

Annualized returns

INTRODUCTION TO PORTFOLIO ANALYSIS IN PYTHON



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Comparing returns

1. *Annual Return*: Total return earned over a period of one calendar year
2. *Annualized return*: Yearly rate of return inferred from any time period



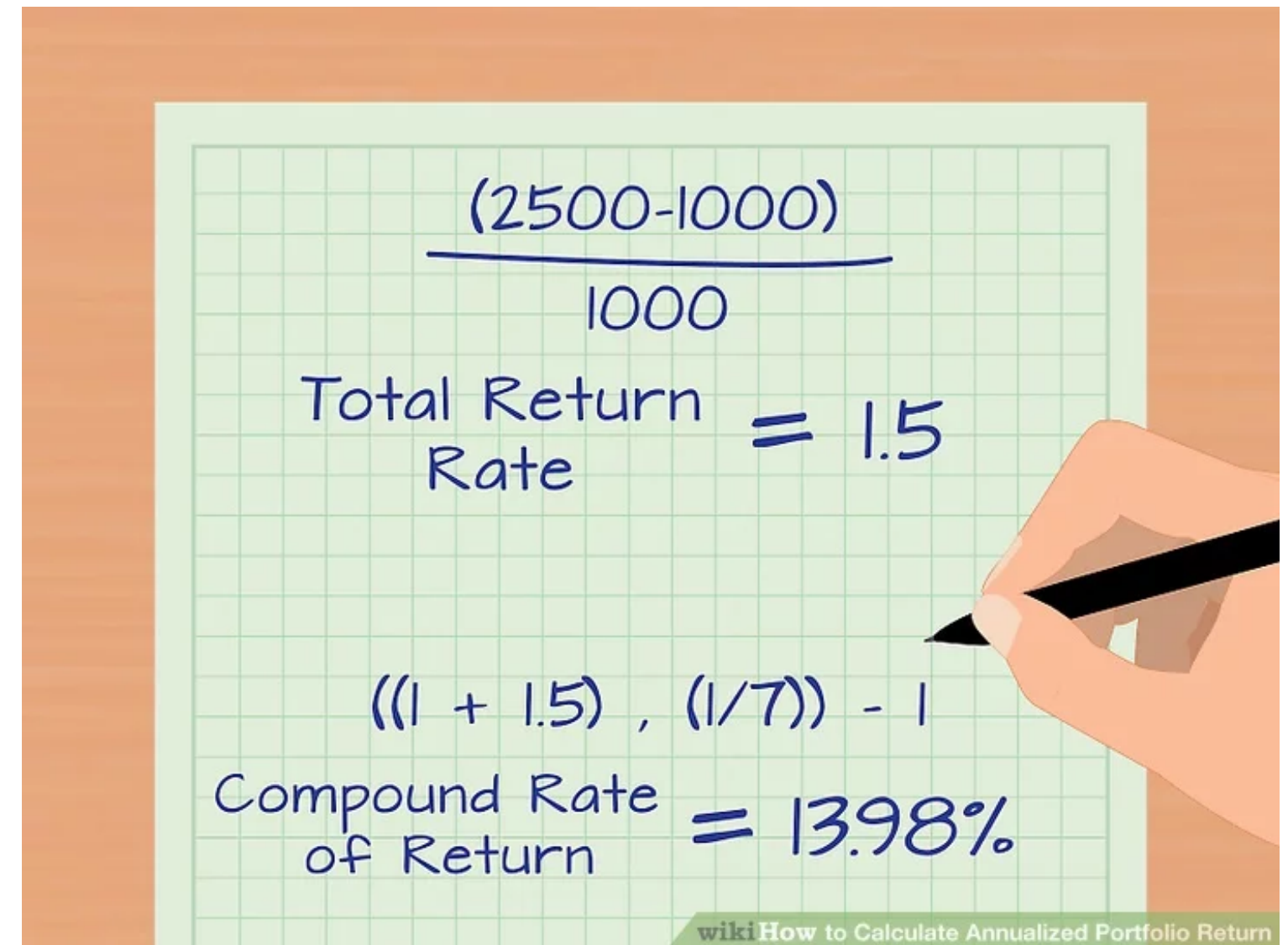
A hand-drawn illustration of a formula for Return on a green grid background. The text is written in a blue, hand-drawn font. The formula is:

$$\text{Return} = \frac{\text{Ending Value} - \text{Beginning Value}}{\text{Beginning Value}}$$

A hand holding a black pencil is shown on the right side of the grid, pointing towards the formula.

Comparing returns

1. *Average Return*: Total return realized over a longer period, spread out evenly over the (shorter) periods.
2. *Cumulative (compounding) return*: A return that includes the compounded results of re-investing interest, dividends, and capital gains.



The image shows a hand-drawn calculation on a grid background. A hand is holding a black pen, writing the formulas. The first formula calculates the Total Return Rate as $\frac{(2500-1000)}{1000} = 1.5$. The second formula calculates the Compound Rate of Return as $((1 + 1.5), (1/7)) - 1 = 13.98\%$. A small text at the bottom right reads "wikiHow to Calculate Annualized Portfolio Return".

