Empirical Applications from Time Series Methods Slides

This document lists all empirical applications found in the lecture slides across 4 parts.

Part 1: Linear Time Series Models

1. Autocorrelation - Examples based on Spanish data

Slide: 10/69 **Exercise:** Analysis of autocorrelation patterns of three Spanish economic time series **Series Used:** - Sovereign spreads (bp) - time series plot showing evolution from Jan 1993 to Jan 2014 - Real GDP annual growth rates (%) - time series plot showing evolution from Mar 1996 to Aug 2014 - Ibex-35 monthly returns (%) - time series plot showing evolution from Feb 1990 to Aug 2014 - Autocorrelations of sovereign spreads, GDP growth, and Ibex-35 returns - correlogram plot (lags 1-19)

Source: Spanish data (likely from Banco de España or official statistics)

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2. Correlation: Long-term sovereign spreads

Slide: 5/69 **Exercise:** Visualization of long-term sovereign spreads relative to German yields **Series Used:** - Long-term sovereign spread for Spain (bp) - from Jan 1993 to Apr 2014 - Long-term sovereign spread for France (bp) - from Jan 1993 to Apr 2014 - Long-term sovereign spread for Italy (bp) - from Jan 1993 to Apr 2014 - German sovereign yields (benchmark) - used as reference for calculating spreads

Source: ECB Statistical Data Warehouse (Harmonised long-term interest rates for convergence assessment purposes)

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3. Correlation between sovereign spreads - Table and scatter plots

Slides: 8/69, 9/69 **Exercise:** Analysis of correlation between long-term sovereign spreads for different country pairs across time periods **Series Used:** - Sovereign spreads for Spain (ES) - Sovereign spreads for France (FR) - Sovereign spreads for Italy (IT)

Periods analyzed: - 1993-1999: ES-FR (77%), ES-IT (99%), IT-FR (75%) - 2000-2007: ES-FR (88%), ES-IT (75%), IT-FR (73%) - 2008-2015: ES-FR (83%), ES-IT (95%), IT-FR (93%)

Source: ECB Statistical Data Warehouse

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4. Autocorrelation with confidence intervals

Slide: 12/69 **Exercise:** ACF plots with confidence bands for GDP growth and Ibex-35 returns **Series Used:** - Real GDP annual growth rates (gdp_real_growth) - ACF plot with Bartlett's 95% confidence bands (lags 0-40) - Ibex-35 monthly returns (ibex_35) - ACF plot with Bartlett's 95% confidence bands (lags 0-40)

Source: Spanish data

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5. Stationarity: Dickey-Fuller Unit root test for Ibex-35

Slides: 16/69, 17/69, 18/69, 19/69 **Exercise:** Unit root testing comparing Ibex-35 index levels vs returns, including time series plots, correlograms, and DF-GLS test results **Series Used:** - Ibex-35 index (%) - time series plot (Jan 1990 to Jan 2014) - Ibex-35 daily returns (ribex35) (%) - time series plot (Jan 1990 to Jan 2014) -

Ibex-35 index levels (ibex35) - correlogram (lags 0-40) - Ibex-35 daily returns (ribex35) - correlogram (lags 0-40) - DF-GLS test results for ibex35 (levels) - table with test statistics for lags 1-3 (6659 observations) - DF-GLS test results for ribex35 (returns) - table with test statistics for lags 1-3 (6658 observations)

Source: Ibex-35 stock market index data

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6. Seasonality: Spanish inflation index

Slide: 22/69 **Exercise:** Analysis of seasonal patterns in Spanish inflation using monthly and annual returns with correlograms **Series Used:** - Spanish inflation index - monthly returns (%) (Jan 2003 to Jan 2015) - Spanish inflation index - annual returns (%) (Jan 2003 to Jan 2015) - Monthly inflation returns (monthly_inflation) - correlogram (lags 0-40) with Bartlett's 95% confidence bands - Annual inflation returns (annual_inflation) - correlogram (lags 0-40) with Bartlett's 95% confidence bands

