

## Predictive Modeling with MATLAB



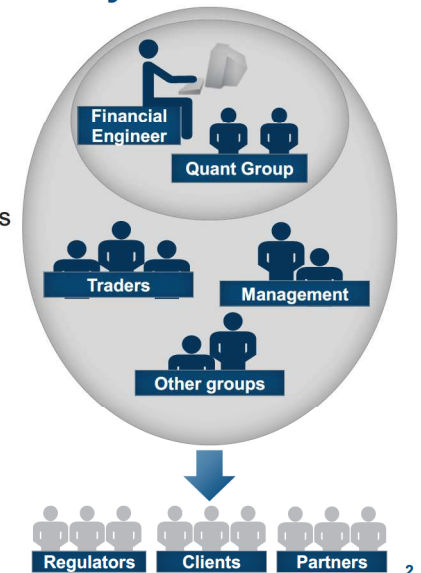
MathWorks Computational Finance Team

Presenter: Francesca Perino

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## The challenges facing you today

- Volatile markets
  - Ever-changing needs
- More data & Larger models
  - Data Management and Analytics
  - Need for computing power
  - Legacy Reuse and Process Automation



## Commerzbank Develops Production Software System for Calculating Derived Market Data

### Challenge

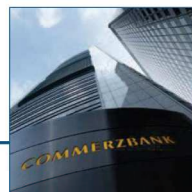
Compute a variety of derived market data from raw market data

### Solution

Use MATLAB to read data from a data management system in a Windows and Linux architecture, perform analyses and optimizations, visualize results, and deploy mission-critical calculations

### Results

- Integration with existing system simplified
- Implementation time reduced by months
- Updates made in days, not weeks



Commerzbank headquarters in Frankfurt.

"Our solution required a Windows client and Linux server software. We used MATLAB to rapidly develop both by taking advantage of distributed computing, a MEX-file interface to access our financial data, and fast, built-in functions for optimization, regression, and more."

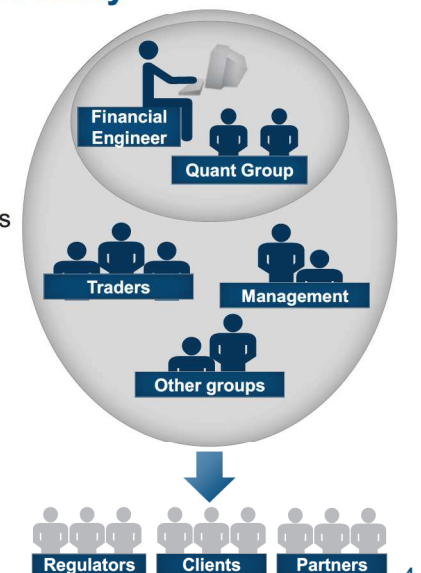
Julian Zenglein  
Commerzbank

[Link to user story](#)

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  - Legacy Reuse and Process Automation
- Need for transparency is increasing
  - More auditing and regulation
  - Customer-Centricity



## Banca Carige Integrates a MATLAB Based Valuation Library with Its Enterprise Pricing and Risk Platform

### Challenge

Replace a black-box Microsoft Excel add-in for pricing financial instruments with a more transparent, customizable alternative

### Solution

Use MATLAB to develop sophisticated pricing models and deploy them as a .NET component that can be integrated with the bank's structured products platform

### Results

- Transparent, flexible pricing model deployed
- Products priced in real time, not weekly
- Integration with existing systems streamlined



Banca Carige corporate headquarters in Genoa.

"We consider MATLAB to be the best choice for mathematical modeling and numerical computation. MATLAB gives us the unmatched flexibility to embed our algorithms in automated finance systems as add-ins for Excel or components in a .NET framework."

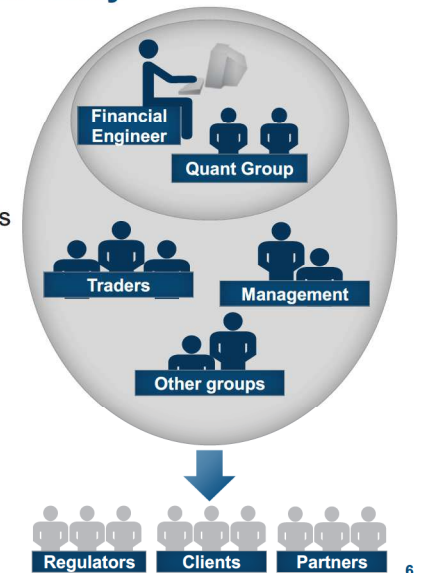
Paolo Raviola  
Banca Carige

[Link to user story](#)

