

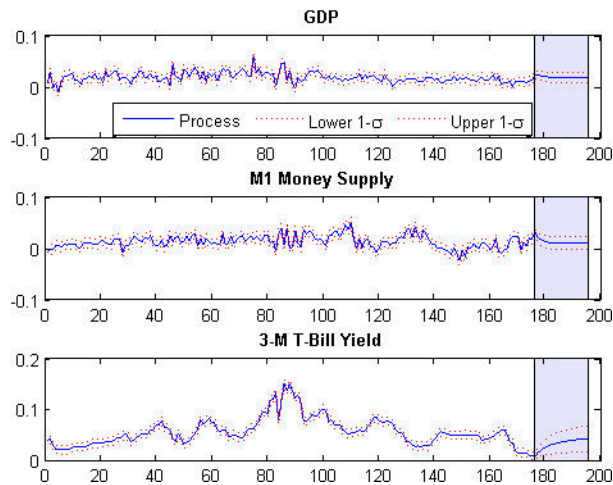
# Econometrics Toolbox 2.0

## Model and analyze financial and economic systems using statistical methods

Econometrics Toolbox™ provides functions for modeling economic data. You can select and calibrate economic models for simulation and forecasting. Time series capabilities include univariate ARMAX/GARCH composite models with several GARCH variants, multivariate VARMAX models, and cointegration analysis. The toolbox provides Monte Carlo methods for simulating systems of linear and nonlinear stochastic differential equations and a variety of diagnostics for model selection, including hypothesis, unit root, and stationarity tests.

### Key Features

- Univariate ARMAX/GARCH composite models, including EGARCH, GJR, and other variants
- Multivariate simulation and forecasting of VAR, VEC, and cointegrated models
- Monte Carlo simulation of stochastic differential equations (SDEs), including Brownian motion, CEV, CIR, Hull-White, Vasicek, Heston stochastic volatility, and user-defined SDEs
- Tests for unit root (Dickey-Fuller, Phillips-Perron) and stationarity (Leybourne-McCabe, KPSS)
- Statistical tests, including likelihood ratio, LM, Wald, Engle's ARCH, and Ljung-Box Q
- Cointegration tests, including Engle-Granger and Johansen
- Diagnostics and utilities, including AIC/BIC model selection and partial-, auto-, and cross-correlations
- Hodrick-Prescott filter for business-cycle analysis



Plot of forecasts from a multivariate VARMAX model, produced by the `vgxplot` function.

### Time-Series Modeling

Econometrics Toolbox facilitates the multistep process of identifying and testing univariate and multivariate time-series models for financial and econometric data. The toolbox supports the full model development and analysis workflow:

- Data analysis and preprocessing
- Model identification
- Parameter estimation

- Simulation
- Forecasting

### **Univariate Time-Series Modeling**

Time-series modeling capabilities in Econometrics Toolbox are designed to capture characteristics commonly associated with financial and econometric data, including data with fat tails, volatility clustering, and leverage effects.

Supported conditional mean models include:

- Autoregressive moving average (ARMA)
- Autoregressive moving average with exogenous inputs (ARMAX)

Supported conditional variance models include:

- Generalized autoregressive conditional heteroscedasticity (GARCH)
- Glosten-Jagannathan-Runkle (GJR)
- Exponential GARCH (EGARCH)

### **Multiple Time-Series Modeling**

Econometrics Toolbox supports multivariate time-series analysis by extending capabilities for univariate models.

