New Developments in MATLAB for Computational Finance

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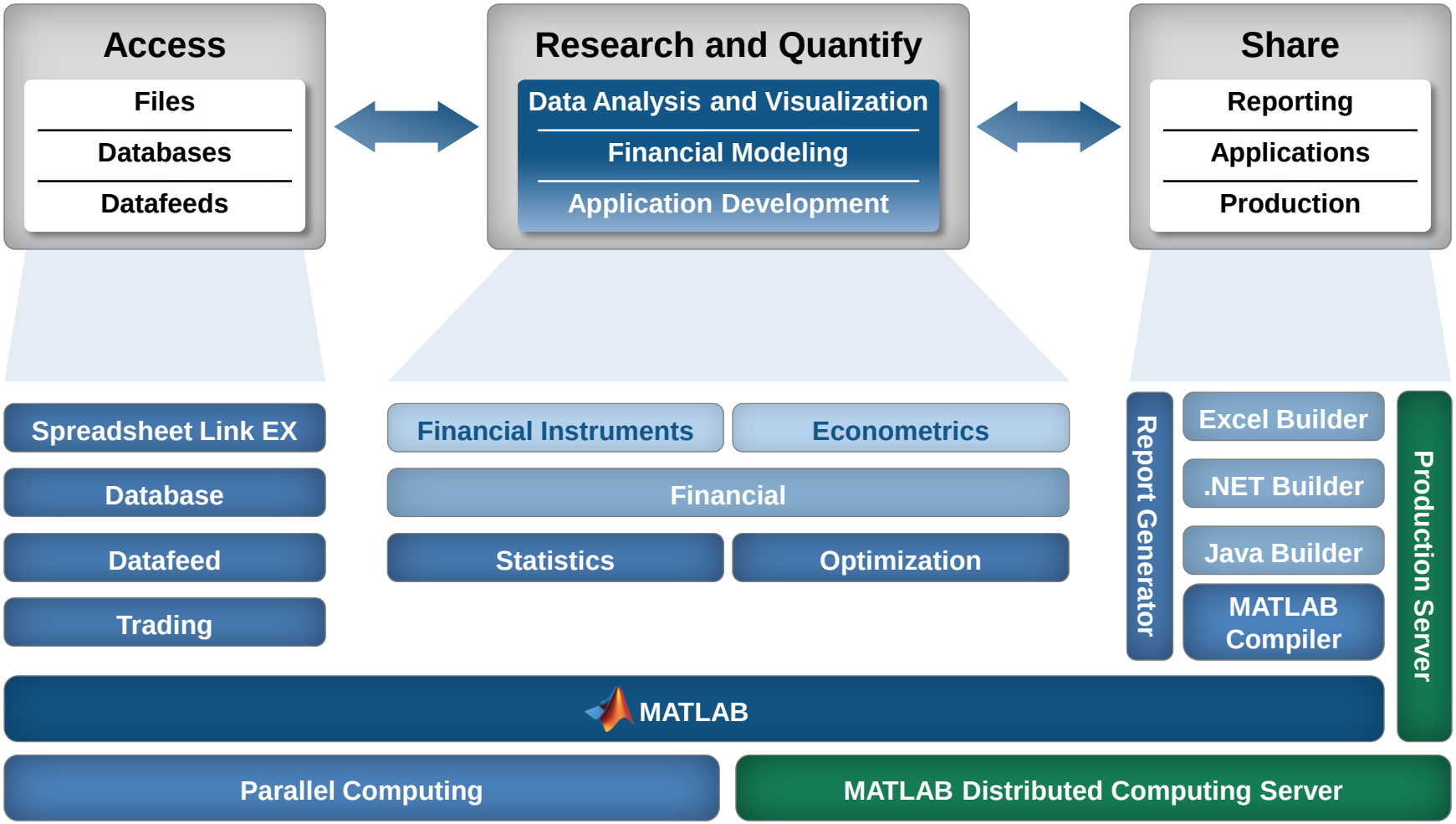
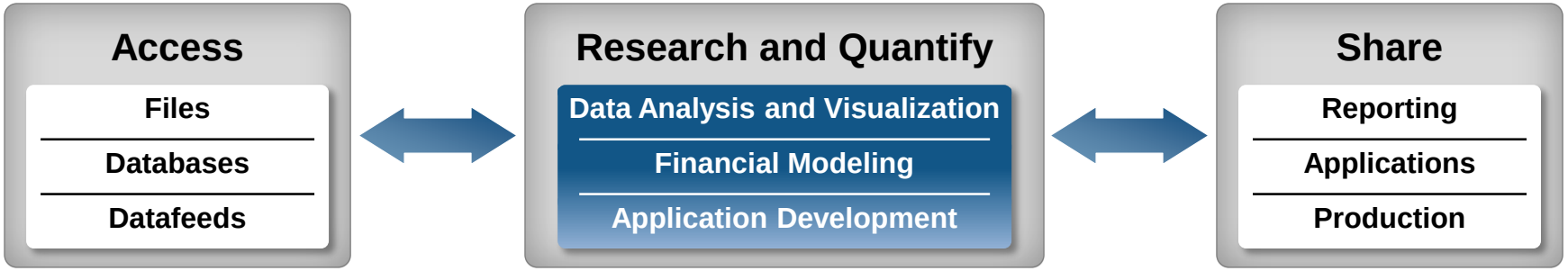
Who uses MATLAB in Financial Services?

- The top 15 asset-management companies
- The top 10 U.S. commercial banks
- 11 of the top 15 hedge funds
- The reserve banks of all OECD member countries
- The top 3 credit rating agencies

Financial Modeling Workflow



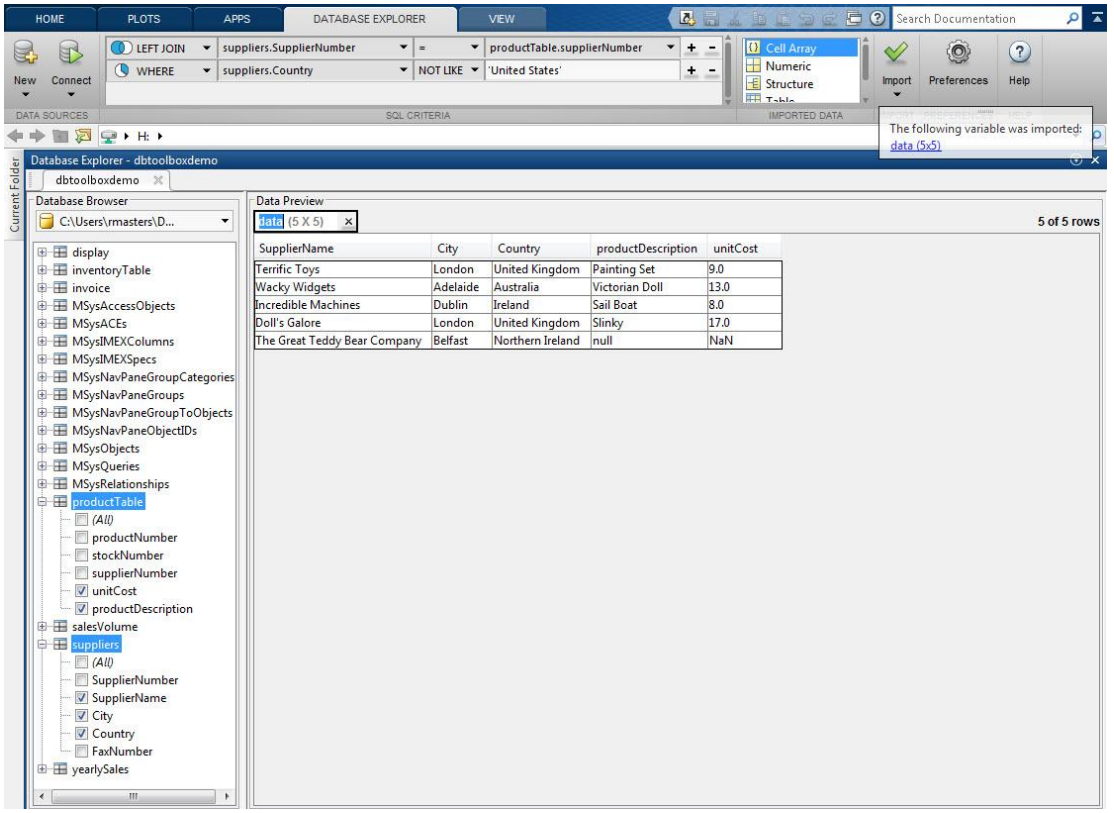
Agenda



- Access
- Research and Quantify
  - Example: State Space Modeling
  - Example: Mixed Integer Linear Programming
- Share
  - User Story: Developing a New Interest Rate Model
- Future Directions

Database Explorer

- Create and configure JDBC and ODBC data sources.
- Import selected data into the MATLAB workspace.
- Save generated SQL queries.
- Generate MATLAB code.



