Constructing a Credit Value Strategy using the BarraOne Optimizer

A Case Study on Fixed Income Portfolio Construction

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June 2017

1 Introduction

The Barra Optimizer, MSCI's portfolio optimization engine, addresses a wide variety of portfolio construction and optimization problems, including index tracking, asset allocation, and other portfolio management use cases.

Investment managers frequently have the opportunity to frame an investment decision into an optimization process. This process can reflect the desire to balance the returns and risk, while still conforming to specified constraints. The Barra Optimizer in BarraOne or "BarraOne Optimizer" allows investment managers to customize the optimization process and select from a wide variety of constraints to construct optimal portfolios that fit into specific investment strategies.

This document presents a case study describing the specific workflow used to set up the credit value strategy discussed in Navigating Central Bank Intervention in Corporate Bond Markets (Sparks and Sharp 2017). It further analyzes the impact of the European Central Bank's corporate bond program from the perspective of a hypothetical asset manager pursuing a credit value strategy in euro-denominated corporate debt.

In the next section, we illustrate how portfolio optimization tools (BarraOne Optimizer, the MSCI Fixed Income Factor Model, and other BarraOne tools) can be used to translate the credit value strategy into a dynamically-managed portfolio with monthly rebalancing. Our strategy emphasizes bottom-up issue selection while incorporating constraints on tracking error volatility (TEV), duration, and sector and issuer concentration.

We then review and discuss the results of our optimization strategy. We also perform a sanity check to make sure the managed portfolio is aligned with the stated goals of the hypothetical asset manager.

The appendices provide initial guidelines for the most common optimization use cases, such as rebalancing and hedging, and also describe the BarraOne workspace and provide a broad overview of the BarraOne Optimizer capabilities.

2 Set Up a Corporate Bond Strategy

The financial crisis of 2008 brought new challenges for central banks seeking to stimulate the economy and return inflation to a target level of 2%. Major central banks adopted unconventional monetary policies to increase monetary supply through actively buying securities in the market. As part of these programs, the European Central Bank (ECB), the Bank of Japan (BOJ), and the Bank of England (BOE) bought corporate bonds.

In our case study, we focus on the ECB's Corporate Sector Purchase Program (CSPP), which is by far the largest and most active program, with a current value of $101b and an average monthly purchase of $9.8b, as of May 31, 2017.

Our analysis considers a hypothetical asset manager who strongly believes that risk premia exists in the corporate market and that high spread bonds will outperform low spread bonds over longer periods of time. The asset manager looks to capture the risk premia with a long-only portfolio using the BofA Merrill Lynch Euro Corporate Index as the benchmark. This manager focuses on credit strategies and wants to target active risk to be approximately 75 bps of annual tracking error volatility (TEV), where the tracking error is measured against the BofA Merrill Lynch Euro Corporate Index. This manager also wants low interest rate and issuer concentration risk, while avoiding excessive trading. Further, the manager wants to limit exposure to banks, euro-denominated emerging market bonds, and bonds with embedded options, including callable and step-up bonds. Monthly portfolio turnover is constrained to be no greater than 5% of market value.

In the subsequent sections, we outline the process used to create this credit strategy, using the following steps:

1. Implement the strategy
2. Select a benchmark
3. Maximize risk-adjusted returns
4. Use a factor model
5. Set up an optimization for the initial rebalance
6. Set up optimization for subsequent monthly rebalancing
7. View results

2.1 Implement the Strategy

The BarraOne Optimizer can be used to analyze a wide variety of investment strategies. For our case study, we use the BarraOne Optimizer to translate the credit value strategy into a dynamic portfolio with periodic rebalancing, while incorporating the asset manager's views on the market. We create a transparent implementation of the strategy within a consistent and rules-based framework. Appendix B provides details about the optimization parameters used in the analysis.

2.2 Select a Benchmark

We will use the BofA Merrill Lynch Euro Corporate as the benchmark portfolio. At the beginning of the analysis, the index has significant weightings in banks, BBBs, and non-Eurozone issuers. Issuer concentration is relatively low and issuers incorporated in France comprise the largest block of issuers in the index.

Table 1: BofA Merrill Lynch Euro Corporate Index[1] (as of December 31, 2015)

Basic Characteristics						
Number of Bonds	**Market Value**	**Effective Duration**	**OAS**	**Weight of Top 50 Issuers**	**Weight of Top 200 Issuers**	**Largest Issuer Weight**
2154	€ 1.8 T	5.25	140	48%	85%	SAS Rue La Boetie 3.2%

Sector Weights						
BBB (BofAML Rating)	**Banks**	**Subordinate Debt**	**Emerging Markets**	**Non Eurozone Developed Markets**	**Callables, Step-Ups, Fxd-to-Float**	**Largest Country Weight**
43%	34%	13%	2%	34%	29%	France 23%

One of the main goals is to keep the managed portfolio as close as possible to the benchmark; in this case, we target approximately 75 bps of TEV.

2.3 Maximize Risk-Adjusted Returns

The BarraOne Optimizer supports different optimization types, including Standard Optimization, Risk Target Optimization, Long/Short Optimization, and Efficient Frontiers. Standard Optimization is a traditional mean-variance optimization type, in which the optimizer tries to maximize the risk-adjusted returns subject to the constraints in the investment strategy. This is the trade-off between risk and returns.

For this case study we use Standard Optimization, defining the objective function for the credit strategy as:

$$Maximize\ OAS - .6 * MSCI\ Bid\_Ask - Risk\ Aversion * Active\ Risk$$

where,

- $OAS - .6 * MSCI\ Bid\_Ask$ denotes the asset returns at bond level and favors bonds with high OAS and low bid/ask spreads[2]. This definition of asset returns includes transaction costs.

[1] Analytics are from MSCI
Index Source: BofA Merrill Lynch Global Research, used with permission. See Appendix for BofA Merrill Lynch Global Research disclaimer.

[2] OAS does not incorporate projected credit loss so it cannot be considered a measure of expected return. Nevertheless, in our analysis, we hypothesize that OAS is positively correlated with realized returns in accordance with the asset manager's beliefs about market risk premia.

- $Risk\ Aversion$ is the portfolio-level risk aversion and is calibrated to achieve the desired TEV. For more details, see Appendix D.
- $Active\ Risk$ is derived from MSCI's factor model risk.

To set up the credit value strategy, we use OAS adjusted by the bid-ask spread as asset returns to favor bonds with high option-adjusted and low bid-ask spreads. The multiplier (.6) is motivated by anticipated annual portfolio turnover of 60%, which is consistent with the monthly turnover constraint of 5%. We found this formula provides reasonable results in balancing the tradeoffs between OAS and transaction costs.

