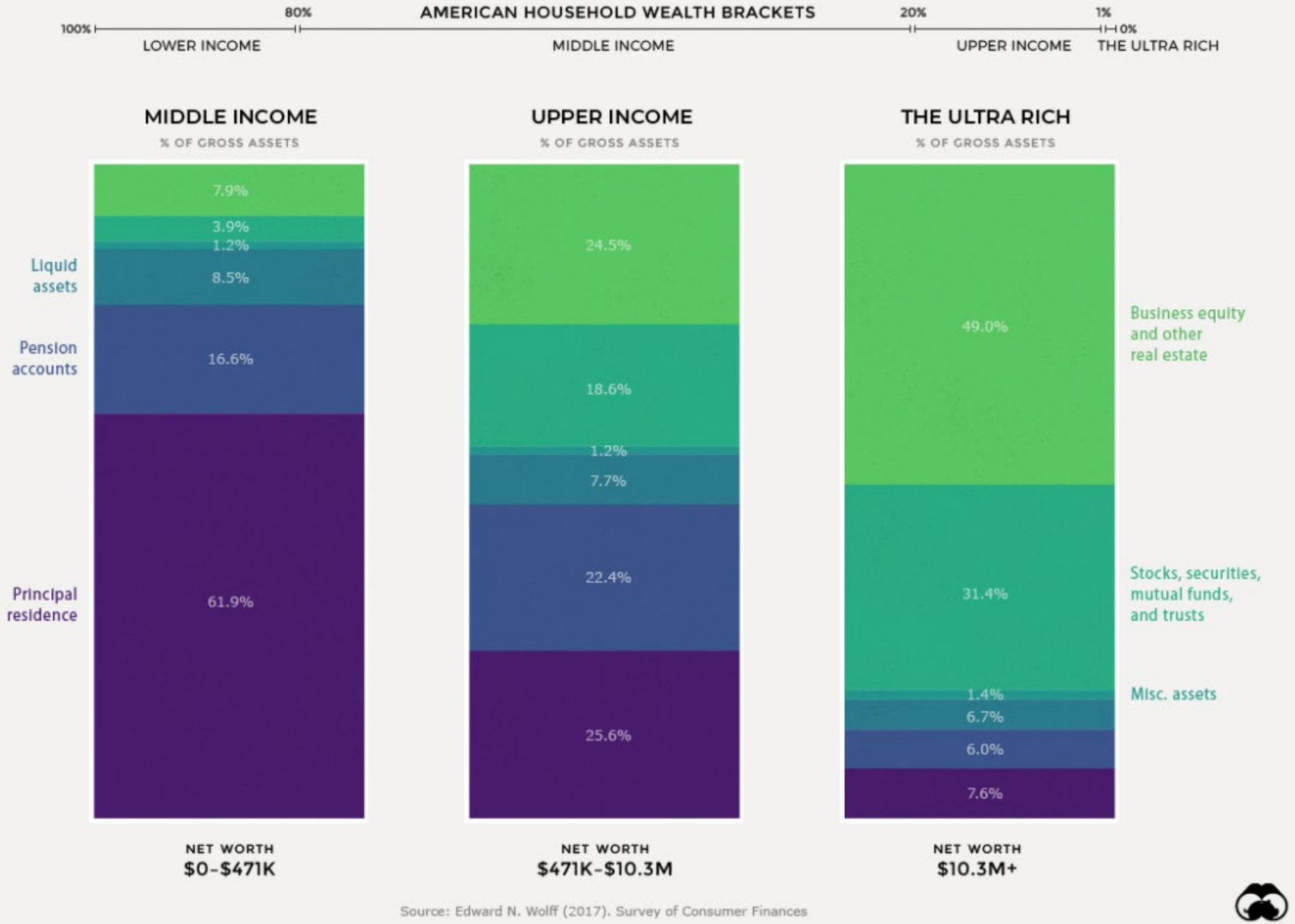
Net Worth Calculation

Net Worth = value of assets – value of liabilities

Assets
Savings & investments
Retirement accounts
Primary home
Real estate
Permanent life insurance
Automobiles

Liabilities
Consumer debt
Personal loans
Student loans
Mortgages
Auto loans
Other debt

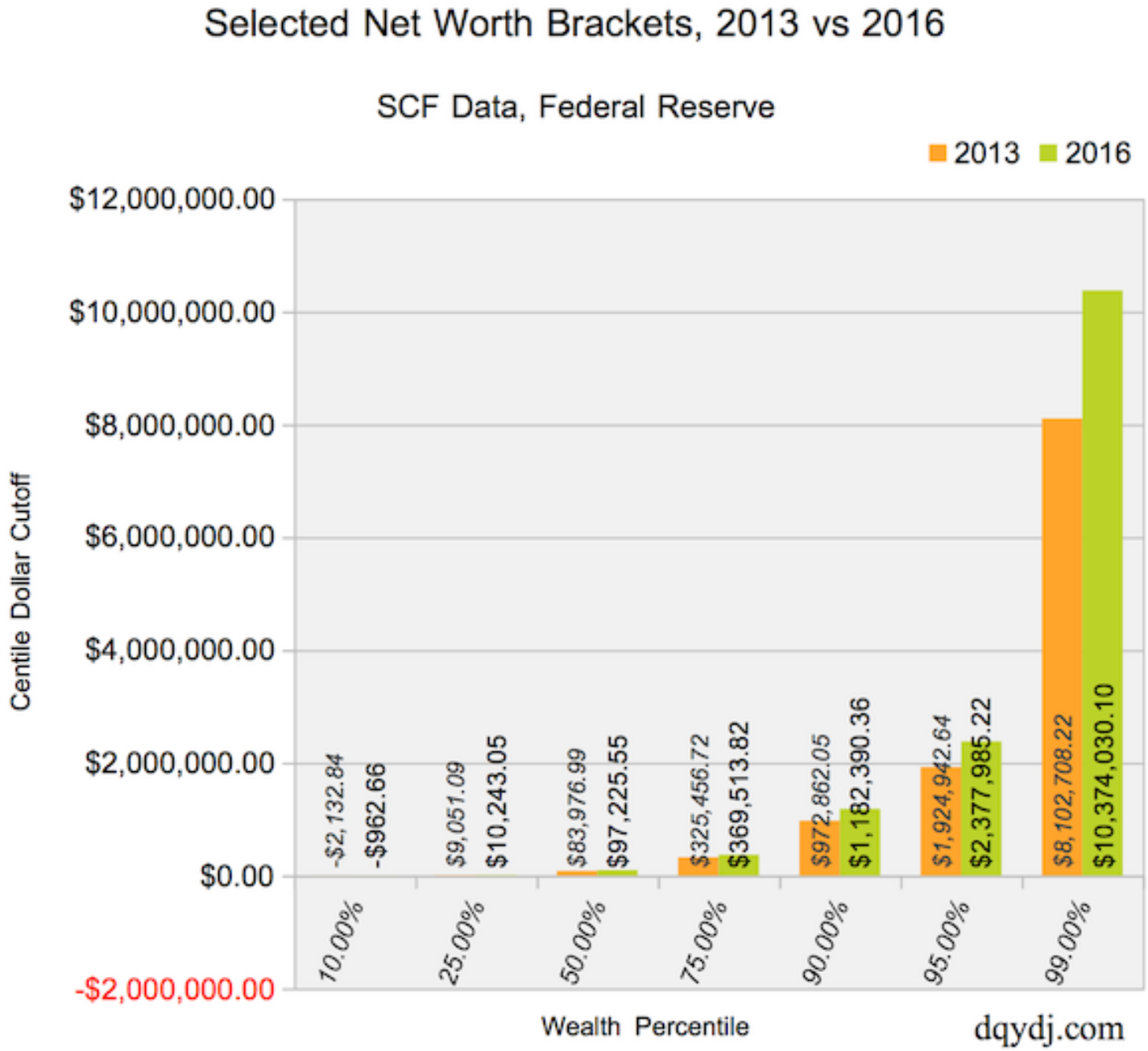

Average Net Worth (USA)
$1,400,000
$1,200,000
$1,000,000
$800,000
$600,000
$400,000
$200,000
$0
Median Net Worth
Average Net Worth
< 35
35-44
45-54
44-64
65-74
75+