$$\frac{(2500-1000)}{1000}$$

Total Return Rate = 1.5

$$((1 + 1.5), (1/7)) - 1$$

Compound Rate of Return = 13.98%

wikiHow to Calculate Annualized Portfolio Return

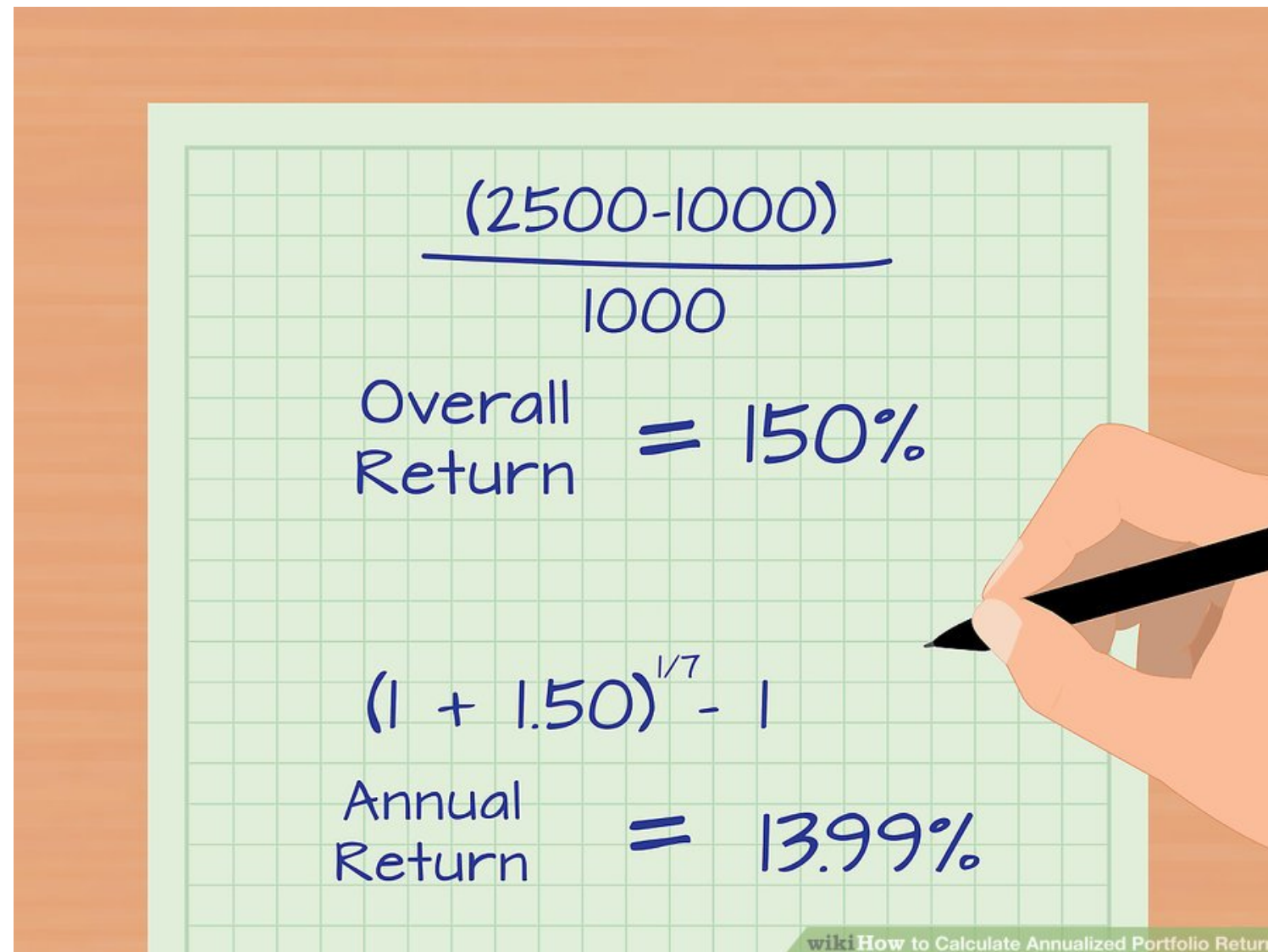
Why annualize returns?

Average return versus annualized return

	Value of the portfolio	Return
Year 1	\$100	
Year 2	\$200	100%
Year 3	\$100	-50%

- Average return = $(100 - 50) / 2 = 25\%$
- Actual return = 0% so average return is not a good measure for performance!
- How to compare portfolios with different time lengths?
- How to account for compounding effects over time?

Calculating annualized returns



- **N** in years:
 $rate = (1 + Return)^{1/N} - 1$
- **N** in months:
 $rate = (1 + Return)^{12/N} - 1$
- Convert any time length to an annual rate:
- **Return** is the total return you want to annualize.
- **N** is number of periods so far.

Annualized returns in python

```
# Check the start and end of timeseries  
apple_price.head(1)
```

```
date  
2015-01-06    105.05  
Name: AAPL, dtype: float64
```

```
apple_price.tail(1)
```

```
date  
2018-03-29    99.75  
Name: AAPL, dtype: float64
```

```
# Assign the number of months  
months = 38
```

Annualized returns in python

```
# Calculate the total return
total_return = (apple_price[-1] - apple_price[0]) /
               apple_price[0]

print (total_return)
```

```
0.5397420653068692
```

Annualized returns in python

```
# Calculate the annualized returns over months
annualized_return=((1 + total_return)**(12/months))-1
print (annualized_return)
```

```
0.14602501482708763
```

```
# Select three year period
apple_price = apple_price.loc['2015-01-01':'2017-12-31']
apple_price.tail(3)
```

```
date
2017-12-27    170.60
2017-12-28    171.08
2017-12-29    169.23
Name: AAPL, dtype: float64
```


Annualized return in Python

```
# Calculate annualized return over 3 years  
annualized_return = ((1 + total_return)**(1/3))-1  
  
print (annualized_return)
```

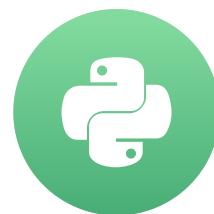
```
0.1567672968419047
```

Let's practice!

