

FlexShares Model Maker User Guide and Methodology

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INTRODUCTION

The FlexShares Model Maker assists you in putting together portfolios of ETFs and single stock securities. It allows investors to understand their current portfolio composition, retrieve saved portfolios or choose a Core Strategic Model Input. The tool lets users adjust and analyze portfolio allocations by modifying asset class, income, and costs.

Model Maker is comprised of three main parts:

1. A portfolio screening tool
2. A mean variance portfolio optimization
3. A backtesting and due-diligence analysis to compare the start and end portfolio

The tool is designed to bring these three components into a single, rapid workflow. Typically, each of these steps is a separate tool or workflow when going through an investment management workflow. The goal of Model Maker is to simplify all these steps while also:

- Highlighting the benefits of FlexShares' funds
- Showcasing FlexShares' suite of model portfolios
- Providing a user-friendly interface for modifying a model portfolio to a user's liking

Model Maker outputs show the modified weights of constituents that are in line with your modification selections, as well as the performance, yield, and cost of the initial portfolio vs. the modified portfolio.

Analytics Datapoints from the Model Maker tool fall into 3 categories:

- | | | |
|-------------|--------|-----------------|
| 1. | 2. | 3. |
| Performance | Assets | ETF Information |

By allowing users to see the performance and compositions of the input vs. modified model in a highly visual manner, we believe that users may be better informed about their model and the relative differences that exist on an analytical level.

The Model Maker tool generates an analysis of one selected portfolio and its modified state. This analysis is based on historical data. The historical data presented is based on common time periods which are time periods when all constituent ETFs existed and have price history.

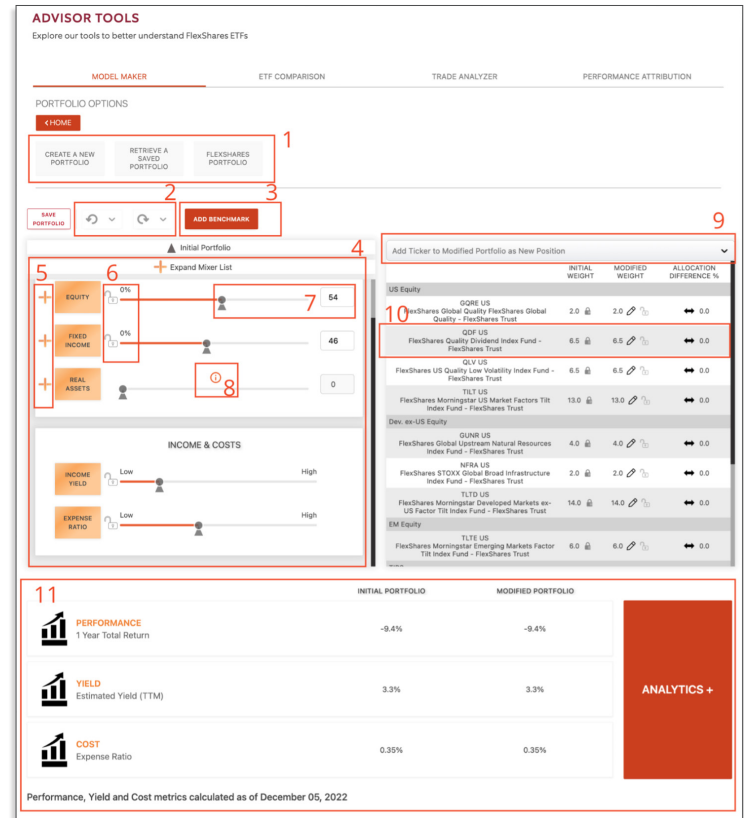
VISUAL WALKTHROUGH

The below screenshot of the main Model Builder interface serves to introduce the interface and some of the terminology employed to describe the Model Maker workflow.

It is important to note that the tool is designed to be used in conjunction with a user login so that user-specific portfolios and features can be stored in the user profile.

The annotated boxes with the numbers are described as such:

- Portfolio retrieval interface. This allows the user to save new portfolios, retrieve old portfolios or explore pre-loaded model portfolios.
- Undo and Redo Buttons: keeps track of the user's interaction with Model Maker. Allows to see the steps the user has taken and revert to a previous state.
- Benchmark Add: Allows the user to add a benchmark to compare performance in step 11.
- Slider Interface: Sliders allow users to change their exposures to various sets of descriptors. Descriptors are a way to explain a security in a numerical fashion.
- Sliders can be expanded into sub-categories. For example, equity exposure can be further broken down into US, Developed and Emerging market equity exposures.
- Sliders can be locked to their numerical value. In optimization terms this is a hard constraint on exposure to a descriptor.
- Sliders are manipulated by clicking on the circle and dragging it left and right. The black chevron indicates the current level of exposure of the optimized portfolio.
- Exposures that are unachievable with the current universe cause the sliders to be greyed out. The user is reminded to expand the portfolio by adding tickers or asset classes.
- Ticker Add: This allows the user to search for any ETF or single stock in the allowed universe extension.
- The output of the optimization is on the right side. The leftmost column of numbers is the starting position in percent exposure terms. The middle column indicates the resulting weights of the optimization. The right-most column shows the difference in starting and ending position weights.
- Quick Analysis: provides a backtested view on risk, return, and current expense ratio of the starting and ending portfolio. A benchmark column is added if a benchmark was set in step 3.



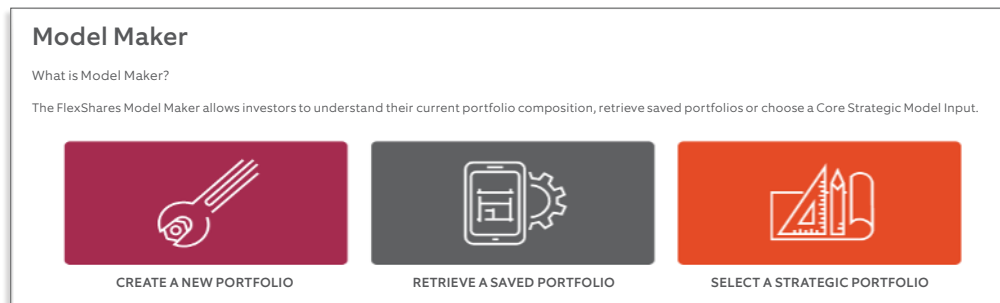
TYPICAL WORKFLOW STEPS

1. Input a starting portfolio
2. Analyze the descriptor exposure of this portfolio
3. The user interacts with Model Maker either by changing the sliders or modifying (adding or removing) securities in the portfolio
4. A portfolio optimization with minimum variance target under descriptor constraints is calculated
5. A new portfolio with weights is generated and displayed

USER GUIDE

PORTFOLIO SELECTION

When you launch the Model Maker tool, you select an input portfolio for analysis.



