MathWorks KeyNote: Accelerating Model Development Across Risk-Aware Institutions

Jos Martin
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<th>Compliance Regulation</th>
<th>Solvency II</th>
<th>AIFMD</th>
<th>EBA/CCAR</th>
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<th>IFRS 13, 9</th>
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= Direct  = Indirect
Risk Communities: Take Risk
In All Cases..... Good Process Required
Notable Industry Errors

Top 5 Spreadsheet errors
(European Spreadsheet Risks Interest Group)

1. JP Morgan
2. Reinhart & Rogoff
3. U.S. Federal Reserve
4. Fidelity Magellan Fund
5. AXA Rosenberg

http://www.eusprig.org/horror-stories.htm
http://www.nextnewdeal.net/rortybomb/researchers-finally-replicated-reinhart-rogooff-and-there-are-serious-problems
Why?

- **Accidents Happen:**
  - Theory of Normal Accidents (Perrow, 1984, 1999),
    - Complex Systems; nonlinearities
    - Tight coupling; subsystem interaction
  - Applied to Finance (Lo, 2005, 2010)
    - Human Behaviour
    - Model Flaws
    - Ineffectual risk management

- **Complex Processes**
  - “Throw it Over the Wall”
  - Asset Class/Department Silos

- **Technical Debt**
- **Etc**
Unintended Consequences: Legal Risk

Example: GPL Code

- GPL license implications
  - Code *you* (or your company) develop that includes GPL code *also* falls under GPL license

- Distributing *your* code makes it public domain
  - If you’re selling or deploying solutions, avoid using GPL.
Whose code is it?

www.vanityfair.com

Goldman Sachs vs. Sergey Alkeynikov

- An expert quant who left the company was charged with stealing code. His claim was that the downloaded code was open source.

  “Sergey quickly discovered, to his surprise, that Goldman had a one-way relationship with open source. They took huge amounts of free software off the Web, but they did not return it after he had modified it, even when his modifications were very slight and of general rather than financial use.”

- Key point ➔ They seemed not to understand the risk

Source: Did Goldman Sachs Overstep in Criminally Charging Its Ex-Programmer?
EMBRACE complexity?

Don’t Add to IT
Embrace Complexity, Reduce Risk, Improve Service
Model Development Across Risk-Aware Institutions

Embracing Complexity

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MATLAB is the easiest and most productive environment for engineers and scientists.
1. MATLAB Speaks Maths
%% Kalman Filter

% Predicted state and covariance
Xp = F*Xe;
Pp = F*Pe*F' + Q;

% Estimation
S = H*Pp'*H' + R;
B = H*Pp';
K = (S\B)';

% Estimated state and covariance
Xe = Xp+K*(z-H*Xp);
Pe = Pp-K*H*Pp;

% Estimated measurements
y = H*Xe;
1. MATLAB Speaks Maths

2. MATLAB Toolboxes just Work
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2. MATLAB Toolboxes just Work
3. MATLAB is Designed for Financial Engineering and Data Analytics
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G = graph(sectorDist, sectors);
T = minspantree(G);

coords = mdscale(sectorDist, 3, 'Criterion', 'stress');

plot(T, 'XData', coords(:, 1), 'YData', coords(:, 2));
3. MATLAB is Designed for Financial Engineering & Data Analytics
1. MATLAB Speaks Maths
2. MATLAB Toolboxes just Work
3. MATLAB is Designed for Financial Engineering & Data Analytics
4. MATLAB has Apps
4. MATLAB has Apps
1. MATLAB Speaks Math
2. MATLAB Toolboxes just Work
3. MATLAB is Designed for Financial Engineering & Data Analytics
4. MATLAB has Apps
5. MATLAB is Fast
5. MATLAB is Fast

MATLAB faster

MATLAB performance over Python | Average | Best |
--- | --- | --- |
Engineering | 3.2x | 64x |
Statistics | 2.7x | 52x |
Graphics | 31x | 540x |
Nested “for” loops | 64x | 64x |

Python faster
MATLAB is Fast

Classification Done by GPU Enabled Deep Neural Network
1. MATLAB Speaks Maths
2. MATLAB Toolboxes just Work
3. MATLAB is Designed for Financial Engineering & Data Analytics
4. MATLAB has Apps
5. MATLAB is Fast
6. MATLAB Integrates Workflows
6. MATLAB Integrates Workflows

1,000+ Hardware Devices
Embedded Code Generation

- C, C++
- VHDL/Verilog
- PLC
6. MATLAB Integrates Workflows

1,000+ Hardware Devices
Embedded Code Generation
From Parallel Desktop to Cloud
6. MATLAB Integrates Workflows

1,000+ Hardware Devices
Embedded Code Generation
From Parallel Desktop to Cloud
Easy Deployment
Stress Test Example: Macroeconomic Modelling

- Diebold *et al* proposed a yield curve model with macro factors that tries to describe an economy
  - We implement this for the *Modelling the US Economy* demo

- Vector Autoregressive Model

\[ Y_t = a + \sum_{i=1}^{p} A_i Y_{t-i} + W_t \quad W_t \sim N(0, Q). \]

- Use Econometrics Toolbox
  - Load and transform the data
  - Partition to support backtesting
  - Fit the models to the data
  - Decide best model
  - Make forecasts
Model-Centered Research and Production Process

Embracing Complexity

- Prototyping, Modelling & Analysis
- Application Development
- (Enterprise) Implementation

Testing: Validation and Verification
MATLAB is Developer Friendly
MATLAB is Developer Friendly

Why MATLAB?

- MATLAB is the leading software used by economists in universities
- Core level of MATLAB proficiency in the Bank
  - Lowers maintenance cost/risk
- A lot of the functionality is based around linear matrix algebra
- Developing new code is fast and easy
  - Policymakers often want to test models rapidly
- Toolboxes are generally comprehensive
- Flexibility in mixing process components

Macroeconomic forecasting at Bank of England

Points to consider:
1. modular—but-interrelated nature of the core problems…
2. unknown location of final solution(s)
3. the requirement to conceive, implement and test certain algorithms…
4. a need to somehow process a large number of policy ideas (rating scenarios)…
5. the need to visualise results quickly and easily…
6. the need for several people to work on the problem simultaneously, passing fragments of code around and then integrating them into the simulator…
7. plus a maintainability burden due to high levels of changes within the project…

...all implied that (1) an object-oriented approach in (2) an interpreted environment would be ideal

- MATLAB in its object-oriented mode is almost perfectly designed for this sort of work
MATLAB is Developer Friendly
Model-Centered Research and Production Process

Embracing Complexity

http://macrostresstest.mathworks.com [Use Chrome]
Deployment

• Royalty-free
• Encryption to protect intellectual property
Conclusions

- Accidents Happen
  - Measure, Monitor and Control

- Understand your Process
  - Embrace Complexity, Don’t Add to IT
  - Reduce Technical Debt

- MATLAB Accelerates Model Development Across Risk Aware Institutions.
  - The easiest and most productive tool for engineers and scientists
  - Enables application development
  - Integrates into the enterprise (and desktop)

- Enjoy the Conference !!!