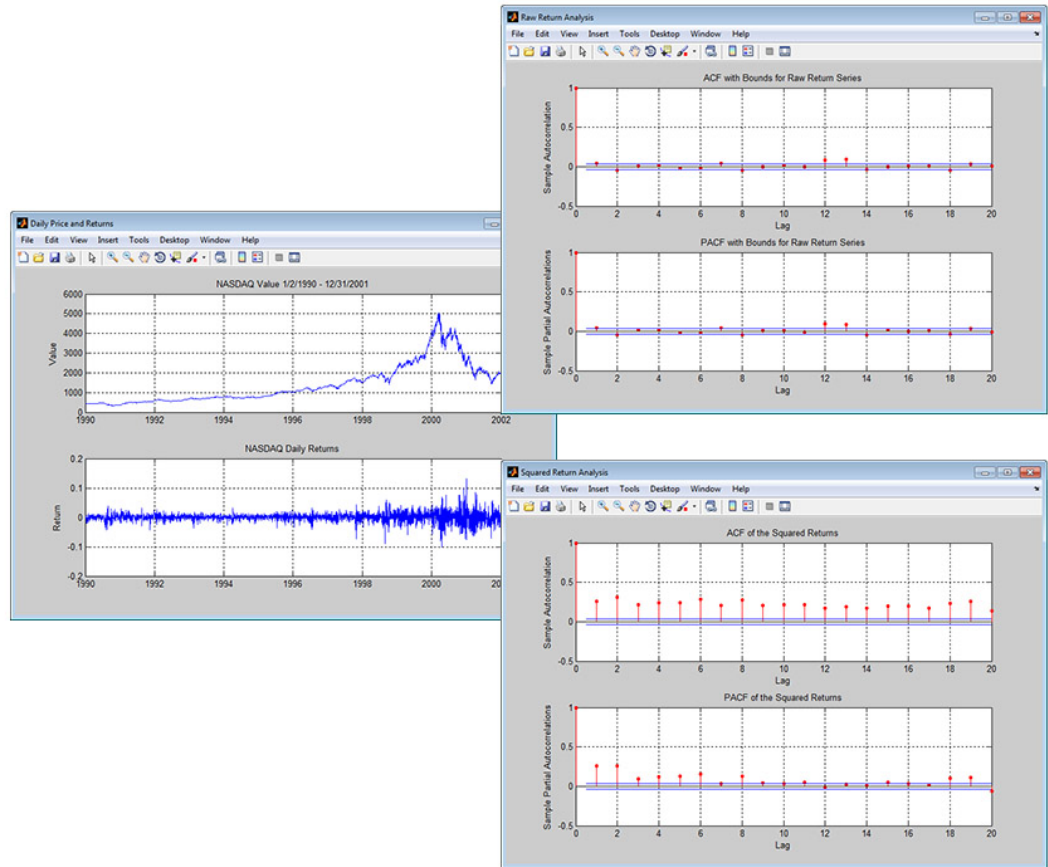
Supported models include:

- Vector autoregressive (VAR)
- Vector moving average (VMA)
- Vector autoregressive moving average (VARMA)
- Vector autoregressive moving average with exogenous inputs (VARMAX)
- Structural VARMAX (SVARMAX)
- Vector error-correction (VEC)

### **Model Identification and Analysis**

With Econometrics Toolbox, you can select and test models by specifying a model structure, identifying the model order, estimating parameters, and evaluating residuals. A variety of pre- and post-estimation diagnostics and tests support these analyses, including:

- Likelihood ratio, Wald, and Lagrange multiplier tests for model specification
- Akaike and Bayesian information criteria for model order selection
- Engle's test for the presence of ARCH/GARCH effects
- Sample autocorrelation, cross-correlation, and partial autocorrelation functions
- Ljung-Box Q (portmanteau) test for autocorrelation
- Dickey-Fuller and Phillips-Perron unit root tests
- KPSS and Leybourne-McCabe stationarity tests
- Engle-Granger and Johansen tests for cointegration
- Variance ratio test for random walks



Testing of NASDAQ Composite Index price series and returns (left) for autocorrelation and partial autocorrelation. The raw return series does not have any correlation (top right), and correlation is present in the squared return (bottom right).