To optimize the risk-adjusted returns, asset returns need to be provided to the BarraOne Optimizer. In BarraOne, there are two ways to provide asset returns: import attributes using a template or create attributes using the Formula Builder tool. If asset returns are not provided, the optimizer will focus on risk reduction to find the optimal portfolio.

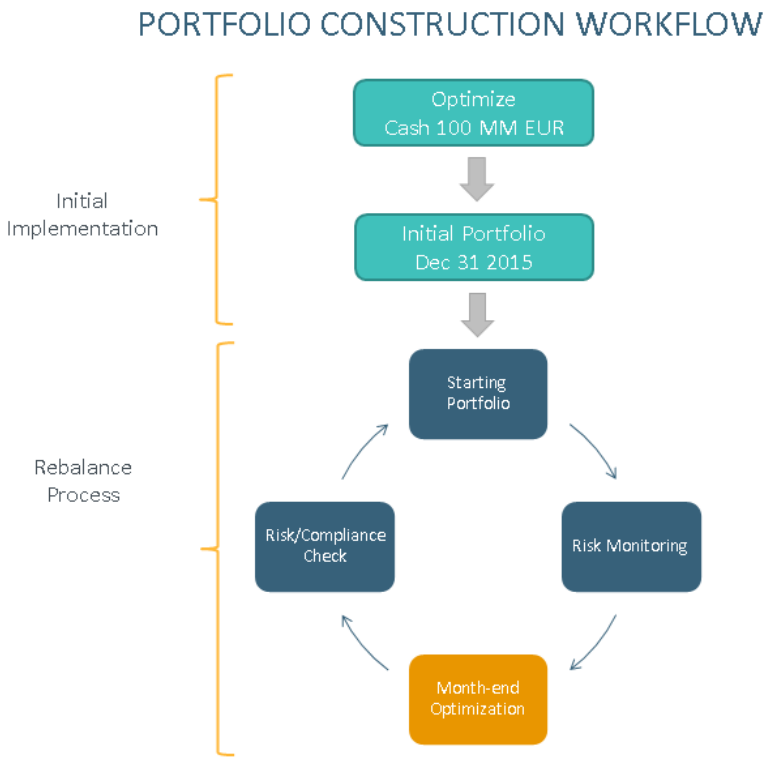
For our case study, we use Formula Builder to create the required user attributes for asset returns, asset bounds, and constraint attributes. For details, see Appendix C.

2.4 Use a Factor Model

Factor models are widely used in optimizations to compute the portfolio tracking error volatility (TEV) based on the portfolio's exposure to risk factors relative to an index benchmark. A portfolio with exposures close to index exposures will have a small TEV and a portfolio with greater differences will have a larger TEV. Factor models reduce the effects of spurious correlations among bond returns and so tend to provide for more robust optimizations. The optimizations in our case study use the MSCI's Fixed Income Factor Model (Shepard et al, 2017).

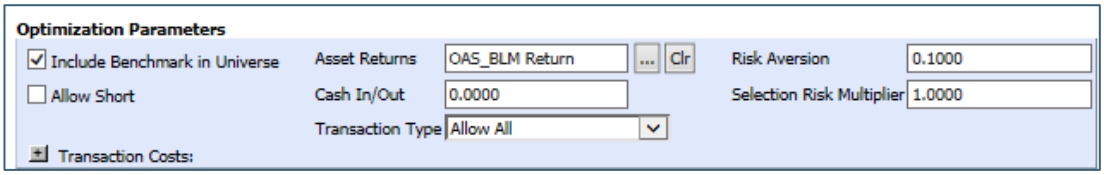
2.5 Set up Optimization Profile

The strategy starts with a cash portfolio of 100 million euros and is launched as of 2016/01/01. The resulting optimal portfolios are subsequently rebalanced at the end of each month starting at 2016/01/31, for 14 months in this case. All securities at time of purchase will belong to the benchmark. In other words, the investment universe will be the benchmark assets on the rebalance date. The optimization profiles are roughly the same across different months but some parameters are tuned to reflect the hypothetical investor preferences and goals. For more details, see Appendix D.



2.5.1 Specify the Optimization Parameters

Investors can specify investment objectives that will be reflected in the utility function being optimized. The key drivers of this analysis are the returns and risk, as well as any transaction costs to be considered by the optimizer. These objectives are established in the *Optimization Parameters* section. For the credit value strategy, inputs must be chosen to meet the TEV risk budget of 75 bps, while also maximizing asset returns subject to constraints.



1. Set **Asset Returns** to OAS_BLM_Return, which is the attribute created using Formula Builder. For details, see Appendix C.
2. Select **Include Benchmark in Universe** to allow the optimizer to consider assets in the BofA Merrill Lynch Euro Corporate portfolio in the optimal solution.
3. Specify the **Risk Aversion** parameter. The impact of risk on the utility function in the BarraOne Optimizer is influenced by this parameter. See Appendix A for definitions and Appendix D for calibration.
4. Set **Transaction Type** to **Allow All.**

2.5.2 Set Constraints

The optimizer allows different combinations of constraints during optimization, and managers need to translate their requirements into constraints when setting up any strategy. In the credit value strategy, we are looking for a portfolio that stays close to the selected benchmark, while avoiding excessive trading and turnover.

The asset manager would like to avoid excessive issuer concentration and have a well-diversified bond portfolio. In our example, for an unconstrained optimization, the initial portfolio had 7 issuers with a combined weight of 1.5% and 35% of portfolio's spread risk. To minimize the issue concentration, we will set up constraints at the issuer level. Note that we added issuers to the list after identifying them in subsequent optimizations as excessive risk contributors to spread risk.

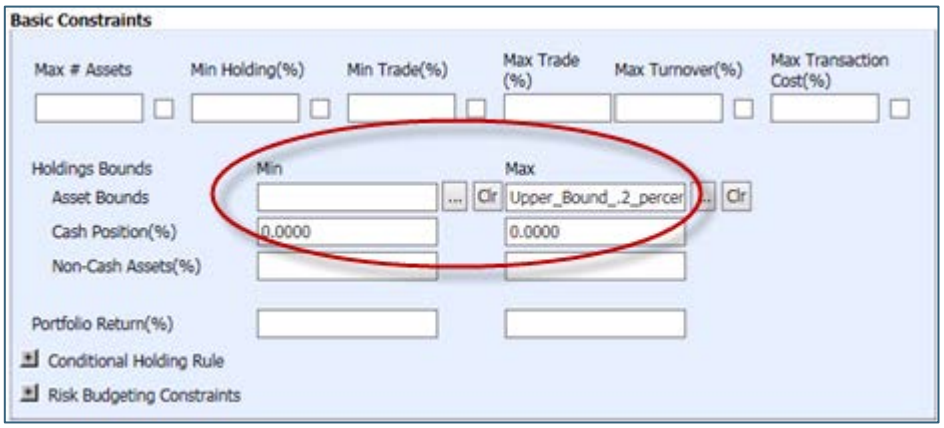
Our hypothetical asset manager has decided on the following guidelines for the investment strategy:

- Banks, the largest sector in the index, should have a market value weight in the portfolio that does not exceed their weight in the index. This reflects the asset manager's belief that this sector is a tough investment given the lack of balance sheet transparency.
- Emerging market bonds issued in euros are allowed to be only modestly overweighted.
- Bonds with exposure to optionality, such as callable or step-ups, should not exceed their weight in the index.

