

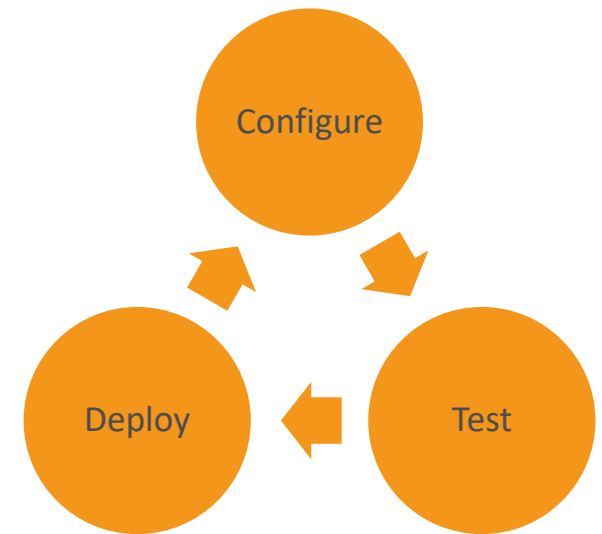
Model deployment in GAMS

GAMS MIRO – An interactive web interface

Motivation

Separation of Tasks:

- Modeling work
 - AMLs are powerful tools for developing solver-independent optimization models
 - GAMS for modeling and optimization
 - 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

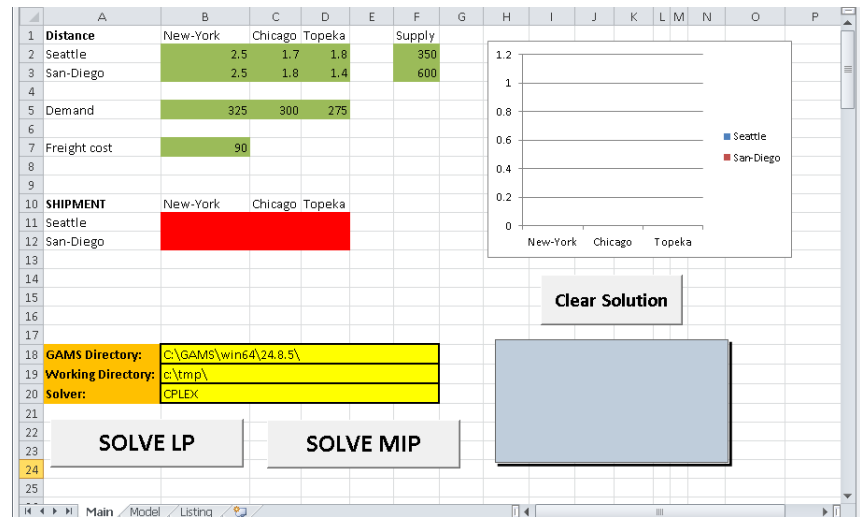


Deployment of GAMS models

current possibilities

Expert level APIs

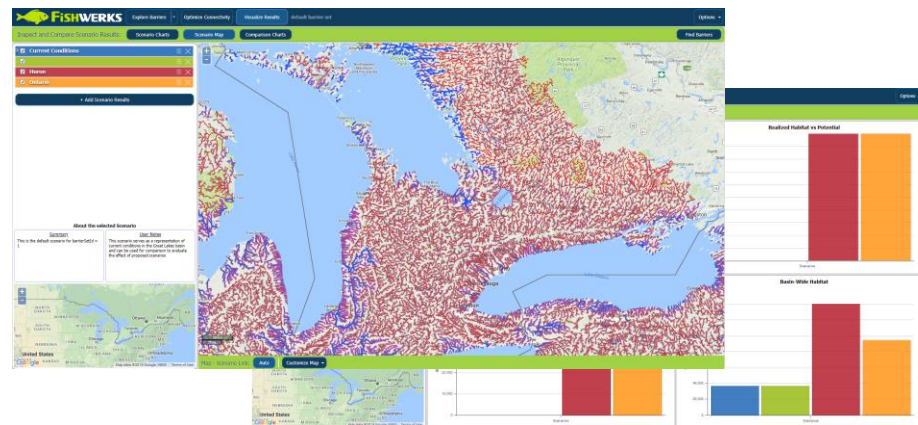
- GDX, OPT, GAMSX, GMO, ...
- High performance and flexibility
- Automatically generated imperative APIs for several languages (C, C++, C#, Delphi, Java, Python, VBA, ...)