Source: Spanish inflation index data

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7. Application: Modelling the VIX index

Slides: 34/69, 35/69, 36/69, 37/69, 39/69, 40/69, 41/69, 42/69 **Exercise:** Comprehensive analysis and modeling of the VIX volatility index including historical evolution, distributional analysis, unit root tests, ARMA model estimation, and out-of-sample forecasting

Series Used: - VIX index - historical evolution time series (Jan 1990 to Jan 2015) - VIX - summary statistics (mean, std dev, skewness, kurtosis, min, max) - log-VIX (lgvix) - summary statistics (mean, std dev, skewness, kurtosis, min, max) - VIX - kernel density estimate vs normal density - log-VIX - kernel density estimate vs normal density - log-VIX (lgvix) - correlogram (lags 0-40) with Bartlett's 95% confidence bands - log-VIX (lgvix) - partial correlogram (lags 0-40) with 95% confidence bands - log-VIX (lgvix) - DF-GLS unit root test results (maxlag=10, notrend, 6287 observations) - log-VIX - ARMA model selection table (comparing ARMA(1,0) through ARMA(6,0), MA(0,1) through MA(0,3), and ARMA(1,1), ARMA(2,1) with log-likelihood, AIC, BIC) - log-VIX (lgvix) - ARMA(2,1) estimates table (6298 observations) - log-VIX (lgvix) - ARMA(2,1) fitted correlogram vs empirical (lags 0-40) - log-VIX (lgvix) - ARMA(2,1) fitted partial correlogram vs empirical (lags 0-40) - VIX - out-of-sample forecasts vs actual (Jan 2015 to Jan 29, 2015)

Source: CBOE (Chicago Board Options Exchange) - computed from S&P500 index options prices

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8. Modelling GDP and Credit to non-financial companies

Slides: 50/69, 51/69, 52/69, 53/69, 54/69, 56/69, 57/69 **Exercise:** VAR modeling of GDP and credit growth including stationarity tests, scatter plots, cross-correlogram, model selection, estimation, and impulse response functions

Series Used: - Real GDP annual growth (%) (dgdp) - time series plot (Mar 1996 to Aug 2014) - Real Credit to non-financial companies annual growth (%) (dcredit) - time series plot (Mar 1996 to Aug 2014) - GDP growth (dgdp) vs Credit growth (dcredit) - scatter plot (contemporaneous) - GDP growth (dgdp) vs Lagged Credit growth (dcredit, L) - scatter plot - Lagged GDP growth (dgdp, L) vs Credit growth (dcredit) - scatter plot - GDP annual growth (dgdp) - DF-GLS unit root test (maxlag=2, notrend, 74 observations) - Credit annual growth (dcredit) - DF-GLS unit root test (maxlag=2, notrend, 74 observations) - Cross-correlogram: Corr(ΔGDPt, ΔCreditt-l) for lags -20 to 20 - VAR model selection table (VAR(1), VAR(2), VAR(3)) with log-likelihood, AIC, BIC - VAR(2) estimation results - table with coefficients for dgdp and dcredit equations - Roots of companion matrix - scatter plot (stationarity check) - OIRF of Credit to a GDP positive shock - impulse response function (steps 0-20) - OIRF of GDP to a credit positive shock - impulse response function (steps 0-20)

Source: Spanish data (likely from Banco de España or official statistics)

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9. Cointegration: Unemployment rates example

Slides: 65/69, 66/69, 67/69, 68/69, 69/69 **Exercise:** Cointegration analysis of unemployment rates between neighboring regions/states

Series Used: - Unemployment rate in Madrid (%) - time series (Sep 1976 to Jun 2012) - Unemployment rate in Catalonia (%) - time series (Sep 1976 to Jun 2012) - Unemployment rate in Connecticut (%) - time series (Mar 1976 to Nov 2012) - Unemployment rate in Massachusetts (%) - time series (Mar 1976 to Nov 2012) - Madrid - DF-GLS unit root test (maxlag=3, notrend, 15 observations) - Catalonia - DF-GLS unit root test (maxlag=3, notrend, 15 observations) - Johansen cointegration test results for Madrid and Catalonia (lags=3, trend=rconstant, 153 observations, sample: 1977q2-2015q2) - Johansen cointegration test results for Connecticut and Massachusetts (lags=3, trend=rconstant, 156 observations, sample: 1976q4-2015q3) - Vector error-correction model (VECM) estimates for Connecticut and Massachusetts