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Risk adjusted returns

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Choose a portfolio

Portfolio 1

- Annual return of 14%
- Volatility (standard deviation) is 8%

Portfolio 2

- Annual return of 6%
- Volatility is 3%

Risk adjusted return

- It defines an investment's return by measuring how much risk is involved in producing that return
- It's usually a ratio
- Allows you to objectively compare across different investment options
- Tells you whether the return justifies the underlying risk



Sharpe ratio

- Sharpe ratio is the most commonly used risk adjusted return ratio
- It's calculated as follows:
- $Sharpe\ ratio = \frac{R_p - R_f}{\sigma_p}$
- Where: R_p is the portfolio return, R_f is the risk free rate and σ_p is the portfolio standard deviation
- Remember the formula for the portfolio σ_p ?
- $\sigma_p = \sqrt{(Weights\ transposed)(Covariance\ matrix * Weights)}$

Annualizing volatility

- Annualized standard deviation is calculated as follows: $\sigma_a = \sigma_m * \sqrt{T}$
- σ_m is the measured standard deviation
- σ_a is the annualized standard deviation
- T is the number of data points per year
- Alternatively, when using variance instead of standard deviation; $\sigma_a^2 = \sigma_m^2 * T$

Calculating the Sharpe Ratio

```
# Calculate the annualized standard deviation
annualized_vol = apple_returns.std()*np.sqrt(250)
print (annualized_vol)

0.2286248397870068
```

```
# Define the risk free rate
risk_free = 0.01
```

```
# Calculate the sharpe ratio
sharpe_ratio = (annualized_return - risk_free) / annualized_vol
print (sharpe_ratio)

0.6419569149994251
```


Which portfolio did you choose?

Portfolio 1

- Annual return of 14%
- Volatility (standard deviation) is 8%
- Sharpe ratio of 1.75

Portfolio 2

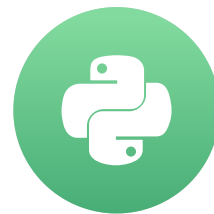
- Annual return of 6%
- Volatility is 3%
- Sharpe ratio of 2

Let's practice!

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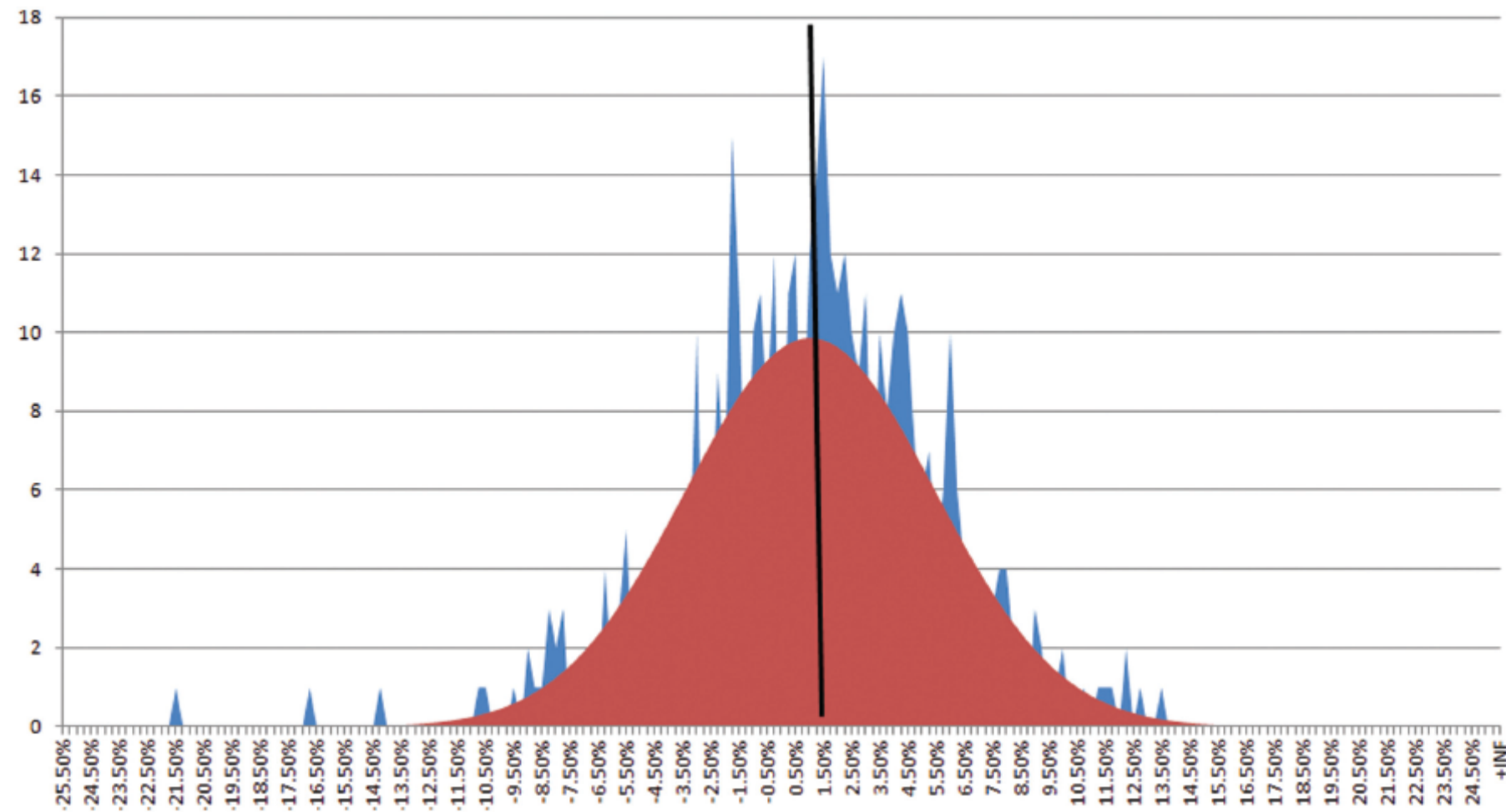
Non-normal distribution of returns

