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Empirical Features and Predictability of Time Series

Parthasarathi Edupally

Quantitative Finance, Russell Square International College, Mumbai

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Time Series in Finance Domain

• So far we looked at population parameters of a time series

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Time Series in Finance Domain

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 - we will look into empirical features, the ones coming from sample
 - stylized facts of statistical properties specific to financial domain

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Time Series in Finance Domain

- So far we looked at population parameters of a time series
- In this lecture.
 - we will look into empirical features, the ones coming from sample
 - stylized facts of statistical properties specific to financial domain
 - Also we will see how to check if a time series is predictable at all

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Returns vs Prices in Finance

- Prices are basic observable quantities in finance, but we prefer returns
- Returns have some advantages over prices
 - an average investor would be more interested in returns than prices
 - returns have certain statistical properties which makes them amenable fo the analysis

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$$R_t = 100[\log P_t - \log P_{t-1}] \tag{1}$$

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 Please refer section 1.1 in Tsay book for more detailed explaination of the return calculations

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Sample Moments

 Recall that when we want to talk about time series we need to specify random variable at every point in time

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Sample Moments

- Recall that when we want to talk about time series we need to specify random variable at every point in time
- A step before that would be to talk about unconditional moments: E(X), Var(X)

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Sample Moments

- Recall that when we want to talk about time series we need to specify random variable at every point in time
- A step before that would be to talk about unconditional moments: E(X), Var(X)
- Given a return series $\{R_t\}$, we can define following unconditional moments,

• Mean:
$$\hat{\mu} = \frac{1}{T} \sum_{t=1}^{T} R_t$$

• Variance :
$$\hat{\sigma} = \sqrt{\frac{1}{T} \sum_{t=1}^{T} (R_t - \hat{\mu})^2}$$

• Skewness:
$$\hat{S} = \frac{1}{\hat{\sigma}^3} \frac{1}{T} \sum (R_t - \hat{\mu})^3$$

• Kutosis:
$$\hat{K} = \frac{1}{\hat{\sigma}^4} \frac{1}{T} \sum (R_t - \hat{\mu})^4$$

• Quantile: For a given α , $\hat{Q}_{\alpha} = R_{(\lceil \alpha T \rceil)}$

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Stylized Facts of Financial Time Series

 Daily returns of the market indexes and individual stocks tend to have high excess kurtoses

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- Daily returns of the market indexes and individual stocks tend to have high excess kurtoses
- For monthly series, the returns of market indexes have higher excess kurtoses than individual stocks

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- Daily returns of the market indexes and individual stocks tend to have high excess kurtoses
- For monthly series, the returns of market indexes have higher excess kurtoses than individual stocks
- The mean of a daily return series is close to zero, whereas that of a monthly return series is slightly larger

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- Among the daily returns, market indexes have smaller standard deviations than individual stocks. This is in agreement with common sense

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- The skewness is not a serious problem for both daily and monthly returns
- The descriptive statistics show that the difference between simple and log returns is not substantial

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 Traditionaly, unconditional distribution of simple returns have been assumed to be normally ditributed and IID

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JB Test for Normality

- Traditionaly, unconditional distribution of simple returns have been assumed to be normally ditributed and IID
- This assumption is not generally true, as evident from stylized facts of asset returns

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- Jarque-Bera test can be used to test normality of a given sample of random variable of interest
- JB Statistic is given by:

$$JB = \frac{T}{6}(\hat{S}^2 + \frac{1}{4}(\hat{K} - 3)^2) \tag{2}$$

• Under null hypothesis of data following normal distribution, JB statistica follows χ_2^2 distribution

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Autocorrelation Function

 Key premise to modelling time series data is that persistence exists in the underlying process

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Autocorrelation Function

- Key premise to modelling time series data is that persistence exists in the underlying process
- This is manifest as correlation between random variables at different points in time

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Autocorrelation Function

- Key premise to modelling time series data is that persistence exists in the underlying process
- This is manifest as correlation between random variables at different points in time
- Estimator for Autocorrelation of a returns series $\{R_t\}$ at lag j, is given by:

$$\rho_j = \frac{\frac{1}{T-j} \sum_{t=j+1}^{T} (R_t - \hat{\mu})(R_{t-j} - \hat{\mu})}{\sum_{t=j+1}^{T} (R_t - \hat{\mu})^2}$$
(3)

where $\hat{\mu}$ is sample unconditional mean of $\{R_t\}$

 Under the assumption of data being IID, it follows below distribution:

$$\hat{\rho}_j \sim N(0, \frac{1}{T}) \tag{4}$$

 We can also test for autocorrelations at different lags together, using Ljung-Box Q-statistic

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"In $God\ we\ trust,\ all\ others\ bring\ data."$

William Edwards Deming (1900 - 1993).