Statistical Properties of Asset Returns (2018–2025)

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August 27, 2025

Abstract

This paper explores the fundamental statistical properties of financial market returns using daily price data from major U.S. stocks and indices between 2018 and 2025. The study demonstrates how to collect data, compute returns and log-returns, analyze volatility, and evaluate correlations between assets. While financial analysis is often presented in complex, technical language, this report is designed to be accessible even to beginners, including students with little or no prior exposure to finance. Through charts, rolling statistics, and basic description measures such as skewness and kurtosis, we highlight key features of market behavior: volatility clustering, time-varying correlations, and the non-normal distribution of returns. These insights provide a foundation for more advanced quantitative finance methods such as forecasting, risk management, and trading system development.

1. Introduction

Financial markets may seem intimidating, but at their core they are just systems where people buy and sell assets like stocks, bonds, and currencies. Each day, the price of these assets moves up or down, and those movements are what traders, investors, and researchers analyze.

One of the most important questions in finance is: "How risky is this asset?" To answer this, we cannot simply look at prices directly — we need to look at returns, or how much the price changes relative to its previous value. Returns capture both gains and losses and allow us to compare across different assets.

This study focuses on three basic but essential ideas:

1. Returns and log-returns – ways to measure price changes.
2. Volatility and rolling statistics – understanding how risk varies over time.
3. Correlations – measuring how assets move together (important for diversification)

By studying these ideas, we take the first steps toward becoming a quantitative trade: someone who uses math, statistics, and coding to analyze markets.

2. Data

We collected daily price data from Yahoo Finance for five popular assets between January 2018 and January 2025:

- AAPL – Apple Inc. (Technology Stock)
- MSFT – Microsoft Corp. (Technology Stock)
- GOOG – Alphabet/Google (Technology Stock)
- TSLA – Tesla Inc. (Automative/EV Stock)
- SPY – SPDR S&P 500 ETF (represents the overall U.S. stock market)

For this study, we used the daily Closing Price. Normally, financial researchers prefer the Adjusted Close (which accounts for dividends and stock splits), as it gives a more precise measure of total returns. However, for these tickers, Yahoo Finance did not provide an Adjusted Close column, only raw Close values.

Since our focus is on relative daily price changes rather than the total return (including dividends), using the Closing Price is sufficient for computing returns, log-returns, rolling volatility, and correlations. This choice does not materially affect the statistical properties being studied.

3. Methodology

3.1 Returns and Log-Returns

- Simple Return (**r**t):

$$r_t = \frac{P\iota - P\iota - 1}{P\iota - 1}$$

Where P□ is today’s price and P□ - 1 is yesterday’s price.

- Log Returns (ℓt):

$$\ell_t = ln\left(\frac{P\iota}{P\iota - 1}\right)$$

Log-returns are often preferred because they are easier to work with mathematically and they add up over time

Example: If Apple's price went from $100 to $101, the return is 1%. The log-return is very close to 1% too, but when prices fluctuate a lot, log-returns give a more accurate picture of compounded growth.

3.2 Rolling Statistics

Markets are not stable – some periods are calm, others are stormy. To capture this, we use rolling windows (e.g., 30 days) to compute:

- Rolling mean (average return)
- Rolling volatility (standard deviation of returns, often annualized)
- Rolling correlations (how two assets move together over time)

3.3 Distribution Analysis

If returns were perfectly "normal" (bell curve), we could easily predict risk. But in reality, financial returns show:

- Fat tails → extreme events happen more often than expected.
- Skewness → returns are not perfectly symmetric.
- Kurtosis → the distribution has heavier peaks and tails than a normal curve.

These features make financial markets riskier than they may first appear.

4. Results

4.1 Prices and Returns

- SPY shows a steady upward trend over the period, reflecting U.S. market growth.
- Tesla (TSLA) shows extreme ups and downs, consistent with its reputation as a volatile stock.
- Apple (AAPL) and Microsoft (MSFT) generally trend upward, but with noticeable dips during market-wide selloffs (e.g., COVID crash in 2020).

4.2 Rolling Volatility

- Volatility spikes during crises (e.g., March 2020 pandemic shock).
- Tesla's volatility is consistently higher than Apple and Microsoft.
- Volatility "clusters" – quiet periods are followed by more quiet periods, while turbulent times are followed by more turbulence.