Object Oriented APIs

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

→ Programming required to build your applications



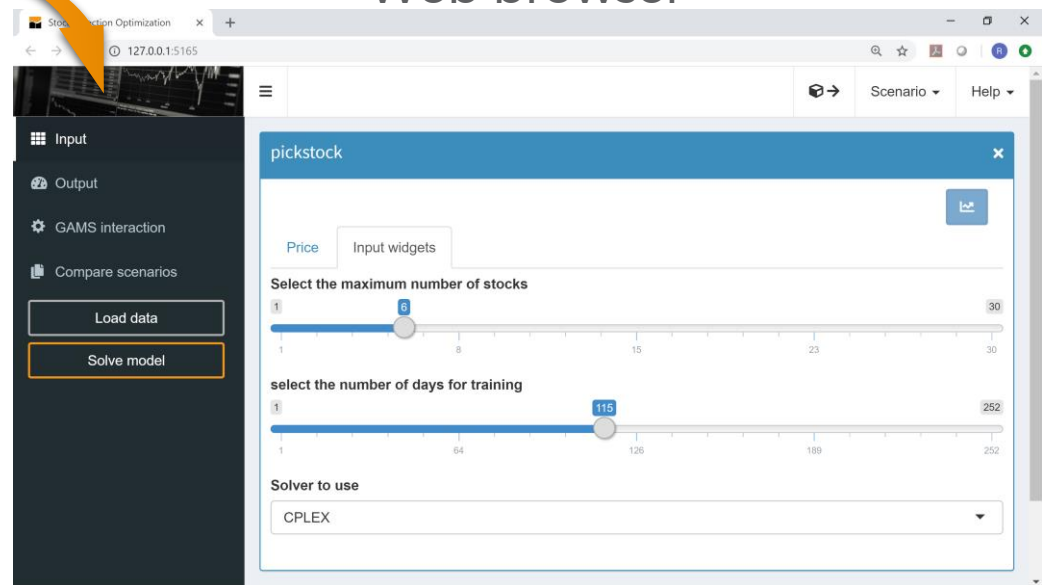
GAMS MIRO

Model Interface with Rapid Orchestration

Develop GAMS model

Click to
deploy

Web browser



```

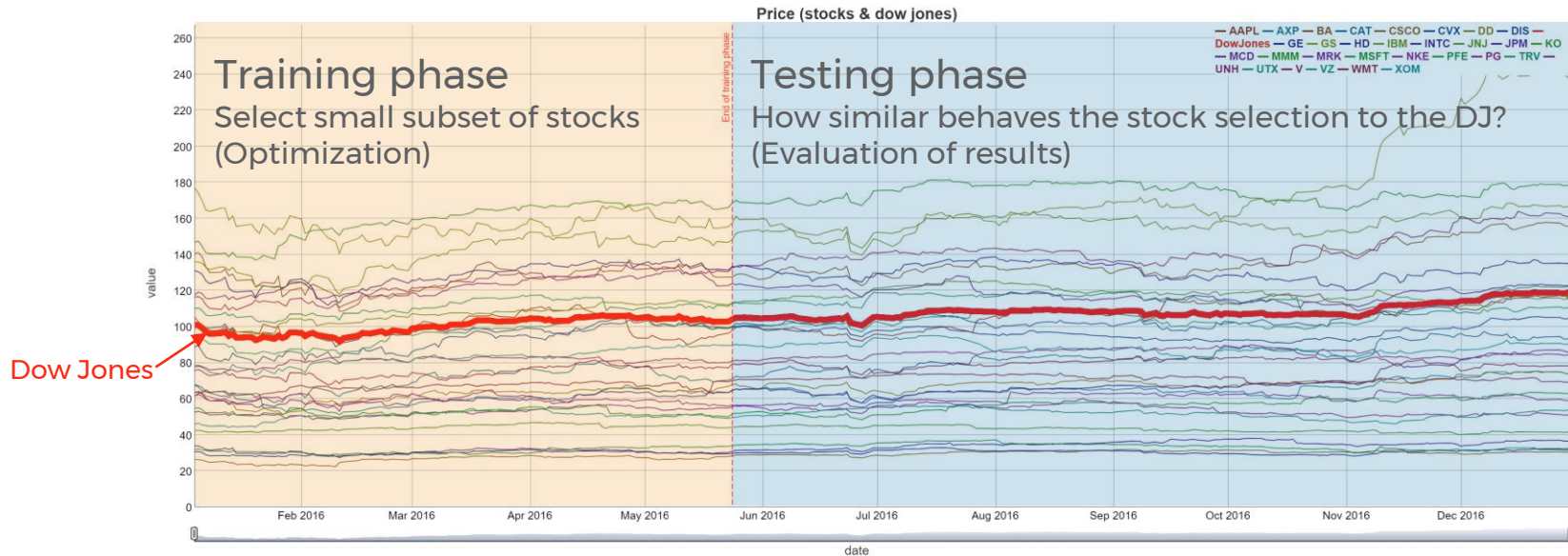
minimize  obj := ∑ds slposds + slnegds
subject to  ∑s priceds,s · ws = indexds + slposds - slnegds  (∀ds)
           ws ≤ ps  (∀s)
           ∑s ws ≤ maxstock
           ws ≥ 0,  ps ∈ {0, 1}  (∀s)
           slposd ≥ 0,  slnegd ≥ 0  (∀d)
  
```

- ✓ Web interface for GAMS models
- ✓ Usage via web browser
- ✓ GAMS as a black box
- ✓ Focus on automated deployment
- ✓ Configuration instead of programming

Example

Model: Pickstock

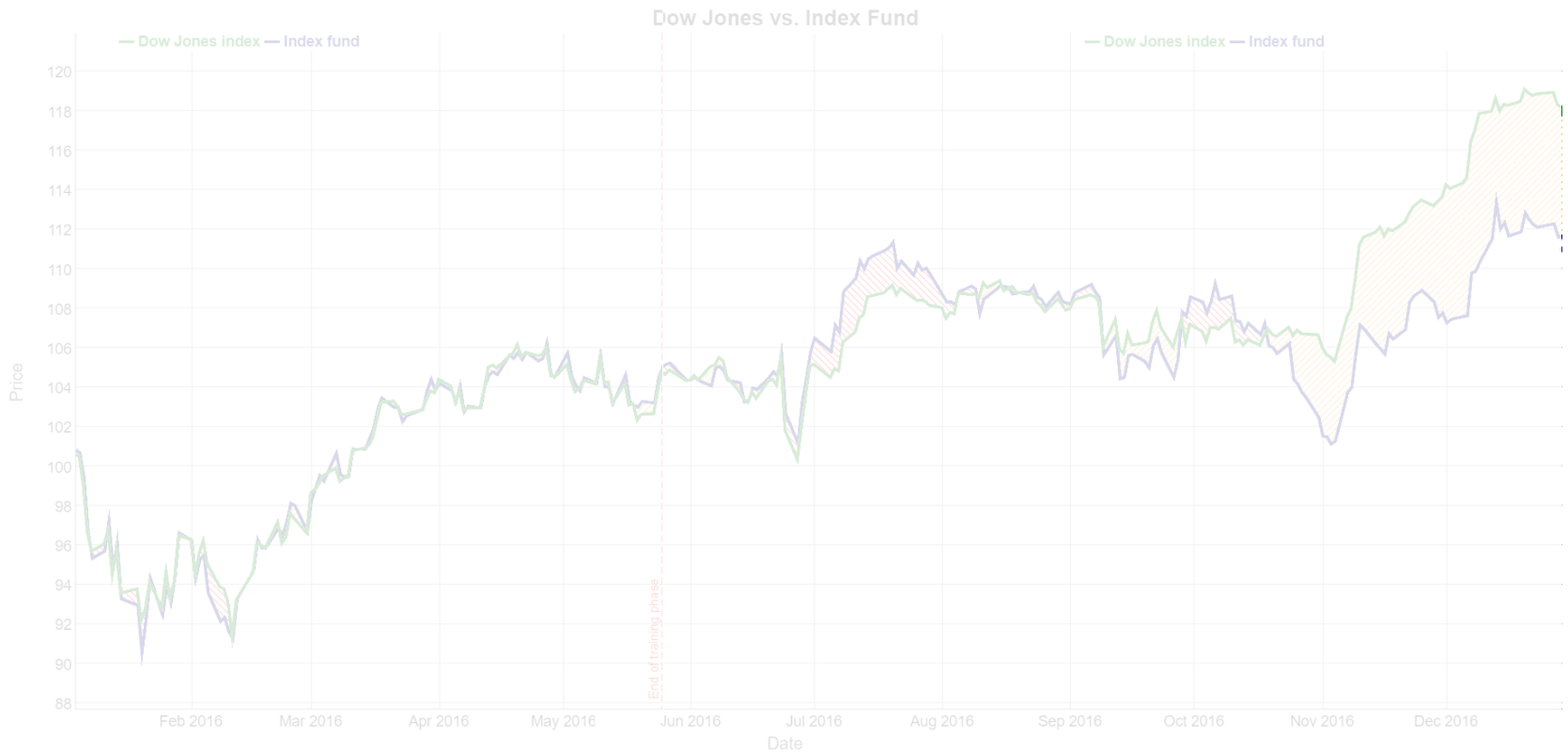
Model: *Pickstock*



- **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 good as possible
- **Optimization model:** Select a subset ($\leq \text{maxstock}$) of Dow Jones stocks, along with weights, so that this portfolio behaves similarly to the overall index (in the training phase)