For the complete list of available optimization parameters, refer to Appendix B.

STEP 1 – Specify basic constraints

To avoid concentration in a single bond, we will limit the amount of investment for each bond. We also want to invest all cash from the initial portfolio.



1. **Asset Bounds** – Leave the **Min** field blank and select an asset-level attribute in the **Max** field. In our case study, we are using maximium bounds between .2% to .22%[3]. For details on how to create attributes for asset bounds, see Appendix C.
2. **Cash Position(%)** - Set both minimum and maximum to 0.

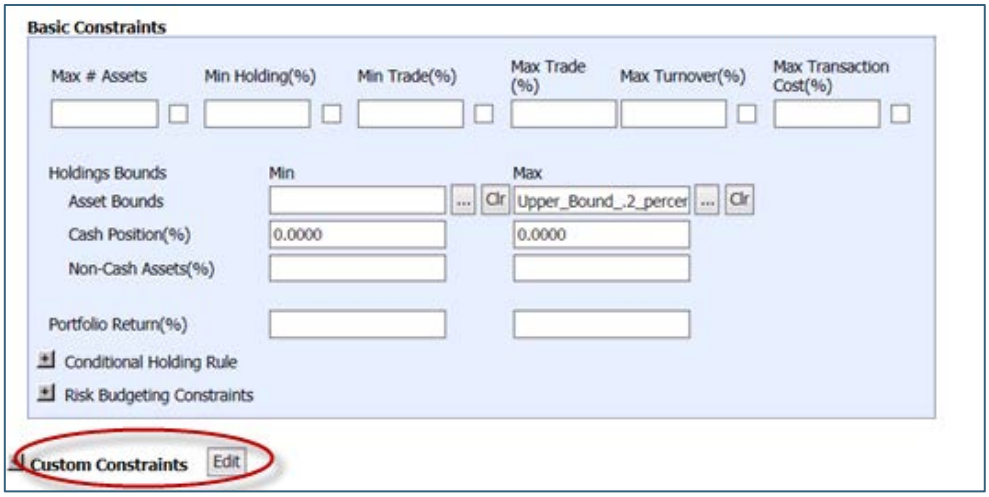
[3] The asset-level bounds vary to impose a minimum number of bonds to be held in the optimal portfolio and at the same time reduce concentration in a single bond.

All other constaints in this section will remain unused.

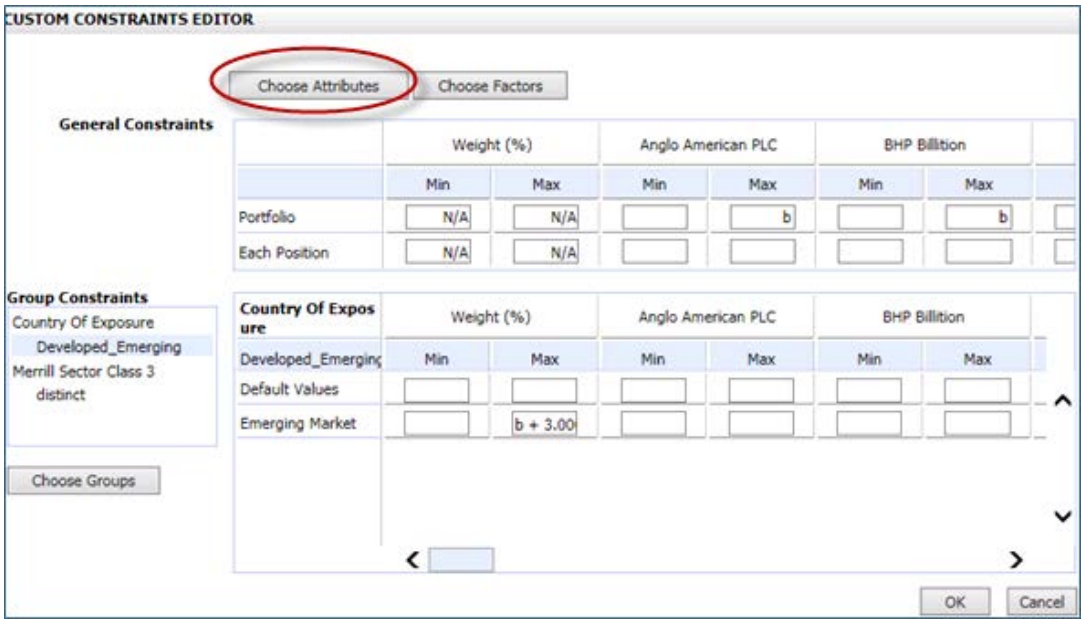
STEP 2: Specify custom constraints

We use custom constraints to define the minimum and maximum values for portfolio-level exposure to asset attributes. The resulting portfolio will satisfy the exposure restrictions imposed in this section. For some custom constraints, we must first import asset attributes.

