MODEL DEPLOYMENT IN GAMS

GAMS Jupyter / GAMS MIRO
Agenda

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3. GAMS MIRO
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   2. Hands-on
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Motivation
Motivation

• AMLs are powerful tools for developing solver-independent optimization models

• Intuitive deployment and visualization are becoming increasingly important
  → End-users of optimization software are very often not modeling experts
  → Need for easy-to-use tool to visualize data and compare results

• Current deployment possibilities are not satisfactory for everyone
Deployment of GAMS models
current possibilities

Expert level APIs
• GDX, OPT, GAMSX, GMO, ...
• High performance and flexibility
• Automatically generated imperative APIs for several languages (C, C++, C#, Delphi, Java, Python, VBA, ...)

Object Oriented APIs
• GAMS comes with several OO APIs (Python, Java, C++, C#, ...) to develop applications

→ Programming required to build your applications
GAMS Jupyter
Welcome to Jupyter @ GAMS!

Sign in

Username:
Password:
Sign In

Welcome to Jupyter @ GAMS!

Enter your credentials in order to sign in or contact GAMS Support for further information.

Getting Started
- Introduction
- Milco Example
- PickStock Example
- A GAMS Tutorial by Richard E. Rosenthal

Further Help
- Jupyter Notebook Users Manual (from Bryn Mawr College)
- GAMS World Forum
- Contact GAMS

Currently under Development
GAMS Jupyter Example

Parameter fund(date) 'Index fund report parameter'; fund(d) = sum(s, price(d, s) * w.l(s));
Parameter error(date) 'Absolute error'; error(d) = abs(index(d) - fund(d));

Plotting of the results

In [18]:
```python
%gams pull -d fund error
fig, ax = plt.subplots()
index.plot(y="value", ax=ax, xticks=[0, trainingDays, len(date)], yticks=[], label="Dow Jones")
fund.plot(y="value", ax=ax, xticks=[0, trainingDays, len(date)], yticks=[], label="Index Fund")
```

![Graph showing Dow Jones and Index Fund comparison](image.png)
Using GAMS Jupyter Notebooks to tell “optimization stories”

• Runs in a browser / on a server → No local installation needed
• Allows to use notebook technology in combination with GAMS
• Notebooks allow to combine GAMS and Python
  • GAMS works great with well structured data and optimization models
  • Python is very rich in features to retrieve, manipulate, and visualize data that comes in all sort of ways
  • → Combining GAMS and Python in a notebook it is relatively easy to tell an optimization story with text, data, graphs, math, and models

• This “product” is currently under development. Give it a try at https://jupyterhub.gams.com/hub/login
GAMS MIRO
Overview

- Web interface for GAMS models
- Usage via web browser

Develop GAMS model

Web browser

Click to deploy

minimize obj := sum {d in D} (spos[d] + slneg[d]);
subject to
  sum {d in D} price[d] - w[d] = index[d] + spos[d] - slneg[d];
  w[d] <= p[d];
  sum {d in D} p[d] <= maxstock;
  w[d] >= 0, p[d] in {0, 1};
  spos[d] >= 0, slneg[d] >= 0;

G A M S
Hands-on

Model: Pickstock
**Model: Pickstock**

- **Data**: Performance of all shares of the Dow Jones index over a period of 1 year
- **Goal**: Find a small selection of stocks that follows the Dow Jones as closely as possible
- **Optimization model**: Select a subset (≤ maxstock) of Dow Jones stocks, along with weights, so that this portfolio behaves similarly to the overall index (in the training phase)

**Training phase**
Select small subset of stocks (Optimization)

**Testing phase**
How similar behaves the stock selection to the DJ? (Evaluation of results)

```
minimize obj := \sum_{ds} slpos_{ds} + slneg_{ds}
subject to \sum_{s} price_{ds,s} \cdot w_s = index_{ds} + slpos_{ds} - slneg_{ds} \quad (\forall ds)
w_s \leq p_s \quad (\forall s)
\sum_s p_s \leq maxstock
w_s \geq 0, \quad p_s \in \{0, 1\} \quad (\forall s)
slpos_d \geq 0, \quad slneg_d \geq 0 \quad (\forall d)
```
Model: Pickstock

\[
\text{minimize} \quad \text{obj} := \sum_{ds} \text{spos}_{ds} + \text{slneg}_{ds}
\]
Model: *Pickstock*

\[
\text{minimize} \quad \text{obj} := \sum_{ds} \text{slpos}_{ds} + \text{slneg}_{ds}
\]
Scenario runs and sensitivity analysis

The GAMS MIRO Hypercube mode
Hypercube mode
scenario generation

Base mode

Hypercube mode
Hypercube mode
scenario generation

Select the maximum number of stocks

select the number of days for training

Step size

Step size

+ 1

+ 5

Number of scenarios
= Cartesian product of scalar input combinations

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**Hypercube mode**

Data import & monitoring of scenario runs

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<th>Owner</th>
<th>Submission date</th>
<th>Job tags</th>
<th>Status</th>
<th>Action</th>
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<td>runxy</td>
<td>running</td>
<td>Show log, Discard</td>
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<td>running</td>
<td>Show log, Discard</td>
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<td>run1</td>
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<td>MIP min_ship</td>
<td>completed</td>
<td>Import, Show log, Discard</td>
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</tbody>
</table>

Show history | Manual import
### Hypercube mode

#### Scenario management

#### Load scenarios

**Time created**
- **between** 2019-02-01 and 2019-02-21

**Job tags**
- **is** superman

**AND**

**Time created**
- **between** 2019-02-22 and 2019-03-04

**Job tags**
- **is** wonder woman

**AND**

**OR**

**Fetch results**

#### Show 10 entries

<table>
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<tr>
<th>Owner</th>
<th>Time created</th>
<th>Job tags</th>
<th>maximum number of stocks to select</th>
<th>MIP-Solver</th>
<th>number of days for training</th>
<th>Ratio between error test and error train</th>
<th>Absolute error in entire testing phase</th>
<th>Absolute error in entire training phase</th>
<th>last date of training period</th>
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Showing 1 to 10 of 220 entries

[Choose selected scenarios] [Choose current page] [Choose all]
Hypercube mode
Analysis

Analyze Scenarios

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<th>stat_SolutionQuality</th>
<th>solvedata</th>
<th>documentation</th>
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</table>

SolverTime - arith. means
Filter: all instances

SolverTime
Filter: gap <= 10% and no fail for all solvers

Absolute performance profile (SolverTime)
Summary

Key points
Summary

Key points

• Quick & automated deployment of GAMS models
• Data visualization with powerful charts / graphics
• Generation, processing and evaluation of scenario data
• Generation of performance statistics and sensitivity analyses
• Data export for external GAMS jobs and analyses
• Intuitive and structured work without GAMS knowledge
• Easy and convenient data management
GAMS MIRO on a server
Based on docker technology

- Multi-user management
- Authentication: LDAP, OAuth 2.0, Google, GitHub, Facebook, ...
- Multi-application support
- Load balancing
- Rolling updates
Conclusion

- Commercially supported GAMS product
- Currently a BETA version
- Installer for Windows, MacOS, Linux
- Used in commercial projects
- Already quite extensive documentation
- Configuration Generator
For more information visit: www.gams.com/miro

Watch our YouTube video: https://youtu.be/7pUrZ-u9ZcQ