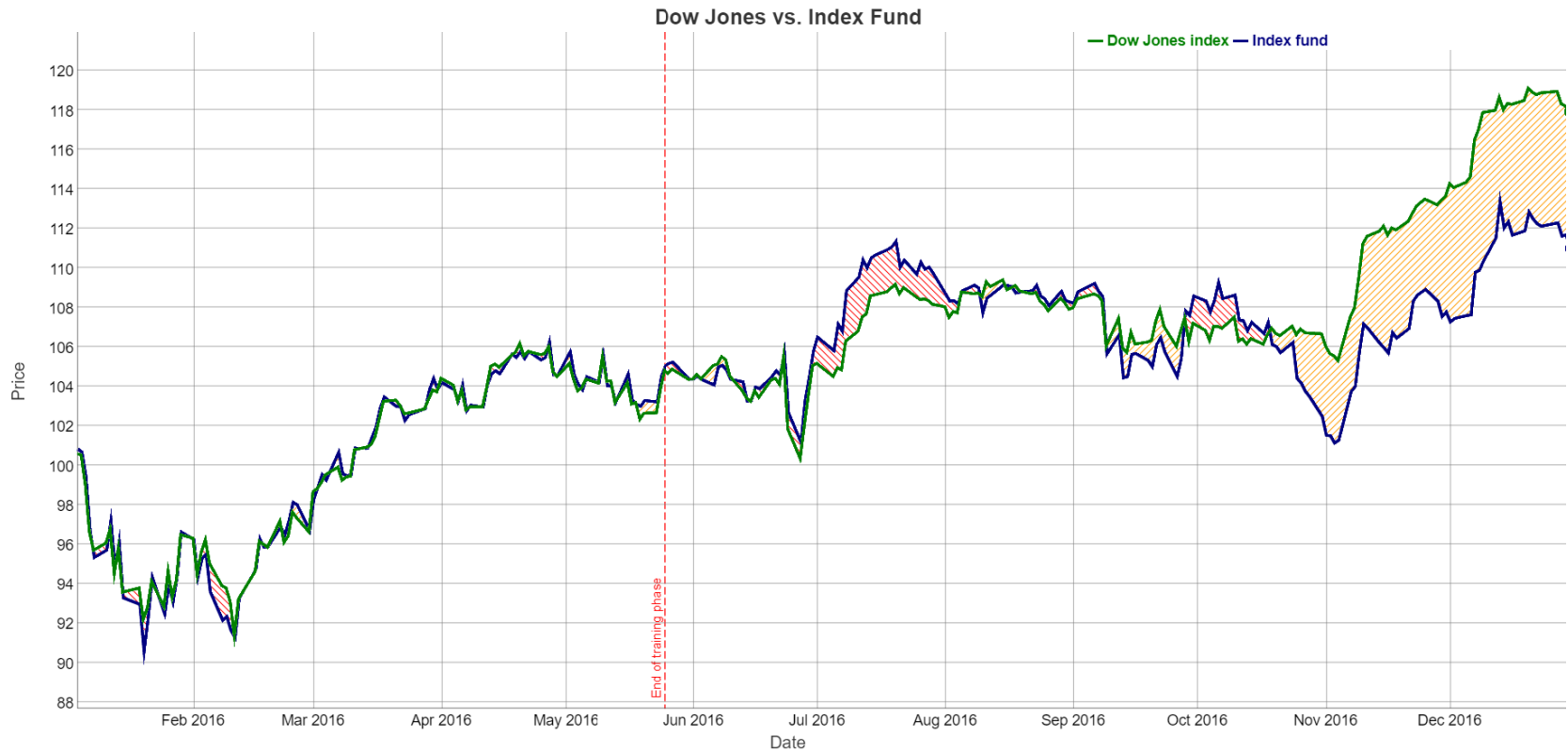
$$\begin{aligned}
 &\text{minimize} && \text{obj} := \sum_{ds} \text{slpos}_{ds} + \text{slneg}_{ds} \\
 &\text{subject to} && \sum_s \text{price}_{ds,s} \cdot w_s = \text{index}_{ds} + \text{slpos}_{ds} - \text{slneg}_{ds} \quad (\forall ds) \\
 & && w_s \leq p_s \quad (\forall s) \\
 & && \sum_s p_s \leq \text{maxstock} \\
 & && w_s \geq 0, \quad p_s \in \{0, 1\} \quad (\forall s) \\
 & && \text{slpos}_d \geq 0, \quad \text{slneg}_d \geq 0 \quad (\forall d)
 \end{aligned}$$