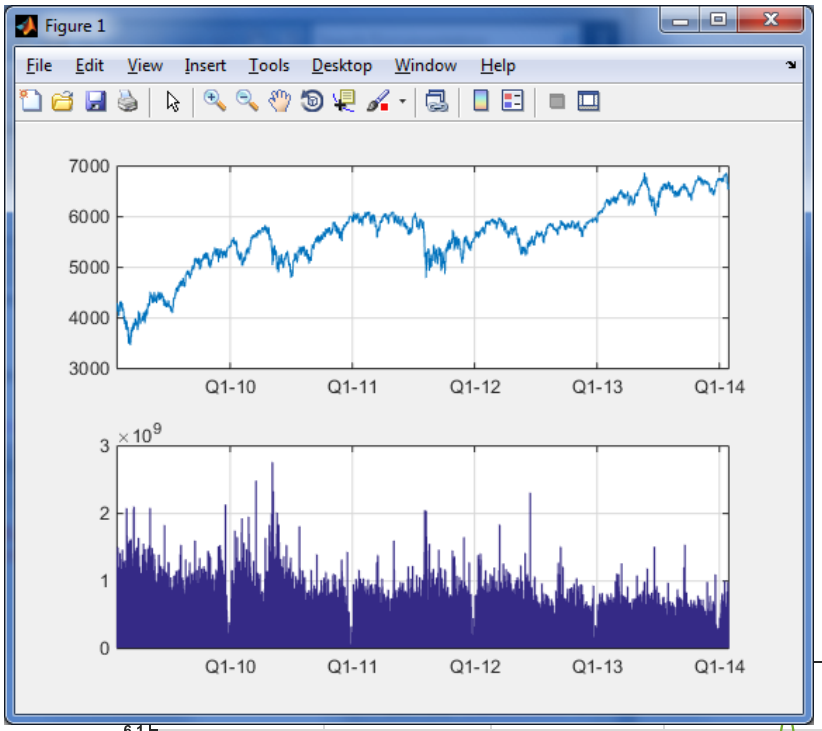
Native ODBC Database Connection

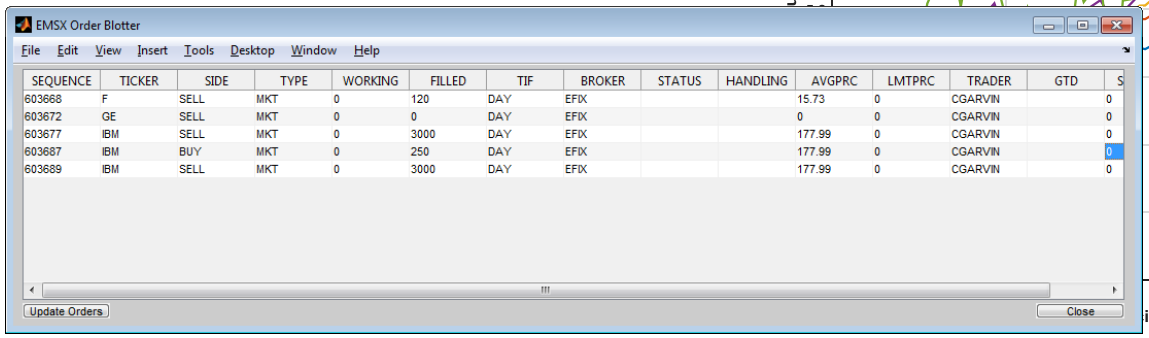
- Support for native ODBC database connection for Windows® platforms.
- The native ODBC interface supports the following functions: `fetch, exec, insert`.

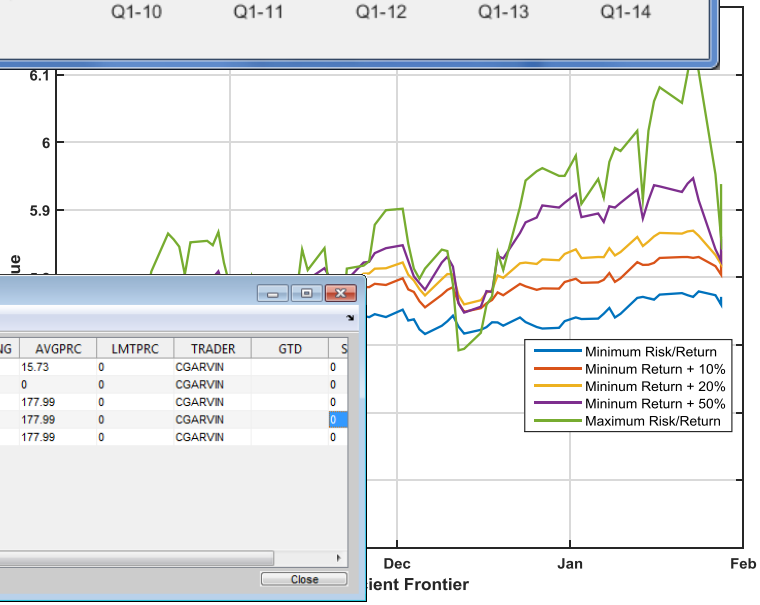
```
conn = database.ODBCConnection('dbtoolboxdemo','admin','admin');
```

Trading Toolbox

- Functionality for accessing trade and quote pricing data, defining order types, and sending orders to financial trading markets.
- Supports Bloomberg® EMSX, CQG® Integrated Client, Interactive Brokers® TWS, and Trading Technologies® X_TRADER®.