1. Click **Edit** to add or modify custom constraints.

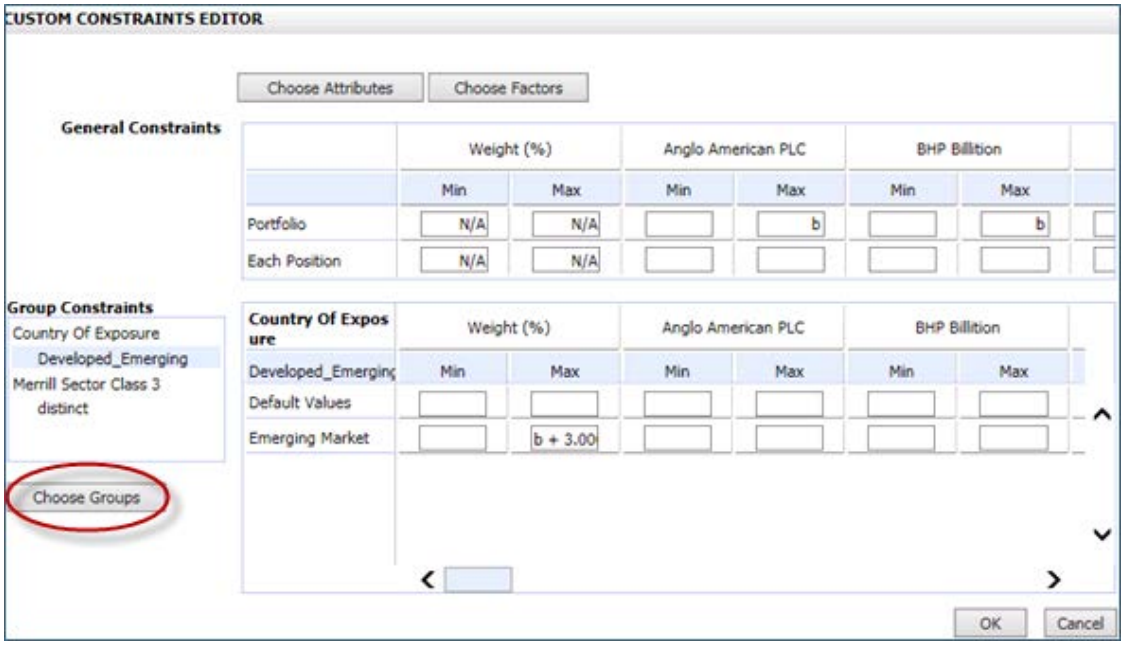


2. Click **Choose Attributes** to create general constraints.

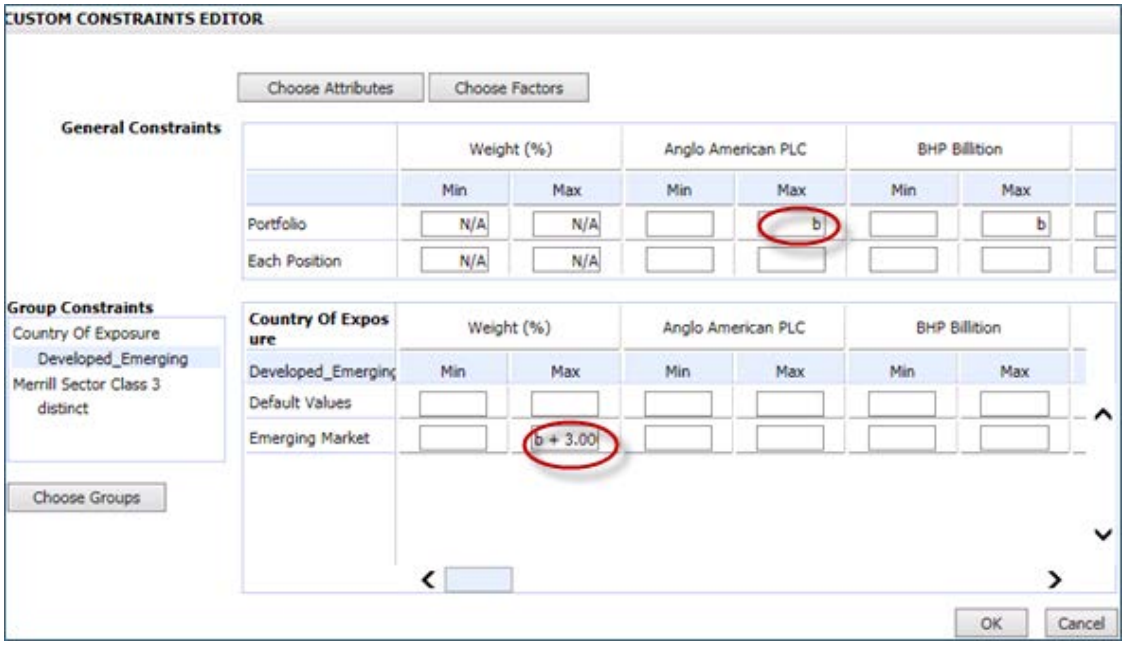


3. Search in the user data and select an attribute by double-clicking or by clicking » .

4. Click **Choose Groups** to create group constraints. Select an attribute, the grouping schemes, and the groups to add. In this case, we added two group constraints:
   - Emerging Market: Select Attribute Country of Exposure, grouping scheme as Developed_Emerging and select Emerging Market group
   - Banking: Select Attribute Merrill Sector Class 3, grouping scheme as distinct and select banking group



5. Type the specified values. “b” is relative to the benchmark value. For example, the maximum share for Anglo American is the benchmark share.



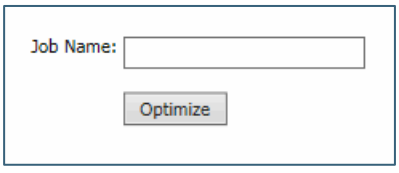
We will constrain the following attributes (for user attribute formulas, see Appendix C):

Constraints	Maximum Weight	System or User	Type of Constraint
Emerging Market	benchmark +3%	System	Group Constraint
Banking (Merrill Class 3)	benchmark	System	Group Constraint
Fixed-to-Float	benchmark	User	General Constraint
Callable	benchmark	User	General Constraint
Step-up	benchmark	User	General Constraint
Effective Duration	benchmark +/- .1	System	General Constraint

Issuer Constraints	Maximum Weight	System or User	
Anglo American PLC	benchmark	User	General Constraint
BHP Billition	benchmark	User	General Constraint
Casino Guichard	benchmark	User	General Constraint
Delta Lloyd	benchmark	User	General Constraint
Glencore	benchmark	User	General Constraint
Sas Rue La Boetie	benchmark	User	General Constraint
Stichting Demeter	benchmark	User	General Constraint
Uniqa Insurance Group	benchmark	User	General Constraint
Mexico States	benchmark	User	General Constraint
Valepar S.A.	benchmark	User	General Constraint
Votorantim	benchmark	User	General Constraint

STEP 3: Submit the optimization job

1. Specify a job name.

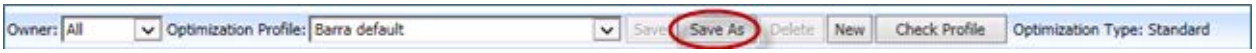


2. Click **Optimize**.

2.6 Set up Optimization Profile for Monthly Rebalance

The strategy for subsequent rebalancing at month-end differs from the initial rebalance strategy. We would like the optimizer to control the amount of trades during optimization and also restrict the trading to a percentage of the actual portfolio, thereby avoiding high portfolio turnover. We save the initial rebalance profile and modify the appropriate parameters as described in this section.