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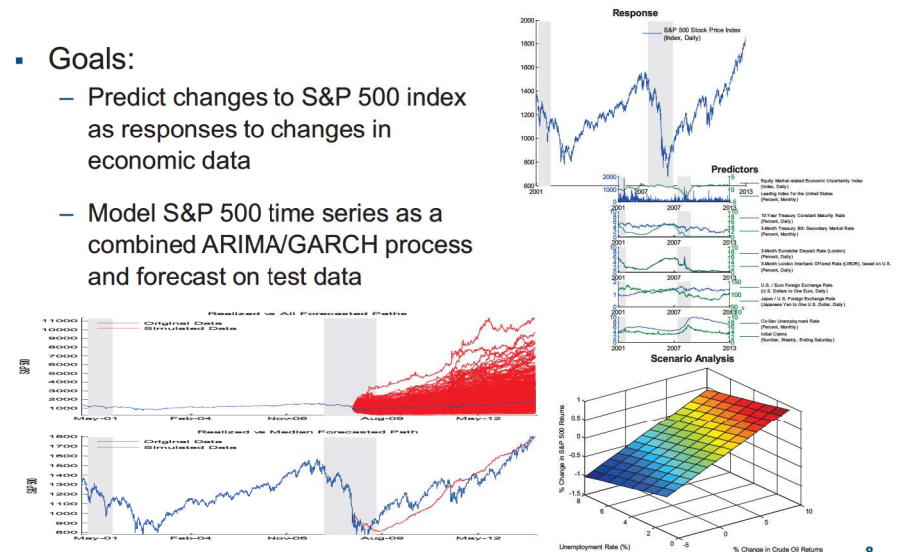
## Challenges Faced During Model Development

Traditional Approach	Challenge
Off-the-shelf software	<i>Inability to customize</i>
Third-party consulting	<b>Lack of transparency</b>
Spreadsheets, Excel	<b>Robustness, Computational speed, limited data size</b>
In-house development with traditional languages	<b>Long development time</b>
Combination of the above	<b>Inefficiencies in Integration &amp; Automation</b>

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## Predictive Modeling Example

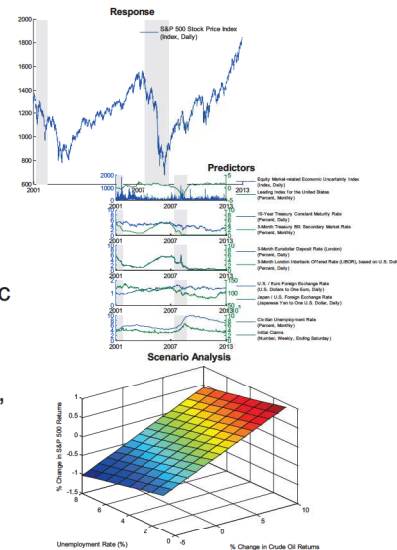
- Goals:
  - Predict changes to S&P 500 index as responses to changes in economic data
  - Model S&P 500 time series as a combined ARIMA/GARCH process and forecast on test data



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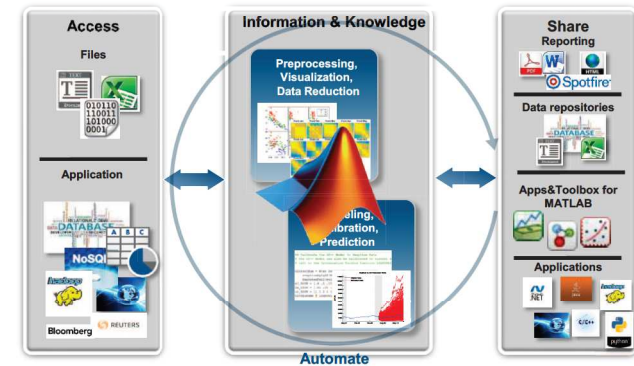
## Example – Predicting S&P 500 Responses to Economic Data

- Goal:
  - Predict changes to S&P 500 index as responses to changes in economic data
- Approach:
  - Collect and “clean up” economic and financial market data
  - Model S&P 500 index returns using multiple linear regression, predictor selection and model diagnostic techniques