Model: *Pickstock*



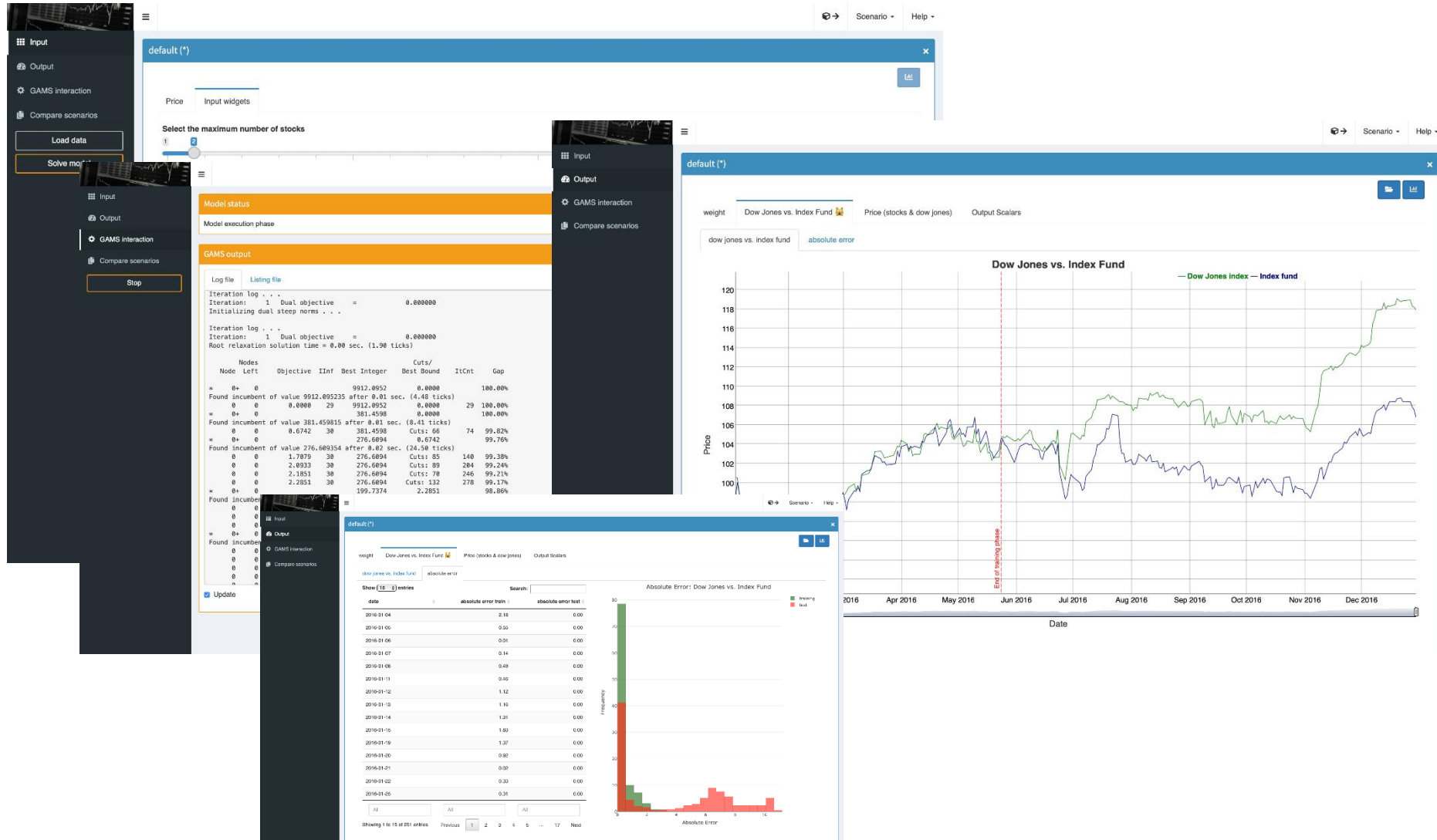
$$\text{minimize} \quad \text{obj} := \sum_{ds} \text{slpos}_{ds} + \text{slneg}_{ds}$$

Model: *Pickstock*

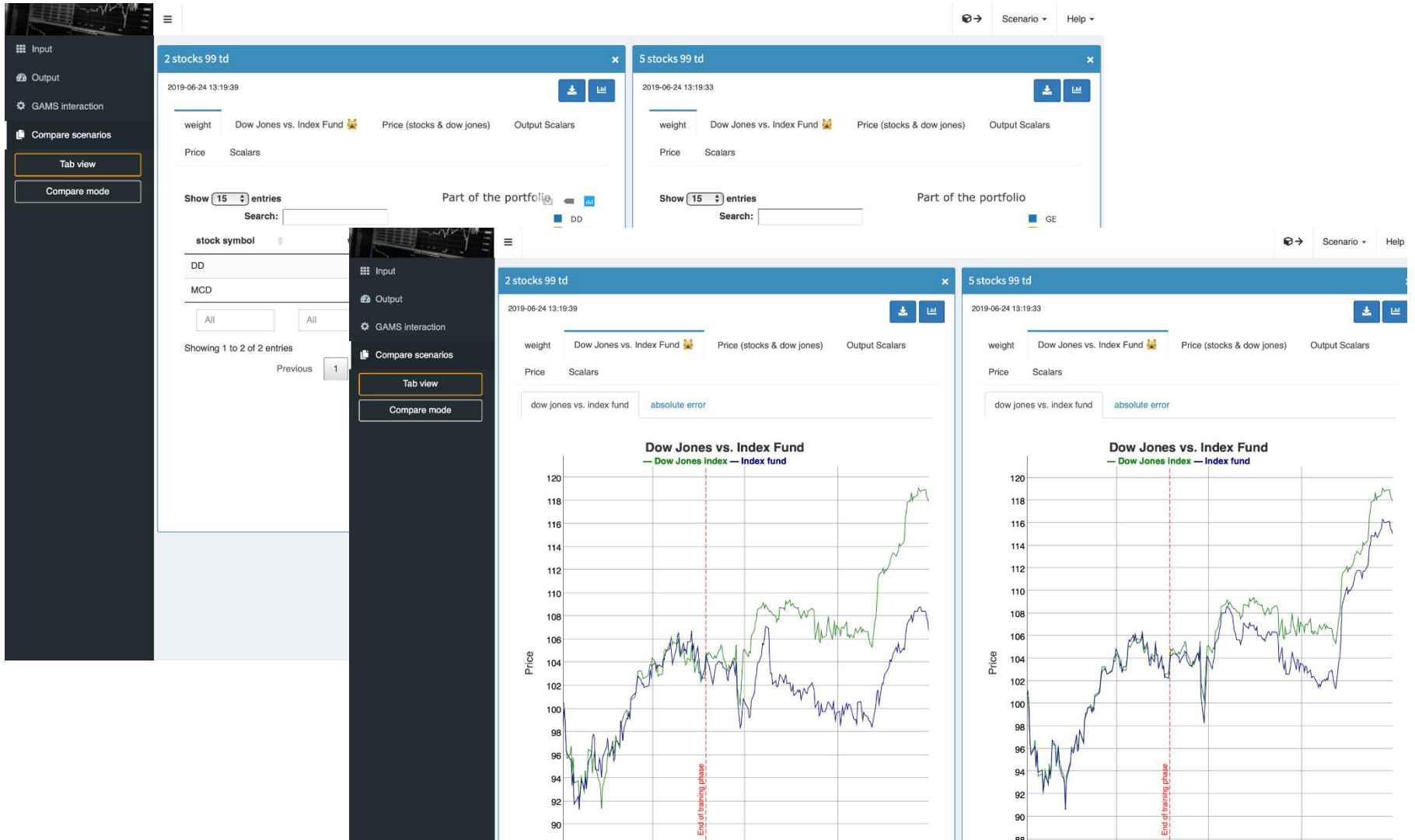


$$\text{minimize} \quad \text{obj} := \sum_{ds} \text{slpos}_{ds} + \text{slneg}_{ds}$$