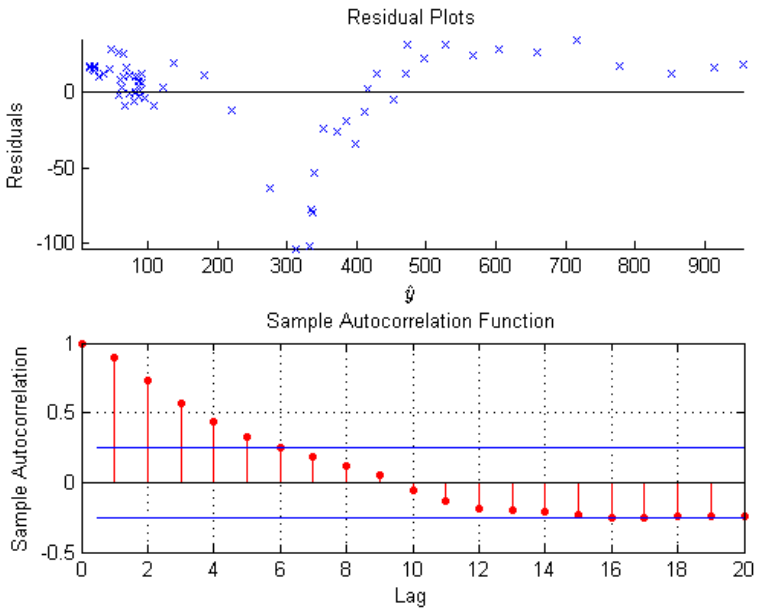




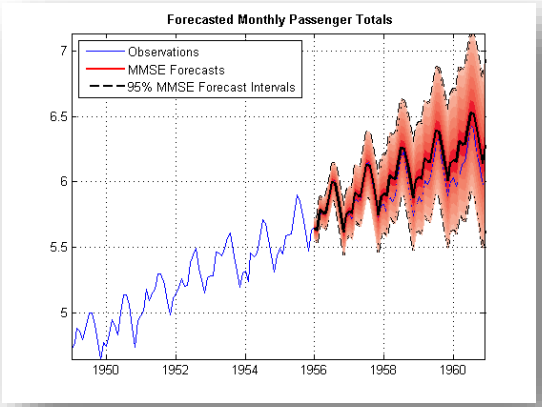


What's New in Econometrics

- Linear regression models with ARIMA error processes, including AR, MA, ARMA, and seasonal error models with `regARIMA`.
- Estimate robust covariances for ordinary least squares coefficients of multiple linear regression models under general forms of heteroscedasticity and autocorrelation using `hac`.



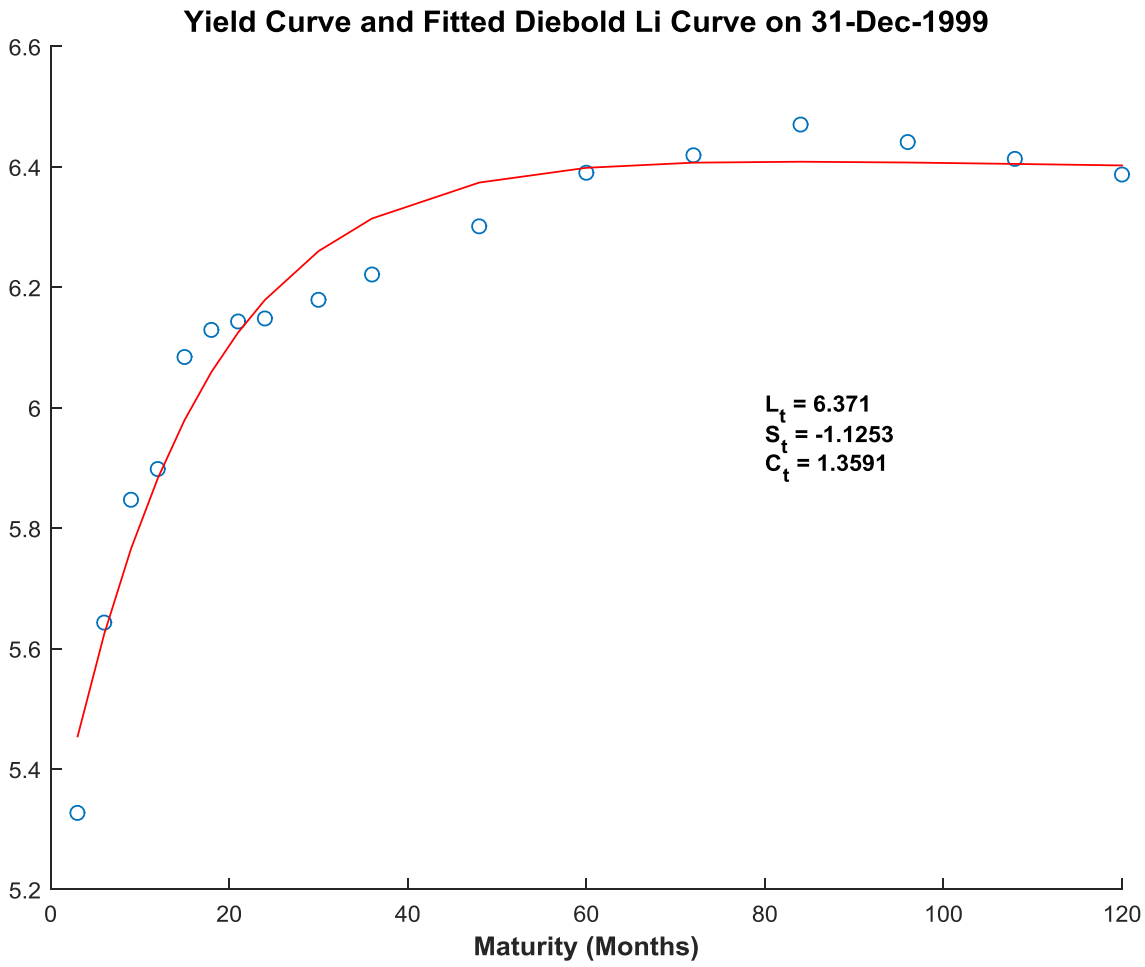
State-Space Modeling



- **`ssm`** model for performing univariate and multivariate time-series data analysis
  - Estimate its parameters using **`estimate`**
  - Implement forward recursion of the state-space model using **`filter`**
  - Implement backward recursion of the state-space model using **`smooth`**
  - Simulate states and observations using **`simulate`**
  - Forecast states and observations using **`forecast`**
- Use the Kalman filter to estimate the states and to manage missing data

Example: Diebold Li Yield Curve Model

$$y_t(\tau) = L_t + S_t\left(\frac{1 - e^{-\lambda\tau}}{\lambda\tau}\right) + C_t\left(\frac{1 - e^{-\lambda\tau}}{\lambda\tau} - e^{-\lambda\tau}\right)$$