Source: - Spanish data: likely from official statistics (INE - Instituto Nacional de Estadística) - US data: likely from Bureau of Labor Statistics (BLS)

Part 2: Volatility Models

10. Stylised facts: Lack of persistence in returns vs persistence in squared returns

Slide: 6/41 **Exercise:** Comparison of autocorrelation functions for Ibex-35 returns vs squared returns **Series Used:** - Ibex-35 returns (ribex35) - correlogram (lags 0-40) with Bartlett's 95% confidence bands - Ibex-35 squared returns (ribex35sq) - correlogram (lags 0-40) with Bartlett's 95% confidence bands

Source: Ibex-35 stock market index data

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11. Stylised facts: Volatility clustering

Slide: 7/41 **Exercise:** Visualization of volatility clustering in Ibex-35 daily returns **Series Used:** - Ibex-35 daily returns (ribex35) (%) - time series plot (Jan 1990 to Jan 2015) - Ibex-35 volatility, estimated with 60-day moving window - time series plot (Jan 1990 to Jan 2015)

Source: Ibex-35 stock market index data

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12. Stylised facts: Asymmetries and leverage effect

Slide: 8/41 **Exercise:** Regression analysis of squared returns on lagged squared returns and lagged returns to detect leverage effect **Series Used:** - Ibex-35 squared returns (sq_ibex35) - dependent variable - Lagged squared Ibex-35 (l.sq_ibex35, l2.sq_ibex35, l3.sq_ibex35) - independent variables - Lagged Ibex-35 returns (l.ribex35) - independent variable - Regression results table (2564 observations, F-statistic, R-squared)

Source: Ibex-35 stock market index data

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13. Stylised facts: Non-normality

Slide: 9/41 **Exercise:** Kernel density estimation comparing Ibex-35 returns distribution to normal distribution **Series Used:** - Ibex-35 returns (ribex35) - kernel density estimate vs normal density (Gaussian kernel, bandwidth = 0.1620)

Source: Ibex-35 stock market index data

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14. ARCH(1) example with Ibex-35 daily returns

Slides: 14/41, 15/41, 16/41 **Exercise:** ARCH(1) model estimation, volatility forecasting, and model diagnostics **Series Used:** - Ibex-35 daily returns (ribex35) - ARCH(1) estimates table (6587 observations, sample: 2-6588) - One-day-ahead volatility estimates in logs (log_sigmat) - time series plot (Jan 1990 to Jan 2015) - Squared Ibex-35 returns (ribex35sq) - correlogram (lags 0-40) vs squared standardized residuals (errorsq) - correlogram (lags 0-40) - Squared Ibex-35 returns (ribex35sq) - partial correlogram (lags 0-40) vs squared standardized residuals (errorsq) - partial correlogram (lags 0-40)

Source: Ibex-35 stock market index data

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15. ARCH(10) example with Ibex-35 daily returns

Slides: 17/41, 18/41, 19/41 **Exercise:** ARCH(10) model estimation, volatility forecasting, and model diagnostics **Series Used:** - Ibex-35 daily returns (ribex35) - ARCH(10) estimates table (ARCH terms L1-L10) - One-day-ahead volatility estimates in logs (log_sigmat) - time series plot (Jan 1990 to Jan 2015) - Squared Ibex-35 returns (y_t^2) - correlogram (lags 0-40) vs squared standardized residuals ((y_t/σ_t)^2) - correlogram (lags 0-40) - Squared Ibex-35 returns (y_t^2) - partial correlogram (lags 0-40) vs squared standardized residuals ((y_t/σ_t)^2) - partial correlogram (lags 0-40)