Run the model



Compare scenarios



How-to

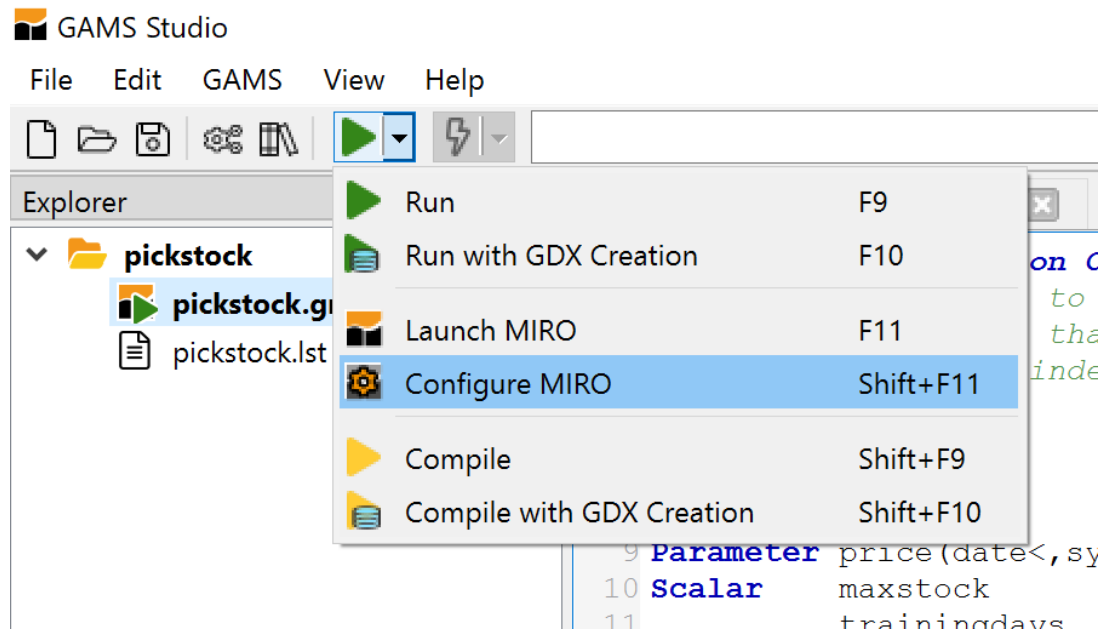
Deployment of a GAMS model with GAMS MIRO

Basic Setup – Model Annotations

```
6 Set      date      'date'
7          symbol    'stock symbol';
8 $onExternalInput
9 Parameter price(date<,symbol<) 'Price';
10 Scalar   maxstock  'maximum number of stocks to select' / 2 /
11          trainingdays 'number of days for training' / 99 /;
12 $offExternalInput

80 $onExternalOutput
81 Scalar error_train 'Absolute error in entire training phase'
82          error_test 'Absolute error in entire testing phase'
83          error_ratio 'Ratio between error test and error train'
84 Parameter
85          stock_weight(symbol) 'weight'
86          dowVSindex(date,fHdr) 'dow jones vs. index fund [MIRO:table]'
87          abserror(date,errHdr) 'absolute error [MIRO:table]'
88 Singleton Set
89 firstDayTraining(date) 'first date of training period'
90 lastDayTraining(date) 'last date of training period' ;
91 $offExternalOutput
```

MIRO configuration mode



The MIRO configuration mode

General settings

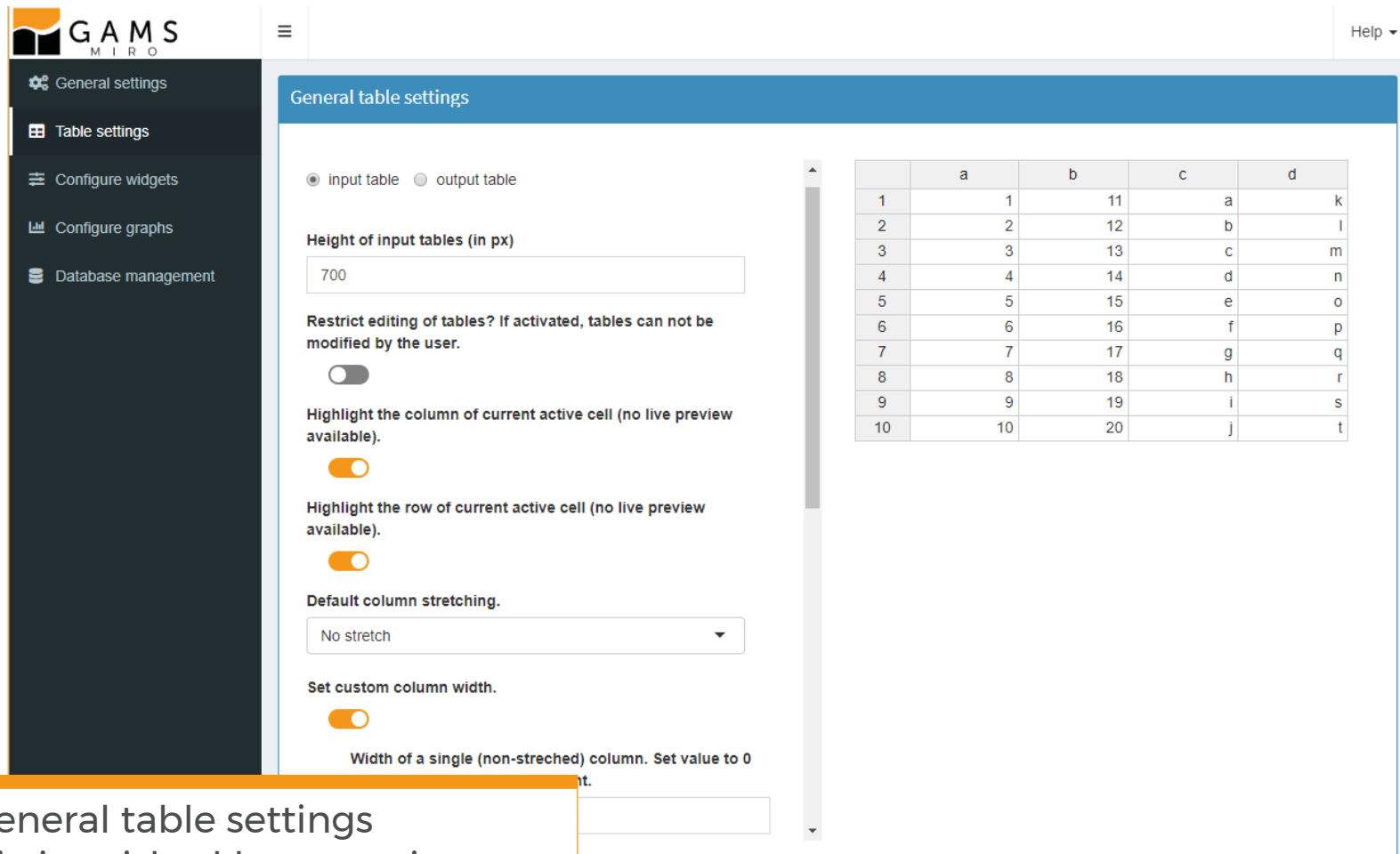
The screenshot displays the GAMS MIRO configuration interface. On the left is a dark sidebar with a menu containing: General settings (selected), Table settings, Configure widgets, Configure graphs, and Database management. The main area is titled 'General settings' and contains several configuration options:

- Alias for the input scalars table:** A text input field containing 'Input scalars'.
- Alias for the output scalars table:** A text input field containing 'Output scalars'.
- Scalars that should not be displayed in the scalars table but can be used in graphs etc.:** A text input field containing 'last date of training period'.
- Background color of row and column headers in pivot tables:** A text input field containing 'rgb(255,128,0)'.
- Duration the GAMS log and lst files are stored in the database (in days):** A slider control ranging from 0 to 999, with a value of 7 selected.
- Number of decimal places used for rounding output values:** A slider control ranging from 4 to 6, with a value of 5 selected.
- Activate local data upload module?:** A toggle switch that is currently turned on.
- Enable scenario sharing between different users:** A toggle switch that is currently turned on.
- Show log file in UI:** A toggle switch that is currently turned on.
- Show lst file in UI:** A toggle switch that is currently turned on.
- Should users be allowed to add attachments to scenarios?:** A toggle switch that is currently turned on.
- Should all input widgets (slider, dropdown menu, etc.) be aggregated on a single tab?:** A toggle switch that is currently turned on.
- Include parent directory of the model folder in your model runs (e.g. because several models share files?):** A toggle switch that is currently turned off.
- Include a metadata sheet in the Excel file (when exporting a scenario?):** A toggle switch that is currently turned on.
- Include empty sheets in the Excel file?:** A toggle switch that is currently turned on.

- ✓ Enable/disable modules
- ✓ Set default behavior
- ✓ Color scheme
- ✓ etc.

The MIRO configuration mode

Table settings



GAMS MIRO

General settings
Table settings
Configure widgets
Configure graphs
Database management

Help ▾

General table settings

☒ input table ☐ output table

Height of input tables (in px)
700

Restrict editing of tables? If activated, tables can not be modified by the user.
☐

Highlight the column of current active cell (no live preview available).
☒

Highlight the row of current active cell (no live preview available).
☒

Default column stretching.
No stretch ▾

Set custom column width.
☒

Width of a single (non-stretched) column. Set value to 0
[input field]

	a	b	c	d
1	1	11	a	k
2	2	12	b	l
3	3	13	c	m
4	4	14	d	n
5	5	15	e	o
6	6	16	f	p
7	7	17	g	q
8	8	18	h	r
9	9	19	i	s
10	10	20	j	t

- ✓ General table settings
- ✓ Distinguished between input and output tables

The MIRO configuration mode

Widgets configuration

The screenshot displays the GAMS MIRO configuration mode interface. On the left is a dark sidebar with navigation options: General settings, Table settings, Configure widgets (selected), Configure graphs, and Database management. The main area is titled 'Configure input widgets' and contains the following sections:


- Symbol type to configure:** Radio buttons for 'Symbol' (selected), 'New GAMS option', and 'New double dash parameter'.
- Which input symbol would you like to create a widget for?:** A dropdown menu showing 'number of days for training'.
- Select the type of widget you want to use:** A dropdown menu showing 'Slider'.
- Enter the element name as it should be displayed in a tab (no live preview available):** A text input field containing 'number of days for training'.
- Choose a label:** A text input field containing 'select the number of days for training'.
- Minimum value:** A text input field containing '1'.
- Static value?:** A toggle switch that is turned on.
- Select symbol and header to depend upon:** Two dropdown menus, the first showing 'Price' and the second showing 'date'.
- Static value?:** A toggle switch that is turned off.

On the right side of the main area, there is a preview of the configured widget: a slider for 'select the number of days for training' with a range from 1 to 10. Below the slider are 'Delete' and 'Save' buttons.

✓ Scalar symbols:
Slider, Dropdown menu,
checkbox, date selector,
textbox

The MIRO configuration mode

Graphics configuration



General settings

Table settings

Configure widgets

Configure graphs

Database management

Configure graphs

Which symbol shall be used?

last date of training period

What label should be used?

End of training phase

Select marker symbol

top

What color should the event line have?

rgb(0,0,0)