There are 3 options for input portfolio selection:

- **Create a New Portfolio** by manually selecting the desired tickers and weights or importing a portfolio.
- **Retrieve a Portfolio** that has already been created and saved in FlexShares.
- **Select a Strategic Portfolio** from a list of FlexShares' pre-built models.

Create a New Portfolio

You can construct a portfolio by choosing what holdings and respective weights you want represented in the portfolio.

- To add more holdings to the portfolio use the **Add** button.
- A holding can be deleted by selecting the trash can icon adjacent to each symbol entry.
- Provide the name of portfolio and optionally the name of advisor – investor before saving the portfolio.
- Select **Upload & Analyze** to save the portfolio and continue.

OR

ENTER HOLDING & WEIGHT

SYMBOL	% OF PORTFOLIO	DELETE
Add Ticker to a New Portfolio ▼	100	
Add	100%	Clear All
<input style="width: 100%;" type="text" value="Name of Portfolio"/>	<input style="width: 100%;" type="text" value="Name of Advisor - Investor (optional)"/>	
UPLOAD & ANALYZE		

You also can upload a portfolio into the Model Maker from any table outside of the tool. Formatting needs to be two columns: One for ticker, one for weight or \$ amount. (Note: The % or \$ must be included in this column). For percentage weights, the total needs to add up to 100%. An example for formatting is shown in the **Import A Portfolio** box.

IMPORT A PORTFOLIO

Click here and paste (Ctrl+V) portfolio holding from a table as illustrated below. Ticker in the first column and weight(%) or amount (\$) in the second.

ABCD	25%
EFG	25%
HI	25%
JKLM	45%

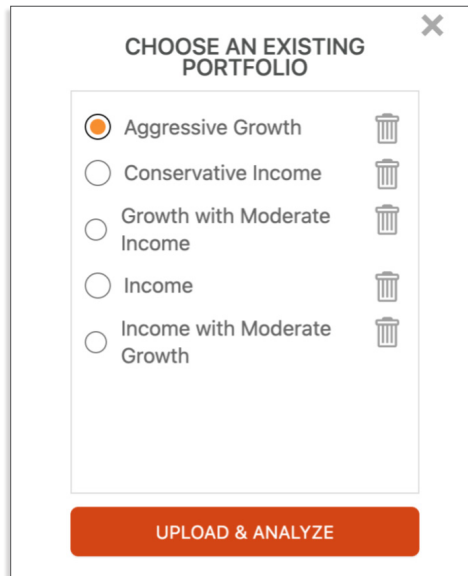
Once you have your table created, simply Copy that table and go back into Model Maker. Click on the **Import A Portfolio** area and paste (Ctrl + V). When you paste the table, the holdings will automatically populate in the bottom half of the screen.

Retrieve a Saved Portfolio

You can select a portfolio to be uploaded and analyzed from the list of existing portfolios that you have previously constructed in Model Maker. When you create a new portfolio, it is automatically added to this list of existing portfolios and saved to your account.

To retrieve a saved portfolio, select it in the list and select **Upload & Analyze** to continue.

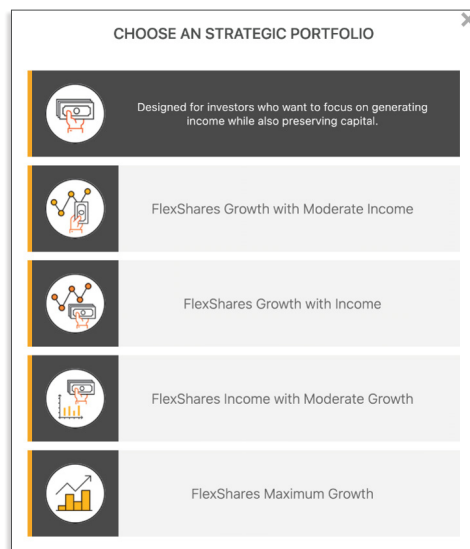
You can also delete a previously saved portfolio by selecting the trash can next to it.



Select a Strategic Portfolio

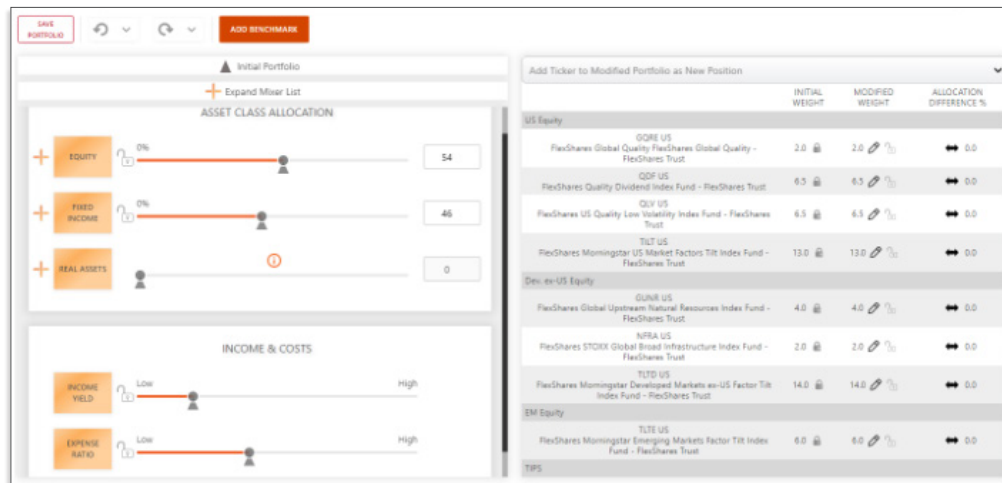
You can select one of the existing FlexShares Strategic Portfolios as an input for your model. These portfolios are based on Risk or Growth orientation relative to risk tolerance.

Note: The FlexShares Strategic Portfolios are built with the FlexShares ETFs only.



Model Maker Input Adjustments

After you select your desired portfolio, the portfolio is loaded into Model Maker, and you are presented with a variety of options to adjust and analyze the portfolio.



You can ensure a certain asset class is not adjusted during composition changes by clicking the **Lock** icon on the left pane. This can be done on an individual holding level by clicking the **Lock** icon next to the holding on the right side of the pane under **Initial Weight**.

If composition adjustments result in a weight for an individual holding that you wish to change, click on the **Pencil** icon on the right pane to adjust that weight manually.