4.3 Rolling Correlation

- AAPL and MSFT are highly correlated (>0.6 most of the time), reflecting both being tech giants.
- Correlations fluctuate, dropping during periods of market stress. This shows diversification benefits may shrink when you need them most.

4.4 Distribution of Returns

- Histograms of returns show fat tails compared to a normal curve.
- Apple's daily returns have a slight negative skew (more extreme drops than jumps).
- Kurtosis values > 3 confirm "heavy tails," meaning market shocks are more common than a normal distribution predicts.

5. Discussion

These findings illustrate why quantitative finance is necessary. Markets are not stable, predictable systems – they are noisy, volatile, and full of surprises. A naive assumption that "returns follow a bell curve" would underestimate risk and lead to poor investment decisions.

For a beginner, the key takeaways are:

1. Returns matter more than price. Price charts look impressive, but returns reveal risk and reward.
2. Volatility changes over time. Risk is not constant; it clusters in crises.
3. Diversification has limits. Assets that usually move independently can crash together.
4. Markets are not normal. Extreme events are more common than the textbook "bell curve."

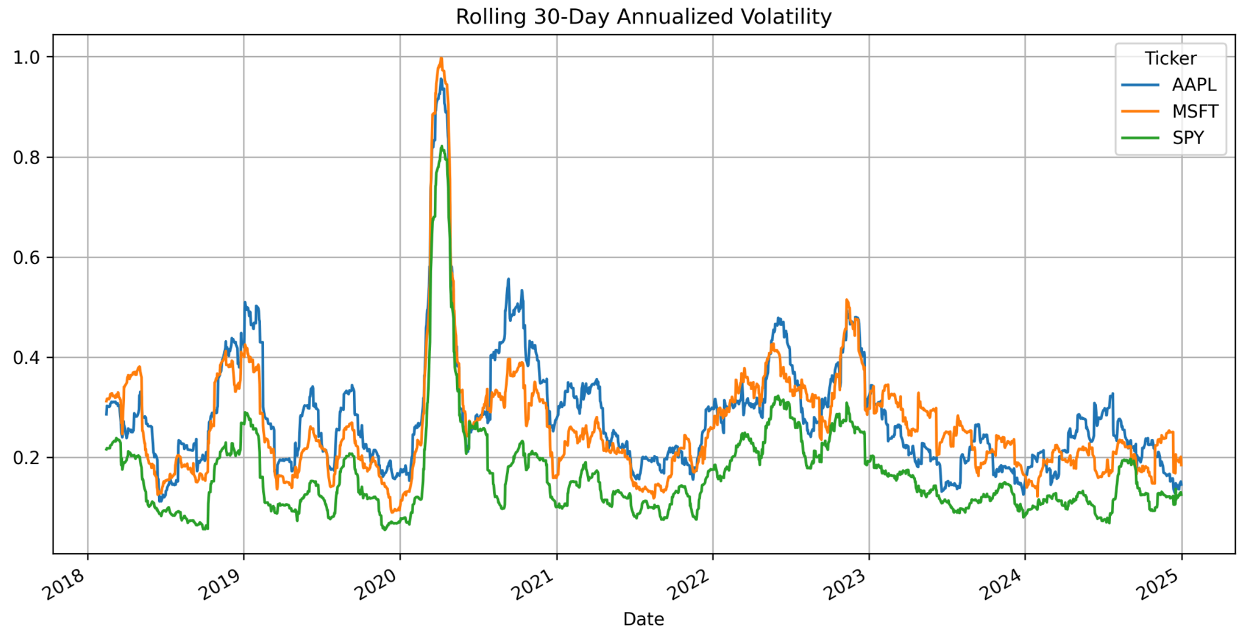
6. Conclusion

This project introduced the core statistical properties of asset returns, accessible to anyone – even without a finance background. By learning how to fetch data, calculate returns, measure volatility, and explore correlations, we establish a foundation for more advanced quantitative methods.