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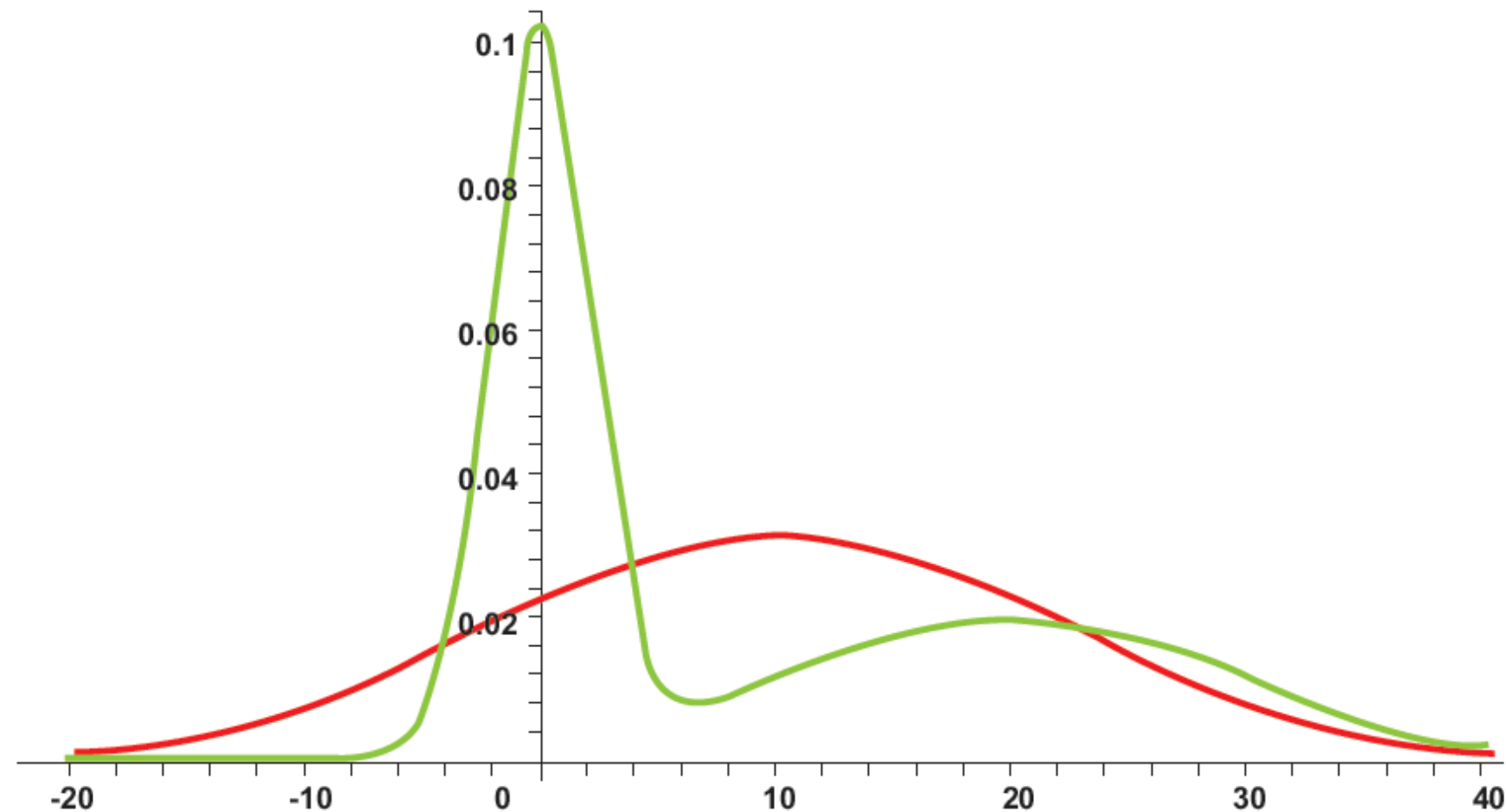
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In a perfect world returns are distributed normally



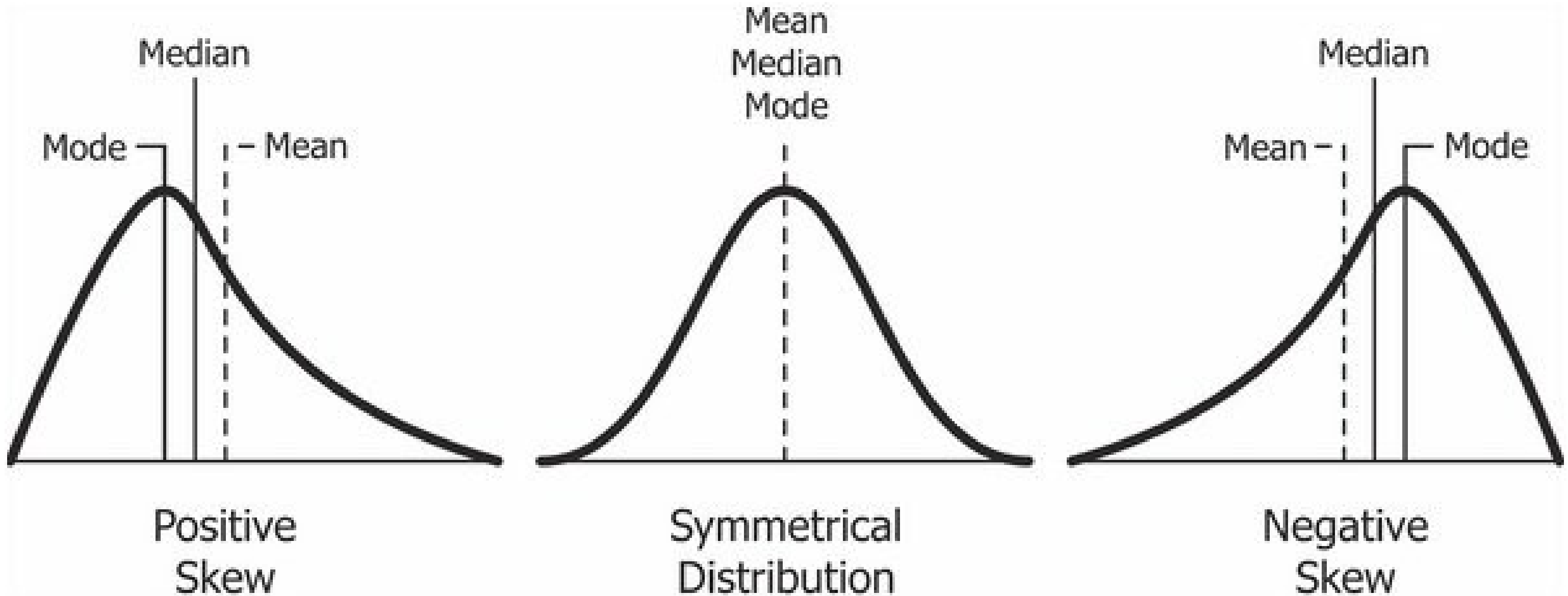
¹ Source: Distribution of monthly returns from the S&P500 from evestment.com

