Stocks

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BUSI 448: Investments

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Where are we?

Last time:

- Returns of portfolios
- Portfolio expected return
- Portfolio standard deviation

Today:

- Equity markets

Fundamental Asset Classes

- Equity markets
- Fixed income markets

Today, we'll focus on some empirical facts about the stock market.

Some empirical facts for today

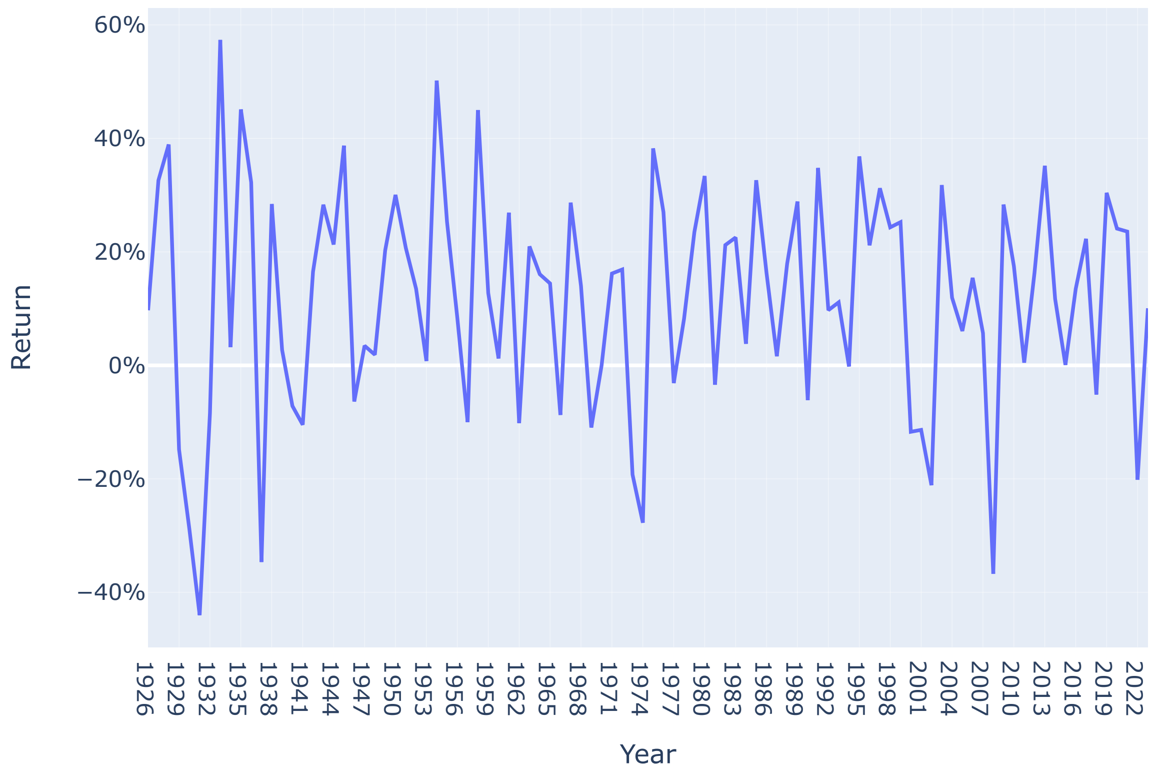
- Over long horizons, average returns in the US stock market have exceeded those of bonds.
- Stock returns are risky; that is, volatile.
- Stock return distributions are fat-tailed and negatively skewed.
- Past aggregate returns do **not** predict future aggregate returns.
- Volatility is time-varying and persistent.

Stock Market Indices

- S&P Indices
  - 500, Midcap 400, Smallcap 600
  - value-weighted index
- Dow Jones
  - price-weighted index
- Russell
  - $1000 + 2000 \rightarrow 3000$
- MSCI int'l indices
- FTSE, DAX, Hang Seng, etc.

Annual Returns

Time-series



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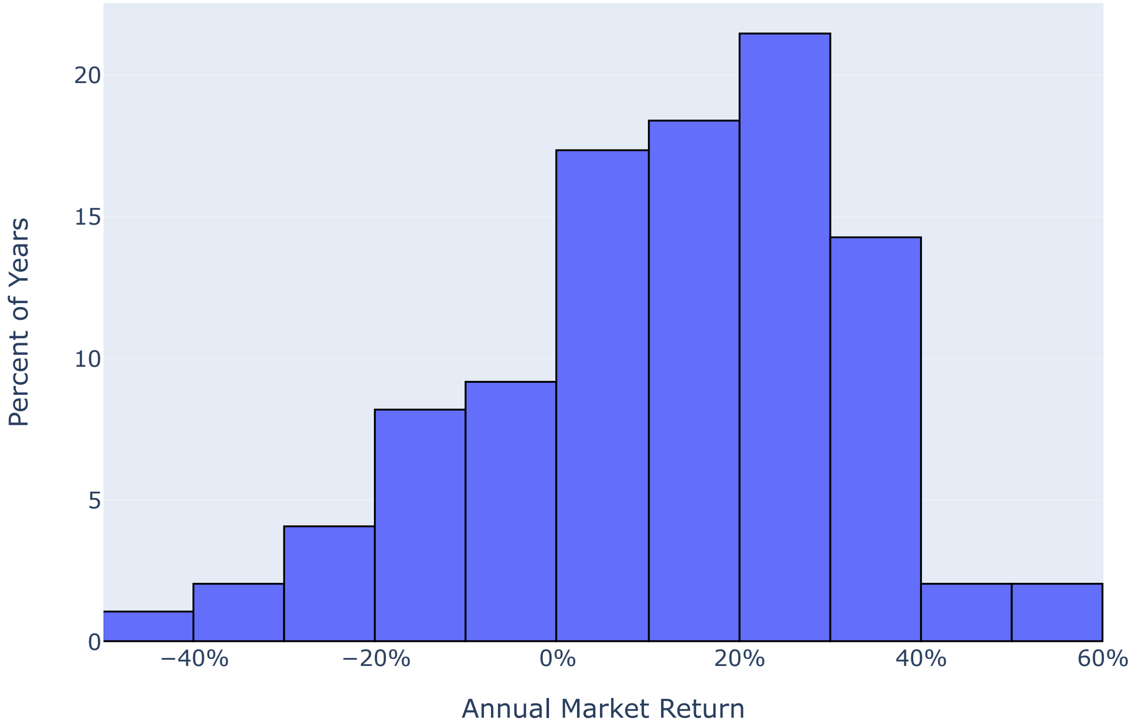
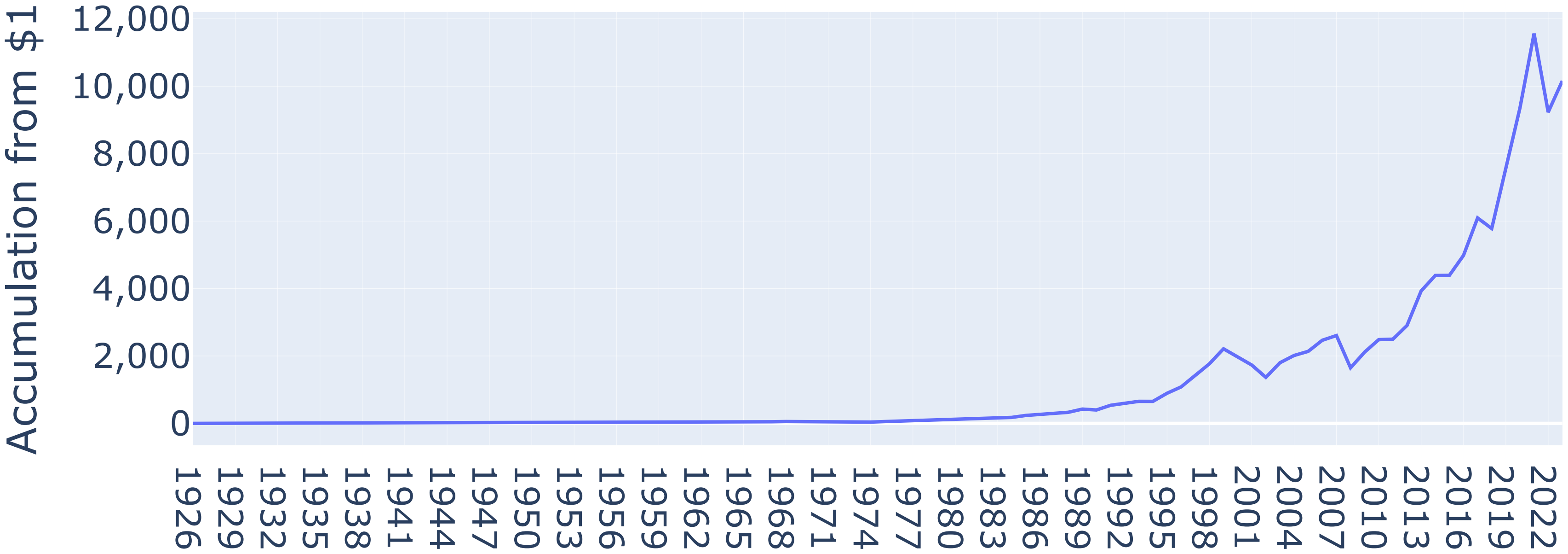
Distribution



