# Consequences of Fat Tailed Data

## Understanding Risk

Thomas Misikoff - Spring 2024

# Overview of Fat-Tailed Distributions

- larger skewness and kurtosis than normal distributions
- potentially infinite variance
- commonly observed in nature and markets
- difficult to work with
- impossible to rule-out

# TailRiskAnalyzer

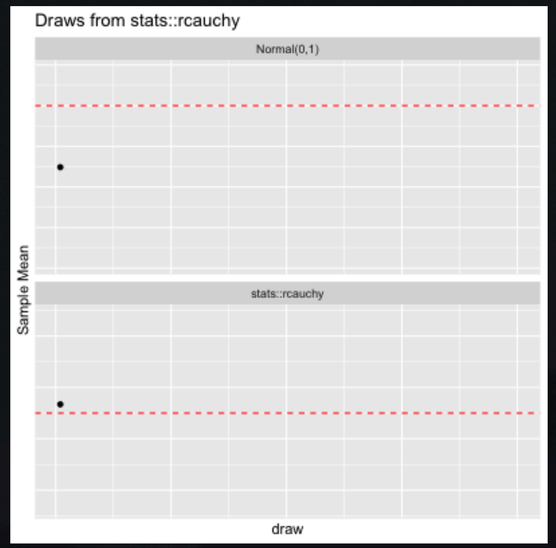
R package available at misikoff.github.io/TailRiskAnalyzer

- analyze distributions for "fat-tailedness", and understand the implications of "fat-tailedness"
- calculate the relative odds of data coming from a normal distribution compared to a distribution with heavier tails, e.g., Student's *t*-distribution, Pareto distribution, etc.
- determine optimal betting strategies using the Kelly Criterion
- plot outcome distributions for different betting strategies, highlighting the difference between median outcome and expected value, and ensemble averages compared to time averages