L_t: level/long-term factor

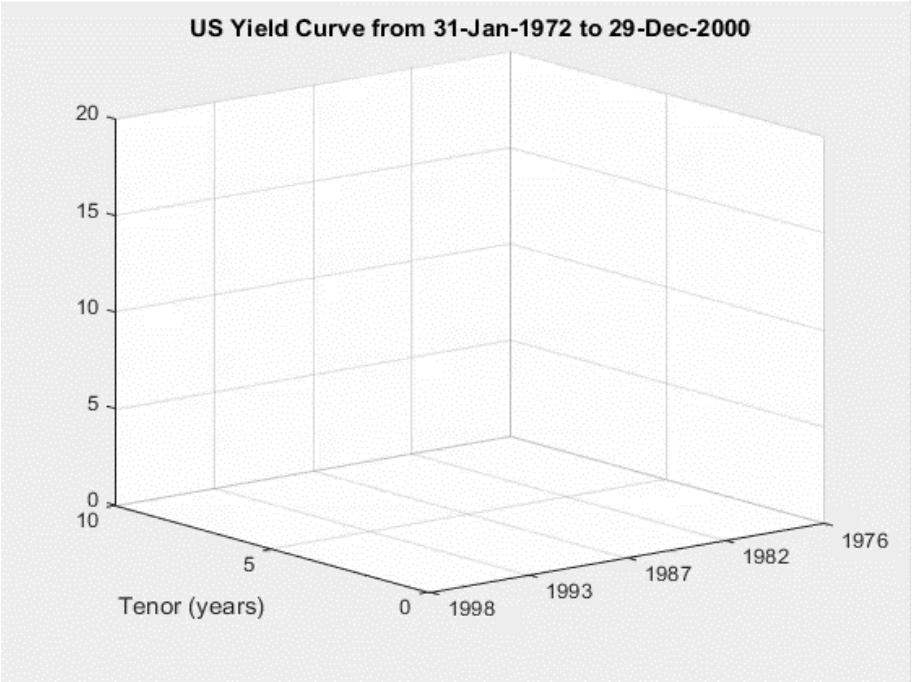
S_t: slope/short-term factor

C_t: curvature/medium-term

λ : time factor

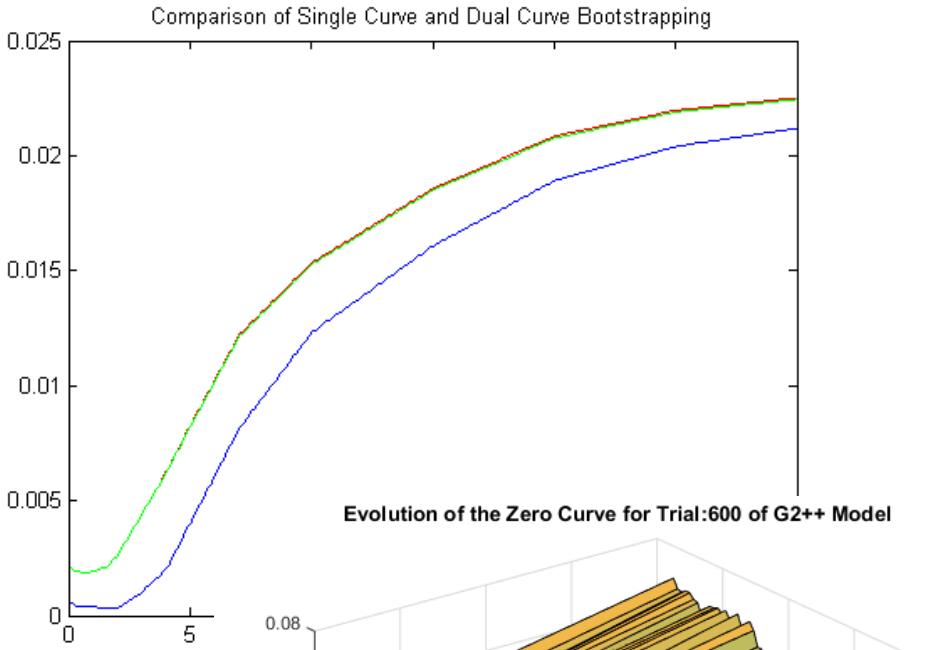
Estimate Diebold Li Parameters

1. Two step process:
   1. Fix λ, estimate L_t, S_t, C_t at each date with linear regression
   2. Fit VAR(1) model to L_t, S_t, C_t
2. Kalman Filter



What's New in Financial Instruments

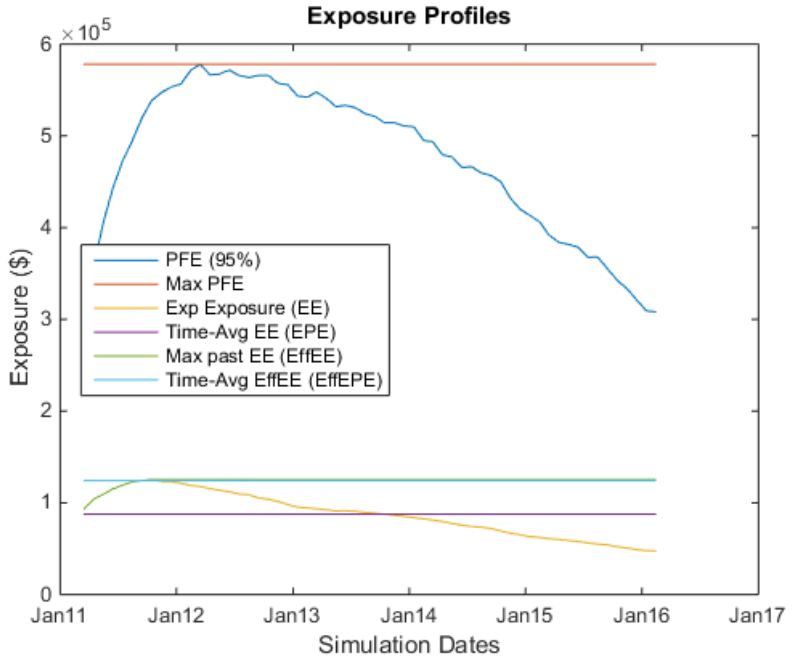
- Pricing spread and swing options using closed form, finite difference and Monte Carlo.
- Dual curve construction and pricing of swaps, caps, floors and swaptions.
- Calibration and simulation of interest rate models (Hull-White, G2++, LIBOR Market Model)
- Calibration of SABR stochastic volatility model



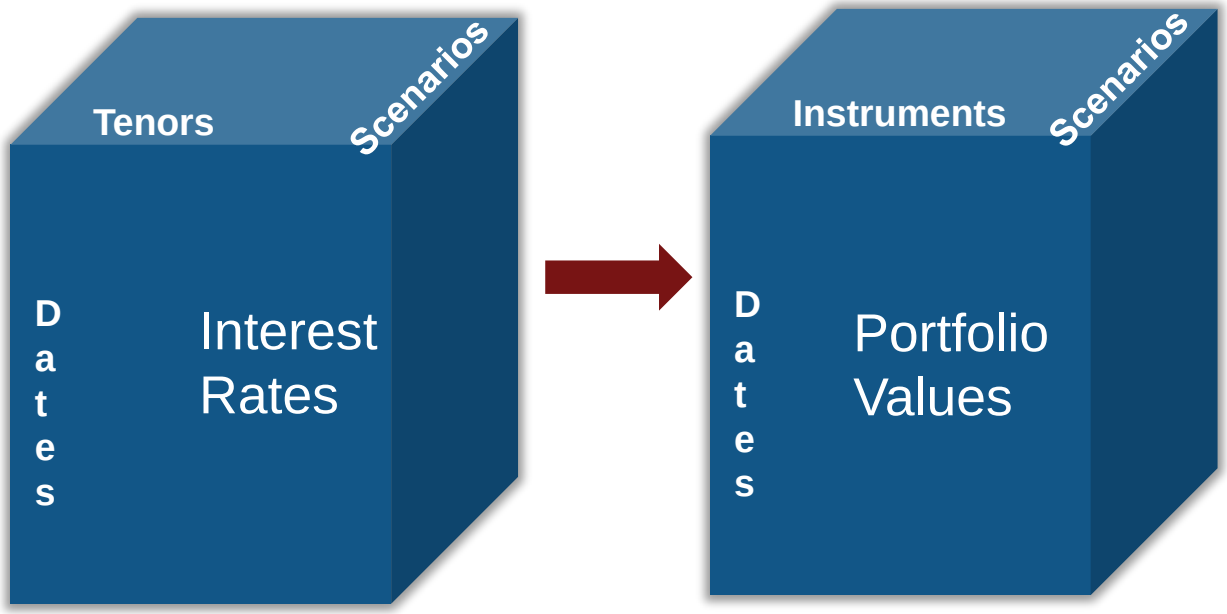
Counterparty Credit Risk

Compute exposures and CCR profiles

- Support for computing credit exposures.
- Support for computing various credit exposure profiles, including potential future exposure and expected exposure.