Source: Ibex-35 stock market index data

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16. ARCH vs GARCH: Likelihood fit comparison

Slide: 27/41 **Exercise:** Comparison of model fit across different ARCH and GARCH specifications **Series Used:** - Ibex-35 daily returns (ribex35) - model comparison table (ARCH(1), ARCH(10), GARCH(1,1)) with log-likelihood and number of parameters

Source: Ibex-35 stock market index data

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17. GARCH(1,1) example with Ibex-35 daily returns

Slides: 23/41, 24/41, 25/41, 26/41 **Exercise:** GARCH(1,1) model estimation, interpretation, volatility forecasting, and model diagnostics **Series Used:** - Ibex-35 daily returns (ribex35) - GARCH(1,1) estimates table - One-day-ahead volatility estimates in logs (log_sigmat) - time series plot (Jan 1990 to Jan 2015) - Squared Ibex-35 returns (y_t^2) - correlogram (lags 0-40) vs squared standardized residuals ((y_t/σ_t)^2) - correlogram (lags 0-40) - Squared Ibex-35 returns (y_t^2) - partial correlogram (lags 0-40) vs squared standardized residuals ((y_t/σ_t)^2) - partial correlogram (lags 0-40)

Source: Ibex-35 stock market index data

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18. Asymmetric GARCH(1,1) estimates

Slide: 29/41 **Exercise:** Asymmetric GARCH model estimation to capture leverage effect **Series Used:** - Ibex-35 daily returns (ribex35) - Asymmetric GARCH(1,1) estimates table (aarch(1), aarch_e L1, garch(1))

Source: Ibex-35 stock market index data

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19. Likelihood fit comparison including Asymmetric GARCH

Slide: 30/41 **Exercise:** Model comparison including asymmetric specification **Series Used:** - Ibex-35 daily returns (ribex35) - model comparison table (ARCH(1), ARCH(10), GARCH(1,1), Asymmetric GARCH(1,1)) with log-likelihood and number of parameters

Source: Ibex-35 stock market index data

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20. Ibex-35 example: Testing for Gaussianity

Slide: 35/41 **Exercise:** Jarque-Bera test for normality of standardized residuals **Series Used:** - GARCH(1,1) standardized residuals (ε_t) - Jarque-Bera test results table (Skewness: -0.35, Kurtosis: 6.79, Total JB: 4072.40)

Source: Ibex-35 stock market index data

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21. GARCH(1,1) with Student t innovations

Slides: 37/41, 38/41, 39/41 **Exercise:** GARCH(1,1) model with Student t distribution for innovations **Series Used:** - Ibex-35 daily returns (ribex35) - GARCH(1,1) with Student t estimates table (degrees of freedom: 7.645) - GARCH(1,1) innovations (ε_t) - kernel density plots comparing Kernel, Gaussian, and Student t densities (full distribution, left tail, right tail)

Source: Ibex-35 stock market index data

Part 3: Multivariate Dependence

22. Correlations between returns of euro area reference stock indices

Slide: 7/33 **Exercise:** Time-varying correlations using 100-day moving window **Series Used:** - Returns of euro area reference stock indices - time series of correlations (100-day moving window, May 1990 to May 2014) - Minimum, median, and maximum correlations across indices - line plot

Source: Euro area stock indices (specific indices not named on slide; could include Euro Stoxx 50, DAX, CAC 40, IBEX 35, FTSE MIB, AEX, etc.)