But using mean and standard deviations can be deceiving



¹ Source: “An Introduction to Omega, Con Keating and William Shadwick, The Finance Development Center, 2002

Skewness: leaning towards the negative



Pearson's Coefficient of Skewness

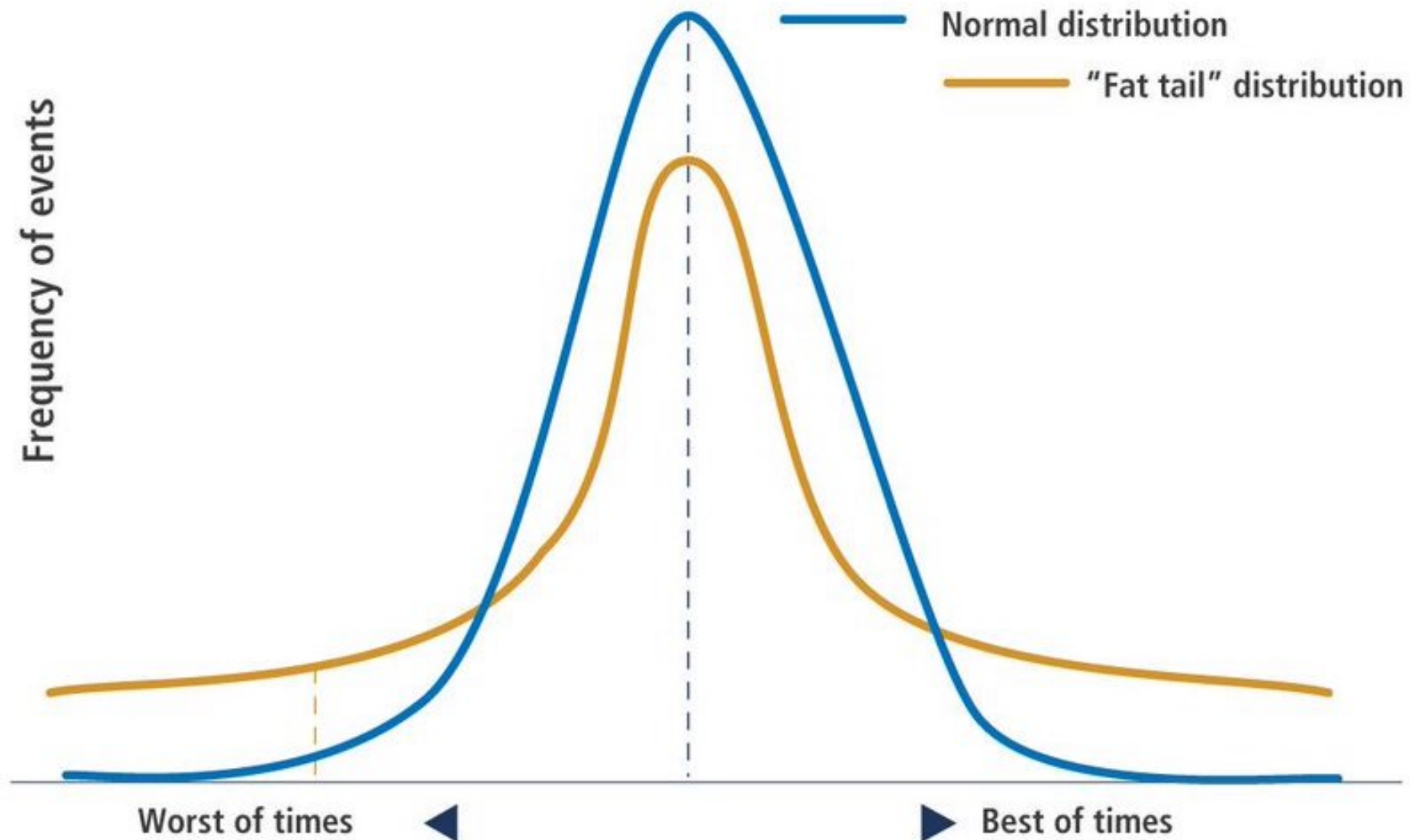
$$Skewness = \frac{3(mean - median)}{\sigma}$$

Rule of thumb:

- $Skewness < -1$ or $Skewness > 1 \Rightarrow$ Highly skewed distribution
- $-1 < Skewness < -0.5$ or $0.5 < Skewness < 1 \Rightarrow$ Moderately skewed distribution
- $-0.5 < Skewness < 0.5 \Rightarrow$ Approximately symmetric distribution

¹ Source: <https://brownmath.com/stat/shape.htm>

Kurtosis: Fat tailed distribution



¹ Source: Pimco

Interpreting kurtosis

“Higher kurtosis means more of the variance is the result of infrequent extreme deviations, as opposed to frequent modestly sized deviations.”