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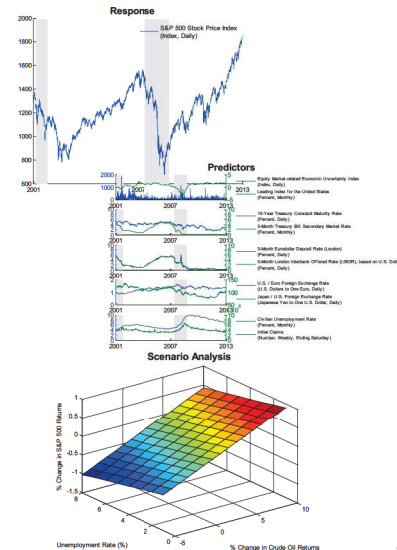
## Financial Modeling and Analytics Workflow



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## Example – Predicting S&P 500 Responses to Economic Data

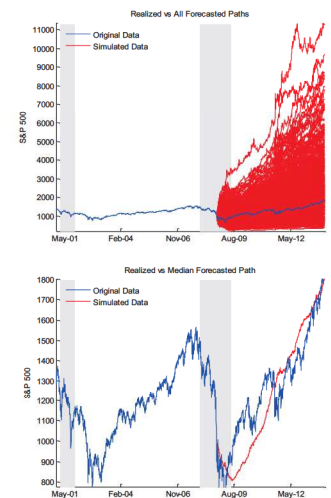
- Support for major data providers
- Numerous regression and linear modeling techniques with rich documentation
- Interactive visualizations
- Rapid exploration & development



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## Example – Time Series Modeling and Forecasting for the S&P 500 Index

- Goal:
  - Model S&P 500 time series as a combined ARIMA/GARCH process and forecast on test data
- Approach:
  - Fit ARIMA model with S&P 500 returns and estimate parameters
  - Fit GARCH model for S&P 500 volatility
  - Perform statistical tests for time series attributes e.g. stationarity

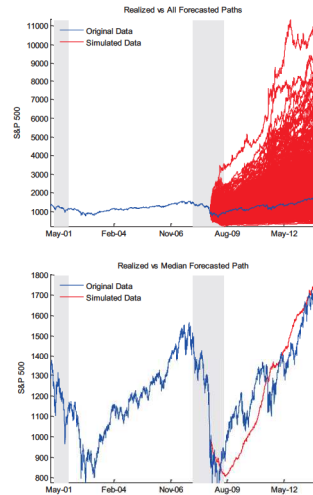


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## Example – Time Series Modeling and Forecasting for the S&P 500 Index

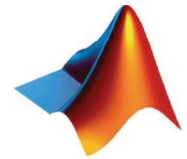
- Numerous ARIMAX and GARCH modeling techniques with rich documentation
- Interactive visualizations
- Code parallelization to maximize computing resources
- Rapid exploration & development



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## Predictive Modeling with MATLAB

- Interactive environment
  - Visual tools for exploratory data analysis
  - Easy to evaluate and choose best algorithm
  - Simple code parallelization to maximize resources usage
  - Apps available to help you get started (e.g., neural network tool, curve fitting tool)
- Multiple algorithms to choose from
  - Regression
  - Time series analysis – ARIMAX/GARCH
  - Machine learning techniques



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## Options for Financial Modeling and Analytics with MATLAB

Challenge	Solution
Inability to customize	<b>Flexible modeling</b> <ul style="list-style-type: none"> <li>▪ Development and Debugging Environment</li> </ul>
Lack of transparency	<b>White-box modeling</b> <ul style="list-style-type: none"> <li>▪ Viewable-source functions</li> </ul>
Subpar computational speed, limited data size	<b>Powerful computation engine</b> <ul style="list-style-type: none"> <li>▪ Run fast Monte-Carlo simulations</li> </ul>
Long development time	<b>Quick prototyping</b> <ul style="list-style-type: none"> <li>▪ Focus on modeling not programming</li> </ul>
Inefficiencies in Integration & Automation	<b>Easy to Integrate &amp; Deploy</b> <ul style="list-style-type: none"> <li>▪ Point-and-click workflow</li> </ul>

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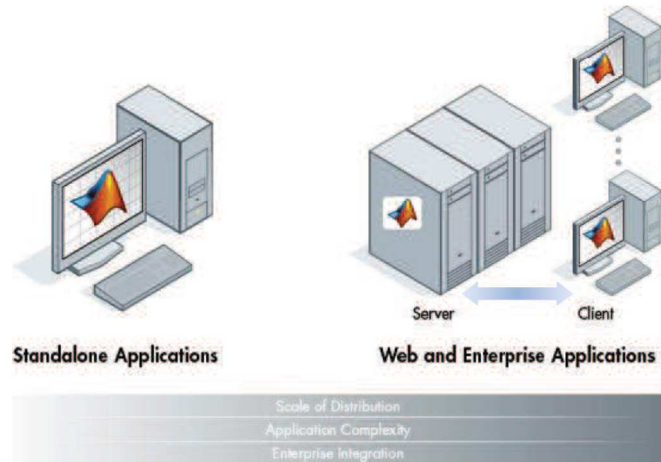
## Benefits of Deploying MATLAB Code

