

Introduction to Financial Econometrics

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Key concepts, tools, and typical applications

1. What Is Financial Econometrics?

- **Definition** – The application of statistical and econometric methods to financial data (prices, returns, volumes, interest rates, etc.) in order to model, test, and forecast economic and financial phenomena.
 - **Goal** – Turn raw market data into quantitative insights for pricing, risk management, portfolio construction, and policy analysis.
 - **Typical Data Types**
 - **Time series**: daily/weekly/monthly asset prices, returns, interest rates.
 - **Cross sectional**: returns of many assets at a single point in time.
 - **Panel (cross section + time)**: returns of many assets over many periods.
 - **High frequency**: tick-by-tick or minute-level data.
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2. Core Foundations

Area	Main Topics	Why It Matters
Probability & Stochastic Processes	Random variables, distributions, Brownian motion, martingales, Itô calculus	Provides the mathematical language for asset price dynamics.
Statistical Inference	Estimation (MLE, GMM), hypothesis testing, confidence intervals	Enables reliable parameter extraction from noisy financial data.
Time Series Analysis	Stationarity, ARMA/ARIMA, ARCH/GARCH, VAR, cointegration, error correction models	Captures serial dependence and volatility clustering typical in finance.
Panel Data Econometrics	Fixed effects, random effects, dynamic panels (Arellano-Bond)	Handles multiple assets observed over time while controlling for heterogeneity.

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Computational Tools	Simulation (Monte Carlo), numerical optimization, bootstrapping, R/Python/Matlab packages	Implements models on real-world data sets efficiently.

3. Typical Modeling Steps

1. Problem Definition

- Example: "Forecast next-month volatility of the S&P500."

2. Data Collection & Cleaning

- Obtain price series, adjust for splits/dividends, handle missing observations, align timestamps.

3. Exploratory Data Analysis (EDA)

- Plot series, histogram of returns, autocorrelation function (ACF), partial ACF, Q-Q plots.

4. Model Specification

- Choose a suitable framework (e.g., GARCH for volatility, VAR for multiple series).

5. Estimation

- Apply appropriate estimator (MLE for GARCH, OLS for VAR, GMM for moment condition models).

6. Diagnostic Checking

- Residual autocorrelation, Ljung-Box test, ARCH-LM test, normality of residuals, parameter stability.

7. Forecasting / Simulation

- Generate out-of-sample forecasts, confidence bands, or simulate paths for risk measures.

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8. Evaluation

- Compare forecasts using RMSE, MAE, predictive likelihood, or backtesting of VaR.

9. Interpretation & Reporting

- Translate statistical findings into economic/financial insight (e.g., risk premium, market efficiency).

4. Fundamental Models

4.1 Asset Return Models

Model	Formulation	Typical Use
Mean-Variance (CAPM)	$R_{i,t} = \alpha_i + \beta_i R_{m,t} + \varepsilon_{i,t}$	Estimate systematic