Add Ticker to Modified Portfolio as New Position			
	INITIAL WEIGHT	MODIFIED WEIGHT	ALLOCATION DIFFERENCE %
US Equity			
QORE US FlexShares Global Quality FlexShares Global Quality - FlexShares Trust	0.5	0.5	0.3
QDF US FlexShares Quality Dividend Index Fund - FlexShares Trust	1.3	2.2	↑ 0.9
QLV US FlexShares US Quality Low Volatility Index Fund - FlexShares Trust	1.3	2.2	↑ 0.9

When locked, this position should not change when exposures change.

Asset Class Allocation, Income & Costs Adjustments

- Adjust the composition of the input portfolio by adjusting the sliders in the **Asset Class** and **Income & Costs** sections. When a slider is adjusted in the Initial Portfolio section on the left, the modified weights of current holdings are shown in the Modified Portfolio section on the right, indicating the correlated change.
- Any constraints on asset class or individual holding that were set prior to the adjustments via the **Lock** icon will not be changed, and manual changes made through the **Pencil** icon can be applied before and after adjustment.
 - Only the sliders on asset classes that are currently in the portfolio can be adjusted. I.e., **Real Assets** are not adjustable in the screenshot above, as there are no real asset holdings in the portfolio.
 - The **Expense Ratio** sliders are only available if there are funds within the portfolio. I.e.: A model of only single stocks will not have any expense ratio to adjust.
 - Using the + button next to Allocation categories to expand the options, you can further adjust allocations for the respective asset classes. Different asset classes as broken down as follows:
 - Equities at a geographical level.
 - Fixed Income by credit rating and maturity.
 - Real Assets by type of asset and geography.



Adding Benchmark

You can set a benchmark for portfolios in Model Maker by clicking the **Add Benchmark** button. The benchmark can be either:

- Any Single Stock, ETF, or Mutual Fund ticker.
- Any existing Portfolio inside of FlexShares.

SELECT A BENCHMARK

You may select a benchmark from:

- The adjacent list of your portfolios.
- By using the search below to select a single security.

Once you have selected a benchmark hit apply to add it to this portfolio.

Add Ticker to a Benchmark

SELECTED BENCHMARK:

SPY US - S&P 500 ETF TRUST ETF - SSgA Active Trust (USD)

APPLY

MY PORTFOLIO (5)	COUNT
Aggressive Growth	1
Conservative Income	1
Growth with Moderate Income	1
Income	1
Income with Moderate Growth	1

Save Modified Portfolio

You can save the current state of the portfolio at any time by selecting **Save Portfolio**.

Any changes made to a portfolio can be undone by selecting the Undo arrow icon next to **Save Portfolio**. The dropdown menu next to undo will show what change to the portfolio is being undone.

The same action can be done with reapplying a change by selecting the **Redo** icon next to **Undo**. The dropdown menu next to the **Redo** icon will also show you what change is being reapplied to the portfolio.

Model Maker

What is Model Maker ?

The FlexShares Model Maker allows investors to understand their current portfolio composition, retrieve saved portfolios or choose a Core Strategic Model Input.

SAVE PORTFOLIO **ADD BENCHMARK**

When saving changes, you will have the option to save as a new portfolio, or to overwrite an existing portfolio.






CREATE A NEW PORTFOLIO:

Name of Portfolio

SAVE

OR

OVERWRITE EXISTING PORTFOLIO




- Aggressive Growth 
- Conservative Income 
- Growth with Moderate Income 
- Income 
- Income with Moderate Growth 

OVERWRITE

RESULTS ANALYSIS

Quick Analysis

The updated comparison Performance, Yield, and Cost metrics for the initial portfolio and the modified portfolio are available in the results section, as soon as any adjustments to the model are made.

	INITIAL PORTFOLIO	MODIFIED PORTFOLIO	
 PERFORMANCE 1 Year Total Return	-6.1%	-6.1%	ANALYTICS +
 YIELD Estimated Yield (TTM)	3.5%	3.5%	
 COST Expense Ratio	0.36%	0.36%	

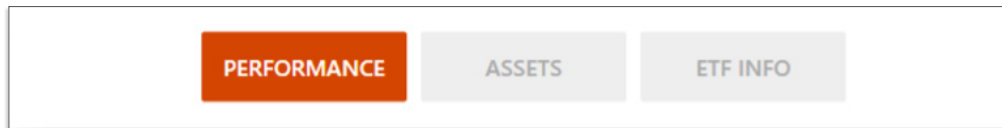
Performance, Yield and Cost metrics calculated as of November 30, 2022

Analytics+ (Deep) Analysis

Selecting **Analytics+** brings up the in-depth portfolio analytics.

The detailed analytics consists of 3 sections with multiple subsections in each:

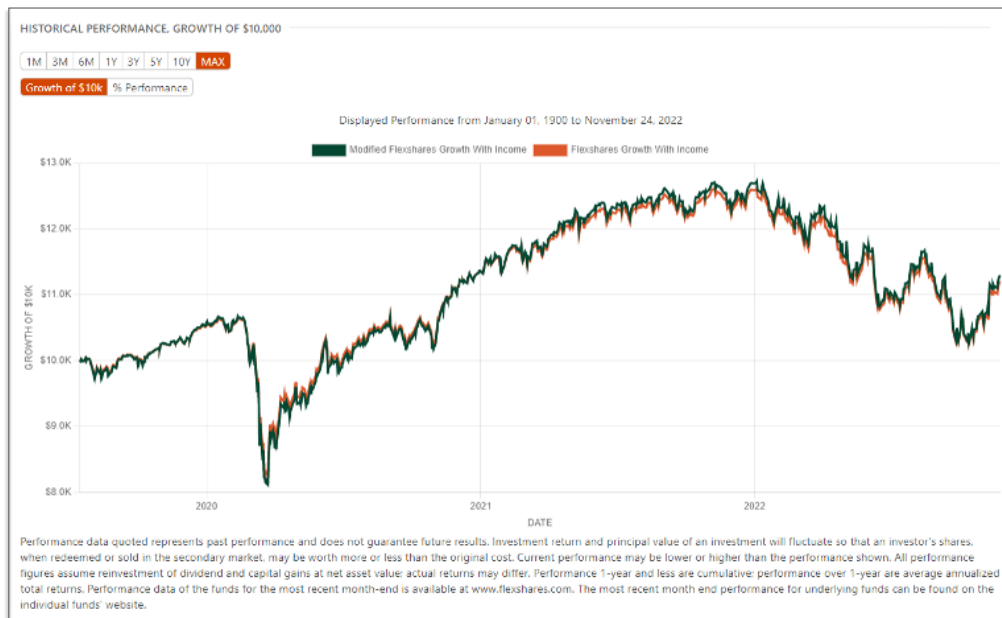
- **Performance:** Growth, Performance, Returns, Scenarios
- **Assets:**
 - Equity And Real Assets: Sector, Mktcap, Geo
 - Fixed Income: Credit, Maturity
- **ETF Info:** Holdings, ETF Data



Performance – Growth

The Performance line chart illustrates total market price returns of the input and modified portfolios in two views and can be adjusted to either start from the Common Time Period start date or a selected time frame. Common Time Period is the furthest back in portfolio history where all funds between both portfolios were created and trading:

- Hypothetical growth of \$10k comparison starting with \$10,000 initial investment; or
- Percentage performance comparison starting at 0.