Compounded return



value of $1 investment with dividends reinvested

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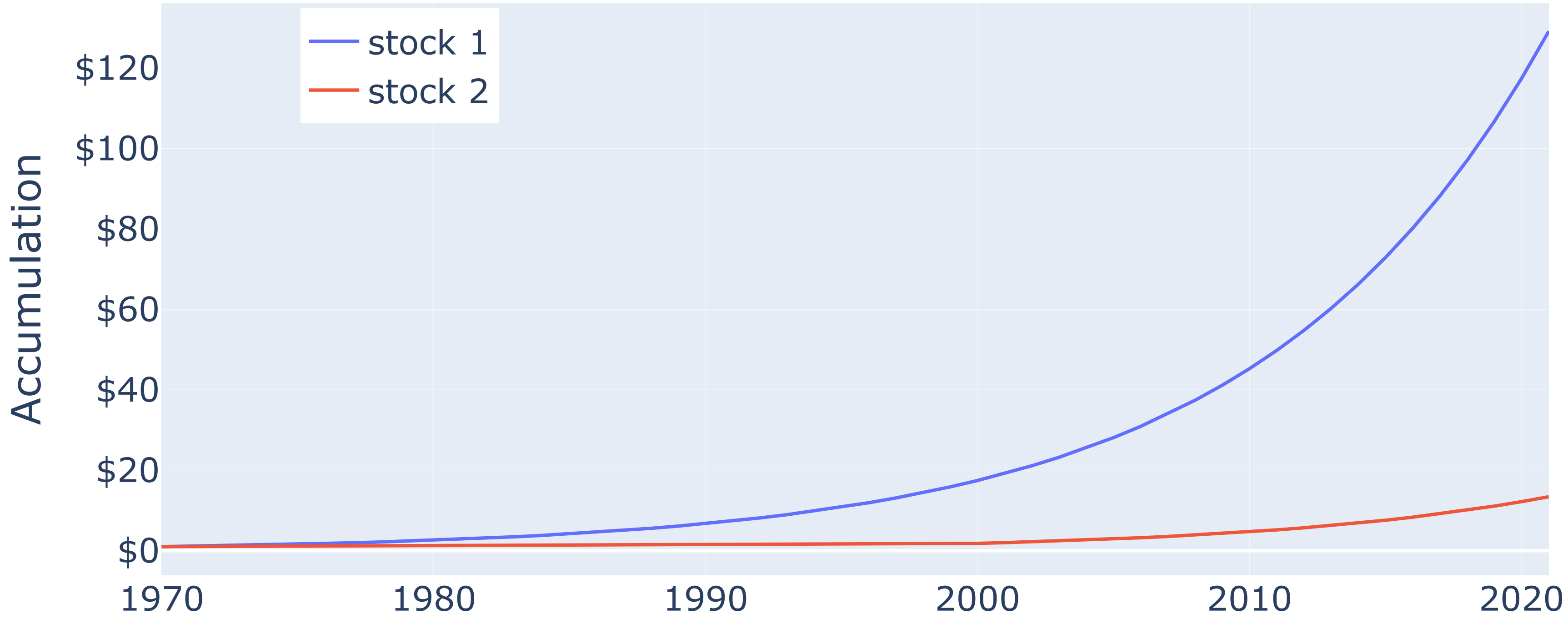
Compounded returns on log scale: motivation

- Let's look at accumulations from two hypothetical stocks.
  - stock 1: 10% per year
  - stock 1: 2% per year until 2000 and 10% afterwards
- It will appear that stock 2 did nothing before 2000 and earned a lot less than stock 1 even after 2000.

Plot of the Example



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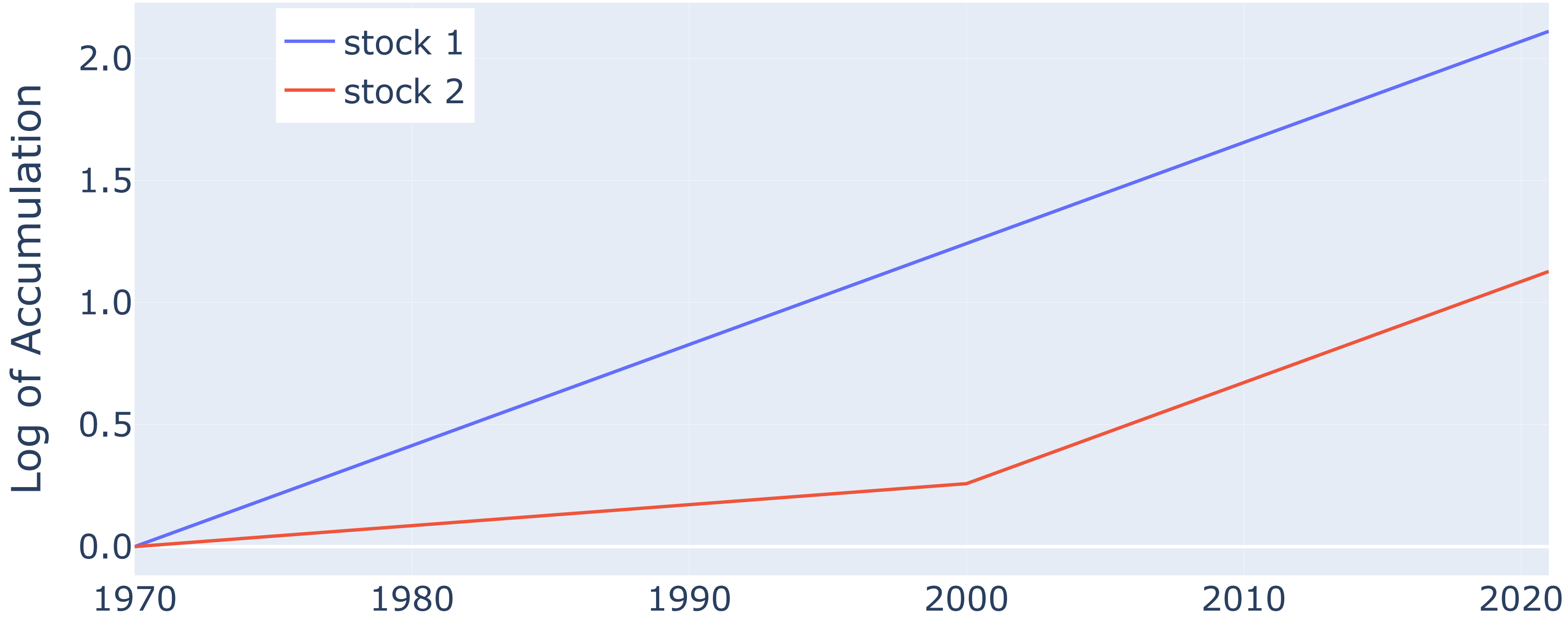
Log (base 10) of accumulation