Select marker symbol

dashed

+ Add event line

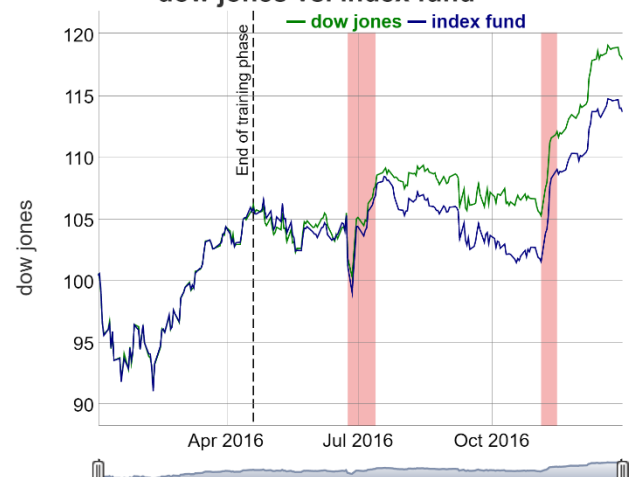
+ Add limit line

Help

Configure graphs

dow jones vs. index fund

— dow jones — index fund



Delete

Save

◀ 17 ▶

Scenario runs

The GAMS MIRO Hypercube mode

Hypercube mode scenario generation

Base mode

pickstock

Price Input widgets

Select the maximum number of stocks

1 6 30

1 8 15 23

select the number of days for training

1 115 12

1 64

Solver to use

CPLEX

Hypercube mode

pickstock

Price Input widgets

Select the maximum number of stocks

1 2 13 30

1 8 15 23 30

select the number of days for training

1 35 140 252

1 64 126 189 252

Solver to use

CPLEX XPRESS CBC

Step size

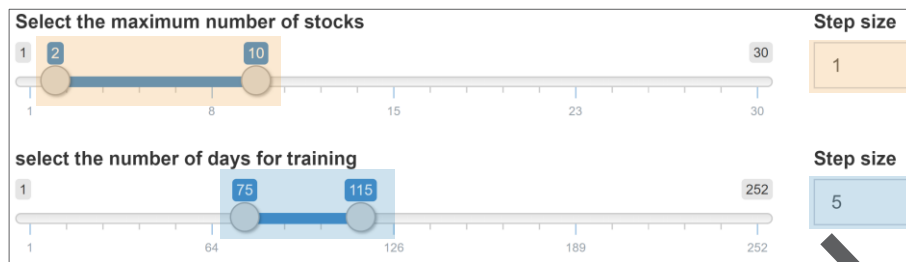
1

Step size

5

Hypercube mode

scenario generation



+ 1

	2	3	4	5	6	7	8	9	10
75	1	2	3	4	5	6	7	8	9
80	10	11	12	13	14	15	16	17	18
85	19	20	21	22	23	24	25	26	27
90	28	29	30	31	32	33	34	35	36
95	37	38	39	40	41	42	43	44	45
100	46	47	48	49	50	51	52	53	54
105	55	56	57	58	59	60	61	62	63
110	64	65	66	67	68	69	70	71	72
115	73	74	75	76	77	78	79	80	81

+ 5

Number of scenarios = Cartesian product of scalar input combinations

Hypercube mode

Analysis

Analyze Scenarios

Index

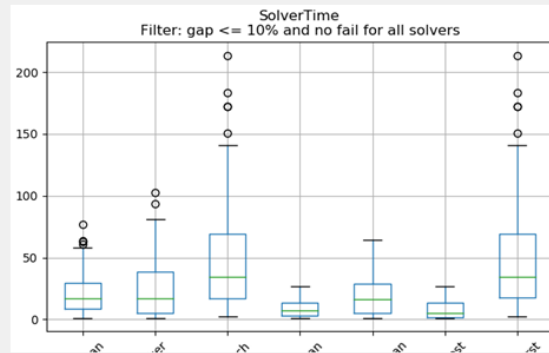
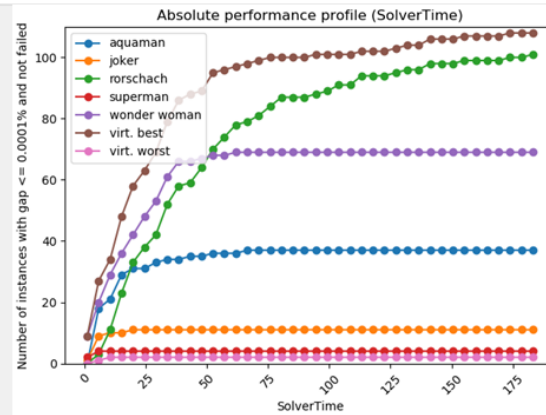
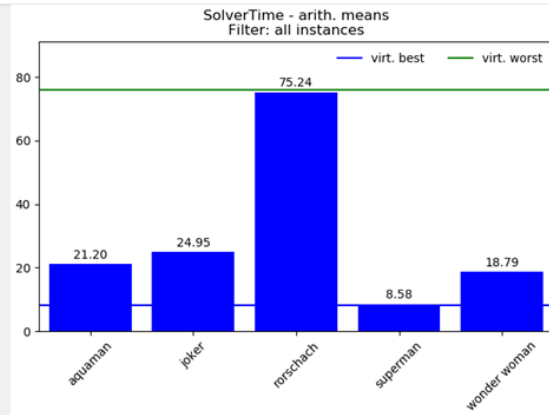
stat_Status

stat_Efficiency

stat_SolutionQuality

solvedata

documentation



- ✓ Perform analyses related to KPIs and/or other indicators
- ✓ Export scenario data for external analyses

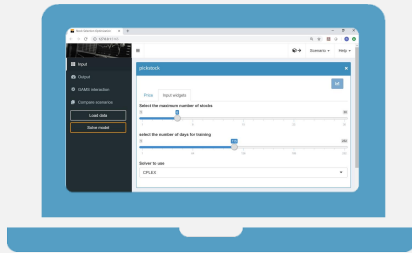
Job execution

MIRO Server

MIRO – job execution

MIRO Desktop

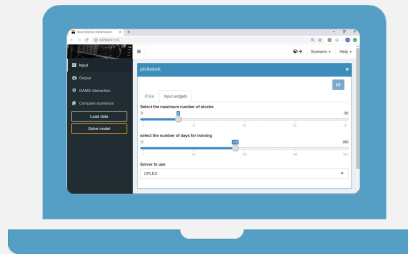
Everything local



- GAMS installed
- MIRO installed
- Synchronous execution of GAMS jobs

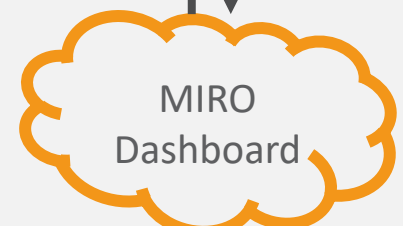
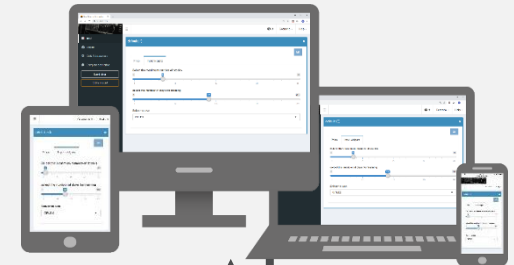
MIRO Server (I)