Performance – Returns and Drawdown

Trailing Returns, Calendar Returns, Drawdown

This section highlights the **Trailing Returns, Calendar Returns, and Drawdown** for the input and modified portfolios. **Calendar Returns & Drawdown** are shown on a yearly basis, whereas **Trailing Returns** are displayed from 1 week up to the entire history of the portfolio.

TRAILING RETURNS (AS OF 2022-11-25)								
	Entire History	YTD	1w	1m	3m	6m	1y	3y
Modified Flexshares Growth With Income	3.68%	-11.02%	1.67%	7.78%	-0.73%	-1.53%	-10.04%	3.22%
Flexshares Growth With Income	3.42%	-11.03%	1.57%	7.29%	-0.78%	-1.53%	-10.11%	2.94%

CALENDAR RETURNS				
	2022	2021	2020	2019
Modified Flexshares Growth With Income	-11.02%	11.67%	7.75%	5.46%
Flexshares Growth With Income	-11.03%	10.75%	7.94%	5.28%

DRAWDOWN					
	Entire History	2022	2021	2020	2019
Modified Flexshares Growth With Income	-23.96%	-19.21%	-3.43%	-23.96%	-3.13%
Flexshares Growth With Income	-22.34%	-18.66%	-3.19%	-22.34%	-2.82%

Quarter-End Performance

This section highlights the performance of each holding within the input and modified portfolio as of the end of the most recent quarter. Timeframes in this section go back to the fund's inception.

QUARTER-END PERFORMANCE (AS OF 09/30/2022)												
Ticker	Name	Price Type	Year-to-Date (YTD)	1-Week	1-Month	3-Months	6-Months	1-Year	3-Years	5-Years	10-Years	Fund Inception
BNDX		Close	15.00%	-1.03%	4.56%	4.59%	9.35%	15.25%	-3.17%	-0.37%	-	0.17%
BNDX		NAV	15.01%	-1.00%	4.54%	4.55%	9.35%	15.20%	-3.11%	-0.30%	-	0.10%
GQRE		Close	-31.21%	-3.10%	-13.06%	-11.13%	-20.35%	-21.67%	-5.50%	-1.45%	-	2.75%
GQRE		NAV	-30.95%	-3.20%	-13.17%	-10.74%	-20.28%	-21.35%	-5.50%	-1.38%	-	2.77%
GUNR		Close	-1.26%	0.23%	-9.08%	-3.88%	-18.77%	7.66%	10.64%	7.38%	3.68%	3.73%
GUNR		NAV	-0.79%	0.68%	-9.15%	-3.44%	-17.73%	8.01%	10.85%	7.51%	3.71%	3.77%
HYCV		Close	-16.64%	-1.06%	-4.66%	-1.41%	-12.89%	-15.98%	-0.72%	-	-	1.13%
HYCV		NAV	-16.51%	-1.33%	-5.00%	-0.96%	-12.59%	-15.85%	-0.55%	-	-	1.17%
NFRA		Close	-18.94%	-4.38%	-11.88%	-11.13%	-20.03%	-15.80%	-1.64%	1.48%	-	4.09%
NFRA		NAV	-18.86%	-4.33%	-11.67%	-10.59%	-19.99%	-15.85%	-1.51%	1.50%	-	4.11%
ODF		Close	-21.64%	-3.26%	-10.19%	-6.20%	-20.45%	-13.09%	4.00%	4.92%	-	9.55%
ODF		NAV	-21.74%	-3.41%	-10.33%	-6.35%	-20.59%	-13.17%	3.96%	4.90%	-	9.54%
QLV		Close	-17.46%	-1.99%	-6.97%	5.26%	-15.61%	-7.28%	6.43%	-	-	6.00%
QLV		NAV	17.41%	2.22%	-7.03%	5.10%	15.73%	-7.17%	6.27%	-	-	6.07%
RAVI		Close	-0.84%	-0.05%	-0.05%	0.35%	-0.00%	-1.16%	0.59%	1.29%	-	1.06%
RAVI		NAV	-0.85%	-0.04%	-0.07%	0.39%	0.02%	-1.19%	0.58%	1.26%	-	1.06%
TDTT		Close	-5.73%	-1.02%	-4.47%	-3.70%	-5.29%	-4.66%	2.39%	2.36%	1.12%	1.38%
TDTT		NAV	-5.77%	-1.10%	-4.50%	-3.79%	-5.46%	-4.79%	2.39%	2.33%	1.14%	1.37%
TILT		Close	-23.41%	-2.39%	-10.12%	-4.41%	-21.01%	-16.86%	7.36%	7.06%	10.40%	11.42%
TILT		NAV	-23.38%	-2.42%	-10.19%	-4.42%	-21.03%	-16.85%	7.37%	7.05%	10.38%	11.42%

Performance – Returns

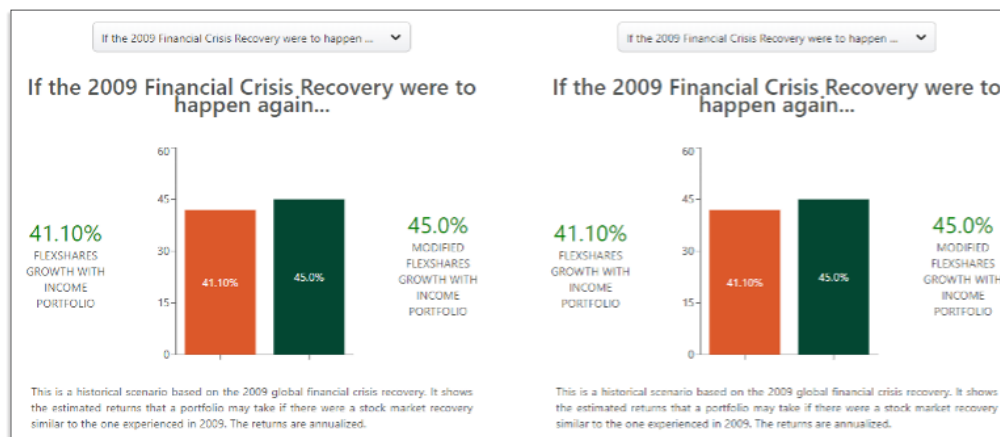
This section highlights the side-by-side performance of the input and modified models in a bar chart format across all available timeframes.