### Parameter Estimation

With Econometrics Toolbox, you can perform parameter estimation (also known as model calibration) of univariate ARMAX/GARCH composite models, multivariate VAR/VARX models, and multivariate VEC models.

```

Command Window
File Edit Debug Desktop Window Help
>> spec = garchset('VarianceModel','GARCH','P',1,'Q',1);
>> spec = garchset(spec, 'Distribution','t','Display','off')

spec =

    Comment: 'Mean: ARMAX(0,0,?); Variance: GARCH(1,1) '
    Distribution: 'T'
    DoF: []
    C: []
    VarianceModel: 'GARCH'
    P: 1
    Q: 1
    K: []
    GARCH: []
    ARCH: []
    Display: 'off'

>> [coeff,errors,LLF,eFit,sFit] = garchfit(spec,nasdaq);
>> garchdisp(coeff,errors)

Mean: ARMAX(0,0,0); Variance: GARCH(1,1)

Conditional Probability Distribution: T
Number of Model Parameters Estimated: 5

Parameter      Value      Standard      T
-----      -
C      0.0011009      0.00017025      6.4665
K      1.1418e-006      3.7414e-007      3.0517
GARCH(1)      0.90793      0.010569      85.9079
ARCH(1)      0.089636      0.010838      8.2702
DoF      7.6358      0.92507      8.2542

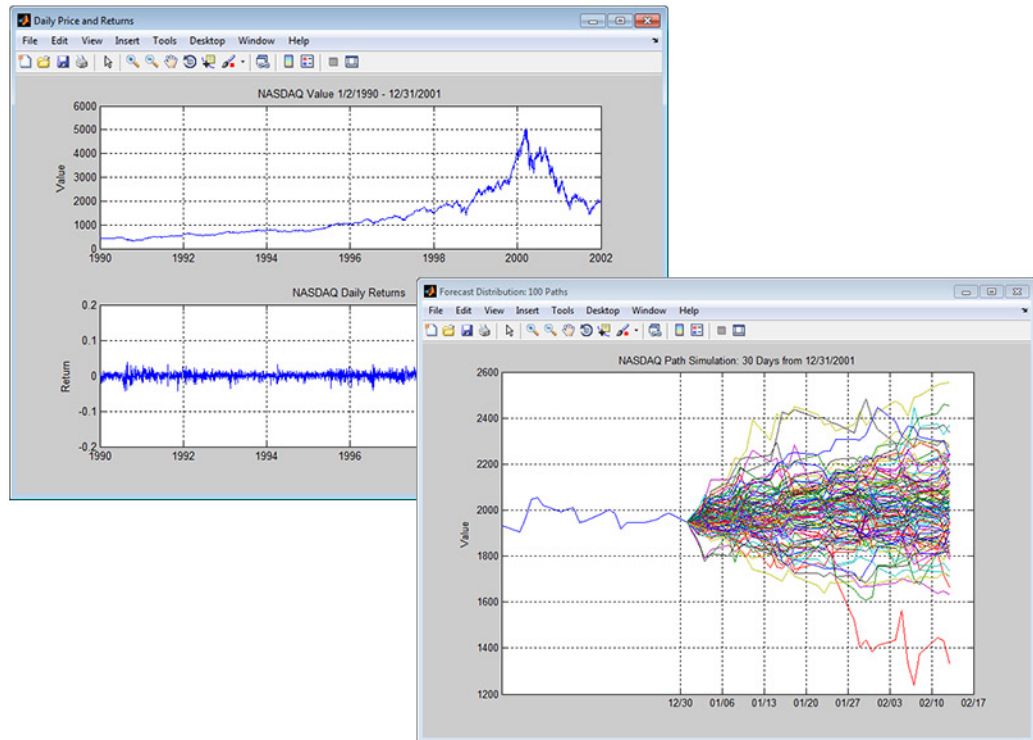
fx >> |
OVR

```

*Interactively developing a GARCH(1,1) model and estimating the model parameters for NASDAQ daily returns in the command window.*

### Monte Carlo Simulation

Econometrics Toolbox lets you perform Monte Carlo simulations to generate forecast distributions of both single and multiple time-series models, including univariate ARMAX/GARCH composite models and multivariate VARMAX models.



Forecast results using Monte Carlo simulation. Time-series plots of historical NASDAQ Index value and daily returns (left) are inputs to the `garchsim` function, which is used to generate a 30-day ahead forecast distribution with 100 possible paths (right).