Parallel Computing for CCR

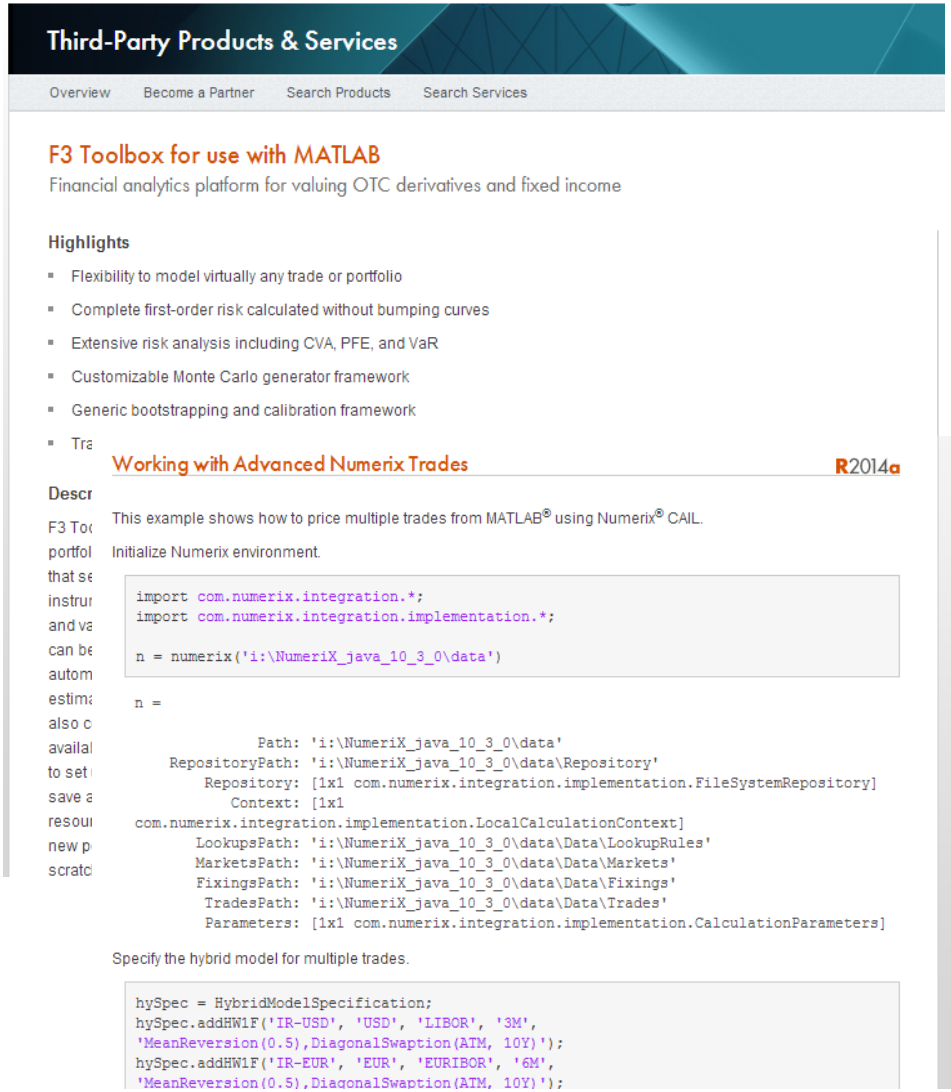



```
parfor dateidx=1:nDates
    Values(dateidx,:,:) = swapbyzero(…)
end
```

Third Party Interfaces

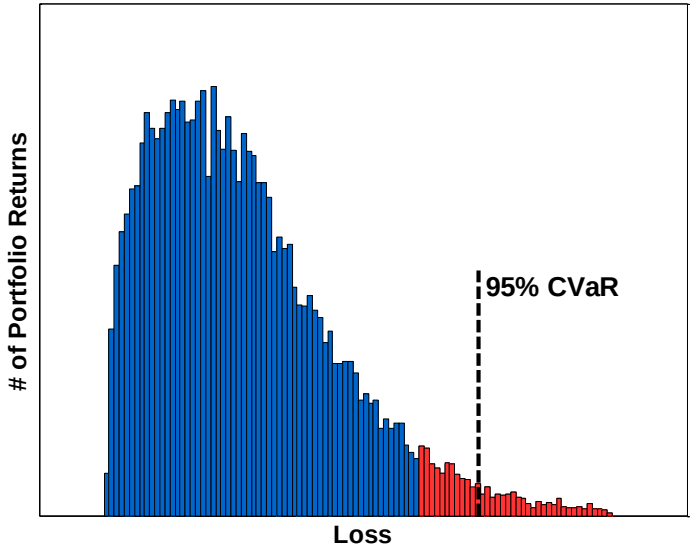
Access third party analytics

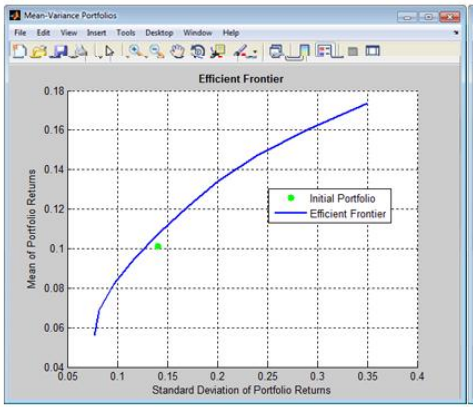
- Support for accessing Numerix® instruments and risk models.
- Support for accessing FinCAD through the F3 Toolbox for MATLAB.

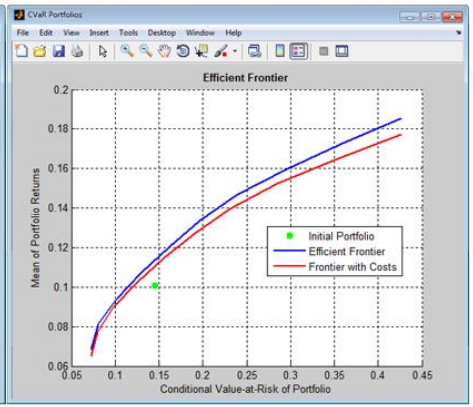


What's new in Portfolio Optimization

- New portfolio object `PortfolioMAD` for mean-absolute deviation (MAD) portfolio optimization.
- New portfolio object `PortfolioCVaR` for conditional value at risk (CVaR) portfolio optimization.







Mixed Integer Linear Programming

- New solver (`intlinprog`) for mixed-integer linear programming (MILP) problems
  - Continuous and integer variables **(Mixed Integer)**

$$x_1 \in [0, 100] \qquad x_2 \in \{1,2,3,4,5\}$$

  - Linear objective and constraints **(Linear Programming)**

$$\min_x \; -x_1 - 2x_2$$

$$\text{such that} \quad \begin{cases} x_1 + 4x_2 \leq 20 \\ x_1 + x_2 = 10 \end{cases}$$

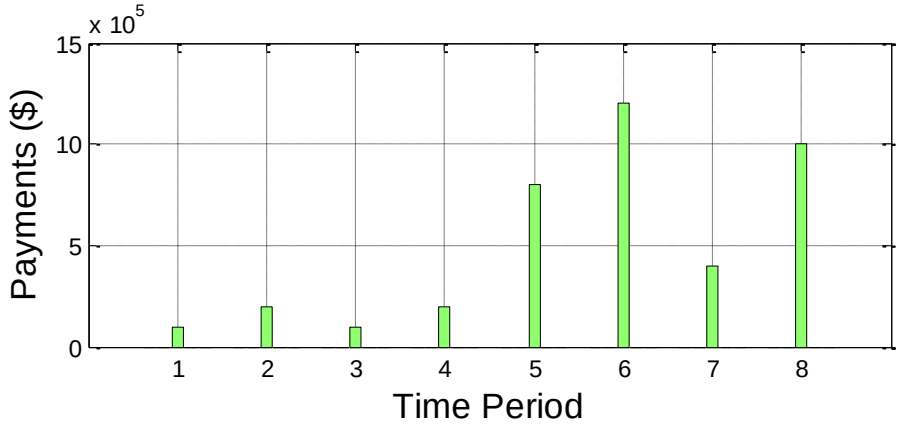
Example: Cash-flow matching

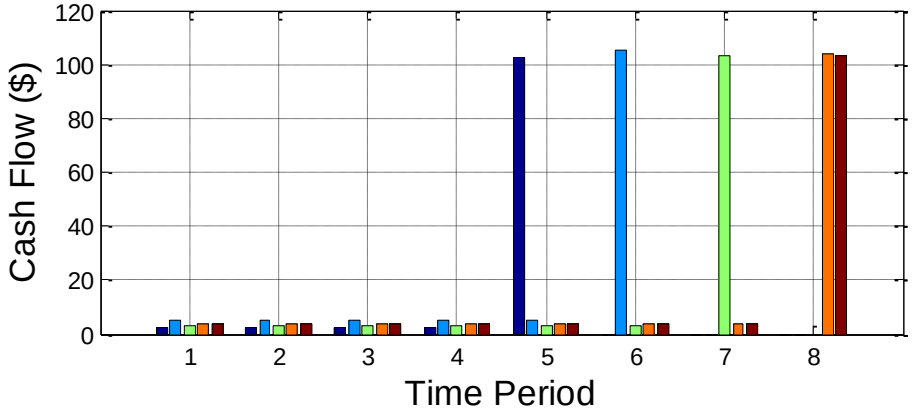
Idea: Buy bonds to cover pension fund obligations

Variables: How many of each bond to buy?