STEP 1: Save a copy of the initial rebalance profile to be reused for monthly strategy

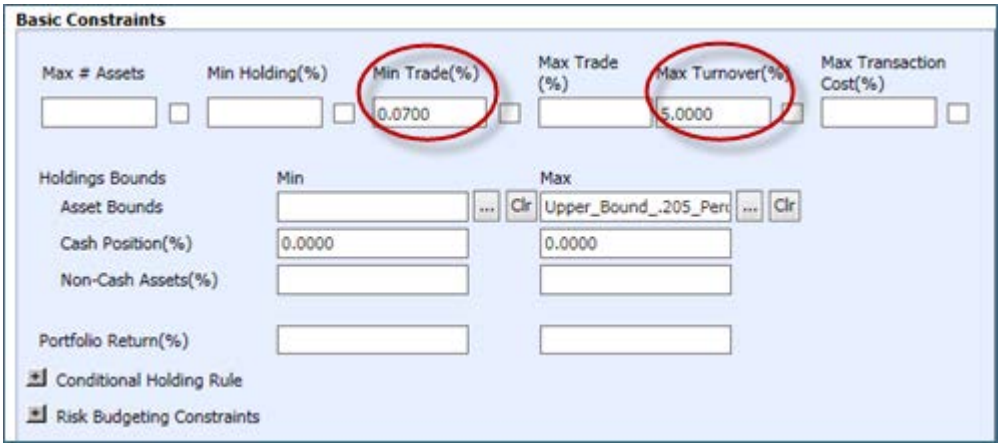


1. Click **Save As.**
2. Specify a profile name.
3. Make sure that the opened portfolio is the one you want to optimize.

Note: To re-use a previously-saved workspace, click **New** and select the **Optimization Profile** from the drop-down list.

STEP 2: Specify additional basic constraints

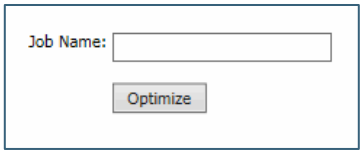
The additional basic constraints help the optimizer align the number of trades with investor expectations. This strategy is based on the assumption of controlled trades and turnover.



1. Set **Min Trade** (%). In our case study, we are using a min trade of between .03 and .1 to restrict the number of trades and regulate the number of bonds in the optimal portfolio. For details, see Appendix B.
2. Set **Max Turnover** (%) to 5.
3. All other constraints in this section will remain unused.

STEP 3: Submit optimization job

1. Specify a job name.



2. Click **Optimize**.

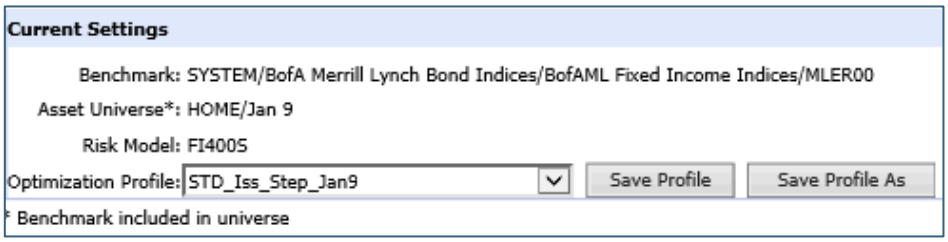
2.7 View Results

The BarraOne Optimizer allows the user to analyze the constraints, generate the trade list, and save the optimal portfolio. The portfolio analysis can then be continued using other BarraOne features, such as performance analytics and reporting tools.

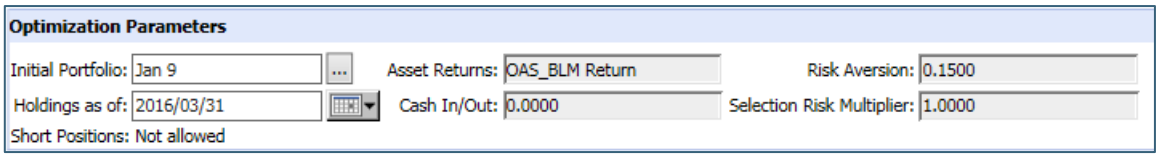
In this section, we focus only on analyzing the results in the optimization module. After the optimization job is submitted, the job name appears in the **Analysis** > **Portfolio Optimization** sidebar. The completed job can be selected to view the following results in the report.

2.7.1 Basic Settings and Optimization Parameters

The optimizer provides for viewing basic settings such as benchmark, risk model, and optimization profile.

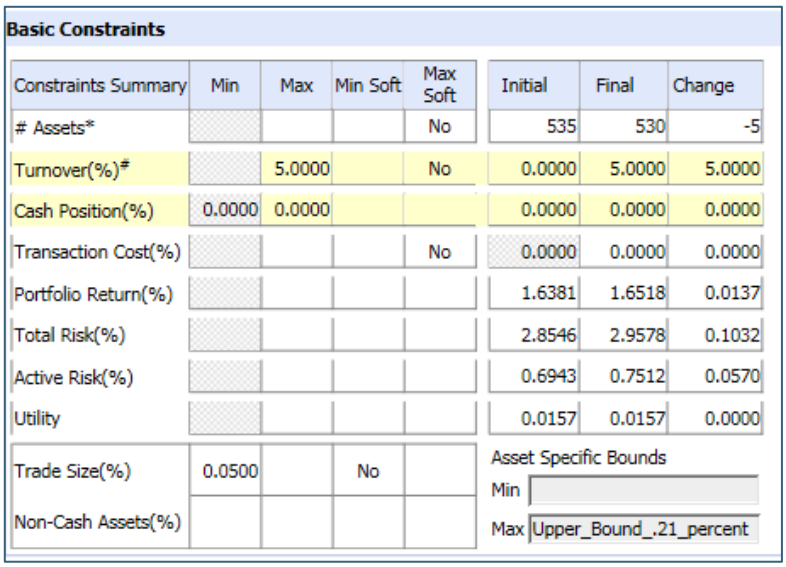


The user can then specify and view the selected portfolio, dates, asset returns, and other parameters such as risk aversion. Risk aversion is calibrated to achieve the desired TEV. For details, see Appendix D.



2.7.2 Specified Constraints

The initial, final, and change in the values of the portfolio can be viewed relative to the constraints. This allows the user to confirm the values that were generated by the optimization and ensure that user preferences were satisfied. The yellow shaded lines in the example below show the constraints that the optimizer hit.