- Domain experts maintain ownership of ideas, algorithms, and applications
- Flexibility to integrate with different programming languages
- Implement a common algorithm on different platforms
- Avoid time consuming and error prone re-coding
- Easily adopt algorithm improvements throughout lifecycle



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## The Range of Application Platforms



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## To learn more, visit:

**Machine Learning with MATLAB**  
Build predictive models and discover hidden patterns from relevant data

Machine learning algorithms use computational methods to "learn" information directly from data without assuming a problem model. They can adaptively improve their performance as you increase the number of samples available for learning.

Machine learning algorithms are used in applications such as computational finance (credit scoring and algorithmic trading), (tumor detection, drug discovery), and DNA sequencing; energy production (price and load forecasting); natural language processing (image recognition, and advertising and recommendation systems).

Machine learning is often used in big data applications, which have large datasets with many predictors (features) and are to single parametric models. Examples of big data applications include forecasting electricity load with a neural network, or bond for credit risk using an ensemble of decision trees.

**Classification**  
Build models to classify data into different categories.

**Regression**  
Build models to predict continuous data.

**Clustering**  
Find natural groupings patterns in data.

**Algorithms:** support vector machine (SVM), boosted and bagged decision trees, k-nearest neighbor, Naïve Bayes, discriminant analysis, neural networks, and more.

**Algorithms:** linear model, nonlinear model, regularization, stepwise regression, boosted and bagged decision trees, neural networks, adaptive neuro-fuzzy learning, and more.

**Algorithms:** k-means, clustering, Gaussian mixture models, self-organizing maps, and more.

**Applications:** credit scoring, target detection, image recognition.

**Applications:** electricity load forecasting, algorithmic trading.

**Applications:** pattern recognition, image, speech recognition.

**Develop, Backtest, and Simulate Dynamic Models**  
You can build and estimate parameters for your models by using traditional techniques, such as solving systems of ordinary differential equations, performing multivariate regression, or using optimization techniques for fitting models to time-series data. Alternatively, you can apply specialized modeling techniques such as ARMAX/GARCH, VAR/VARMA, and linear or nonlinear stochastic differential equations.

MATLAB lets you mix and match different techniques and approaches to develop models that incorporate market dynamics. You can combine continuous and discrete time approaches with random/discrete events. These types of models are used to simulate trading systems that account for exchange trading curbs or describe macroeconomic systems containing random events.

**Solve Models**  
Dependencies for Quantitative Risk Assessment (User story)

**Bayesian Analysis for a Logistic Regression Model (Example)**

For more information on solving machine learning problems, see Statistics and Machine Learning Toolbox™, Neural Network Toolbox™, and Fuzzy Logic Toolbox™.

[www.mathworks.com/machine-learning](http://www.mathworks.com/machine-learning)

<http://www.mathworks.com/solutions/computational-finance/time-series-analysis.html>

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## MATLAB Central

- Community for MATLAB and Simulink users
- Over 1 million visits per month
- File Exchange
  - Upload/download access to free files including MATLAB code, Simulink models, and documents
  - Ability to rate files, comment, and ask questions
  - More than 12,500 contributed files, 300 submissions per month, 50,000 downloads per month
- Newsgroup
  - Web forum for technical discussions about MathWorks products
  - More than 300 posts per day
- Blogs
  - Commentary from engineers who design, build, and support MathWorks products
  - Open conversation at [blogs.mathworks.com](http://blogs.mathworks.com)

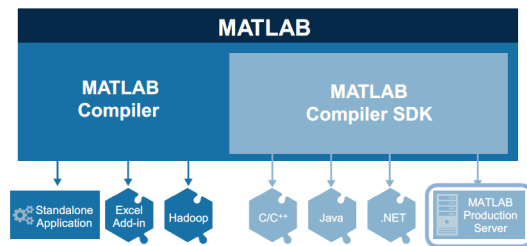


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## Questions?

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## Which Product will Fit Your Needs?



**MATLAB Compiler** for sharing MATLAB programs without integration programming

**MATLAB Compiler SDK** provides implementation and platform flexibility for software developers

**MATLAB Production Server** provides the most efficient development path for secure and scalable web and enterprise applications