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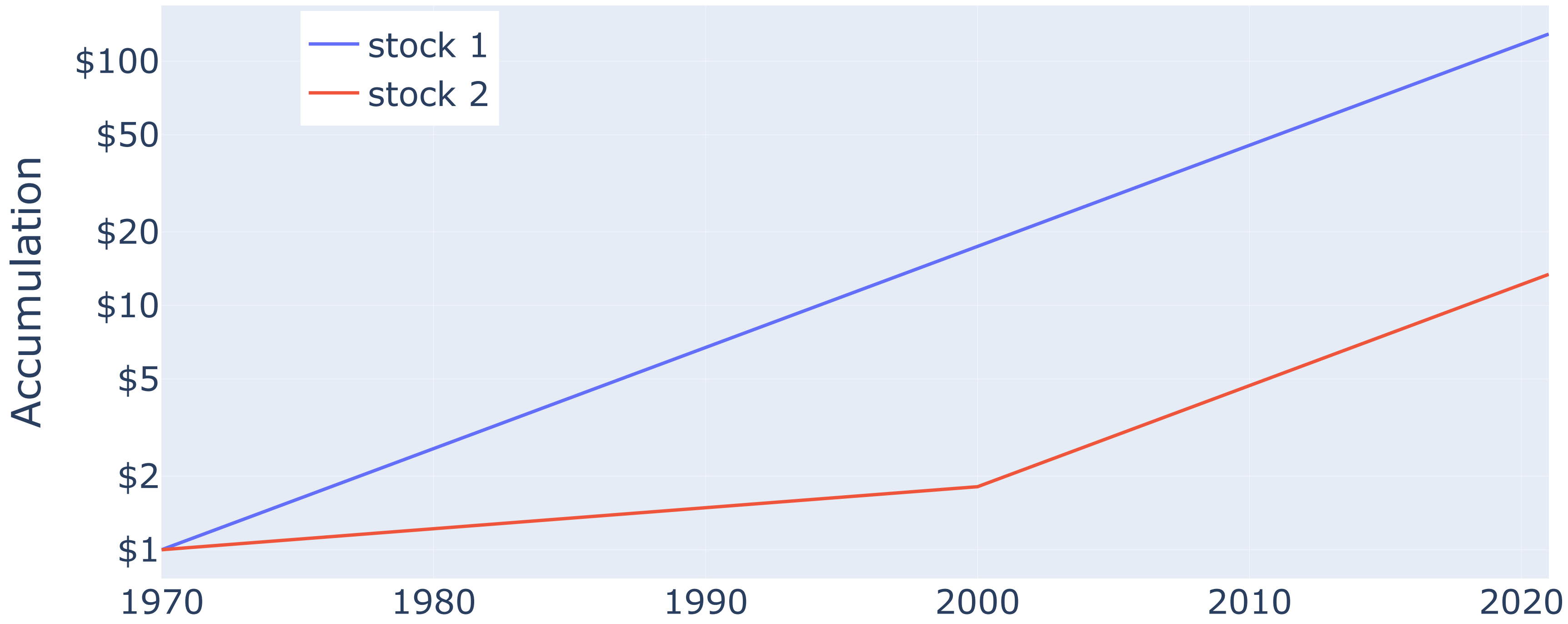
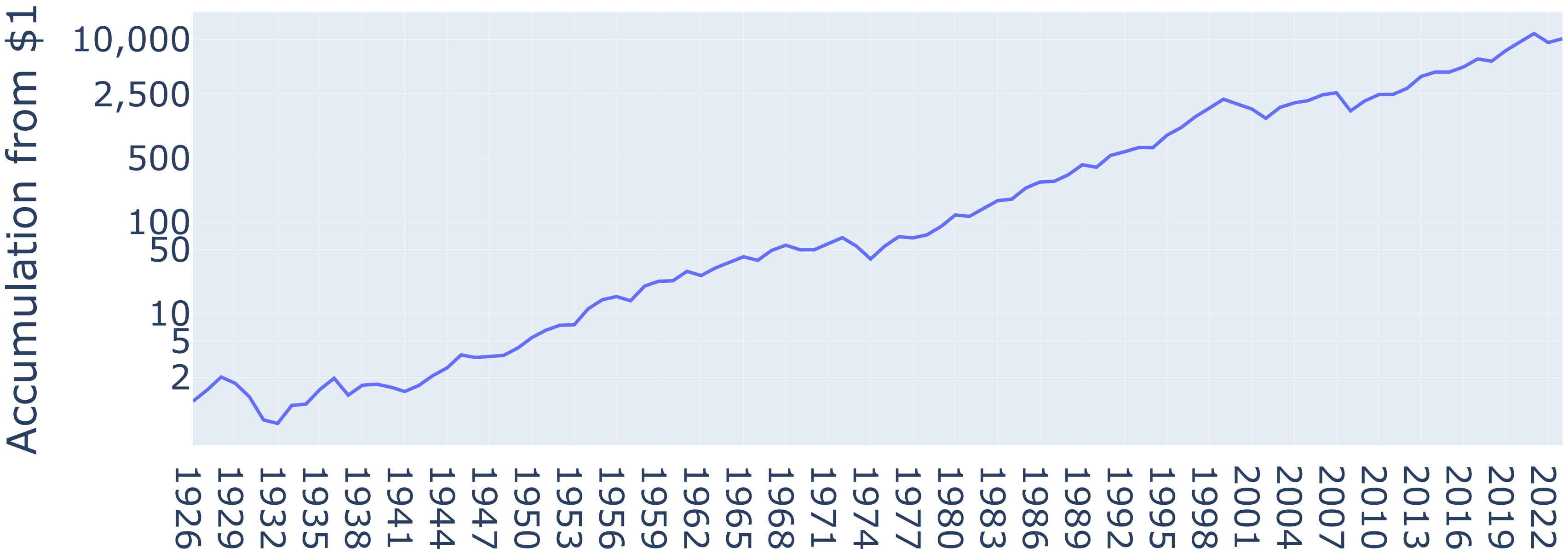
Map y tick labels to dollars



Compounded market returns on log scale



value of $1 investment with dividends reinvested

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Empirical record

dashboard: returns history

Does last year's return predict this year's?

- How would we test this?
- Autocorrelation is the correlation of a time series with its own lagged values.
- Autocorrelation at lag 1 tells us whether the current value predicts the next one.

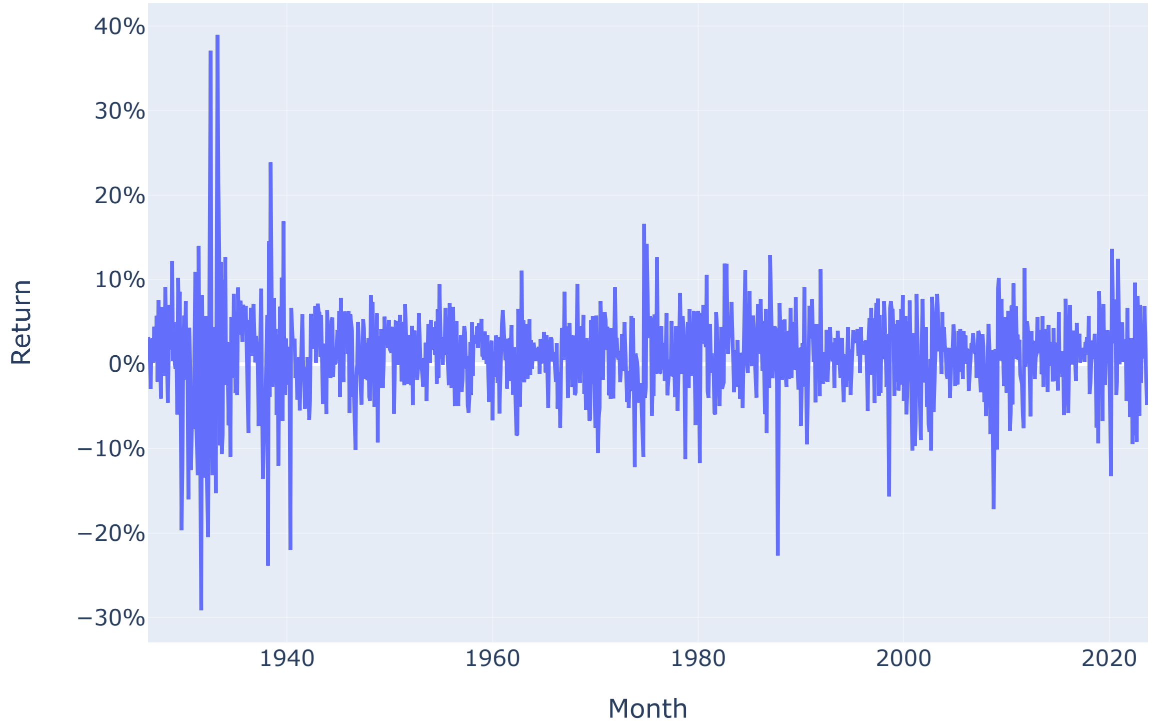
$$r_t = a + \rho \cdot r_{t-1} + \varepsilon_t$$

- What should be true of ρ?

Does last year's return predict this year's?

Monthly Returns

Time-series



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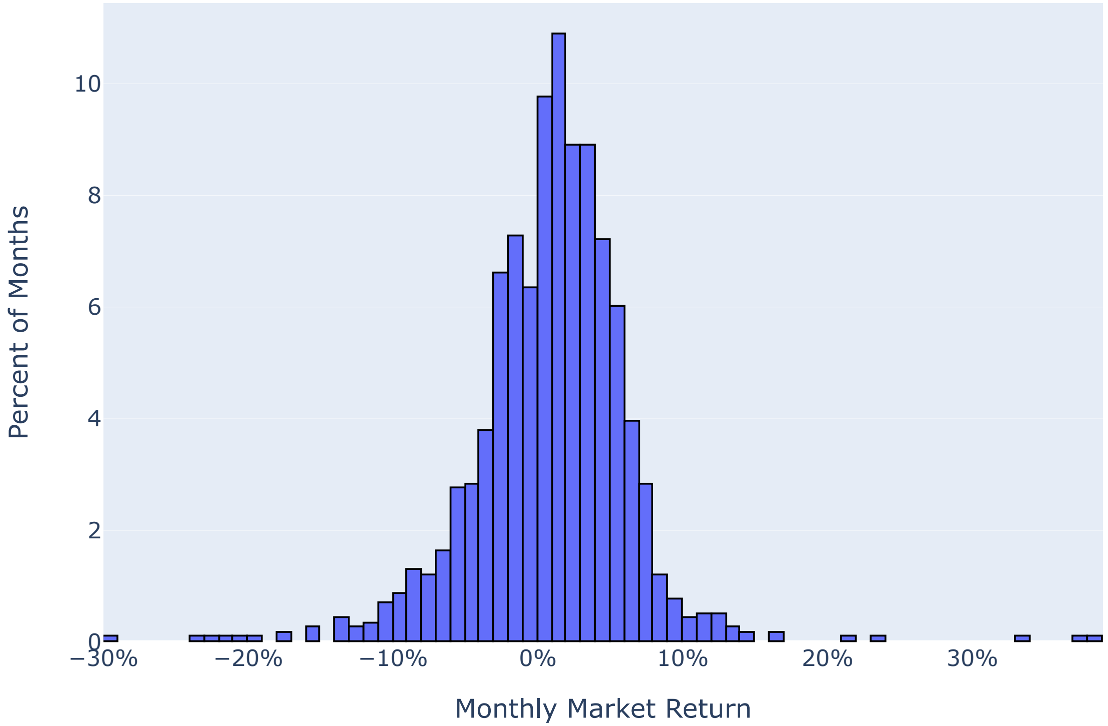
Distribution