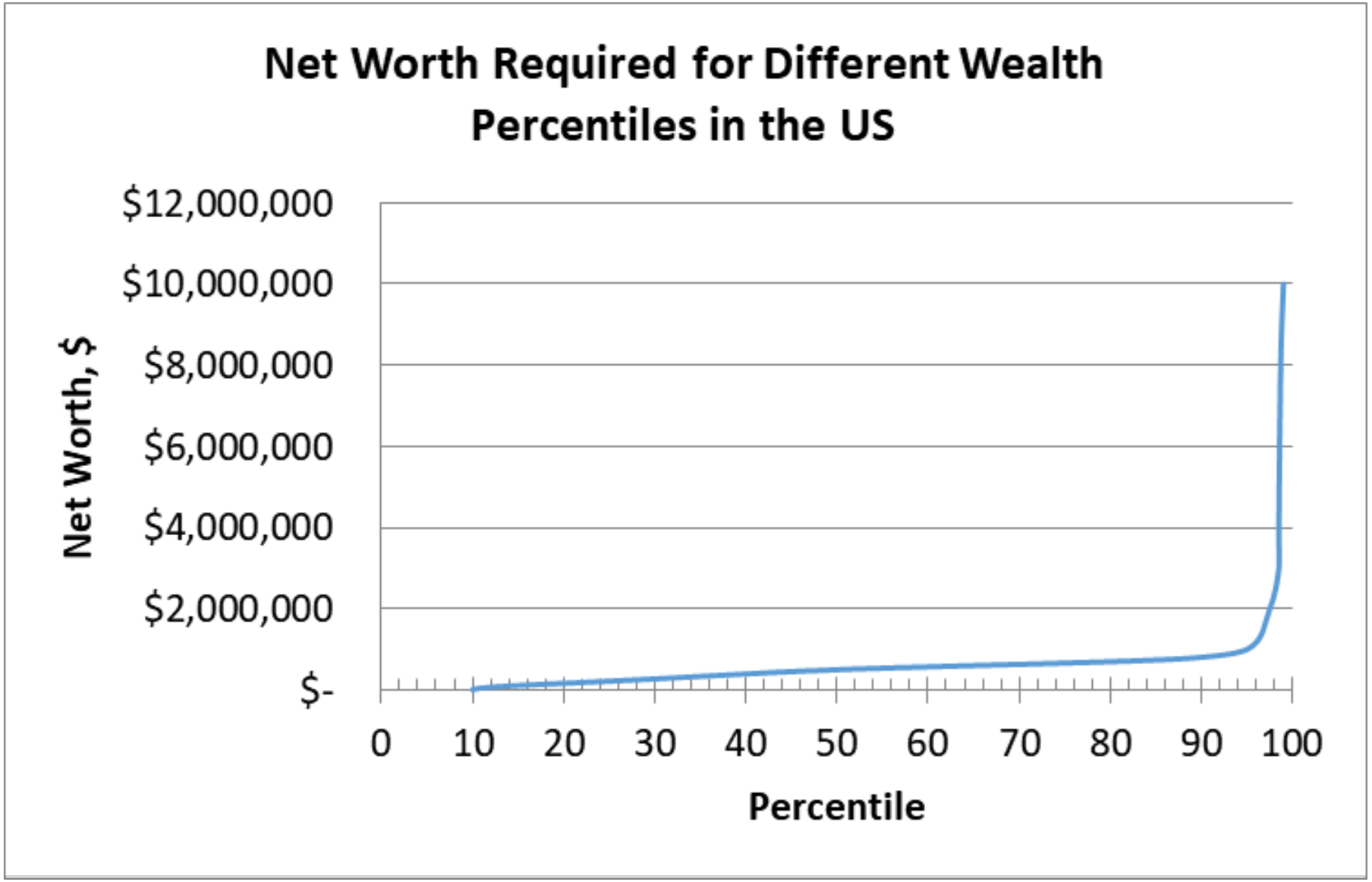
Source: Edward N. Wolff (2017). Survey of Consumer Finances

US Millionaire Statistics

- In 2021, 2,251,000 new millionaires in US
- 20.27 million millionaires in the US
- 13.61 million households have net worth > $1 million
- 8 million households have net worth > $2 million
- 1.4 million households have net worth > $10 million
- 788 Billionaires
- 80% are self-made millionaires
- 8% of American adults are millionaires