Performance – Scenarios

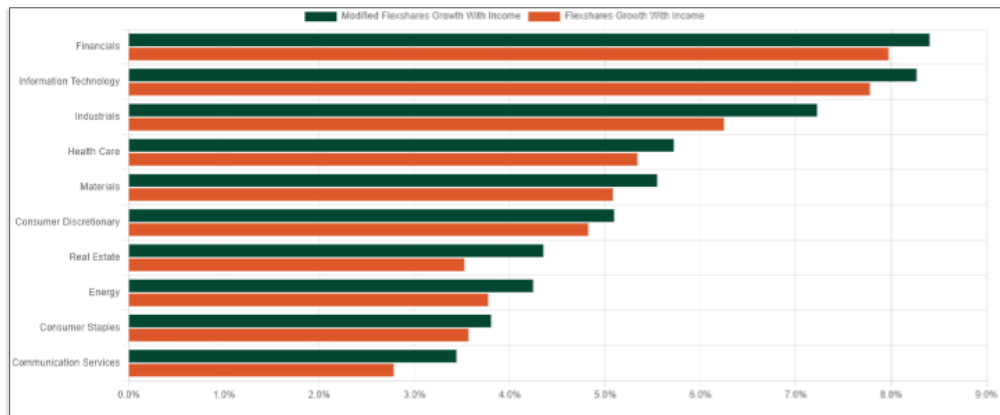
This section employs a factor-based stress testing methodology to understand and visualize the hypothetical risk and return of the input and modified models. This analysis uses observed historical returns of known factors and estimates the sensitivity of each portfolio to these factors. Stress test scenarios, based on well-defined historical market events, are also extracted from history to focus on particular factor shifts.

- Use the dropdown boxes to select up to 2 different stress test scenarios from the available scenarios.
- The hypothetical back-tested returns for each model will be displayed below. Up to two stress test events can be viewed side-by-side.

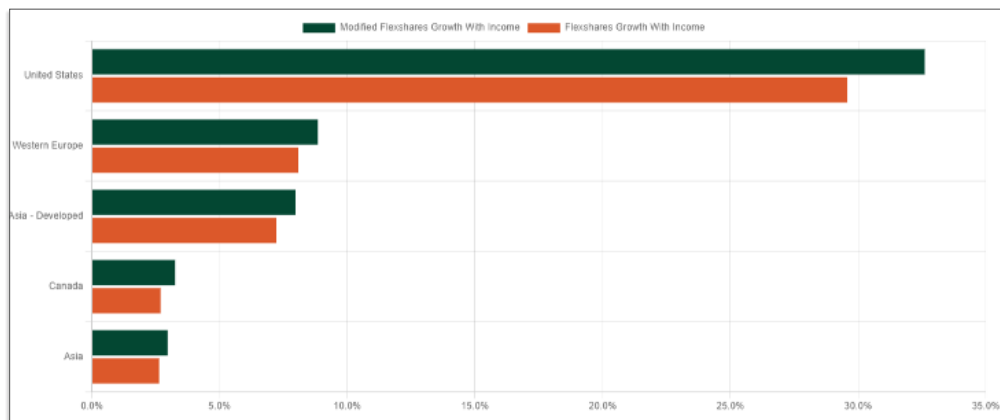


Assets – Equity and Real Assets – Sector Exposure

If either the input or modified portfolios contain ETFs that have exposure to equity holdings and those holdings can be classified, a sector and geography exposure bar chart view will be displayed. This view shows the sector percentage exposure of the holdings in each model. Not all ETF holdings may be reflected if there are equity positions that cannot be classified in the sectors shown.

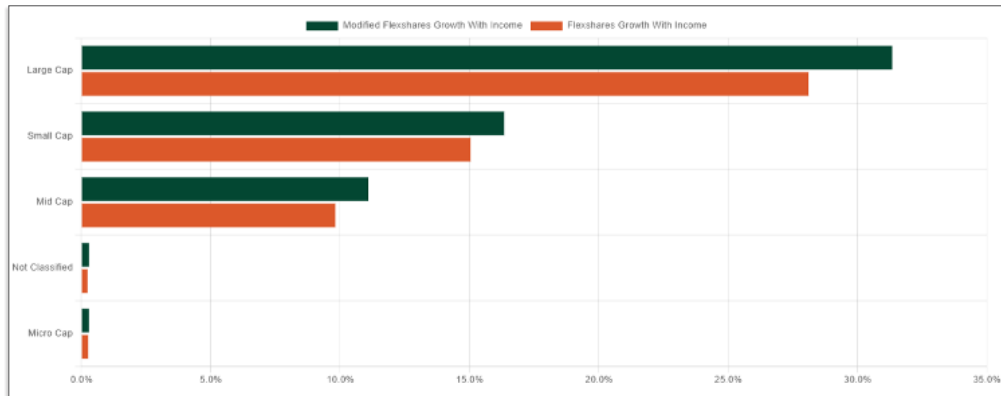


Assets – Equity and Real Assets – Geography



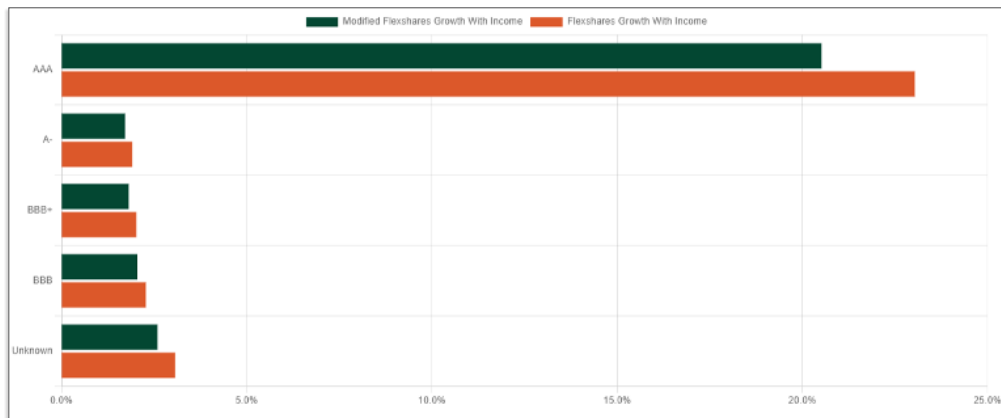
Assets – Equity and Real Assets – Market Cap

If either the input or modified model contains ETFs that have exposure to equity holdings, a market capitalization bar chart view will be displayed. This view shows the market cap percentage exposure of the holdings in each model. Please refer to the Risk and Definitions section for further information on the market capitalization cutoffs.