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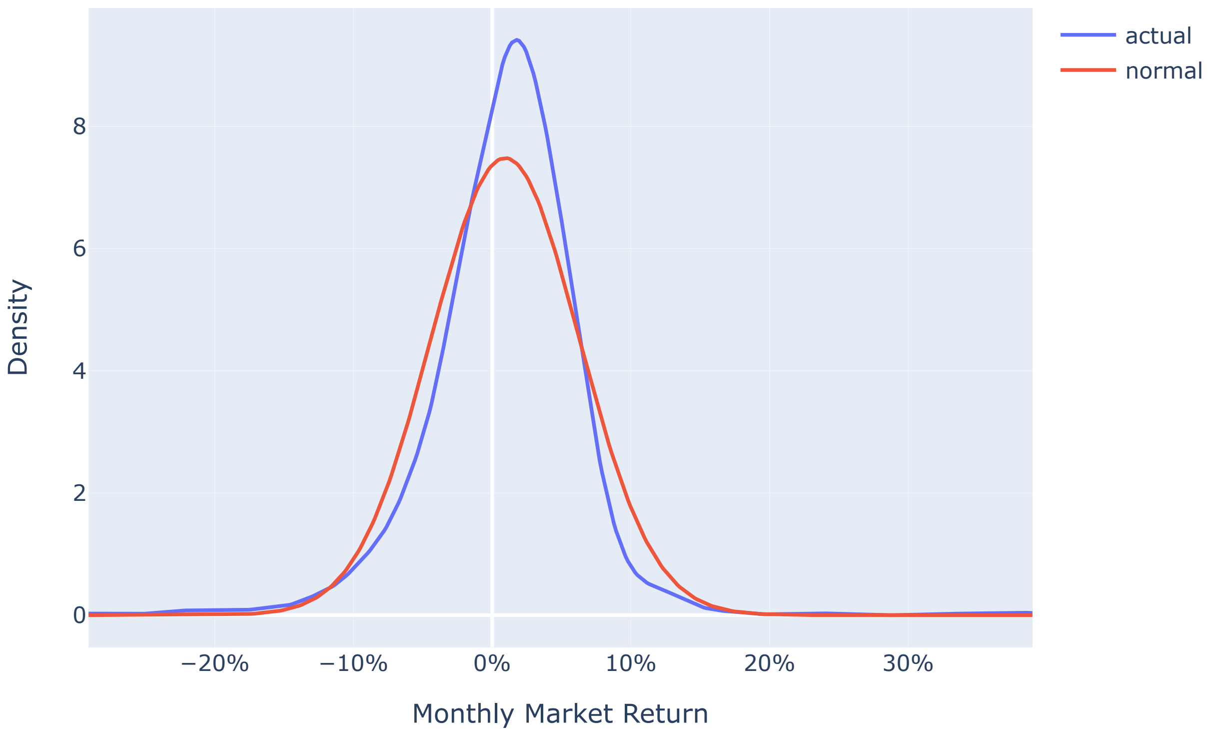
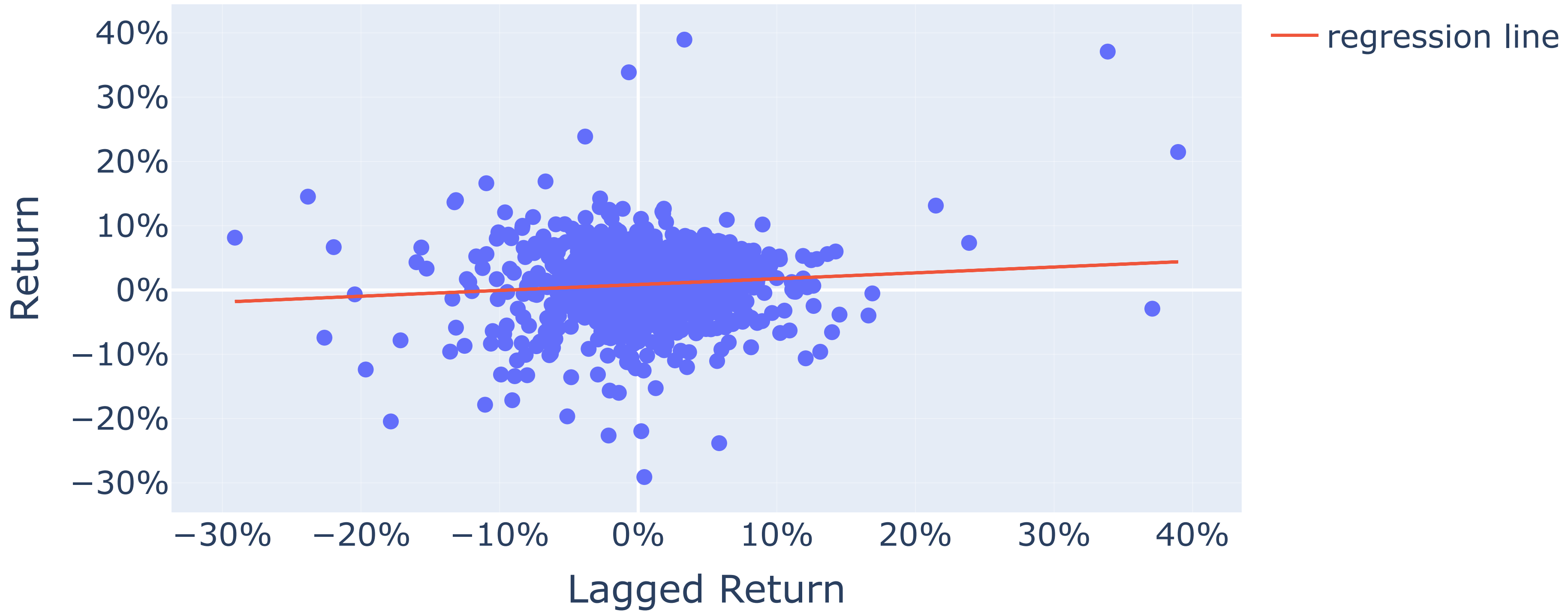
Empirical vs. normal distribution



Does last month's return predict this month's?



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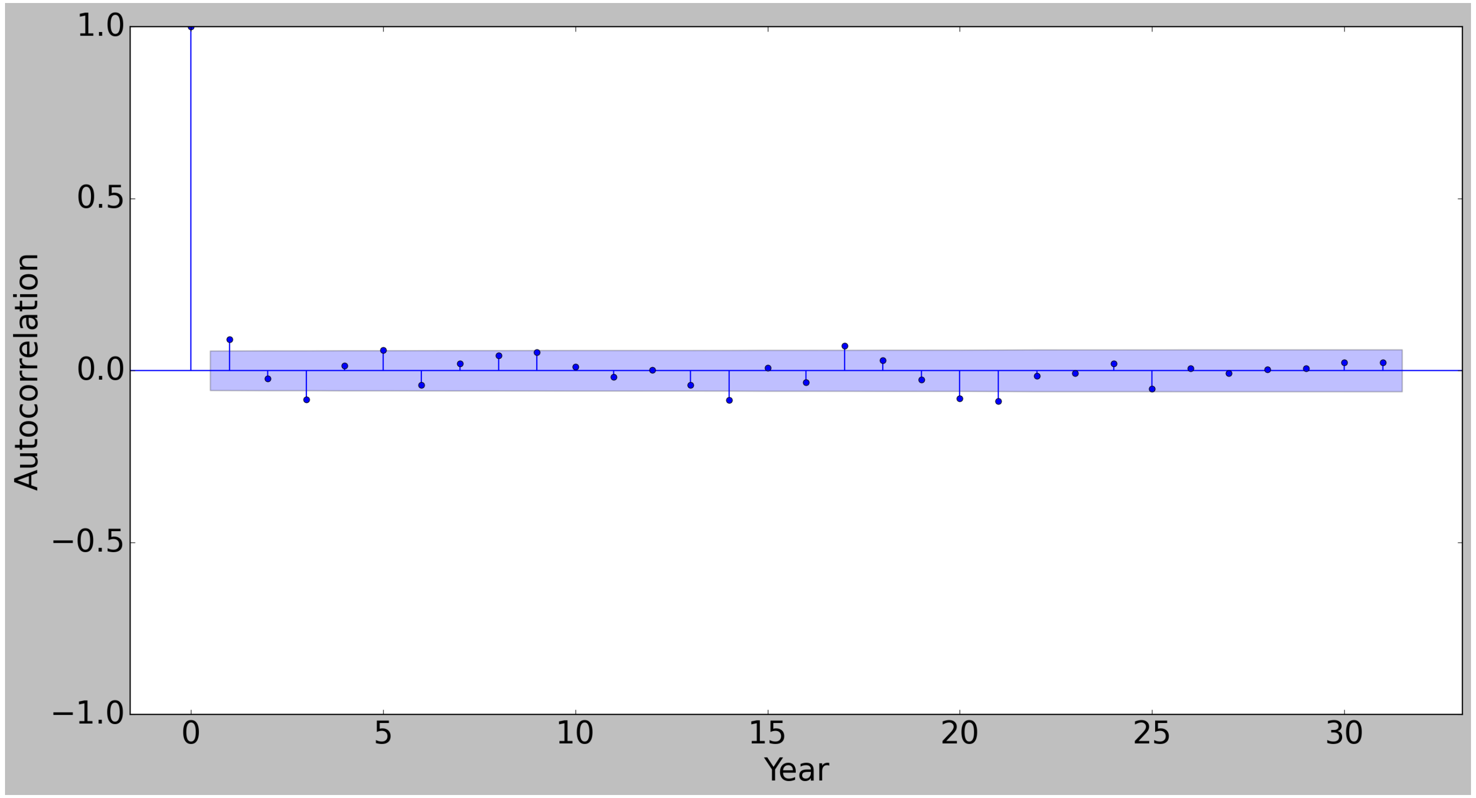
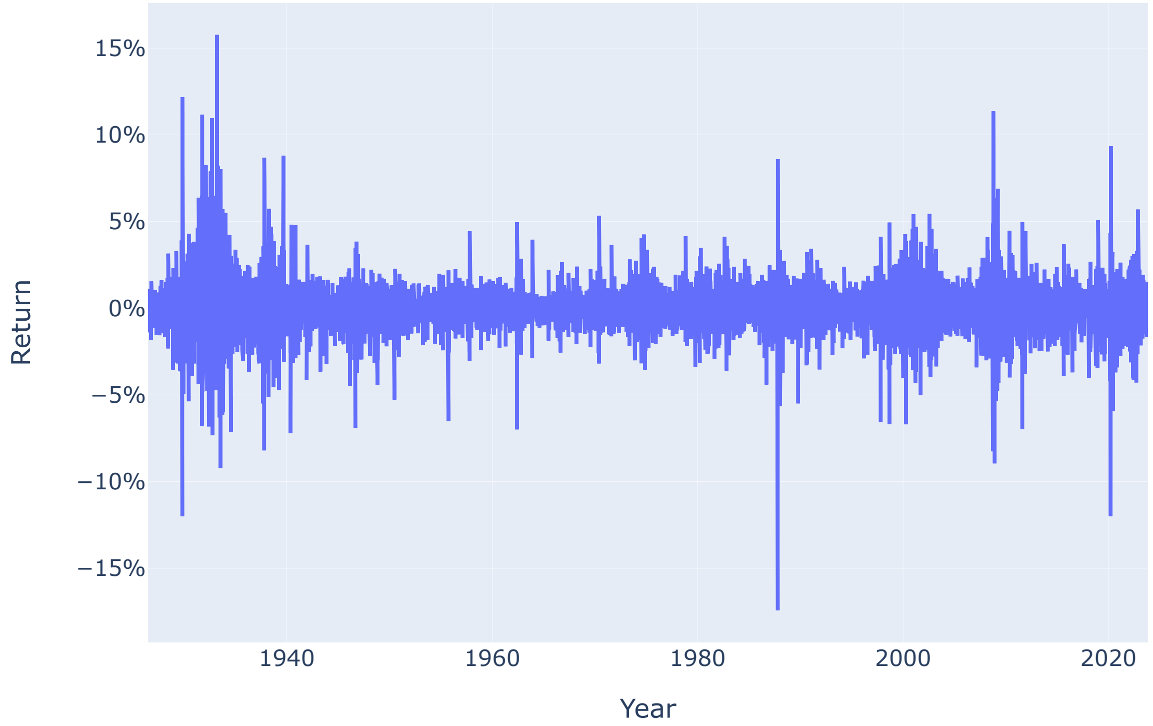
Autocorrelations