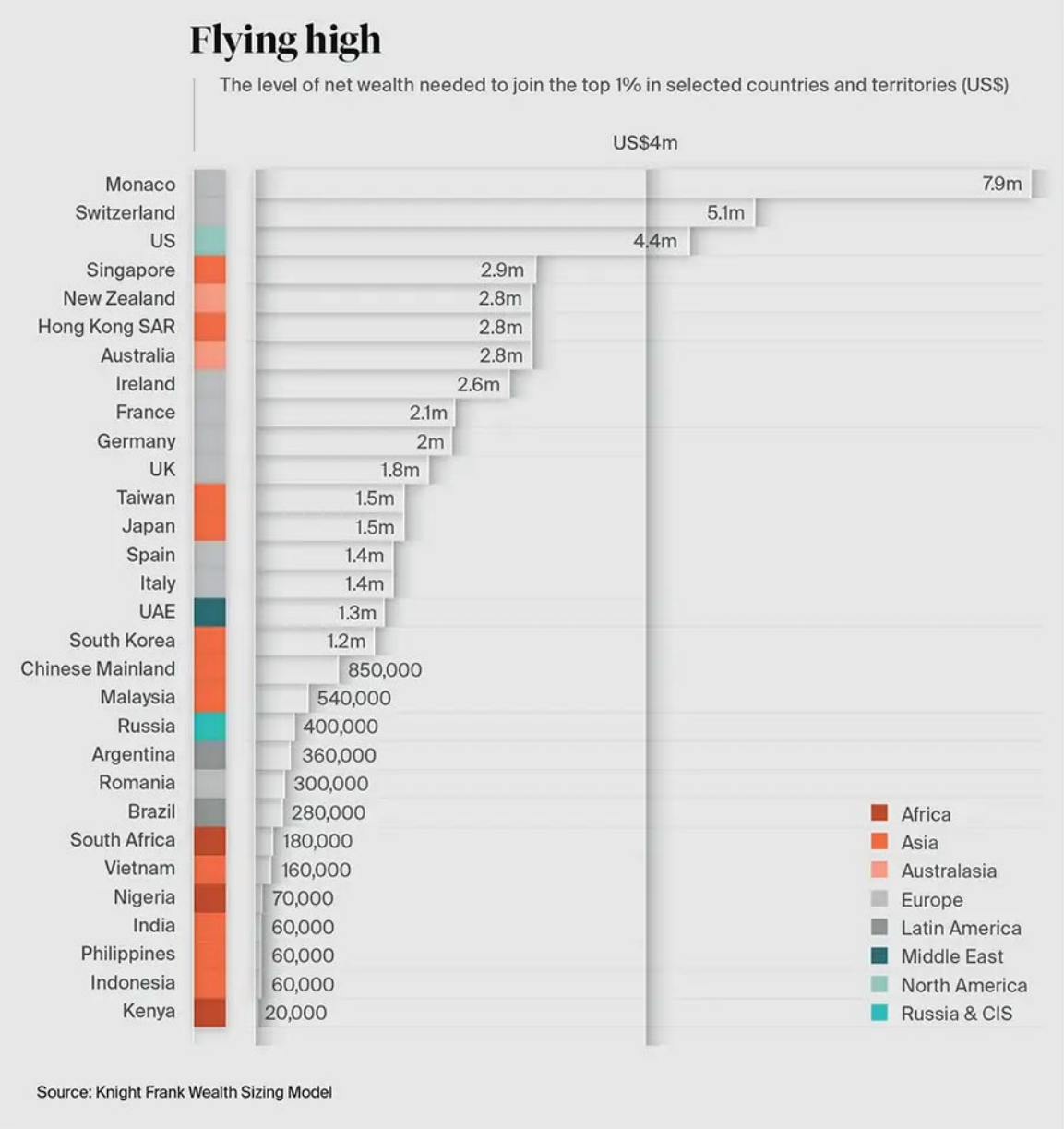

Selected Net Worth Brackets, 2013 vs 2016
SCF Data, Federal Reserve
2013
2016
$12,000,000.00
$10,000,000.00
$8,000,000.00
$6,000,000.00
$4,000,000.00
$2,000,000.00
$0.00
-$2,000,000.00
Centile Dollar Cutoff
-$2,132.84
-$962.66
$9,051.09
$10,243.05
$83,976.99
$97,225.55
$325,456.72
$369,513.82
$972,862.05
$1,182,390.36
$1,924,942.64
$2,377,985.22
$8,102,708.22
$10,374,030.10
10.00%
25.00%
50.00%
75.00%
90.00%
95.00%
99.00%
Wealth Percentile
dqydj.com

Middle Class Crisis



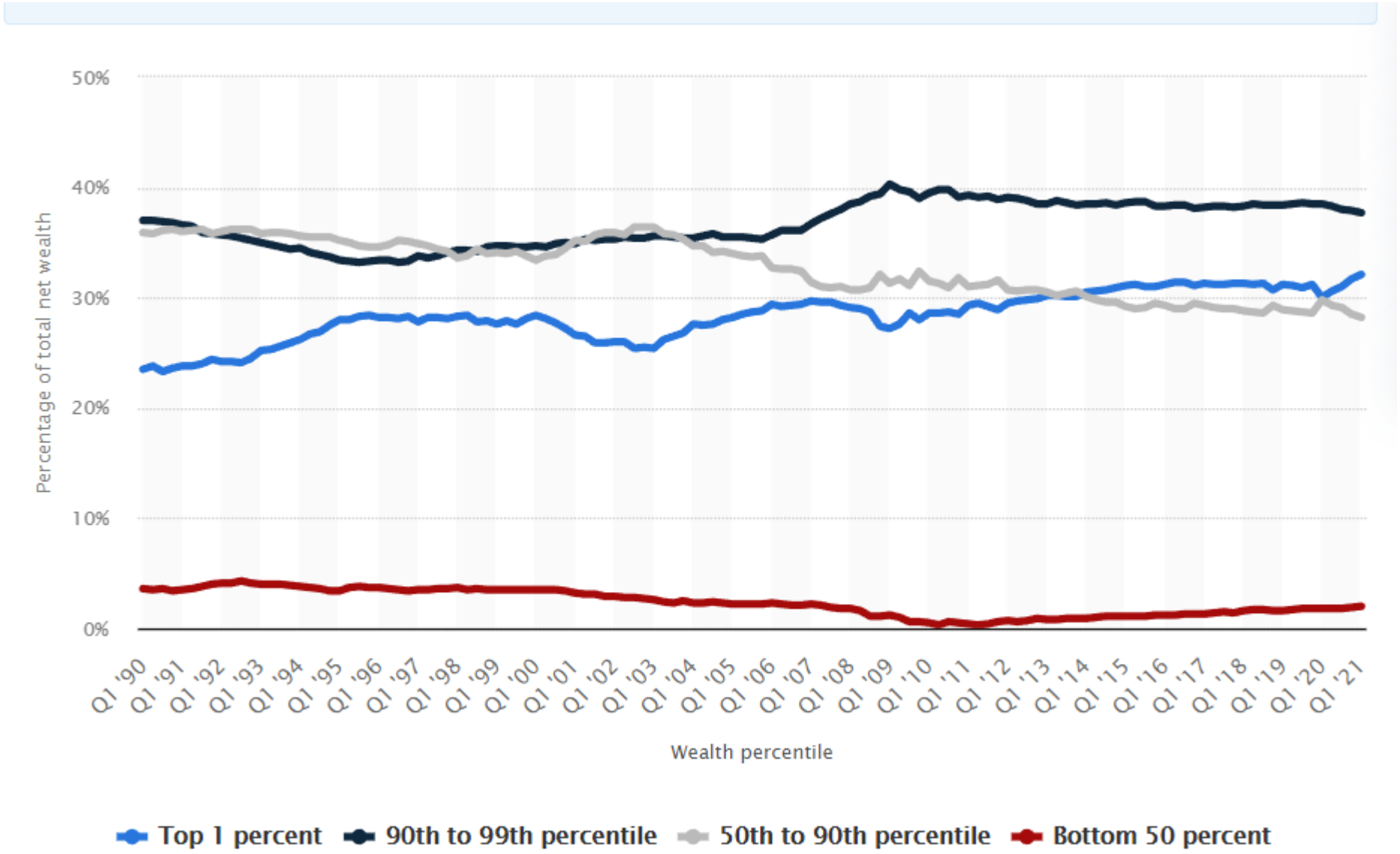
Percentile in US	Net Worth, $
10	$10,000
11	$50,000
14	$100,000
28	$250,000
50	$500,000
86	$750,000
95	$1,000,000
97.5	$2,000,000
98.5	$3,000,000
98.5	$4,000,000
98.7	$8,000,000
99	$10,000,000

Level of Net Worth to be in Top 1% by Country (2020)



US - $4.4 million
China - $850K
Nigeria - $70K

Top 10% Own 70% of US Wealth



Savings Models (Personal Accounts)

For savings models, there are gains in value but no losses/outflows

Personal savings – bank & brokerage accounts

- Stocks
- Bonds
- Mutual Funds
- Interest

Examples of brokerage companies:

- Charles Schwab & Sons (selected branch offices)
- Fidelity
- Vanguard
- Edward Jones (local franchised branches)
- Robinhood (online only)

Savings Models (Retirement Programs)