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23. Correlations between stock indices and sovereign bonds

Slide: 8/33 **Exercise:** Time-varying correlations between stock index returns and sovereign bond returns using 100-day moving window **Series Used:** - France: Stock index returns vs sovereign bond returns - correlation time series (Aug 1991 to Aug 2015) - Spain: Stock index returns vs sovereign bond returns - correlation time series (Aug 1991 to Aug 2015) - Germany: Stock index returns vs sovereign bond returns - correlation time series (Aug 1991 to Aug 2015)

Source: Euro area stock indices and sovereign bond data

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24. Example: Overnight Index Swap (OIS) rates

Slides: 14/33, 15/33, 16/33, 17/33 **Exercise:** Principal Component Analysis (PCA) of OIS term structure **Series Used:** - 27 OIS rate series across different maturities - historical evolution (Aug 2005 to Aug 2015) - OIS rates for maturities: 0.02, 0.06, 0.17, 0.33, 0.50, 0.67, 0.83, 1.00, 1.50, 2.00, 4.00, 6.00, 8.00, 10.00 years - Standard deviation of yield daily changes - term structure plot (across maturities) - PCA eigenvalues table (correlation matrix based, 2666 observations, 27 components, first 4 components retained) - PCA eigenvectors plot - first 4 principal components (PC1, PC2, PC3, PC4) across time horizons

Source: Overnight Index Swap (OIS) rates data

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25. CCC (Constant Conditional Correlation) Example

Slides: 20/33, 21/33 **Exercise:** CCC-MGARCH model estimation for Spain and Germany **Series Used:** - Spain returns - CCC-GARCH estimates table (mean equation constant, ARCH(1), GARCH(1)) - Germany returns - CCC-GARCH estimates table (mean equation constant, ARCH(1), GARCH(1)) - Constant conditional correlation (Spain, Germany) - estimate: 0.709 - Log volatility Spain (lgv_Spain_Spain) - time series plot (Jan 1990 to Jan 2015) - Log volatility Germany (lgv_Germany_Germany) - time series plot (Jan 1990 to Jan 2015) - Constant correlation (cor_Germany_Spain) - time series plot (Jan 1990 to Jan 2015)

Source: Spanish and German financial/economic series (likely stock index returns)

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26. DCC (Dynamic Conditional Correlation) Example

Slides: 23/33, 24/33 **Exercise:** DCC-MGARCH model estimation and comparison with CCC model **Series Used:** - Spain returns - DCC-MGARCH estimates (individual GARCH processes) - Germany returns - DCC-MGARCH estimates (individual GARCH processes) - Dynamic conditional correlation (cor_Germany_Spain_dcc) - time series plot (Jan 1990 to Jan 2015) - Constant correlation (cor_Germany_Spain) - reference line (Jan 1990 to Jan 2015) - Log volatility Spain (lgv_Spain_Spain) - time series plot (Jan 1990 to Jan 2015) - Log volatility Germany (lgv_Germany_Germany) - time series plot (Jan 1990 to Jan 2015) - Likelihood ratio test: DCC vs CCC (LR = 837.84, 2 degrees of freedom)

Source: Spanish and German financial/economic series (likely stock index returns)

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27. Asymmetric and tail dependence: Equity index returns

Slides: 27/33, 28/33 **Exercise:** Analysis of asymmetric and tail dependence using exceedance correlations **Series Used:** - Spain equity index returns (ES) - standardized returns (εyt) - *France equity index returns (FR) - standardized returns (*εyt) - Germany equity index returns (DE) - standardized returns (εyt) - *Italy equity index returns (IT) - standardized returns (*εyt) - Asymmetric correlation ES-IT (acorr_es_it) - exceedance correlation plot - Asymmetric correlation ES-FR (acorr_es_fr) - exceedance correlation plot - Asymmetric correlation ES-DE (acorr_es_de) - exceedance correlation plot

Source: Euro area equity indices

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28. Copulas: Scatter plots of cdf transforms

Slide: 31/33 **Exercise:** Visualization of copula relationships via cdf transforms **Series Used:** - Spain cdf transform (es_cdf) vs Germany cdf transform (de_cdf) - scatter plot - Spain cdf transform (es_cdf) vs Italy

cdf transform (it_cdf) - scatter plot - Spain cdf transform (es_cdf) vs France cdf transform (fr_cdf) - scatter plot

Source: Euro area equity indices (cdf transforms derived from standardized returns)

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29. Copulas: Contour plots of copula densities

Slide: 33/33 **Exercise:** Comparison of different copula specifications for Spanish vs German equity index returns **Series Used:** - Spanish equity index returns - German equity index returns - Contour plots for: Independent normals, Correlated normals, Symmetric mixture, Asymmetric mixture

Source: Euro area equity indices

Part 4: Risk Management

Note: Part 4 is primarily theoretical, focusing on definitions and concepts of Value at Risk (VaR) and risk management measures. No empirical applications with plots or tables were found in this section.