Constraints: Payments from bonds must be greater than or equal to pension fund obligations

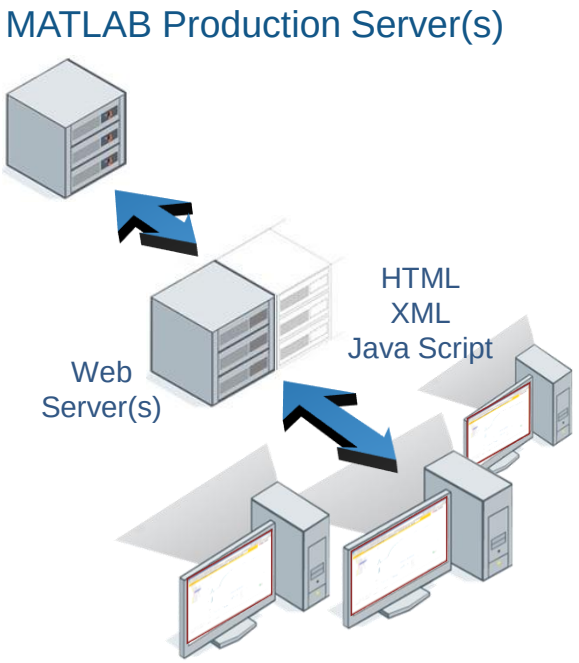
Objective: Minimize the size of the investment you make





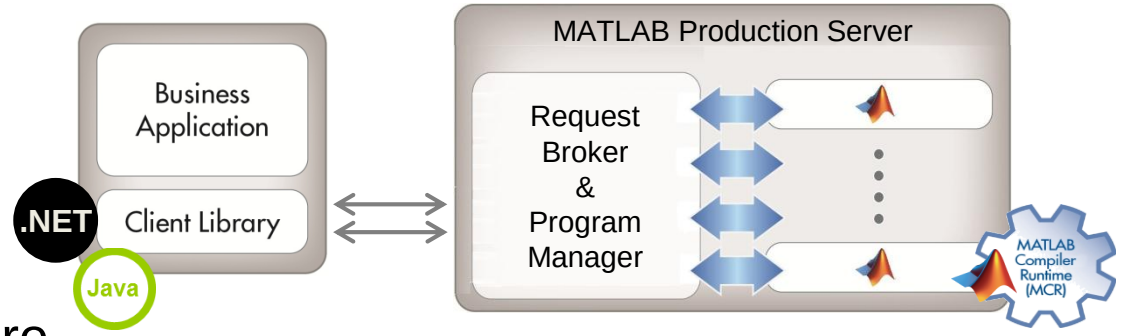
MATLAB Production Server™

- Directly deploy MATLAB programs into production
  - Centrally manage multiple MATLAB programs and runtime versions
  - Automatically deploy updates without server restarts
- Scalable and reliable
  - Service large numbers of concurrent requests
  - Add capacity or redundancy with additional servers
- Use with web, database and application servers
  - Lightweight client library isolates MATLAB processing
  - Access MATLAB programs using native data types



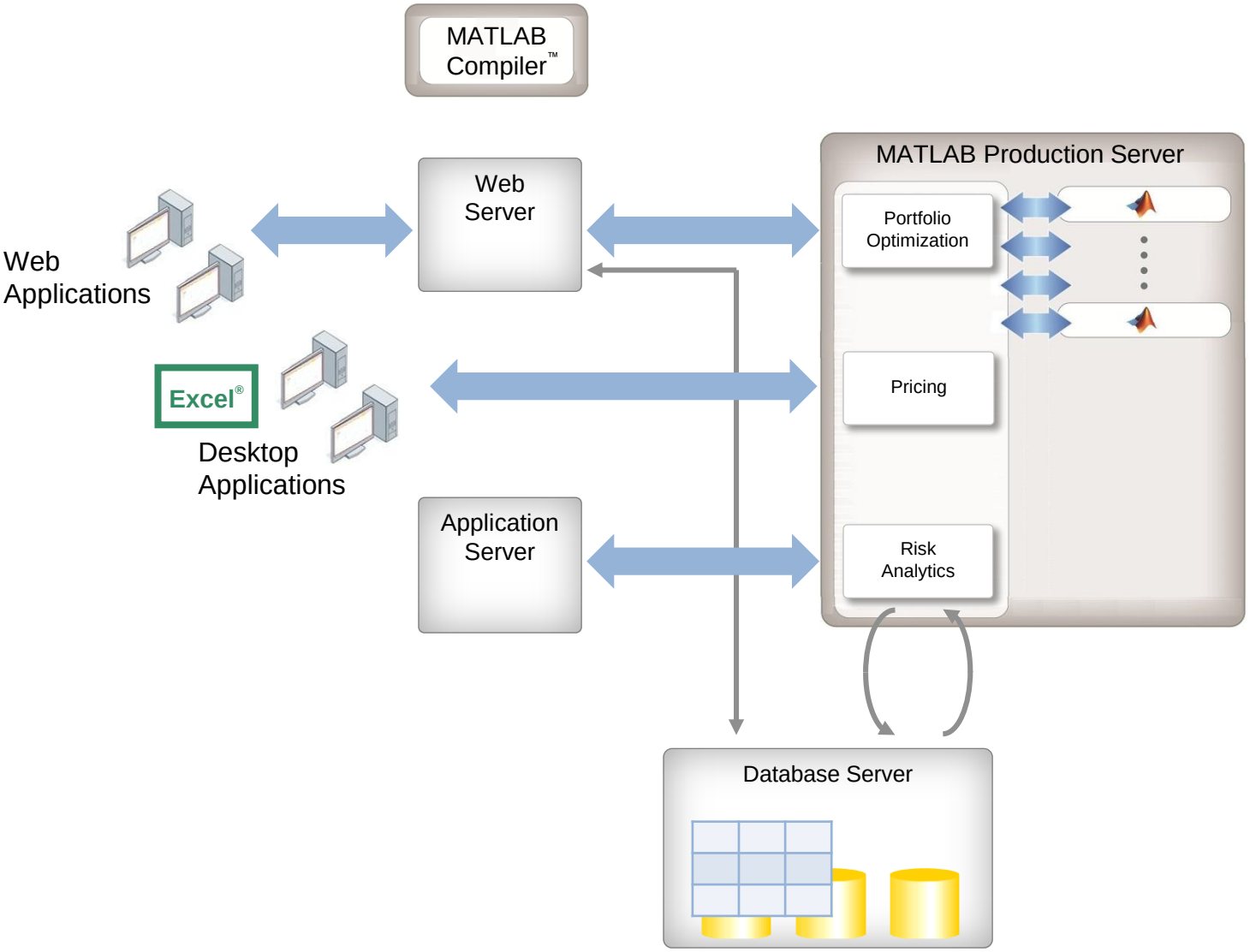
What is MATLAB Production Server?