*__401k__ – typical corporate retirement program

*__403B__ – voluntary educational retirement program

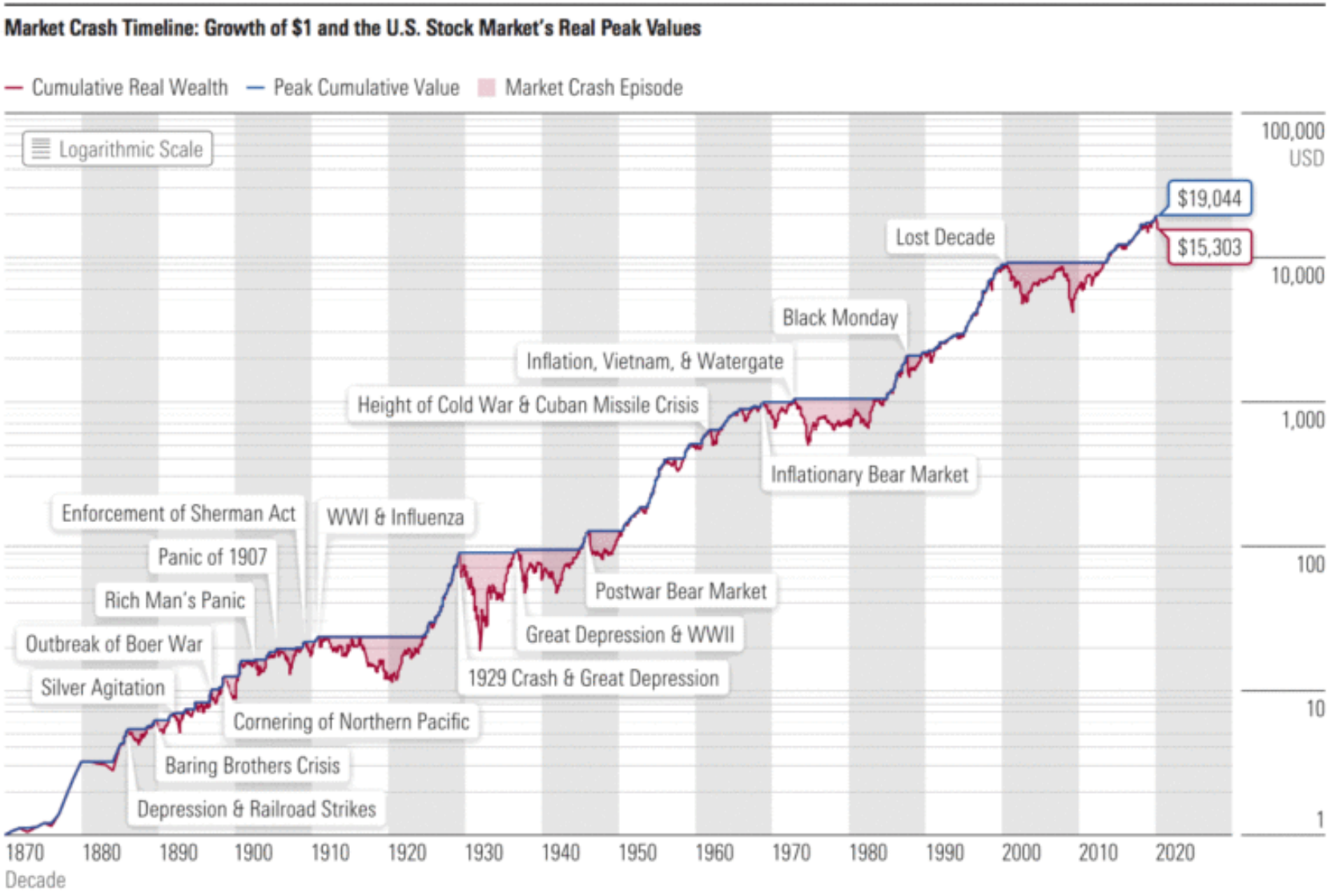
*__457B__ – deferred compensation program

*__Traditional IRA__ – personal retirement program

__Roth IRA__ – personal retirement program (post-tax $, tax free withdrawal)

*pretax $, taxed on withdrawal as earned income

Long Term Stock Market Return is 10% per Year

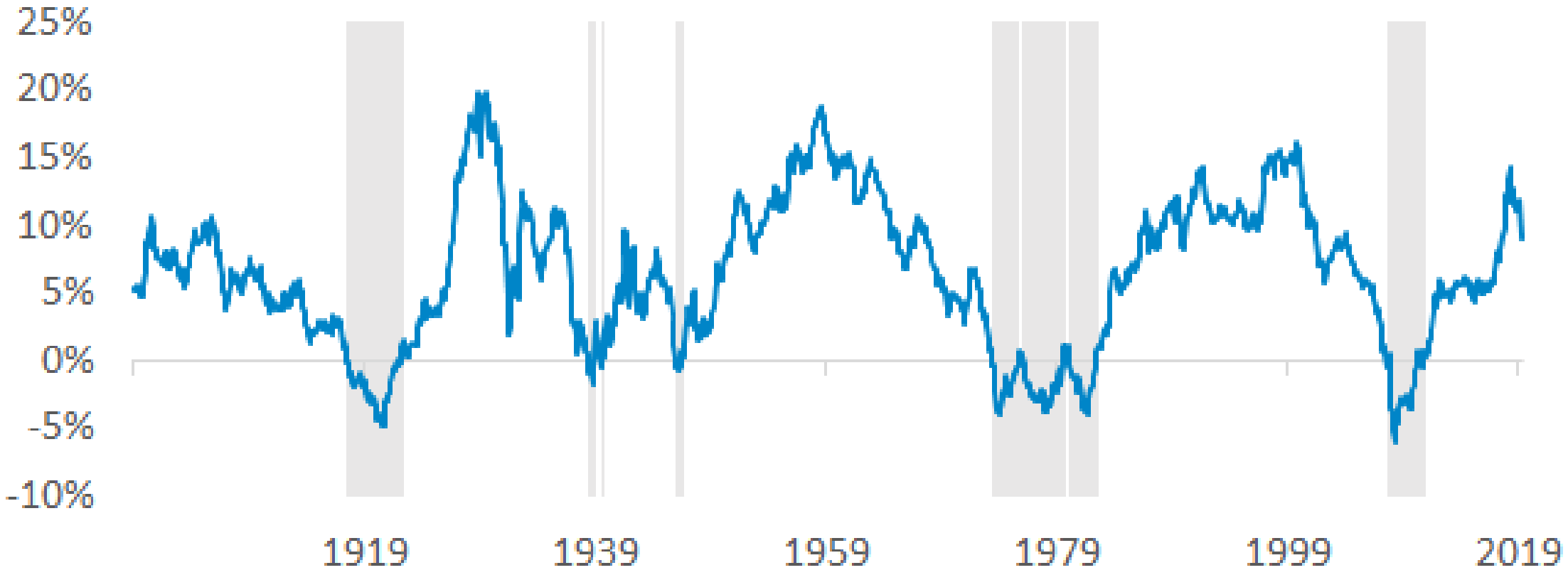


Data as of Mar 31, 2020

Sources: Kaplan et al. (2009); Ibbotson (2020); Morningstar Direct; Goetzmann, Ibbotson, and Peng (2000); Pierce (1982); www.econ.yale.edu/~shiller/data.htm.

S&P 500 10-Year Returns

Compound annualized returns net of inflation



How Self-Made Millionaires Got Rich

Some are Self-made, some are born into wealth

Over 2/3 of people worth over $30 million are self-made

- Appreciation of investments
- Created a company
- Compensation and employee stock options
- Profit sharing
- Set budgets and save!

Source: https://www.businessnewsdaily.com/2871-how-most-millionaires-got-rich.html

How Self-Made Millionaires Got Rich

They set ambitious goals and act on them. Self-made millionaires put their ideas and dreams into action, whether that's starting a business or achieving other professional or personal pursuits. This determination is a common driver among many who made their millions without an inheritance.

They have mentors. Many self-made millionaires are quick to admit that they cannot possibly know how to do everything. They reach out to others who know the ins and outs of different types of saving and investing, tapping into the best minds on each subject for perspective and insight. That certainly pays off.

Source: https://www.businessnewsdaily.com/2871-how-most-millionaires-got-rich.html

How Self-Made Millionaires Got Rich

They look for feedback. For a self-made millionaire, self-improvement never stops. Self-made millionaires look for critique and feedback in their ideas and business practices, ensuring that they can better identify blind spots and guarantee that their ventures will succeed.

They are not afraid of failure. Millionaires understand the benefits of learning lessons through failure. However, the risks they take are thoroughly calculated and each scenario played out. Once they commit to something, they give their all.

Source: https://www.businessnewsdaily.com/2871-how-most-millionaires-got-rich.html

How Self-Made Millionaires Got Rich

They understand the value of time. Time is money, and millionaires know this all too well. They quickly learn how to manage their time.

Source: https://www.businessnewsdaily.com/2871-how-most-millionaires-got-rich.html

What Do Millionaires Do With Their Money?