Basic Constraints

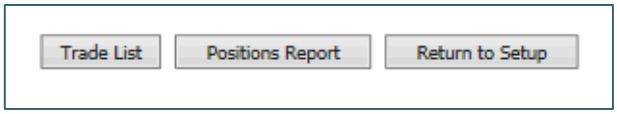
Constraints Summary	Min	Max	Min Soft	Max Soft	Initial	Final	Change
# Assets*				No	535	530	-5
Turnover(%)#		5.0000		No	0.0000	5.0000	5.0000
Cash Position(%)	0.0000	0.0000			0.0000	0.0000	0.0000
Transaction Cost(%)				No	0.0000	0.0000	0.0000
Portfolio Return(%)					1.6381	1.6518	0.0137
Total Risk(%)					2.8546	2.9578	0.1032
Active Risk(%)					0.6943	0.7512	0.0570
Utility					0.0157	0.0157	0.0000
Trade Size(%)	0.0500		No				
Non-Cash Assets(%)							

Asset Specific Bounds
Min
Max Upper_Bound_.21_percent

Each of the specified custom constraints is displayed in a summary at the bottom of the report that includes the initial, final, and change during optimization.

2.7.3 Trade List, Positions Report, and Return to Setup

To view the summary report, trading summary, and general trade list, click **Trade List**.



The Summary report helps to understand the high level status of the initial, final, and change in the portfolio. The report includes statistics such as turnover and the max trade.

Summary Reports

Portfolio Summary

Description	Initial	Final	Change
Assets	536.0000	530.0000	-6.0000
Value($mil)	101.2737	101.2737	-0.0000
Cash($k)	0.0000	0.0000	0.0000

Trading Statistics

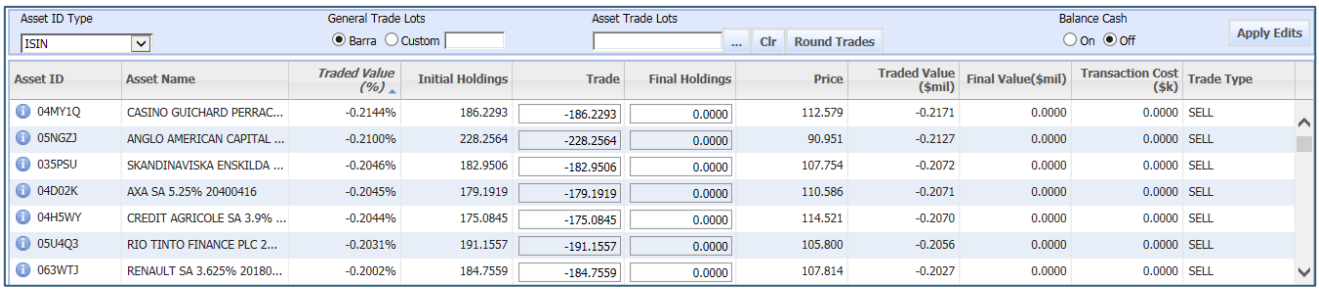
Description	Result
Turnover	5.0000%
Min Trade	0.0499%
Max Trade	0.2144%

The Trading summary helps to identify the high-level changes in the portfolio, indicating the number of buys, sells, and shorts the optimizer made. The asset amounts and purchases in the optimized portfolio can be analyzed.

Trading Summary

Description	Cover Buy	Buy	Sell	Short	Total
Assets	0.0000	43.0000	40.0000	0.0000	83.0000
Shares	0.0000	4,809.1202	4,771.6267	0.0000	9,580.7469
Value Transacted($mil)	0.0000	5.0637	5.0637	0.0000	10.1274
Transaction Cost($k)	0.0000	0.0000	0.0000	0.0000	0.0000

The general trade information allows the user to explore the specifics of each transaction. Each asset ID is matched with the corresponding transaction, including initial holdings, final holdings, price, final value, and transaction cost. The optimal portfolio can also be edited.



Asset ID Type: ISIN | General Trade Lots: Barra / Custom | Asset Trade Lots | Clr | Round Trades | Balance Cash: On / Off | Apply Edits

Asset ID	Asset Name	Traded Value (%)	Initial Holdings	Trade	Final Holdings	Price	Traded Value ($mil)	Final Value($mil)	Transaction Cost ($k)	Trade Type
04MY1Q	CASINO GUICHARD PERRAC...	-0.2144%	186.2293	-186.2293	0.0000	112.579	-0.2171	0.0000	0.0000	SELL
05NGZJ	ANGLO AMERICAN CAPITAL ...	-0.2100%	228.2564	-228.2564	0.0000	90.951	-0.2127	0.0000	0.0000	SELL
035PSU	SKANDINAVISKA ENSKILDA ...	-0.2046%	182.9506	-182.9506	0.0000	107.754	-0.2072	0.0000	0.0000	SELL
04D02K	AXA SA 5.25% 20400416	-0.2045%	179.1919	-179.1919	0.0000	110.586	-0.2071	0.0000	0.0000	SELL
04H5WY	CREDIT AGRICOLE SA 3.9% ...	-0.2044%	175.0845	-175.0845	0.0000	114.521	-0.2070	0.0000	0.0000	SELL
05U4Q3	RIO TINTO FINANCE PLC 2...	-0.2031%	191.1557	-191.1557	0.0000	105.800	-0.2056	0.0000	0.0000	SELL
063WTJ	RENAULT SA 3.625% 20180...	-0.2002%	184.7559	-184.7559	0.0000	107.814	-0.2027	0.0000	0.0000	SELL

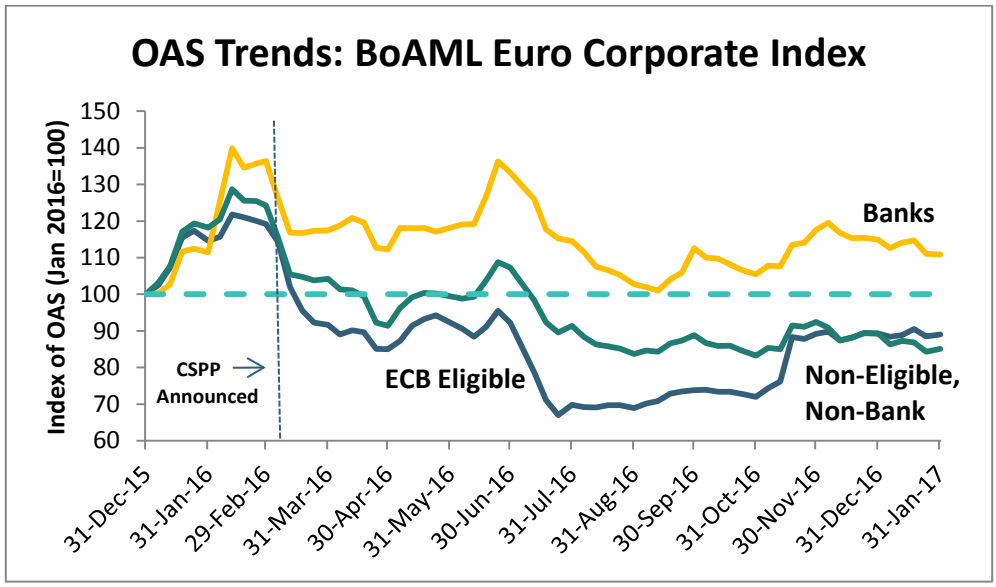
Clicking **Reports** in the Analysis tab allows viewing of the optimal portfolio in the Positions Report. This enables the user to analyze the risk characteristics for selected dimensions.