- Enterprise framework for running packaged MATLAB programs



- Server software
  - Manages packaged MATLAB programs & worker pool
- Runtime libraries
  - MATLAB Compiler Runtime (MCR)
- Lightweight client library (.NET & Java)
  - Request MATLAB programs (functions)

Integrating with IT systems



Developing a New Interest Rate Model

Intuitive Analytics

Challenge

Develop a new interest rate model based on work by Deguillaume, Rebonato and Pogudin (2013).

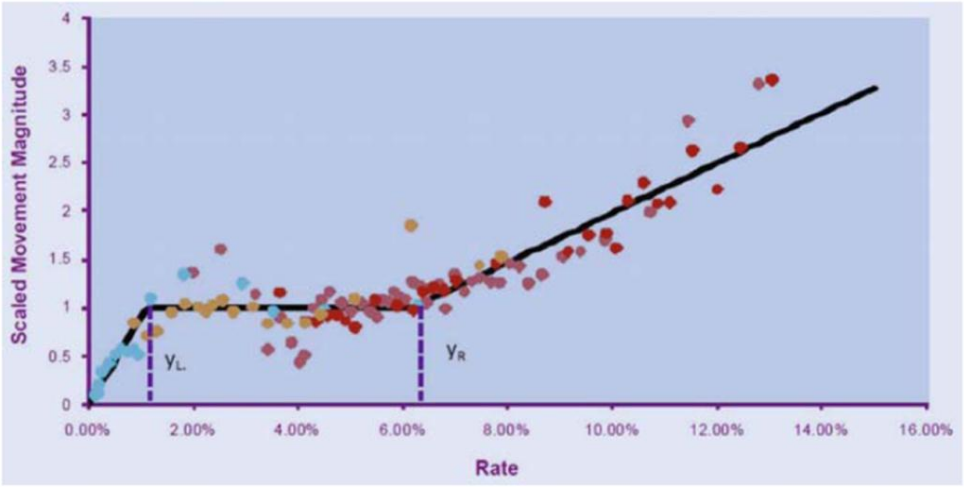


Figure 11. Blue: Japanese yen; red: sterling; maroon: US$; orange: Swiss franc.

Deguillaume, N., Rebonato, R., & Pogudin, A. (2013). The nature of the dependence of the magnitude of rate moves on the rates levels: a universal relationship. *Quantitative Finance*, *13*(3), 351-367.

Developing a New Interest Rate Model

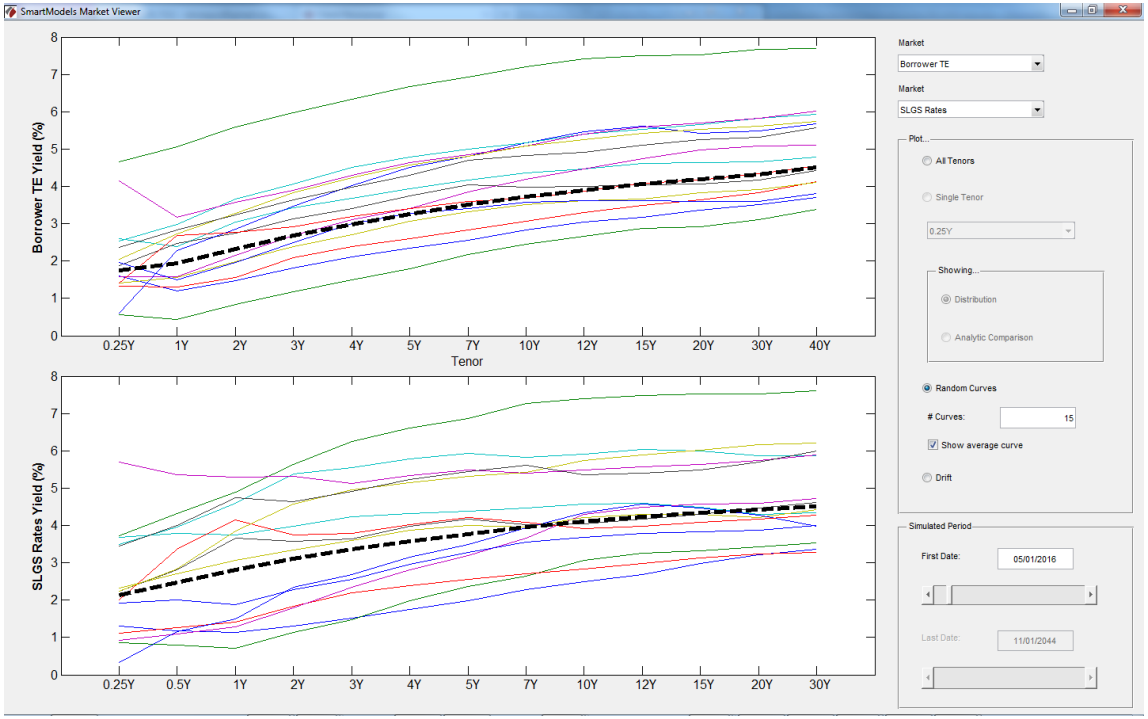
Intuitive Analytics

Solution

The model was developed in MATLAB and can be calibrated to multiple currencies and markets.

Deployment

The model was then deployed to customers via the SmartModels Excel Add-In interface.



Deguillaume, N., Rebonato, R., & Pogudin, A. (2013). The nature of the dependence of the magnitude of rate moves on the rates levels: a universal relationship. *Quantitative Finance*, *13*(3), 351-367.

Future Directions

Graphics


Model IT mProfit Front
File View Report Other Options Help Custom Reports
Statistics & Settings
Historical Forecast
Relative Absolute
01/01/09 to 31/08/09
Reset dates
1 Year YTD
Portfolio Benchmark Difference
Return (%) 28.3410 23.7890 4.5520
Volatility (%) 25.8610 28.7180 -2.8570
Beta 0.8510 1 -0.1490
Tracking Error (%) 9.4980 0 9.4980
Information ratio 0 NaN NaN
Correlation 0.9450 1 -0.0550
Average weight (%) 47.0490 45 2.0490
Current weight (%) 52.8790 45 7.8790
Navigation
Current portfolio: Equity < Total
Attribution portfolio: Total
Risk benchmark: Equity < Total
Choose attribution
Active Return Tracking Error Active Beta
Total allocation selection
1.8210 -0.5250 2.3460
allocation selection
Equity 0.5579 1.8211
Fixed Income 0.1188 -1.5701
Other 1.2302 -1.7631
allocation selection
Asia 0.0488 0.7027
Emerging Markets 0.0283 0.2408
Europe -0.0804 0.8168
Finland -0.0633 0.0955
North America -0.4582 0.4901
SUM 0
Remove this level
Charts
Return vs Benchmark
To clipboard
Open
(%)
20
0
-20
Jan Feb Mar Apr May Jun Jul Aug
Date
PF return
BM Return
Difference
Attribution of sub-portfolios
To clipboard
Open
(%)
3
2
1
0
Jan Feb Mar Apr May Jun Jul Aug
Date
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selection
Portfolio contribution
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2
1
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Jan Feb Mar Apr May Jun Jul Aug
Date
Contribution
Overview
Sub-portfolios
Allocation
Selection
Rolling risk figure