- For monthly data, autocorrelation might be high at lag 12 (seasonality).

Daily Returns

Daily market returns



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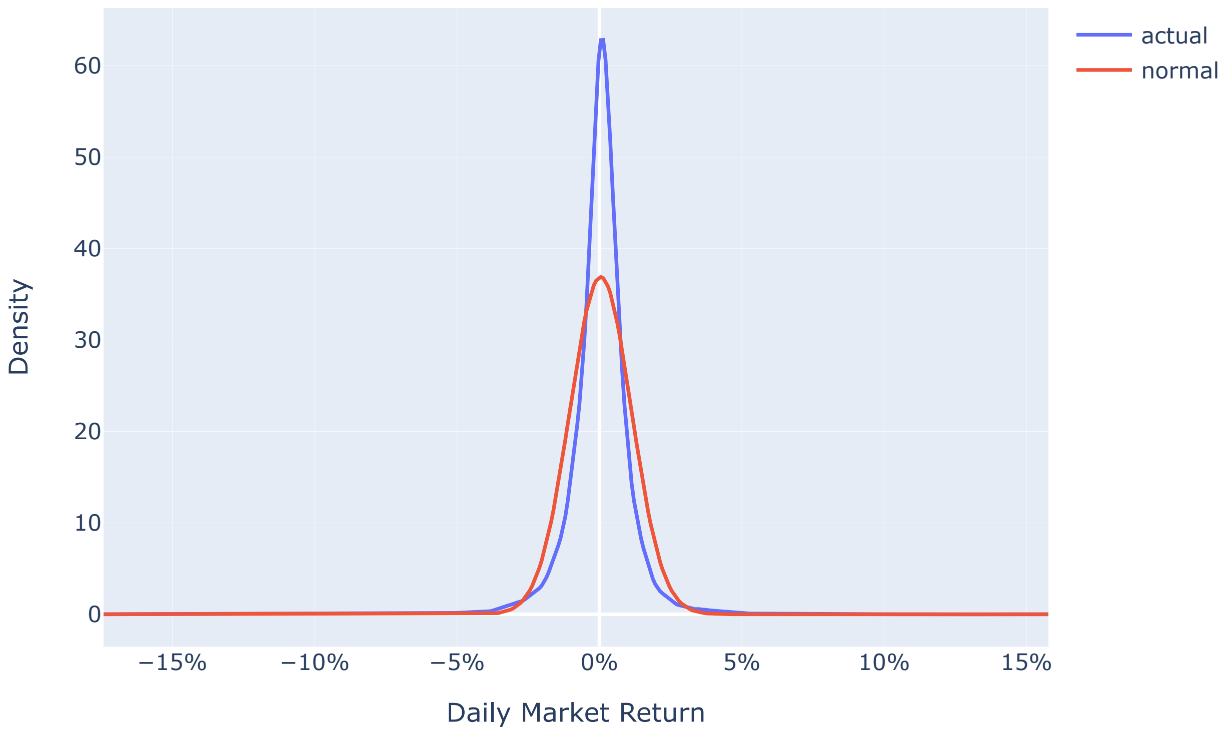
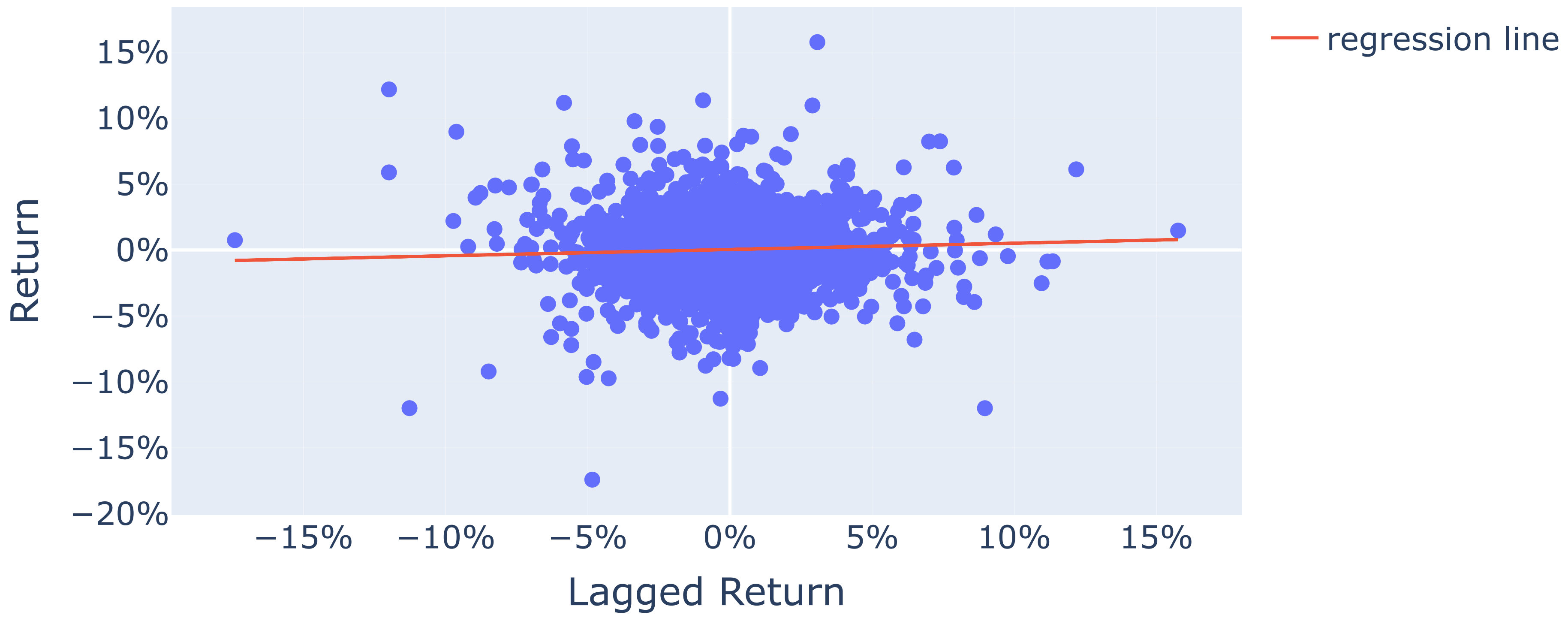
Empirical vs. normal distribution



Normal distribution has same mean and std dev as actual.
x-axis range is minimum to maximum return.

Does today's return predict tomorrow's?



No, the autocorrelation is almost zero.