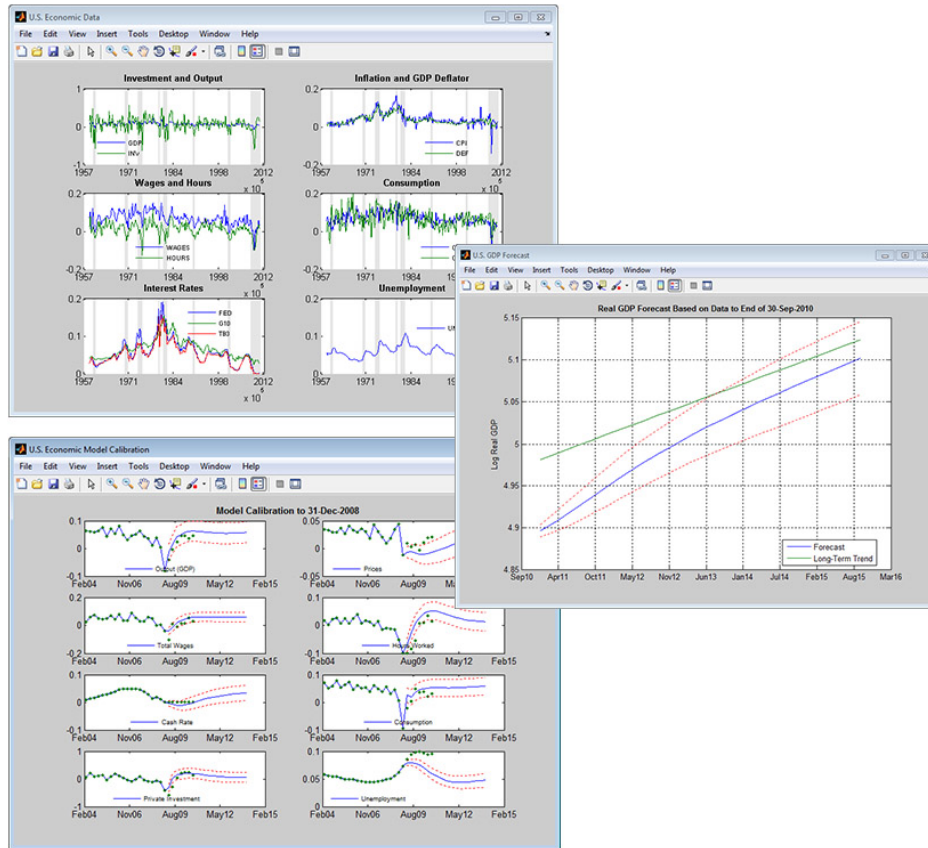
### Monte Carlo Simulation of Stochastic Differential Equations

The toolbox also lets you simulate a variety of popular stochastic differential equations (SDEs), interfaces for customizing your own SDE simulation models and methods.

- Simulate common stochastic differential equations with predefined model classes
- Simulate any linear or nonlinear stochastic differential equation with predefined interfaces

### Forecasting

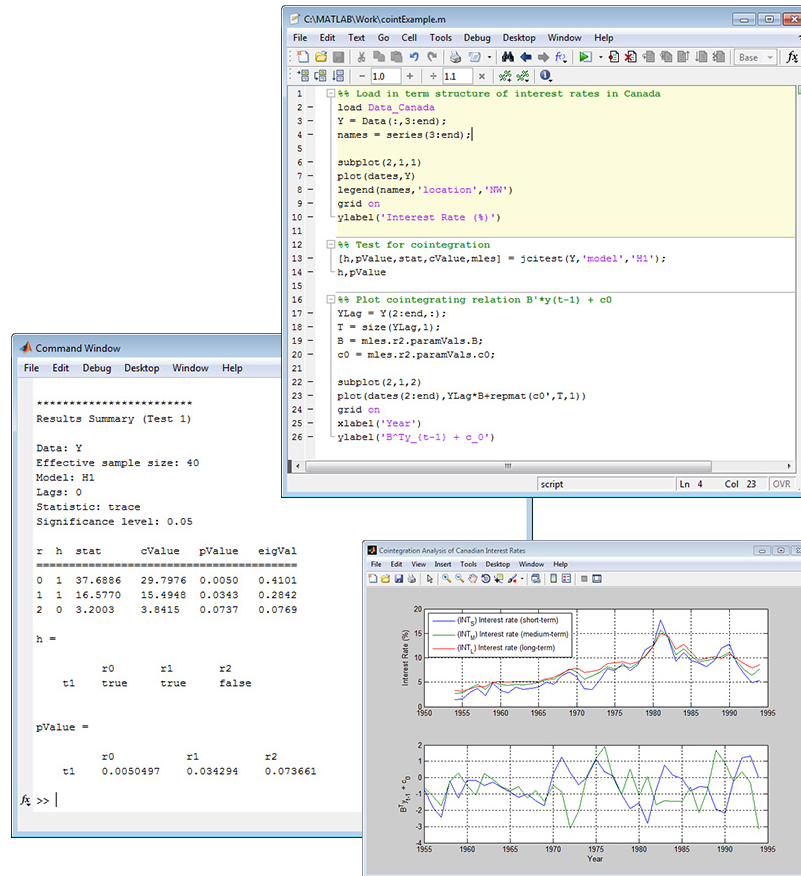
You can forecast market trends to make budgeting, planning, investing, and policy decisions. [Financial Toolbox™](#) provides the foundation for working with financial time-series data; performing regression and parameter estimation with or without missing data; and simulating different scenarios to estimate risk. Econometrics Toolbox extends this foundation with advanced capabilities that account for nonuniform variance across time.



Modeling the U.S. economy. Plots show economic indicators for developing a model of U.S Real GDP (top left); model calibration results and forecasts for indicators (bottom left); and forecast results for Real GDP (right).