Assets – Fixed Income – Credit Exposures

If either the input or modified model contains ETFs that have exposure to fixed income holdings, a credit exposure bar chart view will be displayed. This view shows the credit percentage exposure of the holdings in each model.



Assets – Fixed Income – Maturity Exposures

If either the input or modified model contains ETFs that have exposure to fixed income holdings, a maturity bar chart view will be displayed. This view shows the maturity range percentage of the holdings in each model.



ETF Info – Holdings

The holdings section highlights each of the holdings and their respective weights within the input and modified models, listing the name, ticker, and weight percentages for each holding.

HOLDINGS FOR MODIFIED FLEXSHARES GROWTH WITH INCOME		
Name	Ticker	Size
FlexShares Core Select Bond Fund - FlexShares Trust	BNDX US	32.7%
FlexShares Morningstar Developed Markets ex-US Factor Tilt Index Fund - FlexShares Trust	TLTD US	14.4%
FlexShares Morningstar US Market Factors Tilt Index Fund - FlexShares Trust	TILT US	13.5%
FlexShares Quality Dividend Index Fund - FlexShares Trust	QDI US	7.0%
FlexShares US Quality Low Volatility Index Fund - FlexShares Trust	QIV US	7.0%
FlexShares Morningstar Emerging Markets Factor Tilt Index Fund - FlexShares Trust	TITF US	6.6%
FlexShares Global Upstream Natural Resources Index Fund - FlexShares Trust	GUNR US	4.6%
FlexShares High Yield Value Scored Bond Index LTI - FlexShares Trust	HYGV US	4.4%
FlexShares STOXX Global Broad Infrastructure Index Fund - FlexShares Trust	NFRA US	4.2%
FlexShares Global Quality FlexShares Global Quality - FlexShares Trust	GGRF US	2.7%
FlexShares iBoxx 3-Year Target Duration TIPS Index Fund - FlexShares Trust	TDDT US	1.8%
FlexShares Ready/Access Variable Income Fund - FlexShares Trust	RAMI US	1.1%

Additionally, the Simulation Parameters for this analysis are provided at the bottom of the section.

SIMULATION PARAMETERS	
	Parameter Value
Start Date	Jul 16, 2019
End Date	Nov 25, 2022
Backfill Method	Common Inception
Rebalancing Method	Buy And Hold
Return On Cash	0%
Underlying Data	Daily Observations

ETF Information – Fund Profile Data

The ticker comparison table in this section shows the key statistics and metrics for each of the funds in the input and modified models as of the close of the previous business day.

	TLTD US	TLTE US	RAVI US	QDF US	NFRA US	GQRE US	BNDC US
Issuer Name	Northern Trust	Northern Trust	Northern Trust	Northern Trust	Northern Trust	Northern Trust	Northern Trust
Fund Name	FlexShares Morningstar Developed Markets ex-US Factor Tilt Index Fund	FlexShares Morningstar Emerging Markets Factor Tilt Index Fund	FlexShares Ready Access Variable Income Fund	FlexShares Quality Dividend Index Fund	FlexShares STOXX Global Broad Infrastructure Index Fund	FlexShares Global Quality FlexShares Global Quality	FlexShares Core Select Bond Fund
Inception Date	Sep 25, 2012	Sep 25, 2012	Oct 9, 2012	Dec 14, 2012	Oct 8, 2013	Nov 5, 2013	Nov 18, 2016
NAV (USD)	\$60.24	\$47.86	\$74.47	\$55.68	\$51.96	\$55.01	\$22.21
Fund AUM (USD)	\$514.26M	\$255.82M	\$743.65M	\$1.75B	\$2.76B	\$399.96M	\$200.78M
Creation Unit Size	200,000	100,000	25,000	25,000	50,000	50,000	25,000
Fund Expense Ratio	0.39%	0.59%	0.25%	0.37%	0.47%	0.45%	0.35%
Basket - Constituent Count	1,050	1,080	345	127	238	142	20,576
Basket - Median Weight	0.06%	0.05%	0.19%	0.53%	0.11%	0.32%	0.00%
6c-11 Median Spread (30 Days)	0.1663%	0.1708%	0.0269%	0.0555%	0.0779%	0.1730%	0.0468%
6c-11 Median Spread - As Of Date	Nov 30, 2022	Nov 30, 2022	Nov 30, 2022	Nov 30, 2022	Nov 30, 2022	Nov 30, 2022	Nov 30, 2022
Traded Volume (ADV 20 - in shares)	27.0K	12.4K	63.5K	53.9K	102.5K	25.2K	28.1K
Holder	Modified Flexshares Growth With Income	Modified Flexshares Growth With Income	Modified Flexshares Growth With Income	Modified Flexshares Growth With Income	Modified Flexshares Growth With Income	Modified Flexshares Growth With Income	Modified Flexshares Growth With Income

METHODOLOGY

DATA SOURCES

We should separate the data sources required for core Model Maker functionality from that of the Quick and Analytics+ analysis. The Analytics+ functionality requires a deeper portfolio understanding, going down to ETF constituents and then aggregating that data across dimensions like sectors, industries and market caps.

The core data sources for Model Maker are:

- Historical, Daily Prices (Total returns, corporate action-adjusted)
- Security Descriptors

DATA OBJECTS

The key data objects that feed in and out of the Model Maker interface (the visuals) and engine (the optimization) are described briefly below. Some of these items are discussed in further detail below.

Interface Inputs

- Security descriptors
- A starting portfolio

Interface Outputs

- Current portfolio descriptor positions
- New portfolio weights

Engine Inputs

- Historical daily total returns
- Covariance matrix estimation
- Descriptor details

Engine Outputs

- The optimized portfolio
- The quick and deep analysis of both the initial and the new portfolio

PORTFOLIO OPTIMIZATION

The current implementation of the Model Maker uses a minimum turnover approach. In the past, QP solvers were used to search for risk-minimization in the resulting portfolio (always under exposure constraints). Due to the nature of the problem, mostly its significant degrees of freedom, using a risk optimization leads to unstable and hard-to-reverse results. For users' clarity and understanding, a simpler and more robust minimization of the turnover to achieve the new portfolio has been implemented.

QP solvers is quadratic programming which is the process of solving certain mathematical optimization problems involving quadratic functions. Specifically, one seeks to optimize (minimize or maximize) a multivariate quadratic function subject to linear constraints on the variables. Quadratic programming is a type of nonlinear programming. "Programming" in this context refers to a formal procedure for solving mathematical problems.