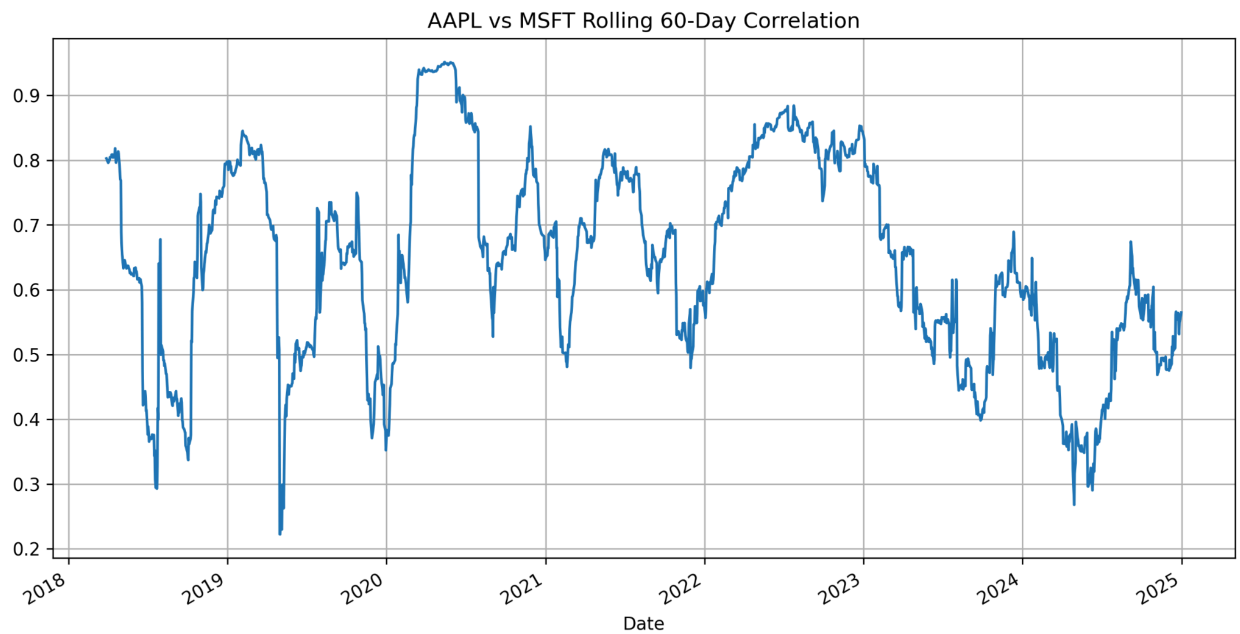
The insights gained here connect directly to future projects in forecasting (ARIMA), volatility modeling (GARCH), and trading strategies (pairs trading, machine learning). This first step shows that with the right tools, even complex markets can be analyzed and understood systematically.

7. Appendix

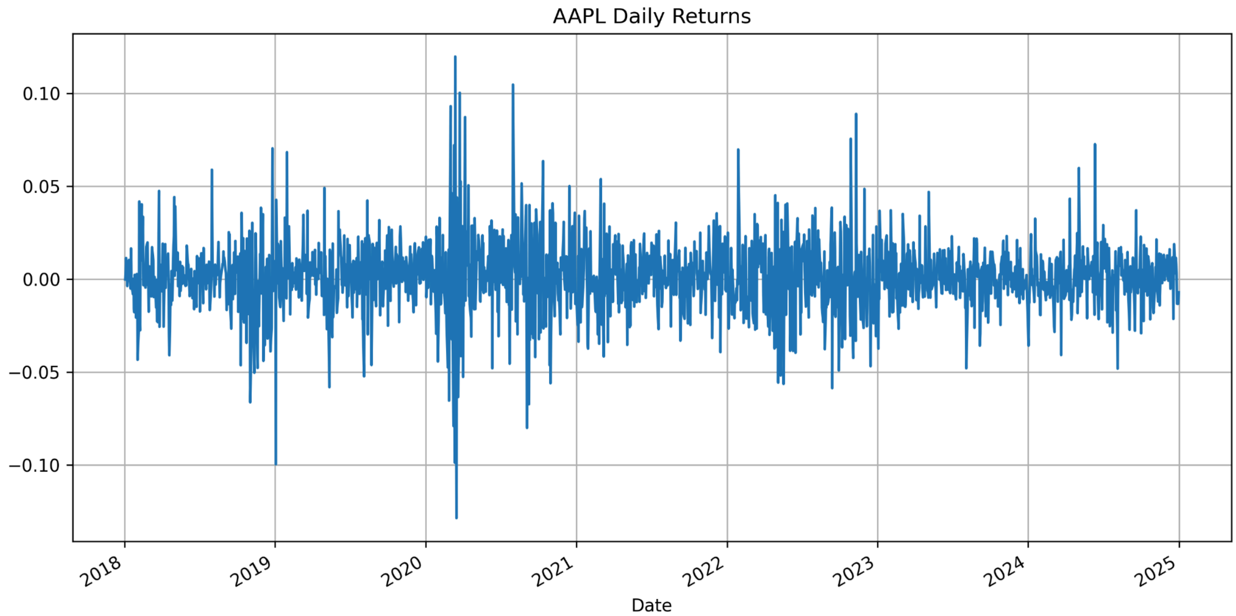
- Python Packages Used: yfinance, pandas, numpy, matplotlib, scipy.stats
- Data Source: Yahoo Finance (free API)
- Period Covered: January 2018 – January 2025

