



Statistics of Financial Markets

Data and Statistical Indicators

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Why do we need data?

- Financial markets are complex systems.
- Understanding their dynamics requires data.
- Understanding the Past
  - Historical data helps us understand past market behavior.
  - Identify trends.
  - Analyze how markets have reacted to different events.
- Predicting the Future
  - Analyzing historical data can provide insights into potential future market movements
  - Inform investment decisions.

OHLC

- Open Price O_t
  - The first traded price at the beginning of the time period t.
  - It reflects the initial market sentiment and can be influenced by news events occurring after the previous close.
- High Price H_t
  - The highest traded price during period t.
- Low Price L_t
  - The lowest traded price during period t.
- Close Price P_t
  - The last traded price at the end of period t.
  - It is often considered the most significant price because it reflects the final consensus of value for that period.

Returns

- Return measures the gain or loss of an investment over a period, expressed as a percentage of the investment's initial cost.
- Simple returns
  - $R_t = \frac{P_t - P_{t-1}}{P_{t-1}}$.
  - P_t is the price at time t.

Returns

- Log-Returns
  - $r_t = \ln\left(\frac{P_t}{P_{t-1}}\right) = \ln P_t - \ln P_{t-1}$.
  - Log-Returns are time-additive:

$$r_{t+2/t} = \ln\left(\frac{P_{t+2}}{P_t}\right) = \ln\left(\frac{P_{t+2}}{P_{t+1}}\right) + \ln\left(\frac{P_{t+1}}{P_t}\right) = r_{t+2} + r_{t+1}.$$

  - $r_t = \ln(1 + R_t)$, i.e. for small changes in price: $r_t \approx R_t$.
  - Under certain conditions, log-returns are more likely to follow a normal distribution.
  - Log-returns simplify the mathematical handling of compounded returns.

Historical Volatility

- Measures the dispersion or variability of returns over a specified period in the past.
- Historical volatility is calculated as the standard deviation of past returns:

$$\sigma = \sqrt{\frac{1}{n-1}\sum_{t=1}^{n}(r_t - \bar{r})^2}.$$

- Annualizing Volatility
  - Since volatility is often expressed on an annual basis, daily volatility can be annualized using the following formula:

$$\sigma_{\text{annual}} = \sigma_{\text{daily}} \times \sqrt{T}.$$

  - T is the number of trading periods in a year (typically 252 trading days).
  - σ_{daily} is the standard deviation of the daily returns.

Sharpe Ratio

- SR measures the excess return of an asset over the risk-free rate, adjusted for risk (volatility).
- It is a widely used measure of risk-adjusted performance.
- $\text{SR}_t = \dfrac{\bar{R}_t - R_f}{\sigma_t}$.
  - $\bar{R}_t$ is the average return of the asset over time t.
  - R_f is the risk-free rate, typically based on government bonds.
  - σ_t is the volatility of returns over time t.
  - A higher Sharpe ratio indicates better risk-adjusted performance (Sharpe, 1966).

Interpreting the Sharpe Ratio

- Higher values indicate better risk-adjusted returns
- Allows comparison of investments with different risk levels

SR	Interpretation
< 0	Worse than risk-free rate
$0 - 0.5$	Poor
$0.5 - 1$	Acceptable
$1 - 2$	Good
> 2	Excellent

Conclusions

- Returns represent the core metric for evaluating asset performance.
- Volatility Estimators measure the magnitude of asset price fluctuations, helping to quantify the level of market risk.
- Volatility is critical for understanding market uncertainty and is a cornerstone of risk management strategies.
- Accurate volatility estimation supports better pricing of derivatives, portfolio management, and strategic decision-making in turbulent markets.
- Traders and analysts rely on volatility forecasts to set risk limits and adjust strategies dynamically.

References I

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