Objective

- We frame the problem as a variation of the Basis pursuit optimization (https://en.wikipedia.org/wiki/Basis_pursuit). To achieve such a mathematical form, we split the weights in the resulting portfolio as the linear contributions of (i) the position in the starting portfolio and (ii) a weight adjustment to said position.
 - The weight adjustment is in fact split into two components, with long and short adjustments being separated to accurately represent turnover in the portfolio.
 - These adjustments are established in the "extended investment universe" (See next paragraph for explanations).
- We use a standard LP (Linear Programming) solver. Our current implementation leverages the HiGHs solvers (https://en.wikipedia.org/wiki/HiGHs_optimization_solver) included in SciPy (<https://docs.scipy.org/doc/scipy/reference/optimize.html>).
- The objective function is written under the following form:

$$\begin{aligned} \min_x \quad & c^T x \\ \text{such that} \quad & A_{ub} x \leq b_{ub}, \\ & A_{eq} x = b_{eq}, \\ & l \leq x \leq u, \end{aligned}$$

This framework allows for:

- Minimization of the turnover in the resulting portfolio (the vector of required adjustments being split into longs and shorts)
- Control over the feasibility of the achieved results (guarantees that adjustment proposed to the portfolio cannot include net short or leveraged positions)
- Most importantly, the profile of the resulting portfolio in the descriptors space matches user's input through the equality constraints.

No Solutions

We introduced several concepts to limit the possibility of falling out of the feasible region.

Investment Universe and pre-loaded Extended Universe

The first objective of Model Maker is to showcase the effectiveness of FlexShares' model portfolios in providing diversified exposures. Without any incentive to trade into a set of specific names, there is a significant chance that the optimization routine will return asset mixes that are complex (in terms of constituents count, for instance) or not in line with this objective.

In order to account for this, the tool maintains the concept of a "greenlist" which is attached to each portfolio being manipulated: a collection of securities we are allowed to trade into. This list is initially set equal to the constituents of the loaded portfolio. We want to emphasize in priority solutions where a simple rebalancing of the portfolio is enough to achieve the desired exposures. Later on, if further securities need to be added to the portfolio, the greenlist is amended every time the user interacts with the GUIs.

Our architecture is designed around the principle of micro-services. The portfolio builder engine is "pre-loaded" with a collection of highly liquid instruments (US-listed ETFs and Single Stocks). This "Extended Investment Universe" notion is implemented in order to save time - and avoid costly database interactions - whenever a new security is added to the greenlist.

Although the idea of an Investment Universe introduces some limitations, we do believe that it greatly helps the user experience.

Making sure that the sliders are being used to navigate a range of achievable values

On the user interface, we walk through the portfolio construction process via the sliders. To ensure smooth interactions, these have to represent a range of achievable values for the resulting portfolio object. Because we have a list of instruments we are allowed to trade into, it is easier to set them in a way that guarantees that, regardless of the user's request, it is "a priori" achievable. In particular, the edge cases of min/max portfolios are very clear: 100% of the security with the lower (respectively higher) exposure to the selected feature.

Making recommendations for "adding" instruments to achieve specific exposures

The Investment Universe, in essence, is a limited set of securities. As a result, some exposures are potentially not achievable. Having pre-loaded the Extended Investment Universe, we can enhance the user experience by making simple "recommendations to add". Here, the goal is to push the user into adding more instruments to the greenlist. Once the action has been performed, we expect the slider to activate - showing that this is now a metric that can be tweaked to its liking.

Discretization of the feasible space for the descriptors

Instead of displaying deterministic values, we expose simple low, medium, high labels. In practice, the exact value of the weighted average P/E ratio of the portfolio is usually not fundamental, per se. It is probably more interesting to highlight that the portfolio is tilted towards the lower/upper end of the spectrum.

Knowing the greenlist + the Extended Investment Universe, we can easily highlight the min/max values that the portfolio can achieve within the descriptors space. Said range is split in a finite number of increments that we use to represent the various states we can achieve.

Not all descriptors are treated equal

We introduced different approaches for the interpretation of the sliders' values.

Namely, the asset classes breakdowns are always considered as "hard" targets, and can not be relaxed - all the other more exotic dials can be somehow relaxed - by focusing on the slider's evolution rather than its value - if the optimization routine fails to converge.

Relaxing some of the constraints if a solution can not be found

The backend logic embeds a safety net in case the optimization procedure fails to converge. As mentioned, we discretize the range of achievable values into separate states.

Except for specific sliders (which are considered as “hard” targets), most of them are read as the desired range for the portfolio. Instead of reading the value of the slider, the recent user action on the slider (increased/decreased it) is translated into a request to move down/up one notch.

In practice, several calls to the optimization procedure can be made:

- On the first pass, every slider’s value is recovered and stored under a vector form (used as $b = [b_i]$ - the vector of constraints in the optimization problem).
- If the previous call does not converge:
 - User-locked sliders, as well as those that are identified as non-relaxable (the asset classes breakdowns, for instance) are kept within the equality constraints.
 - For all the others, we use the inequality constraints to request a range of exposures – instead of deterministic values. In particular, the exposures for the sliders that have been modified are bounded with amended values, highlighting the desired change of state.
- Finally, if this second call fails again, we display a warning to the user.

Edge Case Data Handling

How do we handle short history of data or missing data?

Generally, short price return history can create issues. We have a configurable set of parameters that allows us to:

1. **Do not proceed:** Exit out of the optimization and warn the user. This may be desired if the securities in the portfolio are new listings.
2. **Force proceed:** attempt to proceed with an optimization. This may be desired if the securities in the portfolio have a few months of history.
3. **Proxy handling:** Here we attempt to lengthen the return history of short-history securities in the portfolio with a proxy. This proxy can either be
 - a. An index represented by a tradeable ETF
 - b. A cash replacement. In other words, a fixed percentage allocation could be assigned to the security for the purposes of obtaining new weights. It is assumed to have existed as cash prior to its inception.

QUICK ANALYSIS

The quick analysis provides standard performance, risk and cost historical backtested results. We run the newly constructed portfolio through our simulation engine to obtain its historical evolution.