Big Data


BIG
DATA
MATLAB
ANALYTICS
TECHNOLOGIES
STORAGE
INTERNET
MANAGEMENT
PETABYTES
SYSTEMS
PARALLEL
COMPLEX
SOCIAL
RELATIONAL
DISK
TARGET
TOOLS
APPLIED
SHARED
SENSOR
DEFINITION
EXAMPLES
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GARTNER
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NETWORKS
DATABASES
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CAPACITY
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TENS
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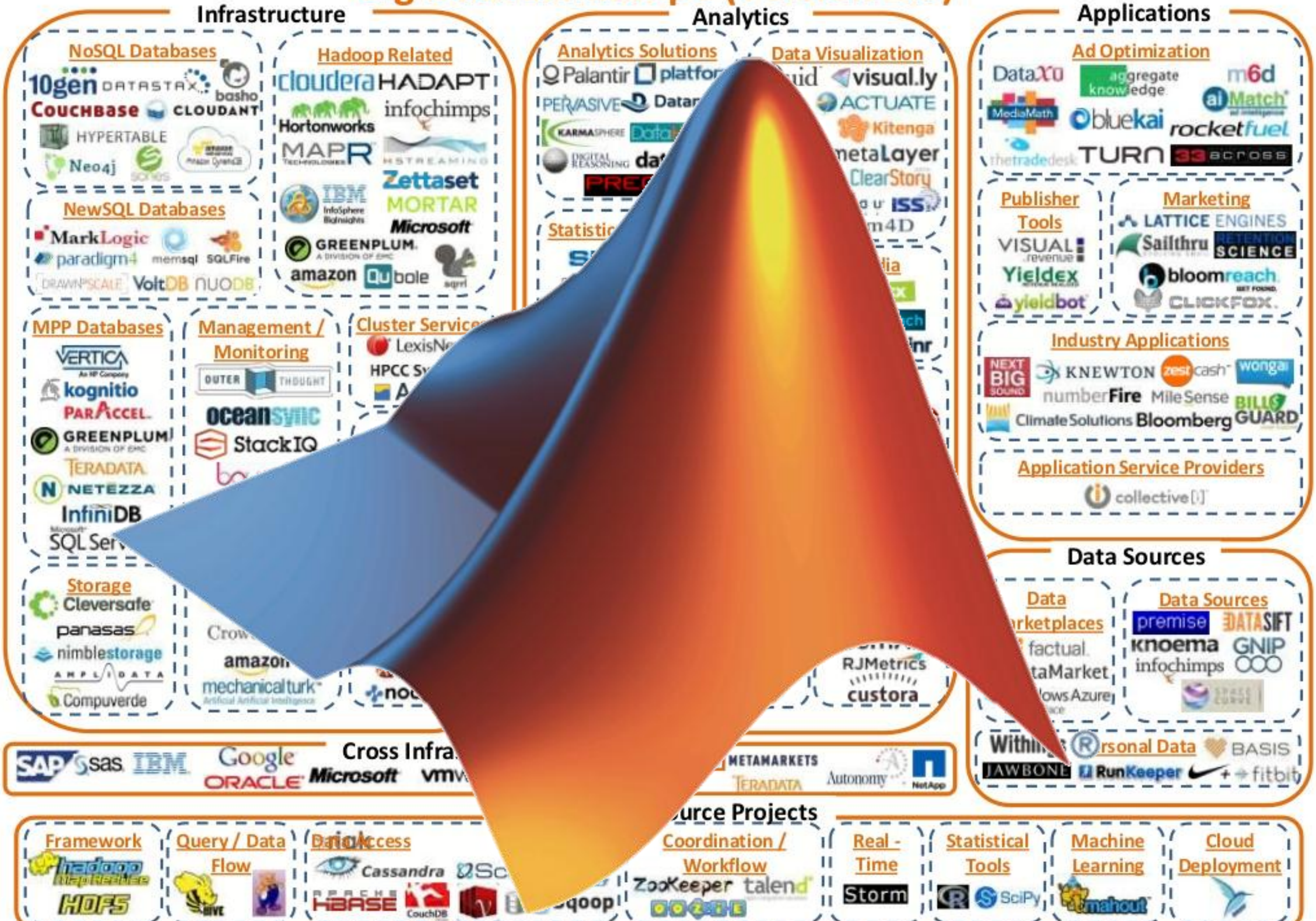
CONTINUES
CITATION
SET
USE

Big Data Landscape (Version 2.0)



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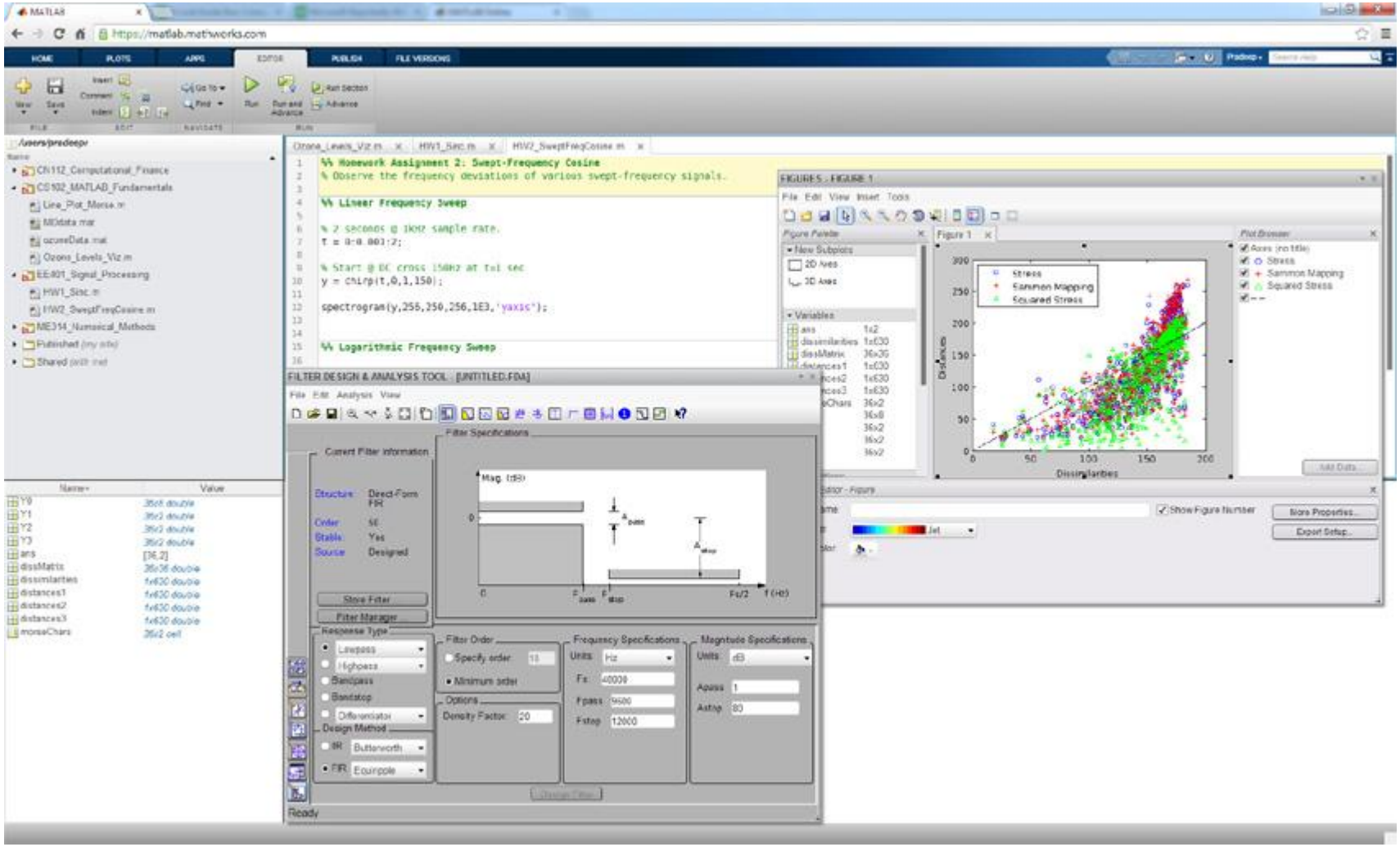
MATLAB Online

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