- A normal distribution has kurtosis of exactly 3 and is called (mesokurtic)
- A distribution with kurtosis <3 is called platykurtic. Tails are shorter and thinner, and central peak is lower and broader.
- A distribution with kurtosis >3 is called leptokurtic: Tails are longer and fatter, and central peak is higher and sharper (fat tailed)

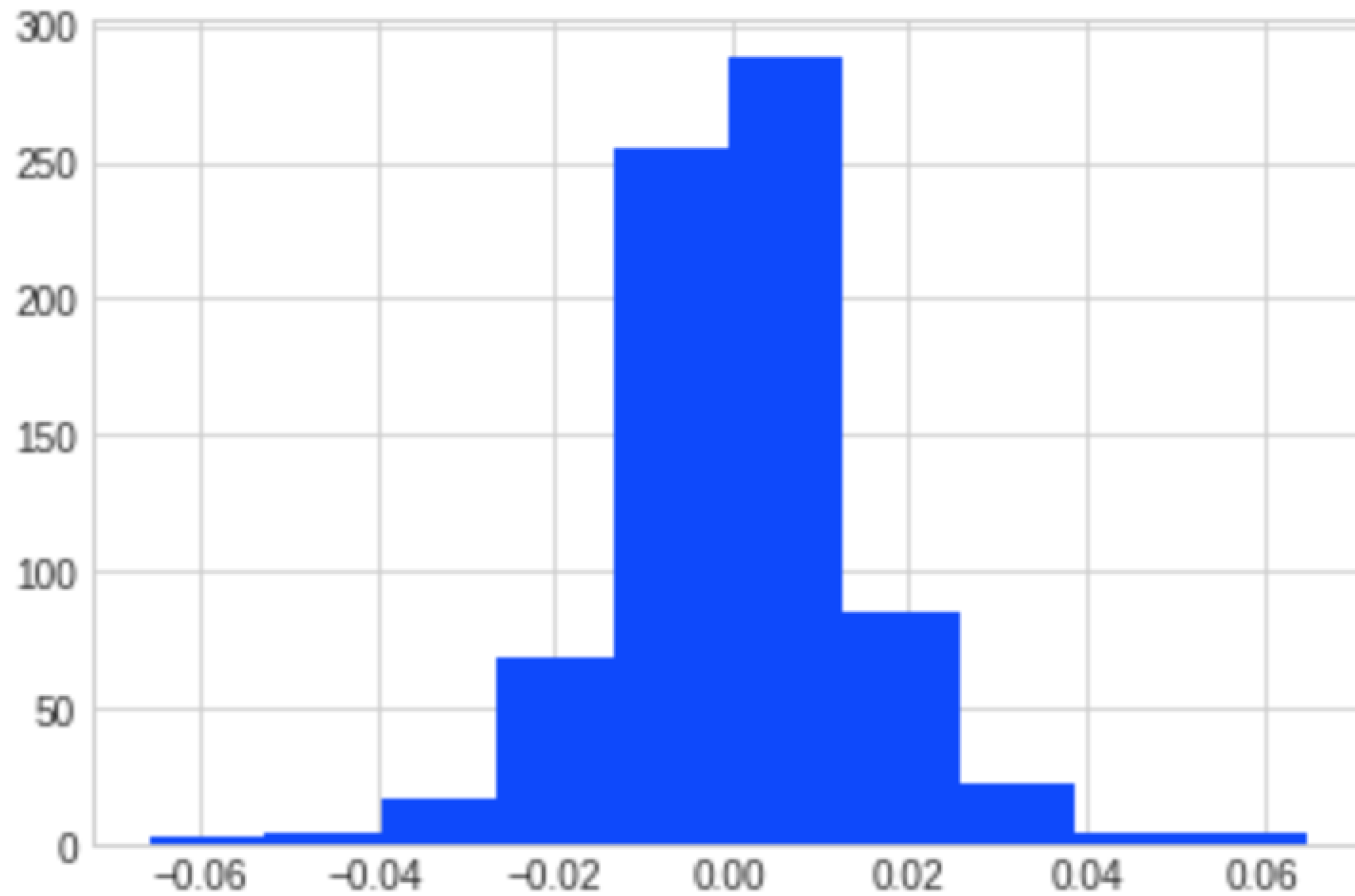
¹ Source: <https://brownmath.com/stat/shape.htm>

Calculating skewness and kurtosis

```
apple_returns=apple_price.pct_change()  
apple_returns.head(3)
```

```
date  
2015-01-02      NaN  
2015-01-05   -0.028172  
2015-01-06    0.000094  
Name: AAPL, dtype: float64
```

```
apple_returns.hist()
```



Calculating skewness and kurtosis

```
print("mean : ", apple_returns.mean())  
print("vol  : ", apple_returns.std())  
print("skew : ", apple_returns.skew())  
print("kurt : ", apple_returns.kurtosis())
```

```
mean :  0.0006855391415724799  
vol   :  0.014459504468360529  
skew  : -0.012440851735057878  
kurt  :  3.197244607586669
```

Let's practice!