Complete List of Unique Series to Download

Below is the consolidated list of all unique time series identified across all empirical applications:

Financial Market Indices

1. **Ibex-35 index** - Spanish stock market index (levels)
2. **Ibex-35 daily returns** (ribex35) - Percentage returns
3. **Ibex-35 monthly returns** - Percentage returns
4. **Ibex-35 squared returns** (ribex35sq) - For volatility analysis

Sovereign Spreads and Interest Rates

5. **Long-term sovereign spread - Spain** (vs German yields, in basis points)
6. **Long-term sovereign spread - France** (vs German yields, in basis points)
7. **Long-term sovereign spread - Italy** (vs German yields, in basis points)
8. **German sovereign yields** - Long-term interest rates (benchmark)

Macroeconomic Series

9. **Real GDP annual growth rates** (gdp_real_growth, dgdp) - Spain, percentage
10. **Real Credit to non-financial companies annual growth** (dcredit) - Spain, percentage
11. **Spanish inflation index** - Monthly data (to compute monthly and annual returns)
12. **Spanish inflation - monthly returns** (monthly_inflation)
13. **Spanish inflation - annual returns** (annual_inflation)

Volatility and Options

14. **VIX index** - CBOE Volatility Index (levels and log-VIX)
15. **VIX** - Raw index values
16. **log-VIX** (lgvix) - Natural logarithm of VIX

Unemployment Rates

17. **Unemployment rate - Madrid** (%) - Quarterly or monthly
18. **Unemployment rate - Catalonia** (%) - Quarterly or monthly
19. **Unemployment rate - Connecticut** (%) - Quarterly or monthly
20. **Unemployment rate - Massachusetts** (%) - Quarterly or monthly

Euro Area Stock Indices (Returns)

21. **Spain equity index returns** (ES) - Daily or monthly returns
22. **France equity index returns** (FR) - Daily or monthly returns
23. **Germany equity index returns** (DE) - Daily or monthly returns
24. **Italy equity index returns** (IT) - Daily or monthly returns
25. **Euro area reference stock indices** (multiple, for correlation analysis) - Returns

Euro Area Sovereign Bonds

26. **France sovereign bond returns** - Daily or monthly returns
27. **Spain sovereign bond returns** - Daily or monthly returns
28. **Germany sovereign bond returns** - Daily or monthly returns

Interest Rate Derivatives

29. **Overnight Index Swap (OIS) rates** - 27 series for different maturities:
    - Maturities: 0.02, 0.06, 0.17, 0.33, 0.50, 0.67, 0.83, 1.00, 1.50, 2.00, 4.00, 6.00, 8.00, 10.00 years

Data Sources Identified

- **ECB Statistical Data Warehouse** - Sovereign spreads and harmonised long-term interest rates
- **Banco de España** - Spanish macroeconomic and financial data
- **CBOE (Chicago Board Options Exchange)** - VIX index
- **Spanish official statistics (INE)** - GDP, inflation, unemployment
- **US Bureau of Labor Statistics (BLS)** - US state unemployment rates
- **Stock exchange data** - Ibex-35, Euro area indices
- **Financial data providers** - OIS rates, sovereign bonds (likely Bloomberg, Reuters, or central bank sources)

Notes

- Some series are derived (e.g., returns, growth rates, squared returns) and can be computed from underlying price/index levels
- Time periods vary by application but generally span from early 1990s to mid-2010s
- For Spanish data, quarterly or monthly frequency is common; daily frequency is used for financial market data
- For correlation analysis and multivariate models, series need to be aligned by date