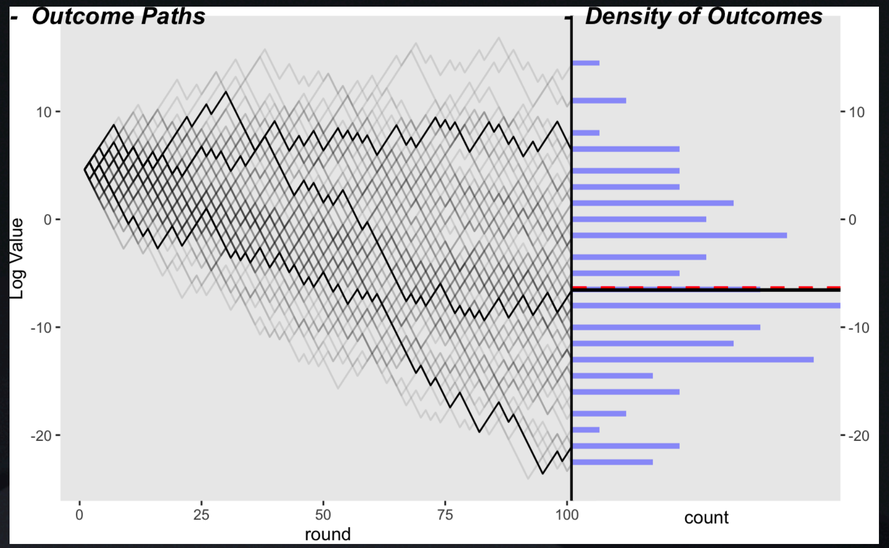
# Examples

## TailRiskAnalyzer Vignettes

### Law of Large Numbers



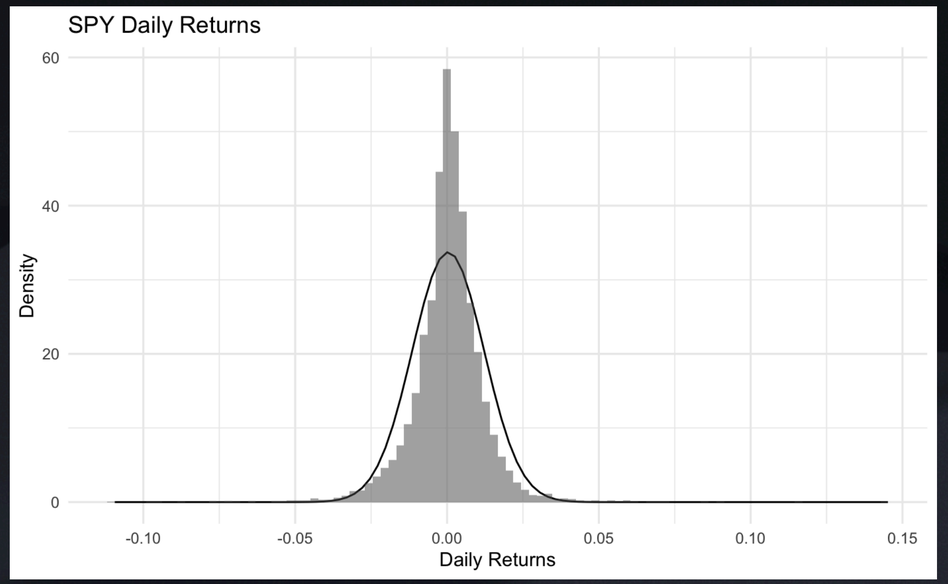

### Patterns in Geometric Growth



# Applications in Finance

## The S & P 500

- Stock market index tracking the 500 largest US companies listed on US stock exchanges in the US, by market capitalization
- Can be traded via index funds, like SPDR S&P 500 ETF Trust (SPY)
- Returns generally fat tailed
  - Kurtosis of S&P 500 daily returns: 14.25316




From Yahoo Finance

# Beating the Benchmark

## The S&P 500

- A classic "Buy & Hold" strategy
- How can this be improved?
- Insurance focused on raising the lower quantile and median outcomes —> lower risk and higher median returns

# Characteristics of Insurance

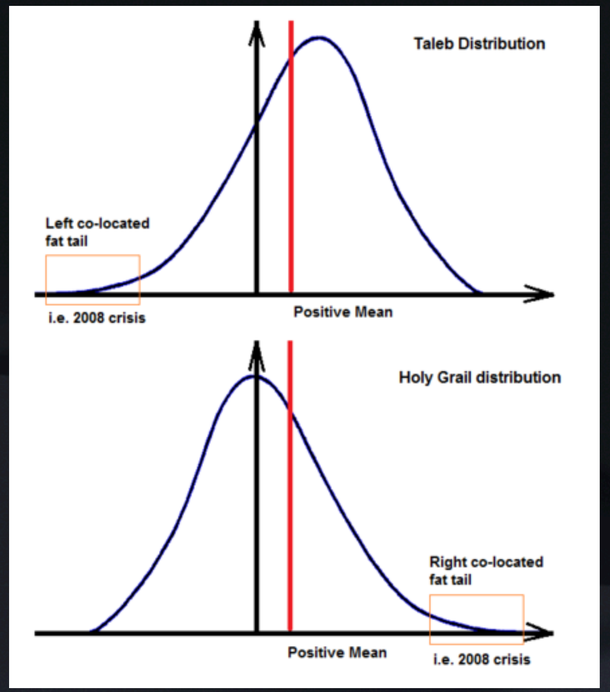
Predictable cost

Offset losses: partially, completely, or more than completely (insurance pays out more than the losses plus cost of contract)