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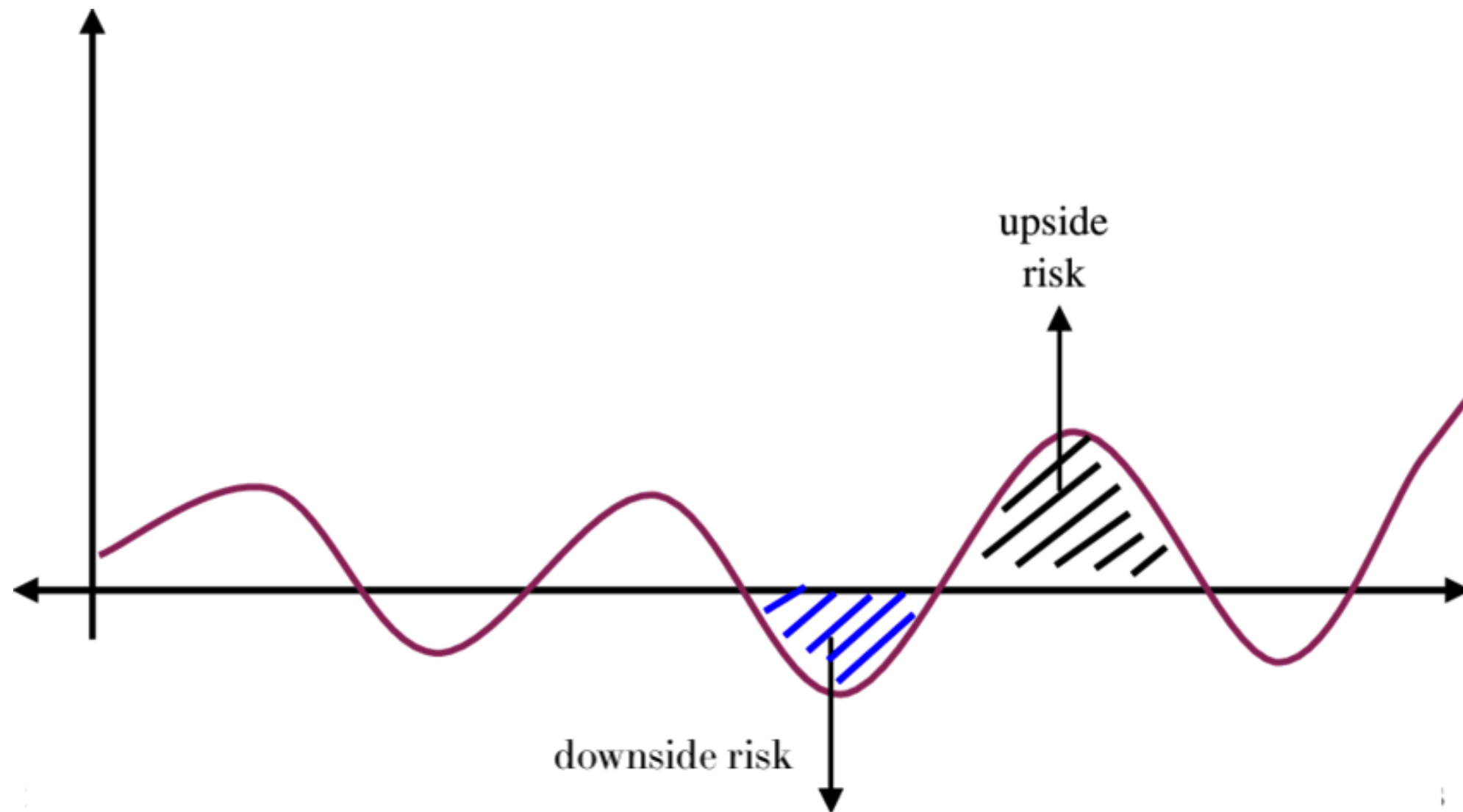
Alternative measures of risk

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Looking at downside risk



- A good risk measure should focus on potential losses i.e. downside risk

Sortino ratio

- Similar to the Sharpe ratio, just with a different standard deviation
- $Sortino\ Ratio = \frac{R_p - R_f}{\sigma_d}$
- σ_d is the standard deviation of the downside.

$$Downside\ risk = \sqrt{\frac{1}{n} \sum_{i=1}^n (return - target\ return)^2 f(t)}$$

$f(t) = 1$ if return < target return

$f(t) = 0$ if return \geq target return

Sortino ratio in python

```
# Define risk free rate and target return of 0
rfr = 0
target_return = 0
```

```
# Calculate the daily returns from price data
apple_returns=pd.DataFrame(apple_price.pct_change())
```

```
# Select the negative returns only
negative_returns = apple_returns.loc[apple_returns['AAPL'] < target]
```

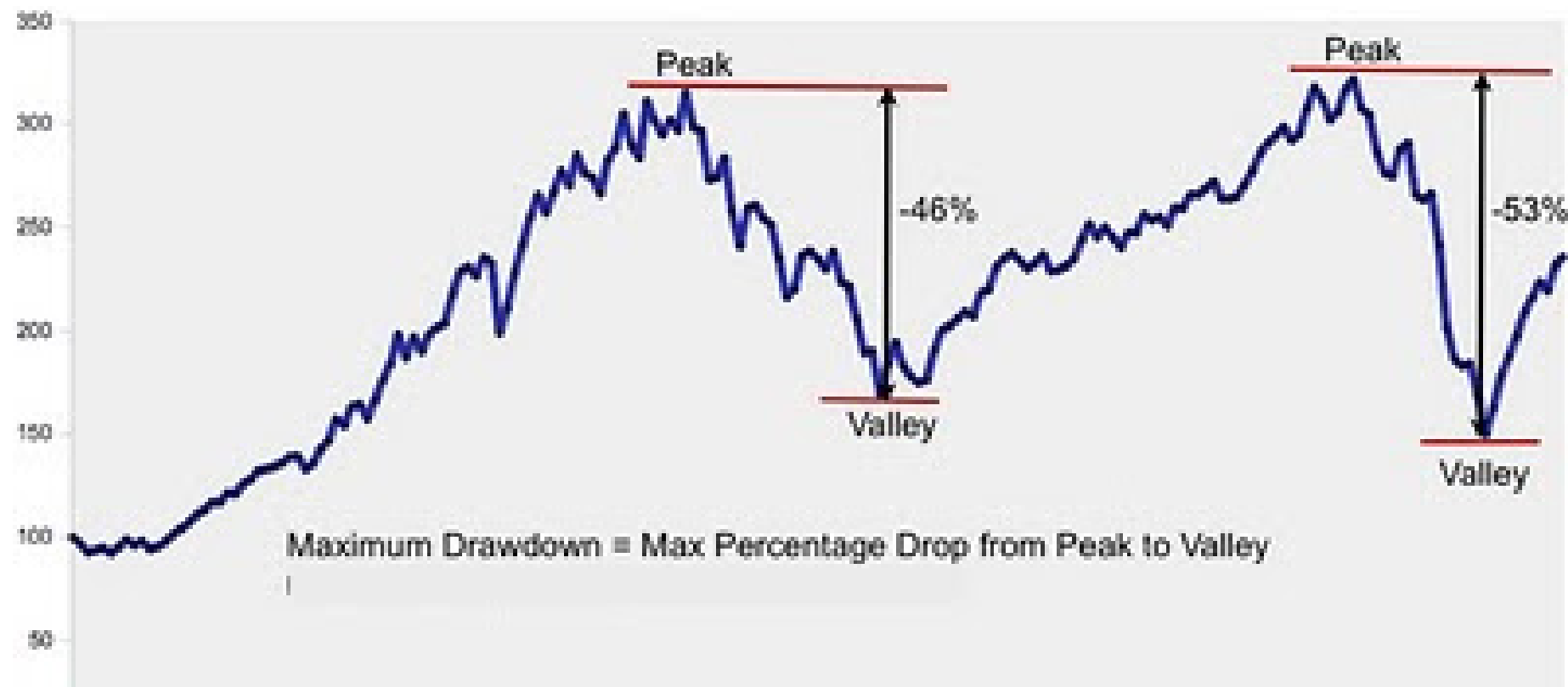
```
# Calculate expected return and std dev of downside returns
expected_return = apple_returns['AAPL'].mean()
down_stdev = negative_returns.std()
```

```
# Calculate the sortino ratio
sortino_ratio = (expected_return - rfr)/down_stdev
print(sortino_ratio)
```

```
0.07887683763760528
```