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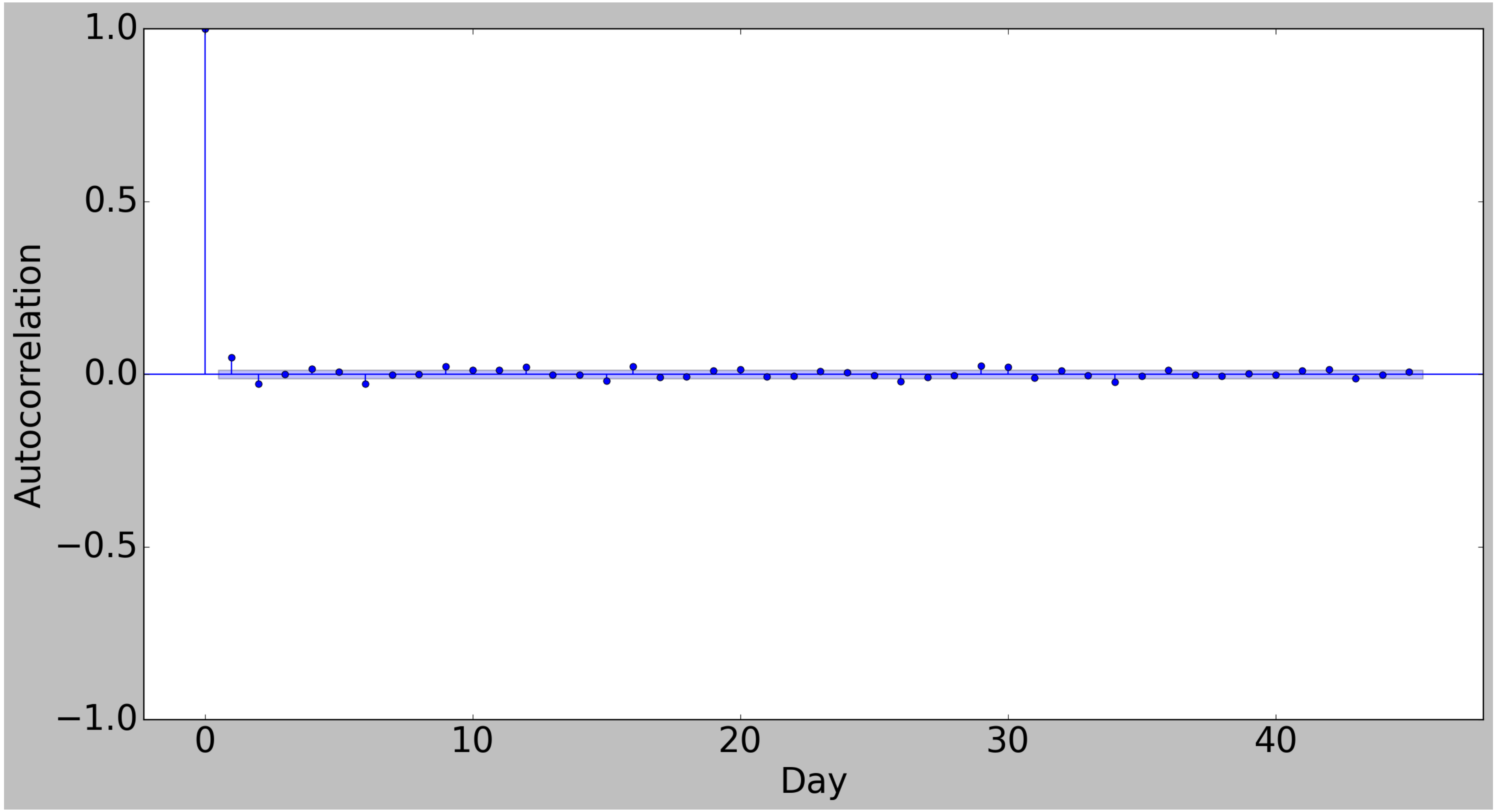
Autocorrelations of daily market returns



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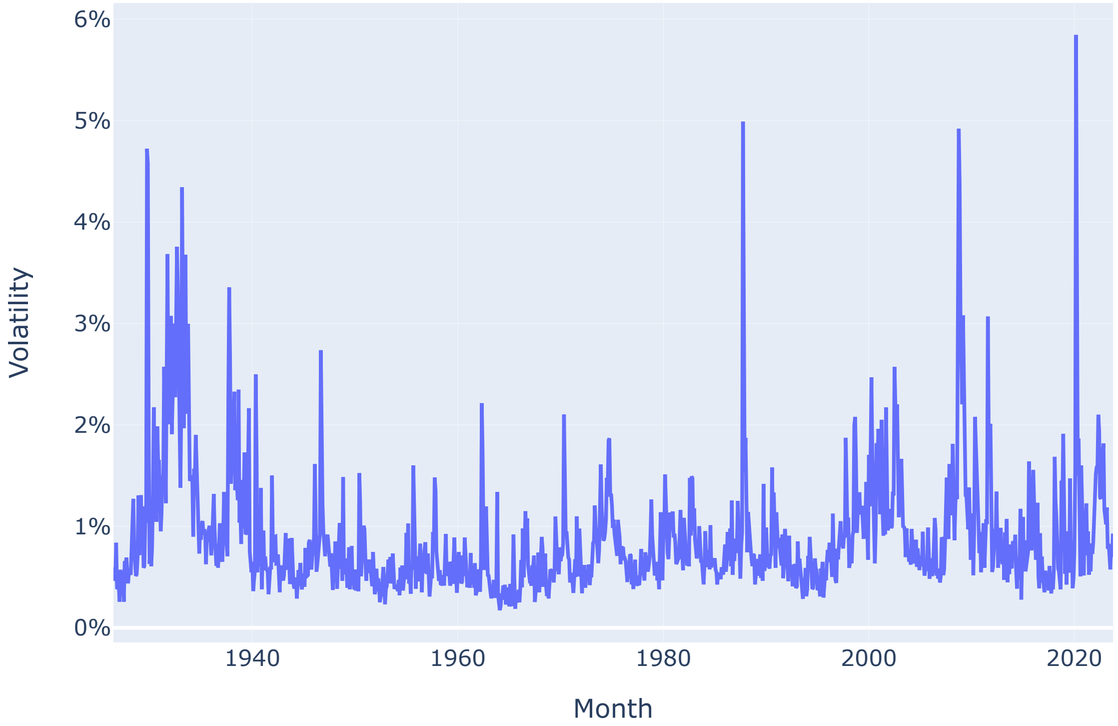
Volatility