Negative expected value

# Optimizing an Investing Strategy

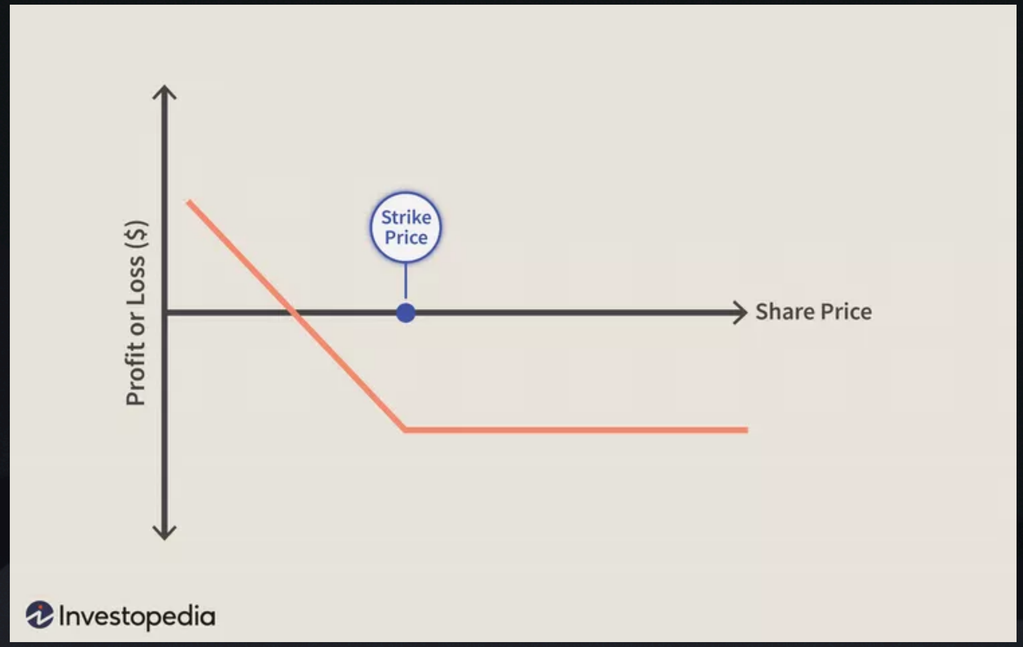
- From previous demonstrations using TailRiskAnalyzer show how the distribution of outcomes controlled by geometric growth can be affected by 'insurance', especially through impacts on the median outcome and lower quantiles.
- pair the S & P 500 with catastrophe insurance for a better payoff profile
  - OOM options w/ a "minus-Taleb" distribution



# Insurance Through Options

## Put Options

- Put options give the owner the right (not obligation) to sell the underlying asset at a predetermined price
- Limited downside (the cost of the option)
- Becomes profitable as stock decreases past strike price*
  *after accounting for transaction fees
- Since options have expiration dates, they must be bought and sold in cycles to maintain coverage
- Payoff profile
  - variable upside
  - fixed downside ( ≤ initial purchase price)



# Metrics

- Beta
  - measures volatility of a portfolio relative to volatility of the market

$$\beta_p = \frac{\mathrm{Cov}(r_p, r_m)}{\mathrm{Var}(r_m)}$$

- Treynor Ratio
  - measures return of the portfolio relative to volatility of portfolio

$$T_p = \frac{r_p - r_f}{B_p}$$

# Strategy

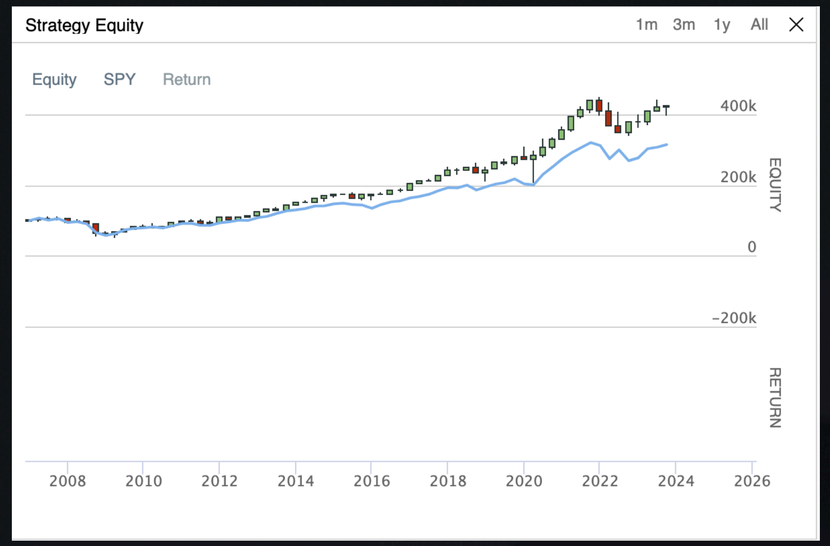
- Each month:
  - sell any held options
  - rebalance portfolio
    - 0.5%: options that will be gain value when SPY drops significantly
      - 30% OOM puts, 60-day expiration*
    - 95.5%: SPY