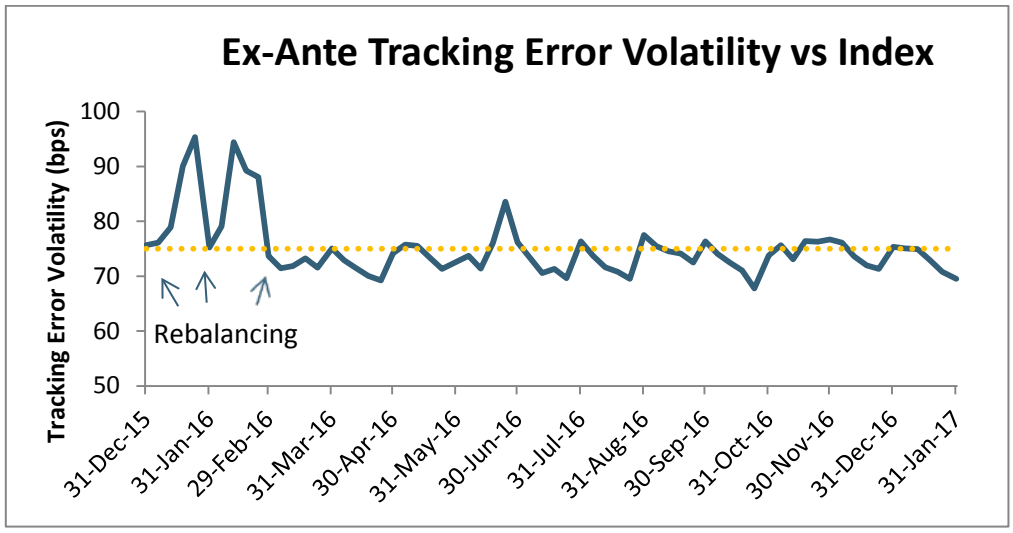
3 Understanding the Optimization Results

Impact of Spreads Variation on TEV

In the beginning of 2016, market spreads widened. After the announcement of the CSPP program in early March 2016, spreads immediately tightened with spreads on ECB eligible bonds generally outperforming other sectors. Spreads widened temporarily in June with the results of the Brexit vote, but then resumed tightening through October. Spreads widened in November—particularly on the ECB eligible sector—as signs of rising inflation and talks of ECB tapering took a toll on the market. However, spreads continue to be much tighter than before the announcement of the program (see the following charts).

Such movements in spreads significantly affect the composition of the optimized portfolio as the portfolio is rebalanced at the end of each month. As spreads widen during the month, for example, TEV will tend to widen above the risk target of 75 basis points. This observation reflects a spread tilt in the portfolio: when the index spread widens, the portfolio spread tends to widen even more. In addition, our factor model uses Duration Times Spread (DTS) as the main risk exposure for spreads. As the portfolio DTS rises relative to the index DTS, the portfolio TEV will tend to rise. At month-end, the optimization will achieve the targeted TEV of 75 bps through portfolio buys/sells, which reduces the difference in DTS between the portfolio and the index.



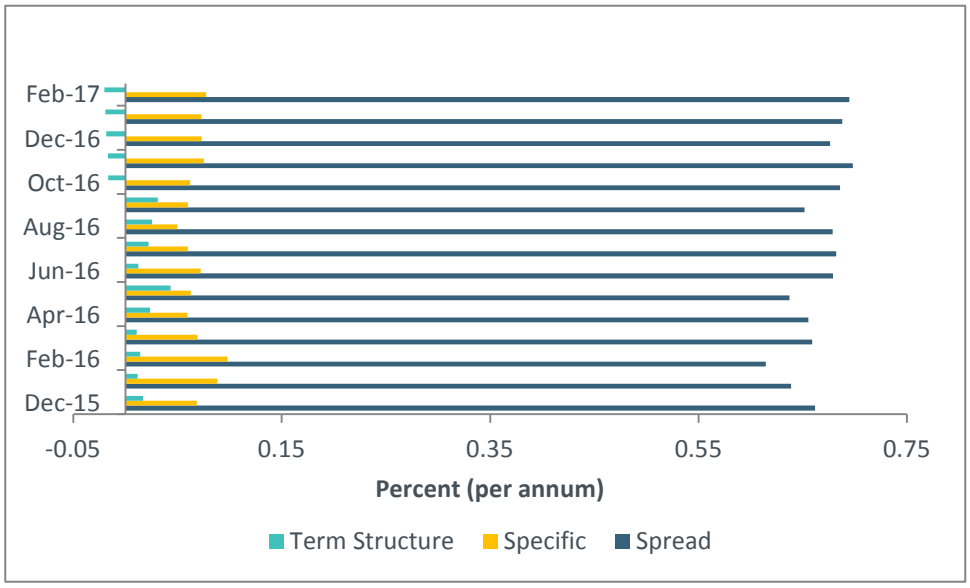


Sanity Check

A core goal of the optimization is to align the managed portfolio with the asset manager's guidelines. In this example, we pursued a credit value strategy and minimized interest-rate risk and issuer concentration. We used MSCI's Fixed Income Factor model to show the contribution to TEV by risk source. The major contributor to risk was spread risk. Term structure and specific risk were small over the entire period. The specific risk reflects the issuer and security spread risk.

We conclude that the optimized portfolio was aligned with the portfolio's investment guidelines and the asset manager's emphasis on taking credit spread bets.