Measuring volatility

1. Monthly series of SD(daily returns)
2. Daily series of absolute value of returns

Time-series of monthly volatility



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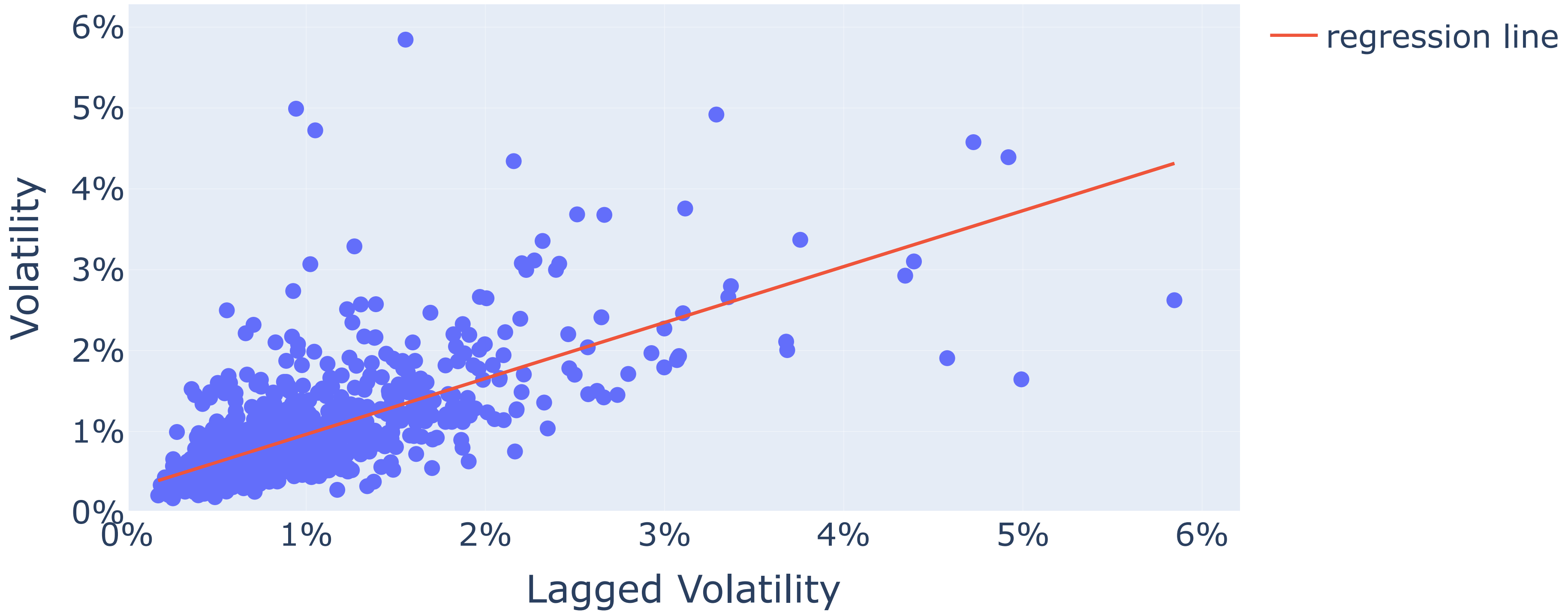
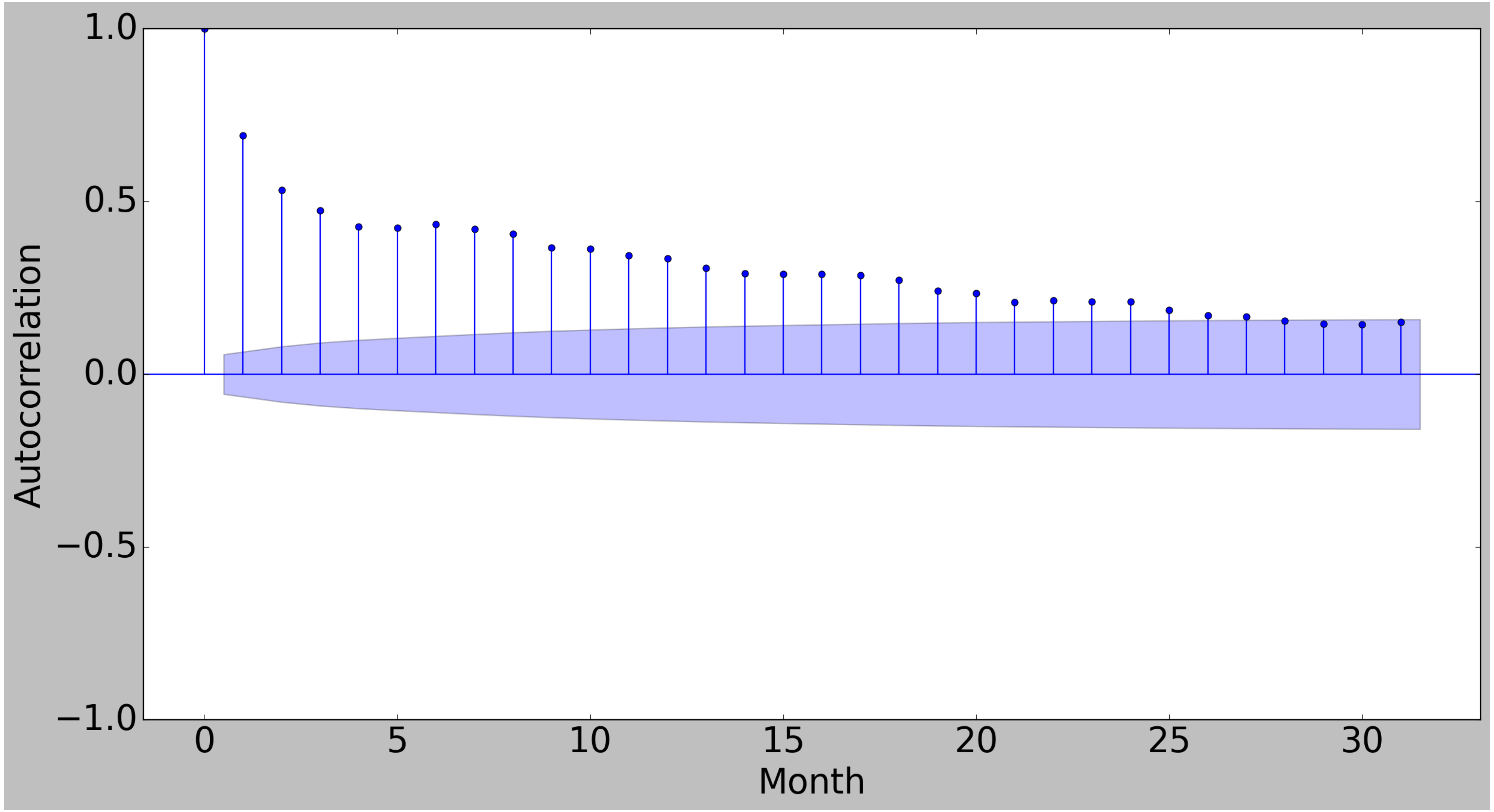
Does last month's SD(ret) predict this month's?



Autocorrelations of monthly volatility



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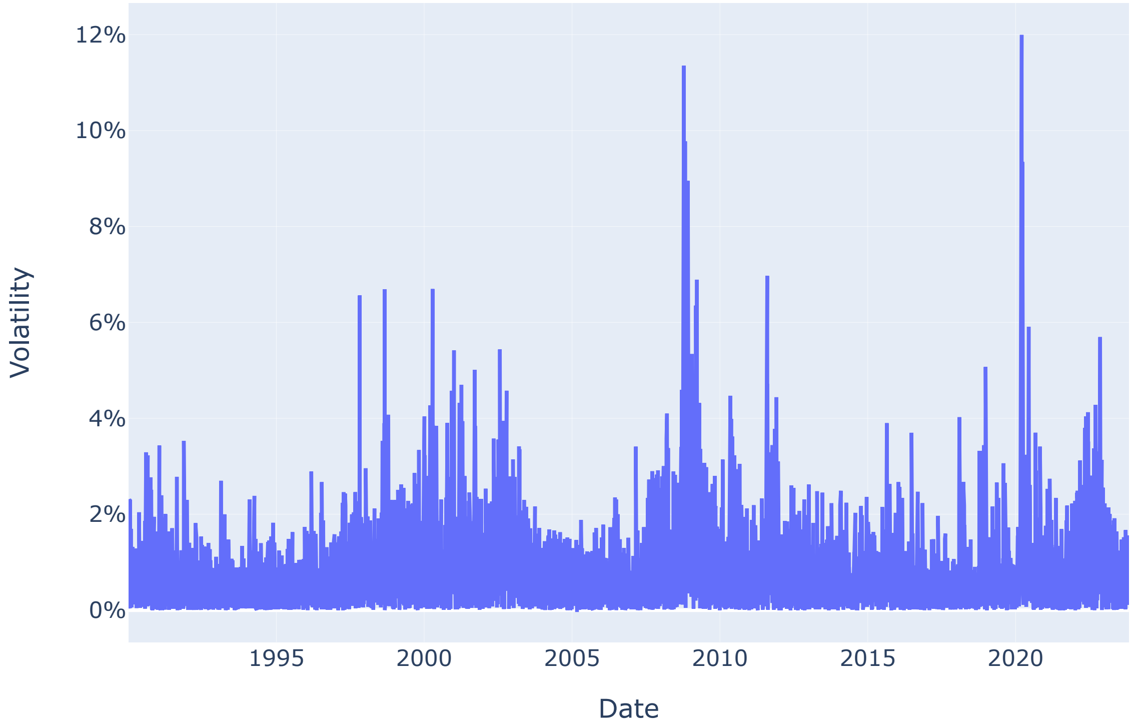
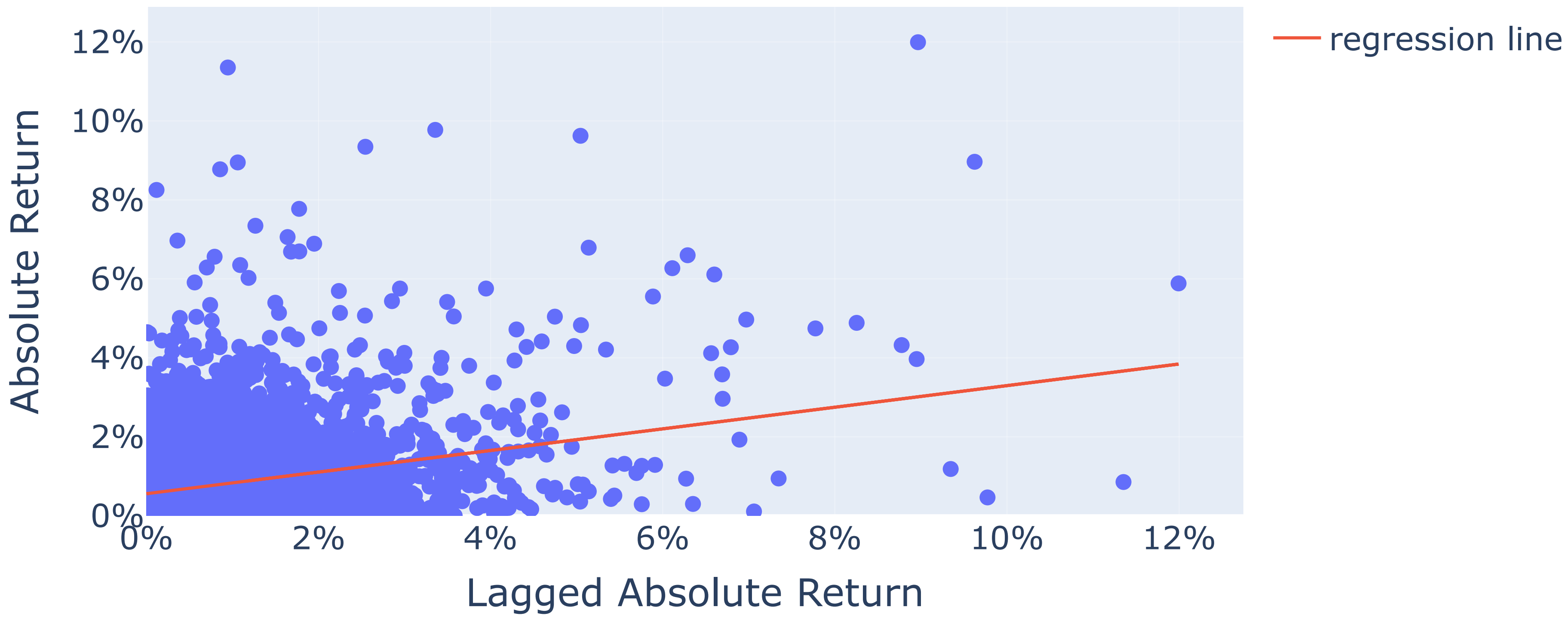
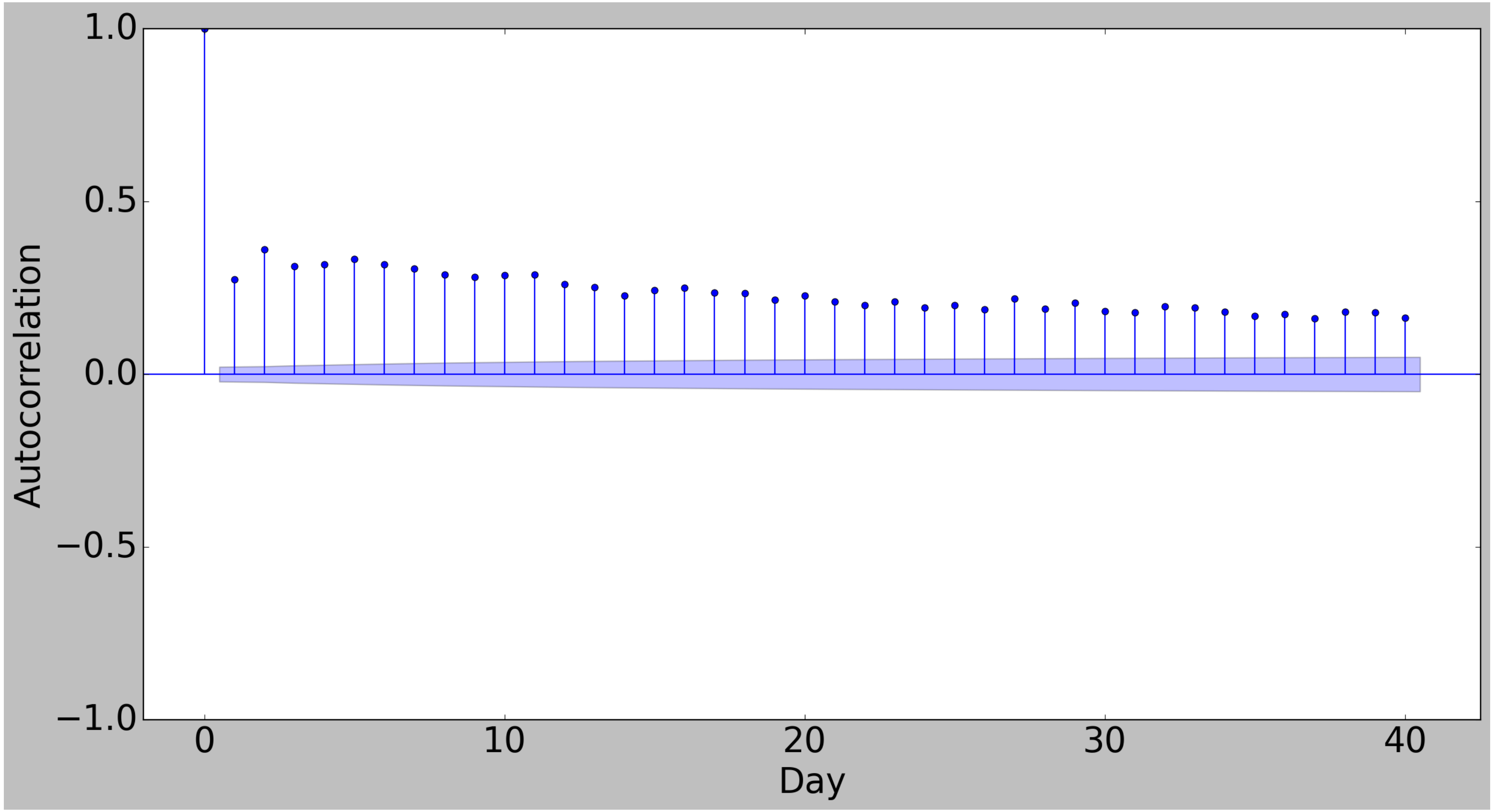
Time-series of daily absolute return