Investments of Millionaires

- Primary residence
- Mutual funds
- Stocks
- Retirement accounts
- Real estate

Characteristics of Millionaires

- Live on a budget
- Prioritize saving over spending
- Put their money where it will grow (not depreciate)
- Cars lose 20% of value in 1 year (depreciating asset)

Best Way to Become a Millionaire

- Set annual financial goals
- Avoid debt (cars, credit cards)
- Cut unnecessary expenses (comfort items)
- Invest early and consistently
- Make savings a priority
- Invest in different places and avenues (diversity)
- Have multiple streams of income (salary, dividends, investments, rental income)
- Save, save, save

50/30/20 rule: 50% for needs, 30% for wants and 20% for savings and paying off debt.

Retirement and Personal Savings Model

$$V^{t+dt} = V^t + (\text{gains} - \text{losses})\, dt$$

$$V^{t+dt} = V^t + (I*V^t + S)\, dt$$

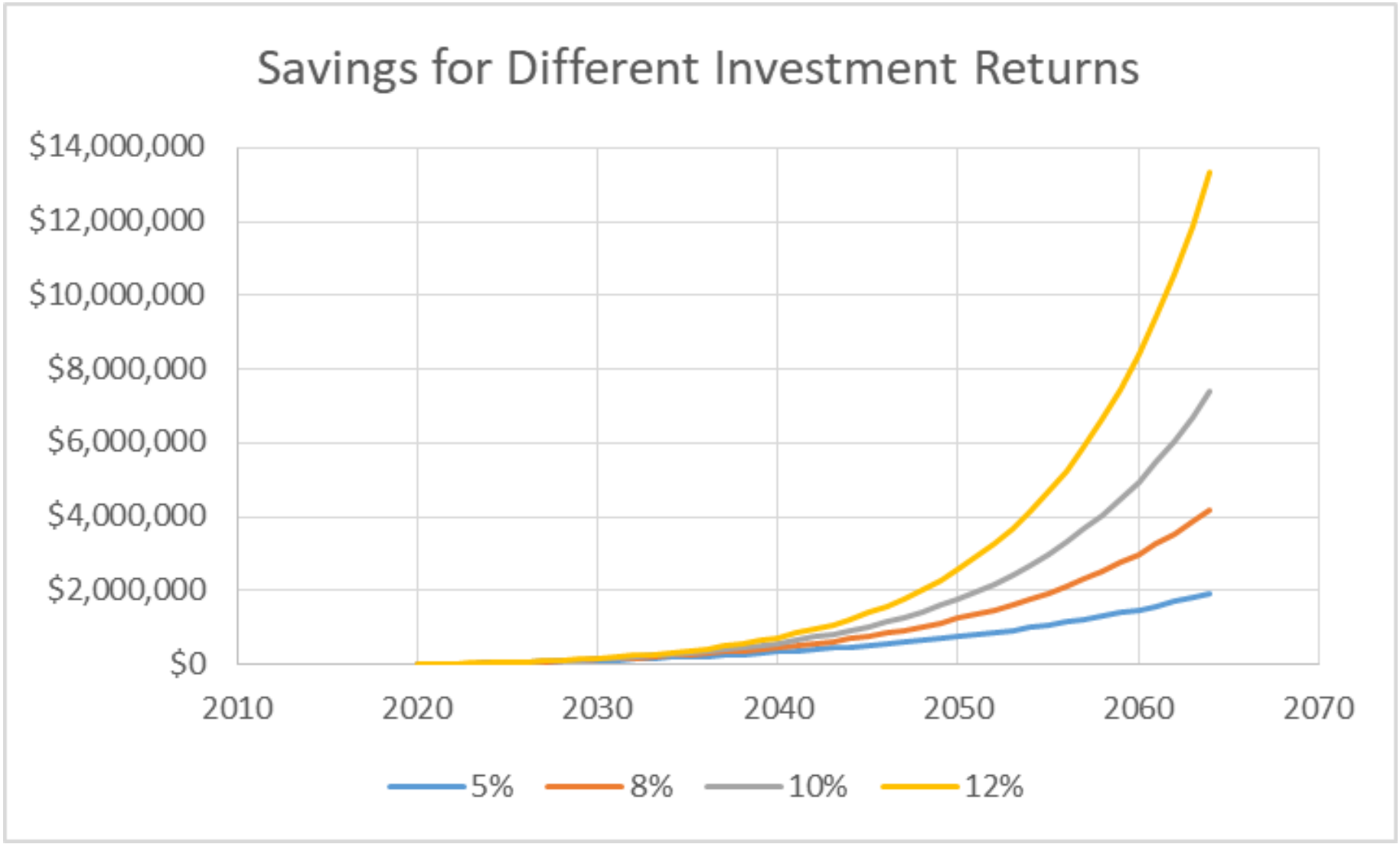
Assuming dt = 1 year,

$$V^{t+dt} = (1+I)\, V^t + S$$

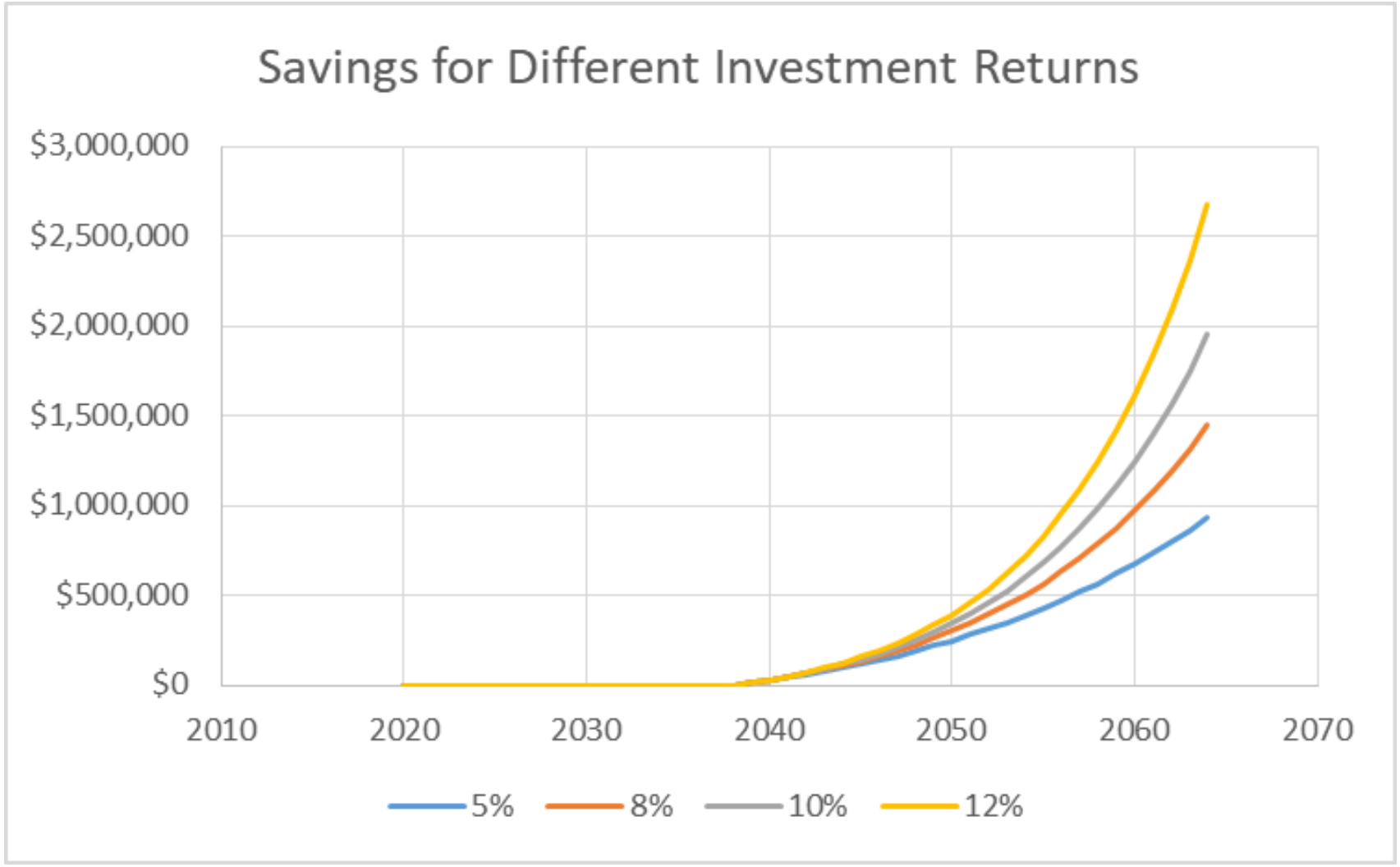
Where
V = value, $
I = annual interest (decimal rate)
S = annual savings, $
dt = assume one year

Note: Losses = $0 for projection models. There may actually be annual losses in bad market times.