- **Performance:** Annualized geometric average of daily returns over the life of the portfolio
- **Risks:** Annualized volatility of daily returns over the life of the portfolio
- **Costs:** Weighted average of the net expense ratios for the constituents of the portfolio

Parameters of the simulation:

- Daily observation data for prices
- No rebalance (buy and hold assumption)
- No backfilling: “common inception” of the constituents if the portfolio has no history, “known history” if previous states if the portfolio are provided (useful in the case of model portfolios, for instance)

Backtest procedure

1. Detect known states for the portfolio.
 - a. Last known state: the “new portfolio” achieved.
 - b. Previous states: whatever is attached to the portfolio as its history (mostly relevant in the case of model portfolios with known rebalances).
2. Do the same for the benchmark - whether explicitly selected or chosen by the algo.
3. Pull historical prices for the securities included in the current portfolio, or any of its previous states.
4. Apply backfilling logic, if any selected, in order to reconstruct daily target allocation weights for the portfolio (concretely: the part of the allocation that is not driven by market evolution).
5. Simulate the evolution of the portfolio with the choice of management routine.
 - a. Compound market returns with target allocation weights in order to compute the matrix of daily weights for constituents of the portfolio.
 - b. Buy and Hold: keep the daily weights “as is”.
 - c. Calendar rebalances enforce that on the day of a rebalances, weights are set equal to the target allocation weights.
6. Recover evolution of the portfolio (through daily returns).
7. Analysis and formatting.

ANALYTICS+ (DEEP ANALYSIS)

Parameters of the simulation:

- Daily observation data for prices
- No rebalance (buy and hold assumption)
- No backfilling: “common inception” of the constituents if the portfolio has no history, “known history” if previous states if the portfolio are provided (useful in the case of model portfolios, for instance)

The backtesting procedure used is similar to the one detailed in the Quick Analysis section.

Output is organized into several tabs, reflecting the different dimensions relevant for a portfolio analysis:

- Summary
 - Constituents of both initial and modified portfolios
 - Simulation parameters recap
- ETF Stats
 - For every ETF included in either the initial or the modified portfolio
 - CUSIP
 - Issuer Name
 - Fund Name
 - Inception Date
 - Asset Class Focus
 - Investment Focus
 - ETFLogic TruLiquidity Score
 - NAV
 - Fund AUM
 - Benchmark
 - Creation Size
 - Creation
 - Fund Expense Ratio
- Backtest
 - Line graph representing the evolution of a \$10k investment throughout the simulated life of the portfolios
- Multiple breakdowns at the “aggregated” basket level
 - Asset Classes
 - Equity
 - Geography
 - Industry
 - Sector
 - Market Cap
 - Fixed Income
 - Bonds Types
 - Credit Ratings
 - Maturity
 - Performance
 - Trailing Returns
 - Calendar Returns
 - Drawdown
 - Returns
 - Bar Chart of trailing returns over various time horizons
 - Risks
 - Bar Chart for volatility and downside volatility

- Factors
 - Bar Chart of sensitivities drawn from an observable factor model.
 - Market proxies are selected for major investment factors and a standard linear regression model is implemented using (at least 48 and) up to 60 monthly observations.
- Factors Hist.
 - Fama-French factor model. We take the latest observations for the portfolio (namely its returns) and compute the most recent profile of the portfolio within the Fama-French framework.
 - We assume these exposures to be constant throughout history and replay past market conditions by applying said sensitivities on historical evolution of the factors.
 - We then derive the evolution of a factor portfolio - maintaining the real portfolio's exposure profile.
- Scenarios
 - Scenario Analysis performed on the factor portfolio previously established
 - Notable market events are highlighted and the focus is put on the evolution of the portfolios and the benchmark throughout said events.

IMPORTANT INFORMATION

For financial professional use only. Not for use with the investing public.

Before investing, carefully consider the FlexShares investment objectives, risks, charges and expenses. This and other information is in the prospectus and a summary prospectus, copies of which may be obtained by visiting www.flexshares.com. Read the prospectus carefully before you invest.

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An investment in FlexShares is subject to numerous risks, including possible loss of principal. Fund returns may not match the return of the respective indexes. The Funds are subject to the following principal risks: asset class; authorized participant, calculation methodology; commodity; concentration; counterparty; currency; derivatives; dividend; emerging markets; equity securities; financial sector, fluctuation of yield; foreign securities; geographic; high portfolio turnover; income; industry concentration; inflation; infrastructure-related companies; interest rate; issuer; liquidity; large cap; management; market; market trading; mid cap stock; MLP; momentum; natural resources; new funds; non-diversification; passive investment; privatization; securities lending; small cap stock; tracking error; value investing; and volatility risk. A full description of risks is in the prospectus.

The Growth of \$10,000 chart is hypothetical based upon the historical performance of the Funds. It does not reflect the deduction of other fees and expenses, in which case the performance would have been lower.

Performance data quoted represents past performance and does not guarantee future results. Investment return and principal value of an investment will fluctuate so that an investor's shares, when redeemed or sold in the secondary market, may be worth more or less than the original cost. Current performance be lower or higher than the performances shown. Shares are bought and sold at market price not net asset value ("NAV") and are not individually redeemable from the fund.

All performance figures assume reinvestment of dividend and capital gains at net asset value; actual returns may differ. Performance 1-year and less are cumulative; performance over 1-year are average annualized total returns. Market price performance is determined using the bid/ask midpoint at 4:00pm Eastern time, when the NAV is typically calculated. NAV price performance is determined using the daily calculated NAV. They do not represent the returns you would receive if you traded shares at other times. Performance figures do not reflect the deduction of taxes that a shareholder would pay on Fund distributions or upon redemption or sale of fund shares. The fund inception date is generally several days prior to when the fund begins trading.

Performance is historical and does not guarantee future results. Current performance may be lower or higher than quoted. Investment returns and principal value of an investment may be worth more or less than their original cost.

All information is provided strictly for educational and illustrative purposes only. No representation is being made that any investment will achieve performance similar to those shown. The information provided is not intended for trading purposes, and should not be considered investment advice. This tool should not be used as the basis for your investment decisions.

Past performance is not indicative of future results.

Note: Stress tests do not represent actual fund performance, are hypothetical in nature and the results do not forecast the likelihood that any event will occur. The stress tests represent analysis of the historical sensitivities of the underlying assets in the given portfolios to various factors, which take into consideration asset classes in multiple geographies, and are built using factor-based linear regression mathematics sourced solely from historical data.

Historical sensitivities (beta) of the individual underlying assets in the portfolio are calculated for each of the factors. The sensitivities describe how much the total return of an asset changed in the past based on the historical change in a factor. These sensitivities are then used to create a hypothetical return for a given model. Historical scenarios are built using observed factor returns from the historical time periods. The historical returns for the specific scenarios are then multiplied by the sensitivity of each asset to each factor to calculate a hypothetical return of that asset in the portfolio. The stress tests are based on observed historical sensitivities, there is no guarantee that the assets will perform in a similar manner to the various factors in the future; additionally, while the historical scenarios presented represent observed historical factor shifts, there is no guarantee that the factors shifts in the future will be the same as the historical scenarios. Data used in the stress test is composed of several sources of historical performance and is updated to reflect the most recent information which can vary with each use and over time; small changes may create large differences in results.