Local MIRO application
Remote GAMS execution



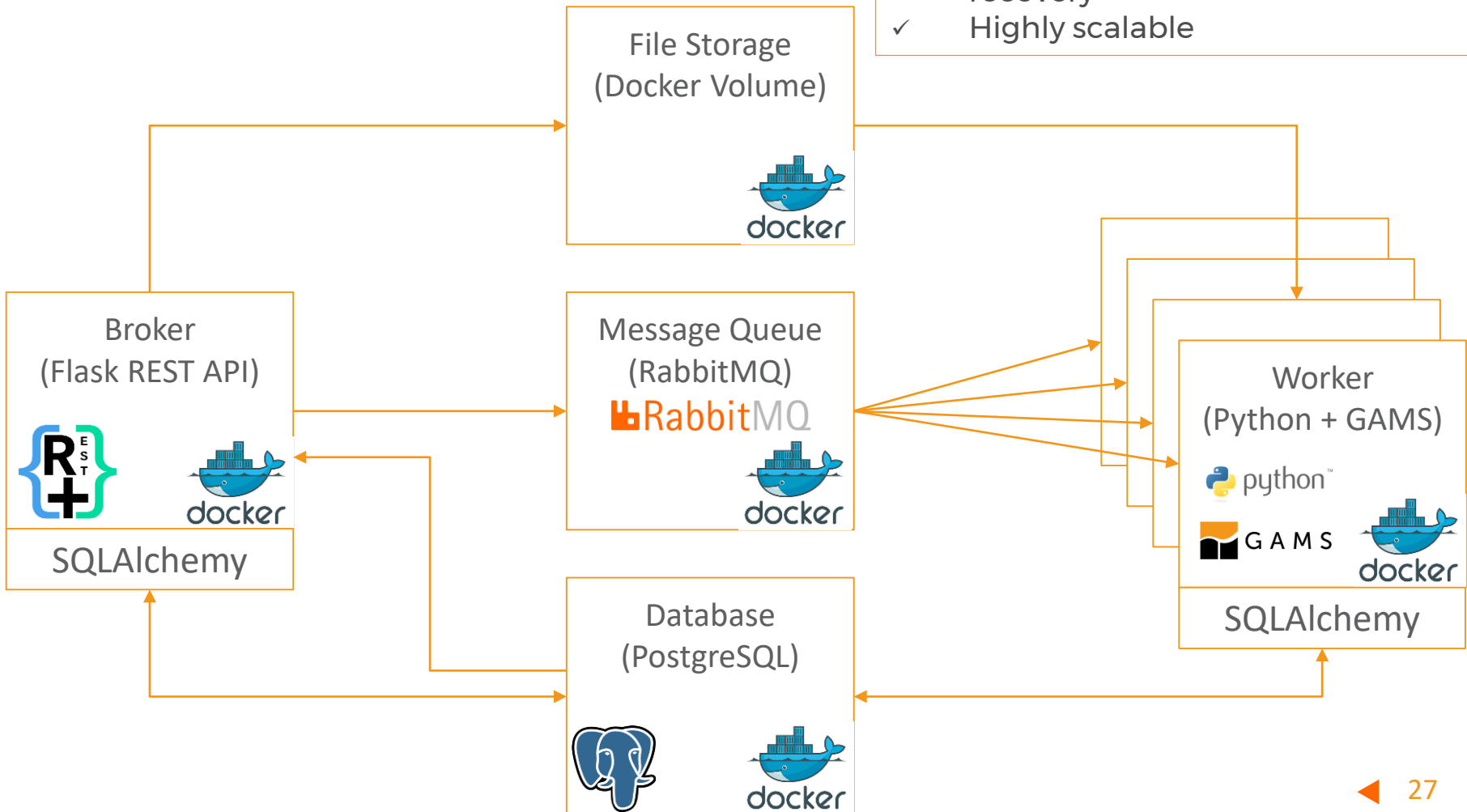
MIRO Server (II)

Everything on a server



Remote job execution

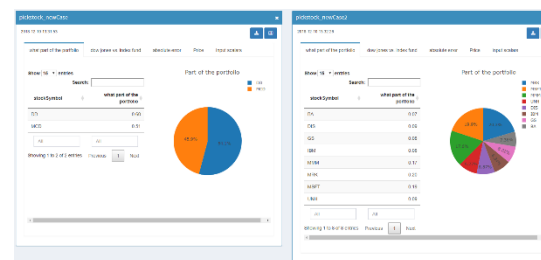
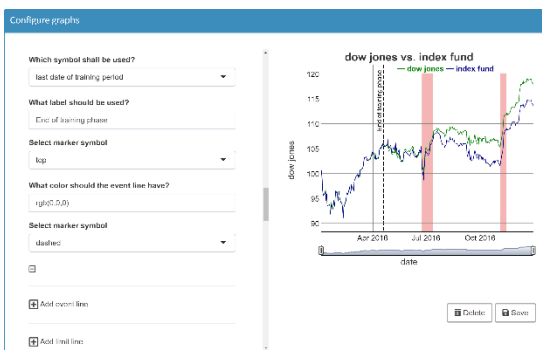
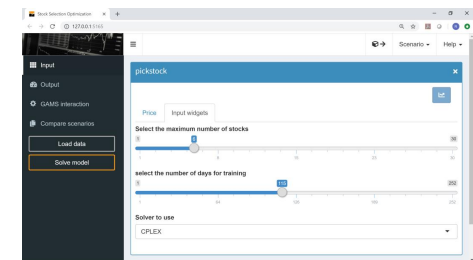
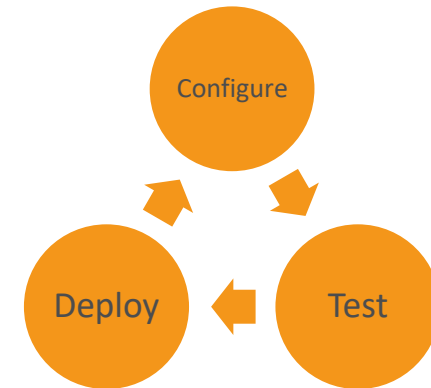
- ✓ REST API for job requests
- ✓ Microservices instead of monolithic approach
- ✓ Automated failure detection and recovery
- ✓ Highly scalable



Summary

Summary

- Separation of tasks:
 - Modeling work
 - Model deployment
 → In OR projects often over several iterations
 → model deployment should not take much time (at least during these iterations)
- End-users are very often not modeling experts
- Quick & automated deployment of GAMS models
- Data visualization with charts / graphics
- Easy to configure
- Desktop and server version





For more information visit:
www.gams.com/miro

Meet us at the GAMS booth!