*based on writings from Mark Spitznagel

# Comparing the Baseline to the "Insured Strategy"

Implemented via QuantConnect

## SPY

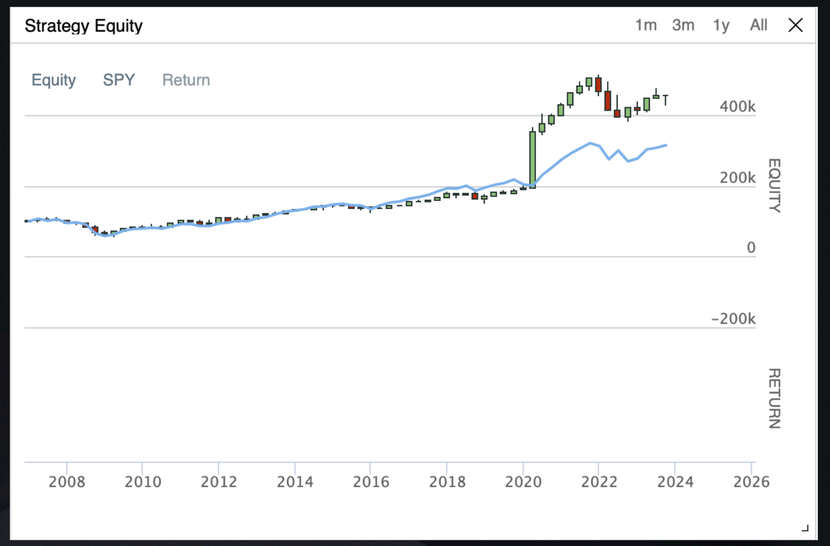



Return: 360.60%

Beta: 0.996

Treynor Ratio: 0.062

## SPY + Puts




Return: 388.68% ↑

Beta: 0.597 ↓↓

Treynor Ratio: 0.113 ↑↑↑

# 82%

Improvement in Treynor Score Achieved Through Insurance

# Conclusions

- better understanding of fat-tailed distributions can be built through software 'playgrounds' like TailRiskAnalyzer
- wide-ranging applications including adjusting payoff profiles in financial markets

# References


- Nassim Nicholas Taleb. (2020). Statistical Consequences of Fat Tails: Real World Preasymptotics, Epistemology, and Applications. Stem Academic Press.
- Mandelbrot, B. B., & Hudson, R. L. (2010). The (Mis)Behaviour of markets. Profile Books.
- Maclean, L. C., Thorp, E. O., & Ziemba, W. T. (2011). The Kelly capital growth investment criterion : theory and practice. World Scientific.
- Ole Peters. (2011). Optimal leverage from non-ergodicity, Quantitative Finance, 11:11, 1593-1602, DOI: 10.1080/14697688.2010.513338
- Ole Peters. (2019). The Ergodicity problem in economics. Nat. Phys. 15, 1216–1221. https://doi.org/10.1038/s41567-019-0732-0
- Ole Peters and Alexander Adamou. (2021). The Time interpretation of expected utility theory. arXiv.org
- Spitznagel, M. (2013). The Dao of capital : Austrian investing in a distorted world. Wiley.
- Spitznagel, M., & Taleb, N. N. (2021). Safe haven: investing for financial storms. Wiley.