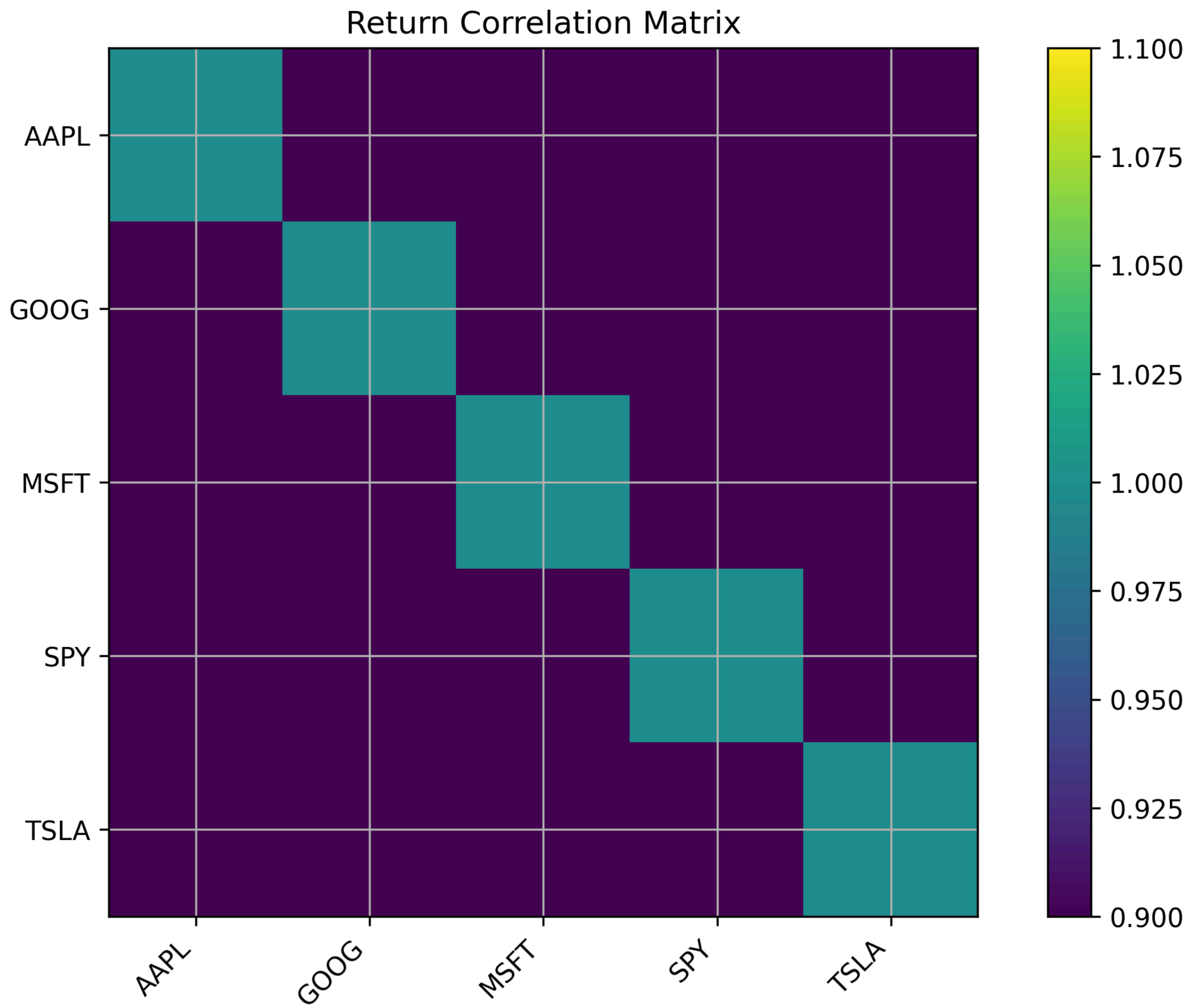


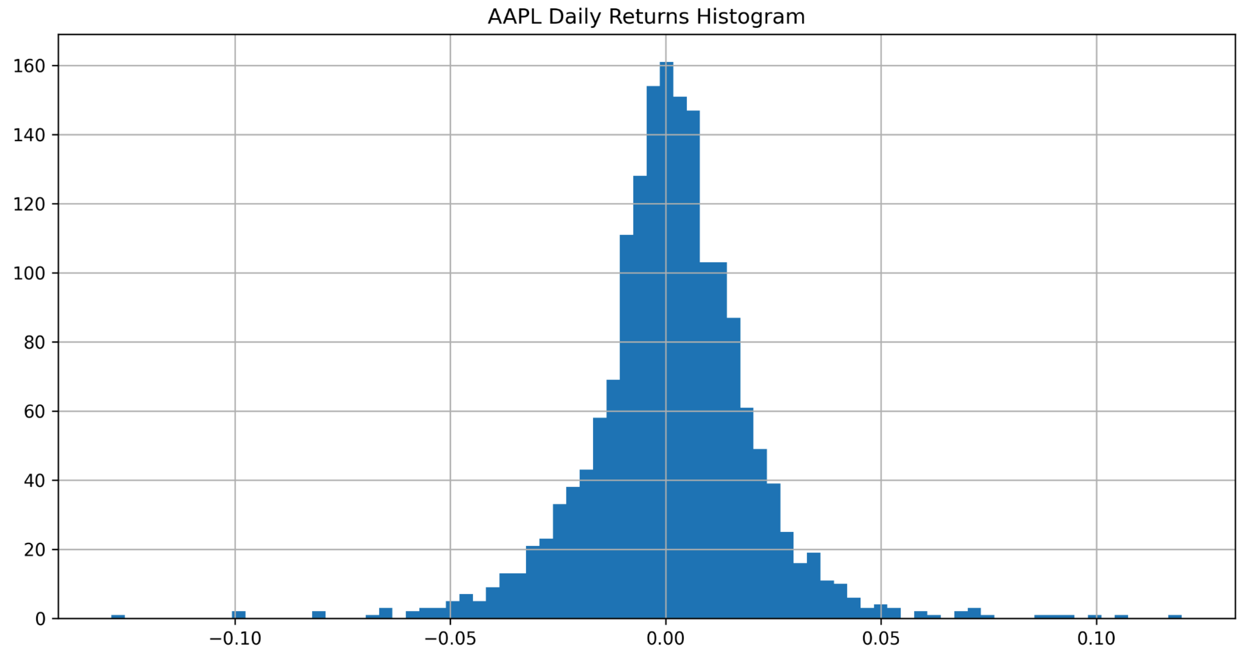
Rolling 30-Day Annualized Volatility
Ticker
AAPL
MSFT
SPY
1.0
0.8
0.6
0.4
0.2
2018
2019
2020
2021
2022
2023
2024
2025
Date



AAPL vs MSFT Rolling 60-Day Correlation
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
2018
2019
2020
2021
2022
2023
2024
2025
Date


AAPL Daily Returns
0.10
0.05
0.00
−0.05
−0.10
2018
2019
2020
2021
2022
2023
2024
2025
Date


Return Correlation Matrix
AAPL
GOOG
MSFT
SPY
TSLA
AAPL
GOOG
MSFT
SPY
TSLA
1.100
1.075
1.050
1.025
1.000
0.975
0.950
0.925
0.900


AAPL Daily Returns Histogram
160
140
120
100
80
60
40
20
0
−0.10
−0.05
0.00
0.05
0.10