A 23 year old has $50,000 initial salary, annual raise of 3%, savings rate of 15%, 43 years (year 2064). Saves $4.1 million @ 8% return



Impact of Delaying Retirement Savings



Delay saving until 40
Pull money from 401k
$1.5 Million @8%

When Does Investment Income = Annual Salary?

Annual Return	Age
8	54
10	47
12	42

It is possible to reach a point where your annual income from investments exceeds your annual income for your job!

Two incomes are better than one!

Taxes on Stocks and Mutual Funds

- If sold in under 1-year – taxed as regular income (10-37%)
- If sold after 1-year, long term capital gains,

Long-term capital gains tax rates for the 2021 tax year

FILING STATUS	0% RATE	15% RATE	20% RATE
Single	Up to $40,400	$40,401 – $445,850	Over $445,850
Married filing jointly	Up to $80,800	$80,801 – $501,600	Over $501,600
Married filing separately	Up to $40,400	$40,401 – $250,800	Over $250,800
Head of household	Up to $54,100	$54,101 – $473,750	Over $473,750

Taxes on Retirement Accounts

Taxed as ordinary income

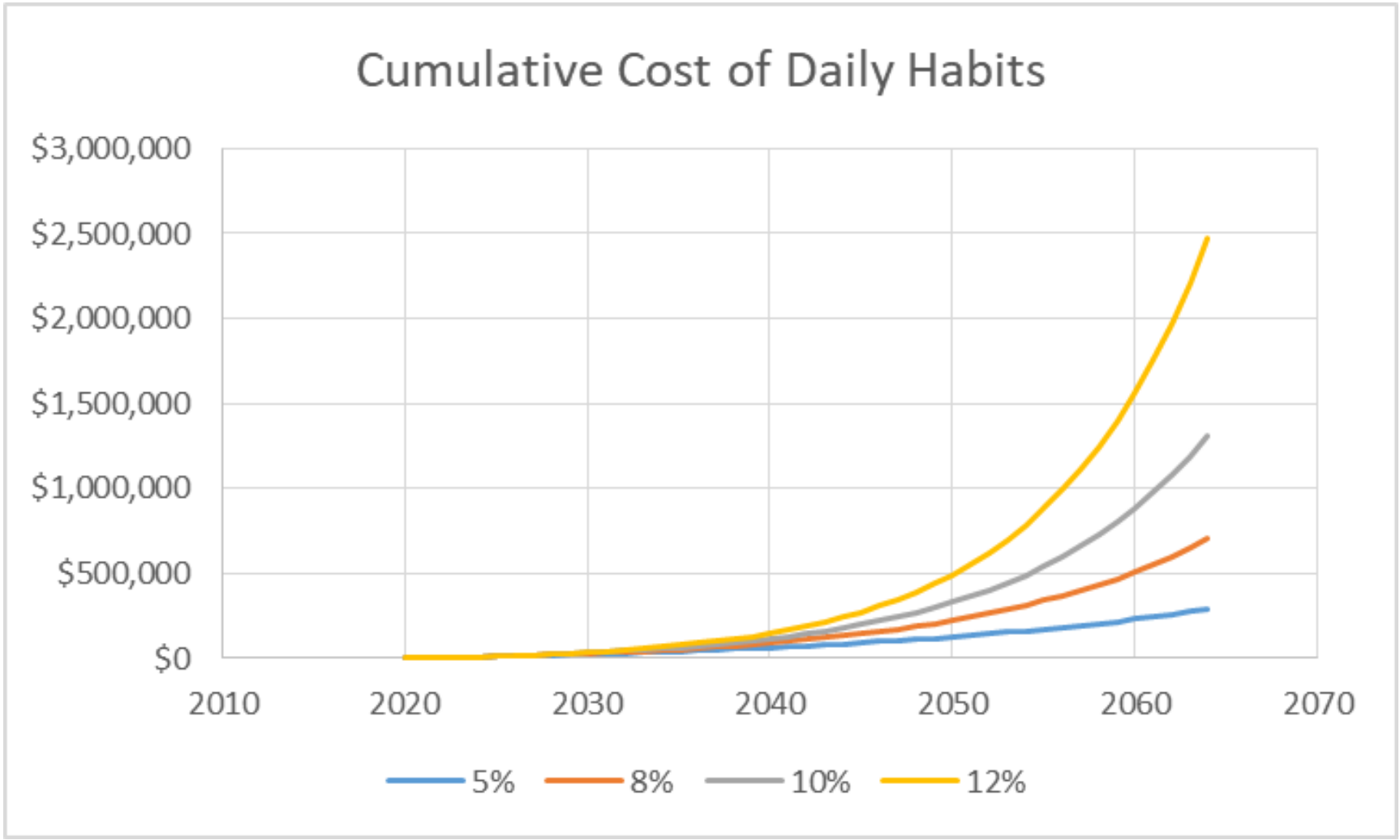
- 401K
- 403B
- 457B
- Traditional IRA

Roth IRA's are after tax dollars invested. Withdrawals are tax free!