## Cointegration Modeling

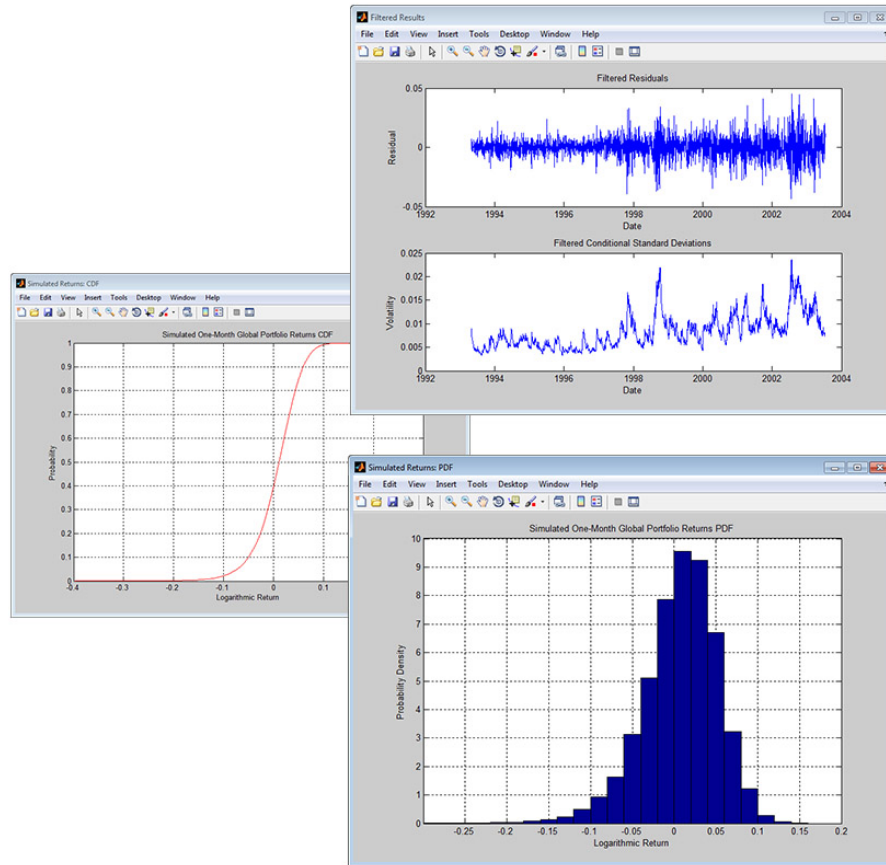
Econometrics Toolbox provides Engle-Granger and Johansen methods for cointegration testing and modeling. The Engle-Granger method tests for individual cointegrating relationships, and estimates their parameters. Johansen methods tests for multiple cointegrating relationships, and estimates parameters in corresponding vector error-correction (VEC) models. In addition, Johansen methods tests linear restrictions on both error-correction speeds and the space of cointegrating vectors, and estimates restricted model parameters.



Cointegration testing and modeling on the term structure of interest rates.

## Volatility Modeling

Econometrics Toolbox has a complete set of tools for building on time-varying volatility models. The toolbox supports several variants of univariate GARCH models, including standard ARCH/GARCH models, as well as asymmetric EGARCH and GJR models designed to capture leverage effects in asset returns. The toolbox supports the simulation of stochastic volatility models, including the Heston model.



Estimating market risk using bootstrapping and filtered historical simulation technique. Plots show filtered residuals and volatility of portfolio returns from an  $AR(1)/EGARCH(1, 1)$  model (top right), the simulated portfolio returns over a one-month horizon (left), and the probability distribution function (bottom right).

## Resources

### Product Details, Demos, and System Requirements

[www.mathworks.com/products/econometrics](http://www.mathworks.com/products/econometrics)

### Trial Software

[www.mathworks.com/trialrequest](http://www.mathworks.com/trialrequest)

### Sales

[www.mathworks.com/contactsales](http://www.mathworks.com/contactsales)

### Technical Support

[www.mathworks.com/support](http://www.mathworks.com/support)

### Online User Community

[www.mathworks.com/matlabcentral](http://www.mathworks.com/matlabcentral)

### Training Services

[www.mathworks.com/training](http://www.mathworks.com/training)

### Third-Party Products and Services

[www.mathworks.com/connections](http://www.mathworks.com/connections)

### Worldwide Contacts

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