Maximum draw-down

- The largest percentage loss from a market peak to trough
- Dependent on the chosen time window
- The recovery time: time it takes to get back to break-even



Maximum daily draw-down in Python

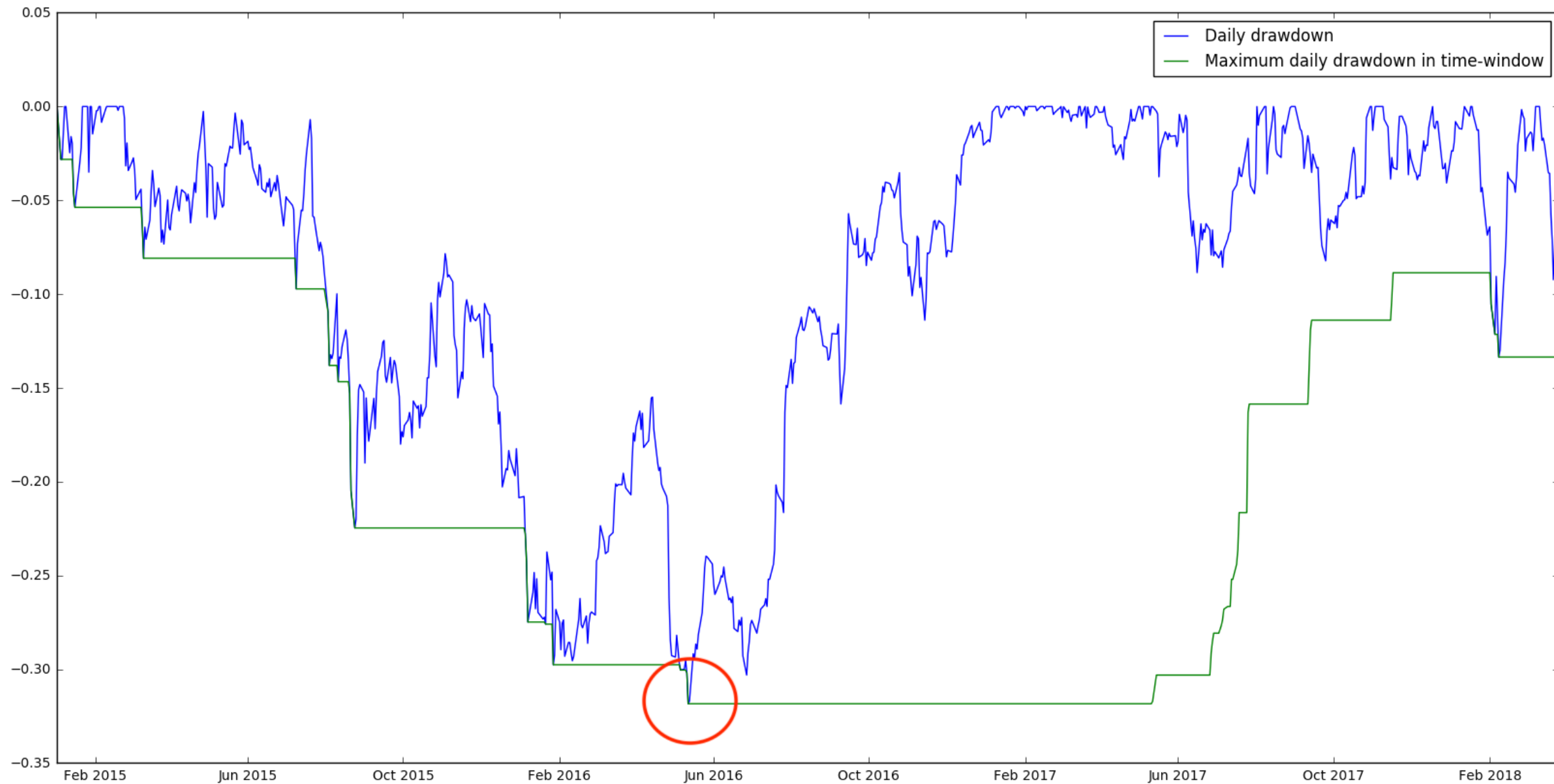
```
# Calculate the maximum value of returns using rolling().max()
roll_max = apple_price.rolling(min_periods=1,window=250).max()

# Calculate daily draw-down from rolling max
daily_drawdown = apple_price/roll_max - 1.0

# Calculate maximum daily draw-down
max_daily_drawdown = daily_drawdown.rolling(min_periods=1,window=250).min()

# Plot the results
daily_drawdown.plot()
max_daily_drawdown.plot()
plt.show()
```

Maximum draw-down of Apple



Let's practice!

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