- Very powerful retirement savings device

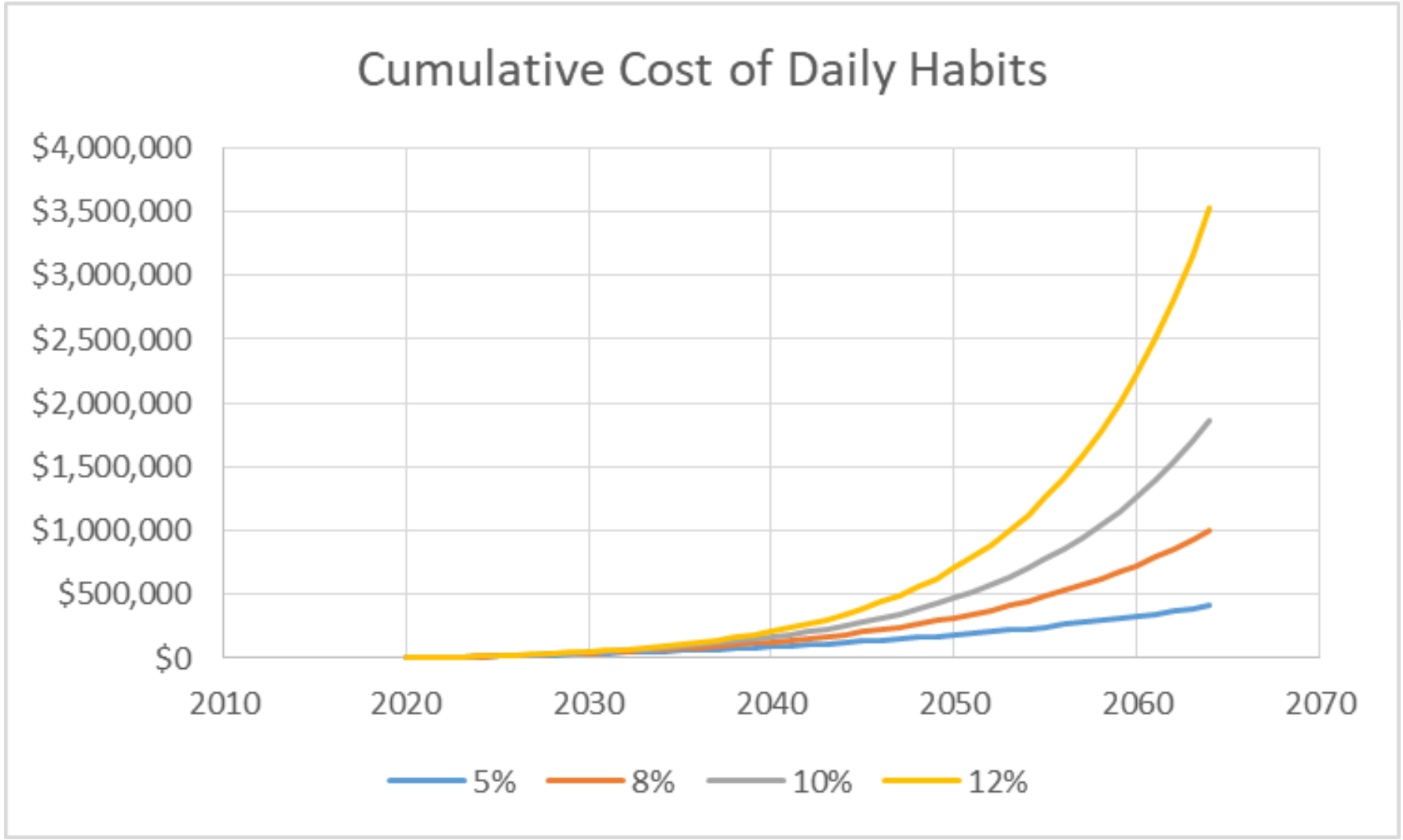
Cost of Daily Habits (Starbucks)

1 Starbucks coffee 5 days/week each year ($7.00)



$10 Lunch Costs $1 million in Retirement

1 AU Lunch 5 days/week each year ($10.00)



Borrowing Money

The PMP Function in Excel can be used to compute monthly payments

=PMT(rate,nper,pv)

Rate = interest rate per payment period
NPER = number of payment periods
PV = present value of the loan

Borrowing Money

Example: What is the monthly payment on a $60,000 car financed at 6% over 72 months?

=PMT(.06/12,72,60000) = $994.37

Note that the annual interest rate of 6% must be converted to monthly interest rate by dividing by 12 months since payments are monthly for 72 months.

Amortization Schedules

Monthly schedule of loan balance, monthly interest and premium payment

Month	Payment, $	Interest, $	Principle, $	Balance, $	Cumulative Principle, $	Cumulative Interest, $
0				$300,000.00		
1	$2,053.76	$718.75	$1,335.01	$298,664.99	$1,335	$719
2	$2,053.76	$715.55	$1,338.21	$297,326.79	$2,673	$1,434
3	$2,053.76	$712.35	$1,341.41	$295,985.38	$4,015	$2,147
4	$2,053.76	$709.13	$1,344.63	$294,640.75	$5,359	$2,856
5	$2,053.76	$705.91	$1,347.85	$293,292.90	$6,707	$3,562
6	$2,053.76	$702.68	$1,351.08	$291,941.83	$8,058	$4,264
7	$2,053.76	$699.44	$1,354.31	$290,587.51	$9,412	$4,964
8	$2,053.76	$696.20	$1,357.56	$289,229.96	$10,770	$5,660
9	$2,053.76	$692.95	$1,360.81	$287,869.15	$12,131	$6,353
10	$2,053.76	$689.69	$1,364.07	$286,505.07	$13,495	$7,043
11	$2,053.76	$686.42	$1,367.34	$285,137.74	$14,862	$7,729
12	$2,053.76	$683.14	$1,370.61	$283,767.12	$16,233	$8,412
13	$2,053.76	$679.86	$1,373.90	$282,393.22	$17,607	$9,092
14	$2,053.76	$676.57	$1,377.19	$281,016.03	$18,984	$9,769

Monthly Mortgage Calculator

Borrow: $300,000
Annual Interest: 2.875%
Duration of Loan: 180 Months
Monthly Payment: $2,053.76

Step 1: Use PMT to compute monthly payments

=PMT(.02875/12,72,300000) = $2053.76

Monthly Payment

- Combination of monthly principle and interest
- Monthly principle can be computed with the PPMT function

Step 2: Compute monthly principle value of payment

= PPMT (rate, per, nper, -pv)

Rate = interest rate in decimal percent (0.02875)
Per = period to compute principal for (ie. 1, 2, 3,…360)
Nper = total number of payment periods (months) of loan (180)
Pv = Initial (present) value of loan ($300,000)

Monthly Payment

- Combination of monthly principle and interest
- Monthly interest can be computed with the IPMT function

Step 3: Compute monthly principle value of payment

= IPMT (rate, per, nper, -pv)

Rate = interest rate in decimal percent (0.02875)
Per = period to compute principal for (ie. 1, 2, 3,…360)
Nper = total number of payment periods (months) of loan (180)
Pv = Initial (present) value of loan ($300,000)

Mortgage Example

Borrow: $300,000
Annual Interest: 2.875%
Duration of Loan: 180 Months
Monthly Payment: $2,053.76

Step 4: Update monthly balance state variable

$V^{t+dt} = V^t + (\text{gains} - \text{losses})\ dt$

Gains = $0
Losses = PPMT (rate, per, nper, -pv)
dt = 1 month

Mortgage Example

Loan Value Calculator

Enter Loan Characteristics in the Table below

Amount of Loan	$300,000.00	
Annual Interest Rate	2.875	%
Duration of loan	180	months
Monthly Payment	$2,053.76	