Does yesterday’s abs(ret) predict today’s?



Autocorrelations of daily absolute return



Long-Run Risks

Betting on the stock market

- Based on history, the bet is definitely in our favor.
- Play for a long time $\Rightarrow$ almost certainly come out ahead.
- But how far ahead is quite uncertain.
  - In **worst 20-year period** in U.S. stock market since 1926, **\$1 $\rightarrow$ \$1.73**, a geometric average return of 2.8% per year (1929-1948).
  - In **best 20-year period** since 1926, **\$1 $\rightarrow$ \$24.65**, a geometric average return of 17.4% per year (1980-1999).
- dashboard: best/worst

Saving with risky returns

- Let's revisit our savings problem with **uncertain** returns
- Mean and std dev of U.S. market return 1970-2021 was 12.5% and 17.4%.
- Simulate 20-year compounded returns.
- On average, what would $1 turn into?
- What is the median amount $1 turns into?

Monte Carlo Analysis: simulate returns

```
from scipy.stats import norm
MEAN, SD = 0.125, 0.174
N_SAVING = 20
PMT, PV  = 0.0, 1.0

def endbal(mean, sd, n_saving, pmt):
    acct = pd.DataFrame(dtype=float,columns=['begbal','return','capgain','deposit'
    acct.deposit = PMT
    acct['return'] = norm.rvs(loc=MEAN,scale=SD, size=N_SAVING)
    for t in acct.index:
        if t==1:
            acct.loc[t,'begbal'] = PV
        else:
            acct.loc[t,'begbal'] = acct.loc[t-1,'endbal']
        acct.loc[t,'capgain'] = acct.loc[t,'begbal']*acct.loc[t,'return']
        acct.loc[t,'endbal'] = acct.loc[t,'begbal'] + acct.loc[t,'capgain'] + acct
    return acct.loc[N_SAVING,'endbal']
```

Monte Carlo Analysis: simulate returns

```
NSIMS     = 1000
df = pd.DataFrame(dtype=float,columns=['endbal'], index=np.arange(NSIMS))
for s in df.index:
    df.loc[s,'endbal']=endbal(MEAN,SD,N_SAVING,PMT)
df.describe()

# More pythonic code
data = [endbal(MEAN,SD,N_SAVING,PMT) for s in np.arange(NSIMS)]
df = pd.DataFrame(data, columns=['endbal'])
```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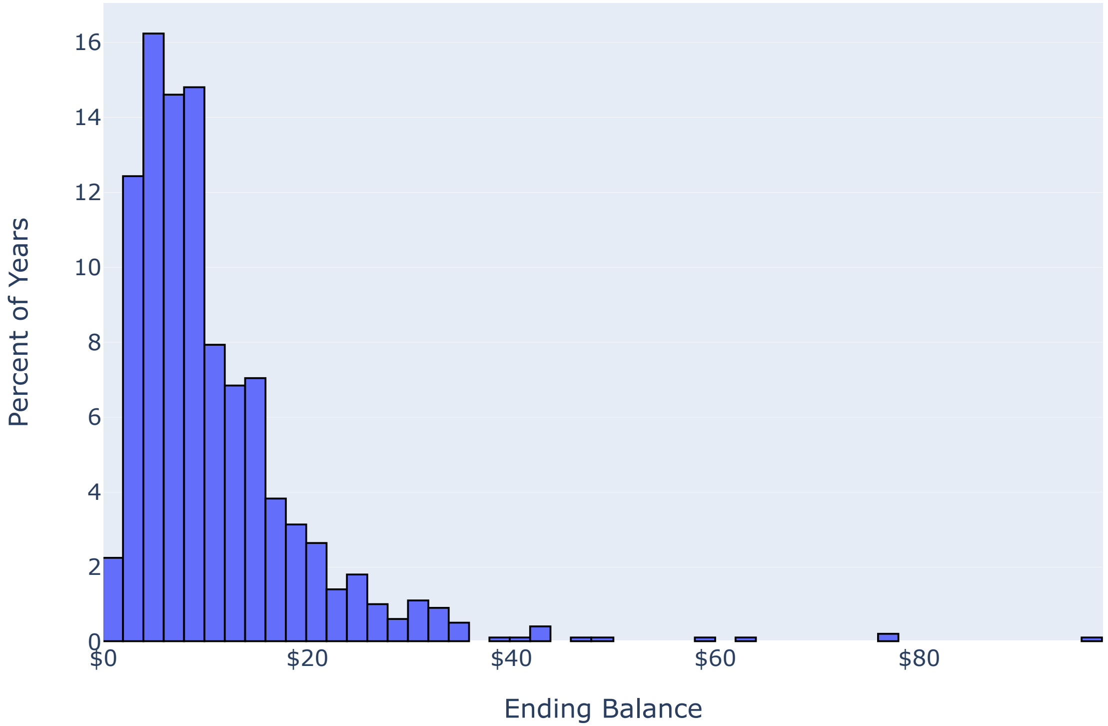
Distribution



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Retirement Planning Simulation

Uncertainty about long-run returns $\Rightarrow$ uncertainty about retirement plans.

- Revisit the retirement plan
- Generate random returns and simulate many lifetimes.
- dashboard: retirement planning

For next time: Treasury Markets