Loan Summary

Cumulative Interest	$69,676
Cumulative Principle	$300,000

Month	Payment, $	Interest, $	Principle, $	Balance, $	Cumulative Principle, $	Cumulative Interest, $
0				$300,000.00		
1	$2,053.76	$718.75	$1,335.01	$298,664.99	$1,335	$719
2	$2,053.76	$715.55	$1,338.21	$297,326.79	$2,673	$1,434
3	$2,053.76	$712.35	$1,341.41	$295,985.38	$4,015	$2,147
4	$2,053.76	$709.13	$1,344.63	$294,640.75	$5,359	$2,856
5	$2,053.76	$705.91	$1,347.85	$293,292.90	$6,707	$3,562
6	$2,053.76	$702.68	$1,351.08	$291,941.83	$8,058	$4,264
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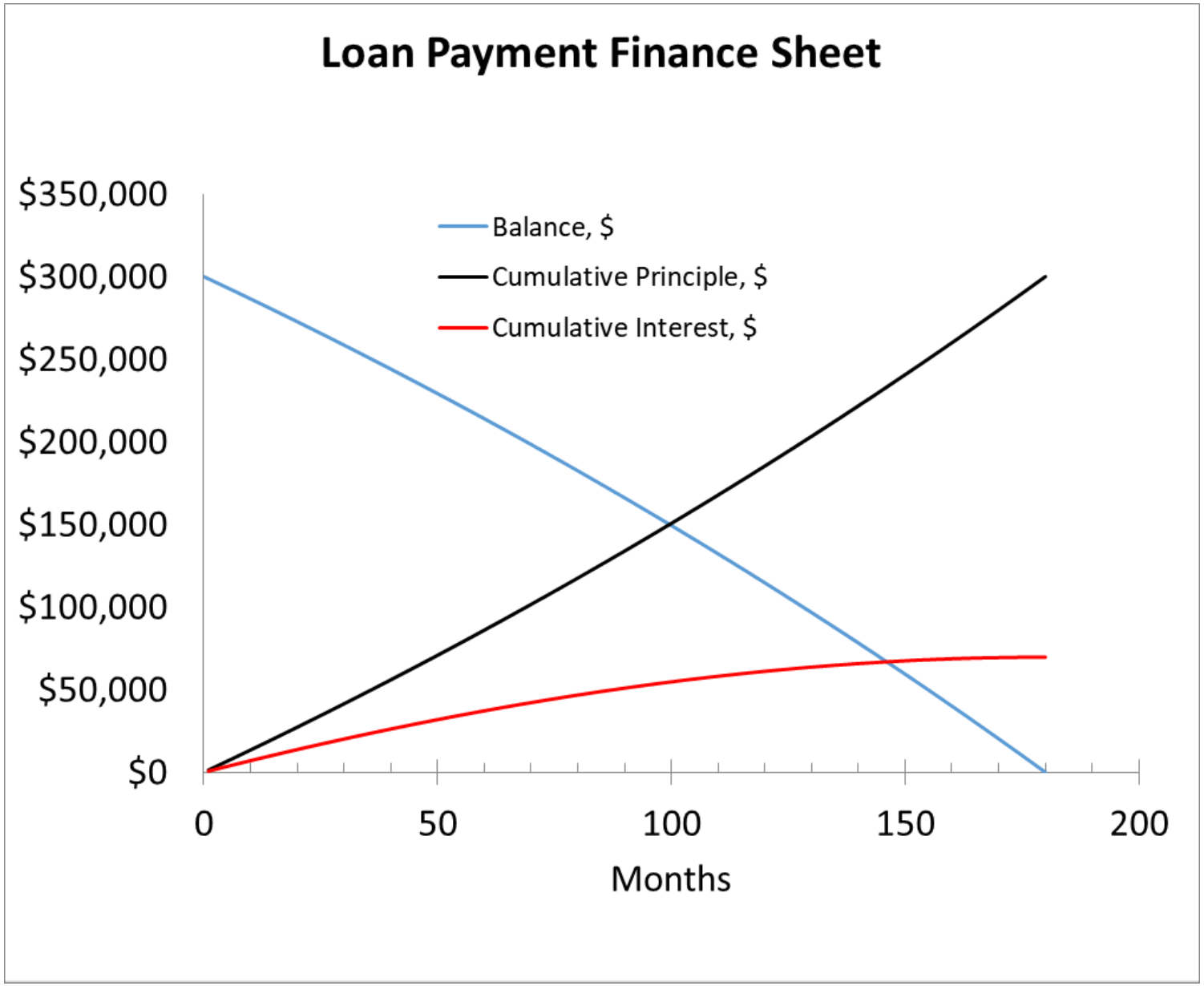
13	$2,053.76	$679.86	$1,373.90	$282,393.22	$17,607	$9,092

- Set up Steps 1-4 as columns
- This creates Amortization Schedule
- Compute cumulative Principle & Interest
- Compare cumulative interest vs terms of loan

Mortgage Example

Borrow: $300,000
Annual Interest: 2.875%
Duration of Loan: 180 Months
Monthly Payment: $2,053.76

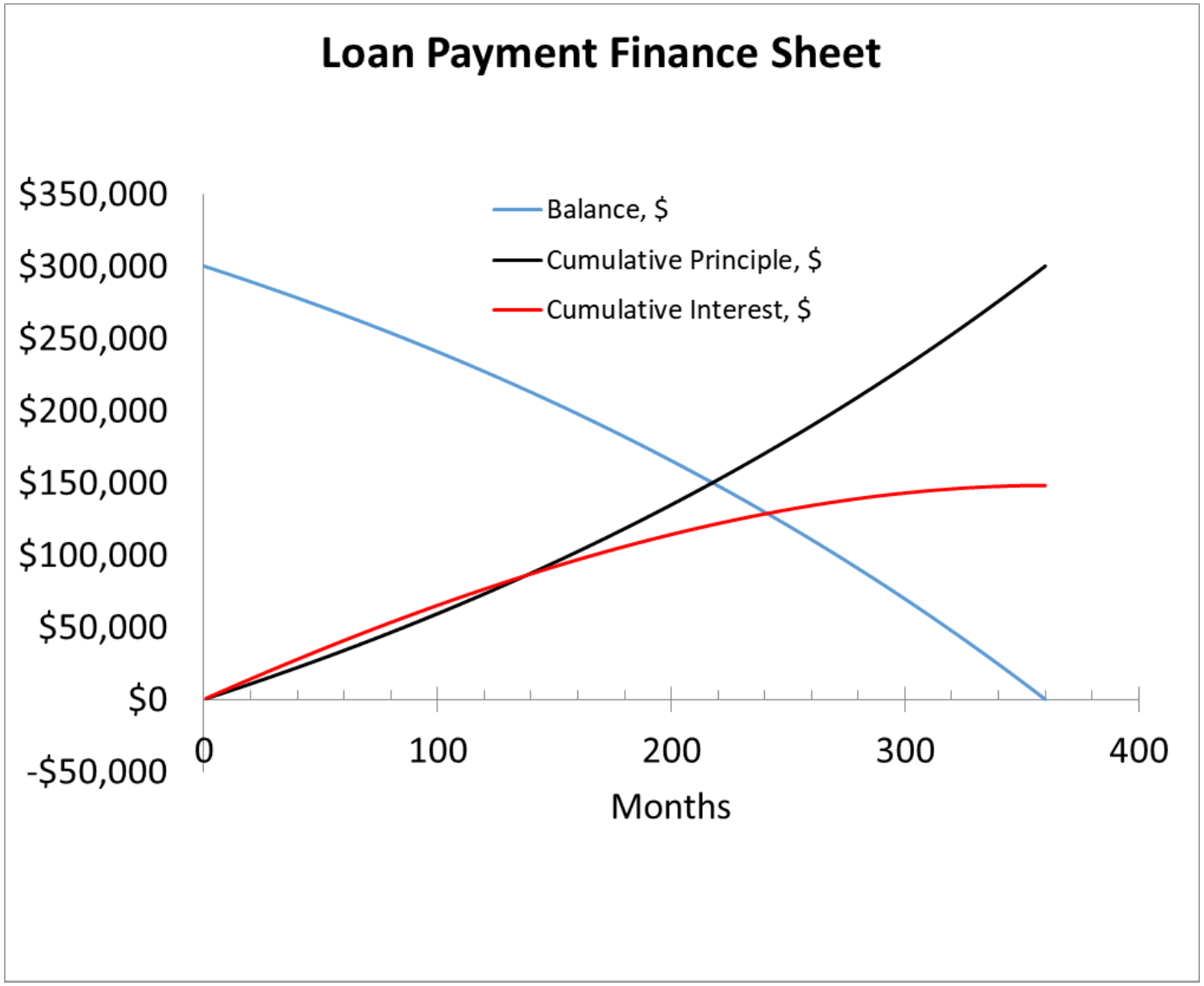
Cum. Interest: $69,676



Mortgage Example

Borrow: $300,000
Annual Interest: 2.875%
Duration of Loan: 360 Months
Monthly Payment: $1,244

Cum. Interest: $148,084



Monthly Struggle

Average Household Budget $63K (2019)

- Rent/Mortgage
- Car payment
- Student loans
- Credit cards
- Child care
- Utilities
- Insurance
- Savings and investing
- Living expenses

Expenditure	Annual Spending	% of Budget
Food	$8,169	13
Housing	$20,679	33
Apparel	$1,883	3
Transportation	$10,742	17
Healthcare	$5,193	8
Personal Care	$786	1
Education	$1,443	2
Entertainment	$3,050	5
Cash Contributions	$1,995	3
Pensions and Social Security	$7,165	11
Other	$1,891	3
Total: $63,096		