Contribution to TEV



Performance Analysis

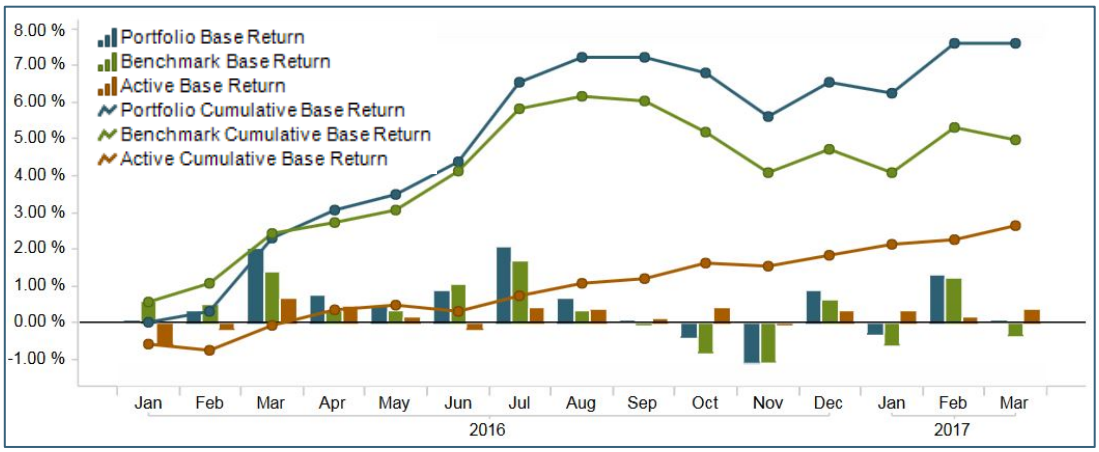
The bottom-up investment strategy outperformed the market from December 31, 2015 to March 31, 2017. Outperformance was driven by exposure to lower-rated bonds within the non-ECB, non-bank sector of the market, which was also the main source of risk within the portfolio.

The summary of performance shows that the investment strategy's bet on high-spread bonds would have yielded a large positive active return of 201 basis points on top of the BofA Merrill Lynch Euro Corporate Index return of 3.83% during the 15-month period ending March 31, 2017. The time-series chart shows that the cumulative active performance (the orange curve) was initially negative until April, declined in June, and then steadily improved.

Summary of Performance

Portfolio Base Return	Benchmark Base Return	Active Base Return	Start Date	End Date
5.84%	3.83%	2.01%	12/31/2015	03/31/2017

Performance Trend - Monthly and Cumulative



The complete performance analysis can be found in the research paper Navigating Central Bank Intervention in Corporate Bond Markets (Sparks and Sharp 2017).

4 Conclusion

Investment managers can leverage the power of the Barra Optimizer in BarraOne to construct optimal portfolios that reflect their investment preferences. The extended optimization features available allow the construction of numerous use cases and strategies.

The case study described here illustrates how a hypothetical investor can construct optimal portfolios based on a credit value strategy in euro-denominated corporate bonds. The manager has a bottom-up style focused on security selection based on bond level option-adjusted spreads (OAS). This particular use case can be further examined in the paper Navigating Central Bank Intervention in Corporate Bond Markets (Sparks and Sharp 2017).

The investment perspective in our optimization assumed that risk premia exists in the corporate bond market and that high spread bonds will outperform low spread bonds over longer periods of time. We used the BarraOne Optimizer to reflect investment principles that focus on core credit strategies, minimal interest risk, avoiding excessive issuer concentration or portfolio turnover, and an approximate TEV of 75 bps. We also chose to avoid investments in banks, large bets on emerging market issuers, and maintain a simple strategy that reduced exposure to optionality (callables, step-ups and fixed-to-float).

We performed sanity checks and concluded that the optimized portfolio was to a great extent aligned with the portfolio's investment guidelines and the asset manager's emphasis on taking credit spread bets.

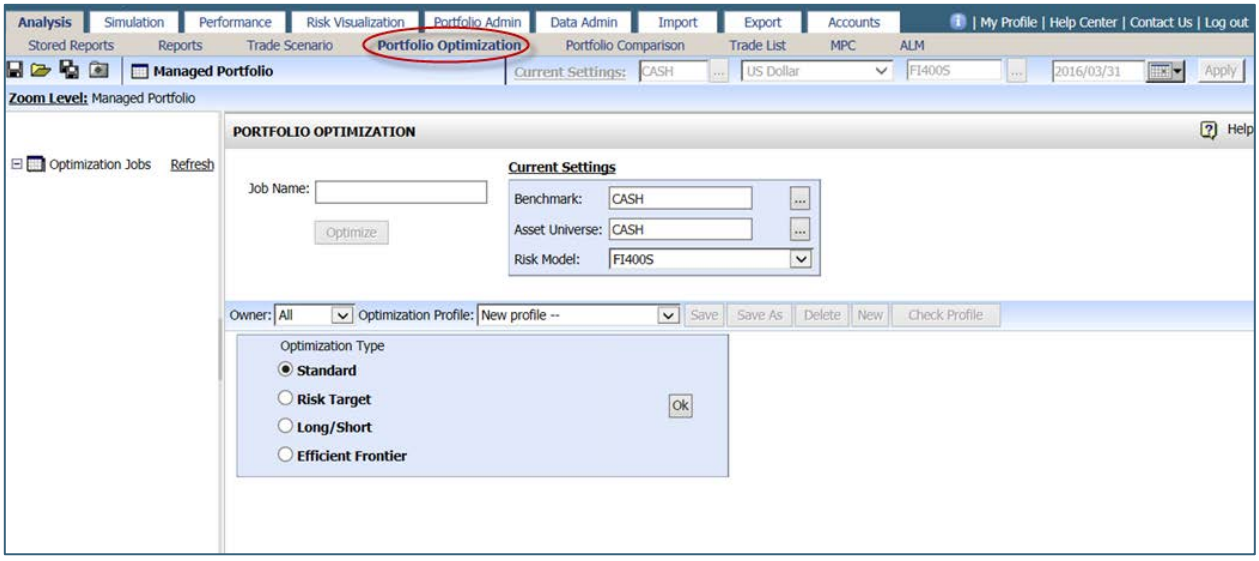
Appendix A: Create a Basic Optimization

The BarraOne Optimizer is a powerful tool that can solve a wide variety of complex optimization problems. The following sections describe the *minimum required workflow* needed to create a Standard Optimization using the BarraOne Optimizer.

1. Set Up the Optimization

Follow these steps to set up the optimization in BarraOne.

1. In the **Analysis** tab, make the following selections:
    - the portfolio you want to optimize (in the example below, we select the managed portfolio)
    - the base currency (in the example below, we select US Dollar)
    - a risk model (in the example below, we use FI400S)
    - an analysis date (in the example below, we use 2017/03/31)
2. In the **Analysis** tab, click **Portfolio Optimization** to launch the optimizer.



In BarraOne, the following types of optimizations are available:

- **Standard**—this is the basic optimization type and offers a richer set of constraints than other optimization types. The level of risk aversion selected will directly impact the TEV generated by the optimizer. The user can also specify the maximum number of assets, minimum holding threshold, and minimum trade size allowed. In addition, the user can set risk budgeting constraints and apply the conditional holdings (5/10/40) rule[4].

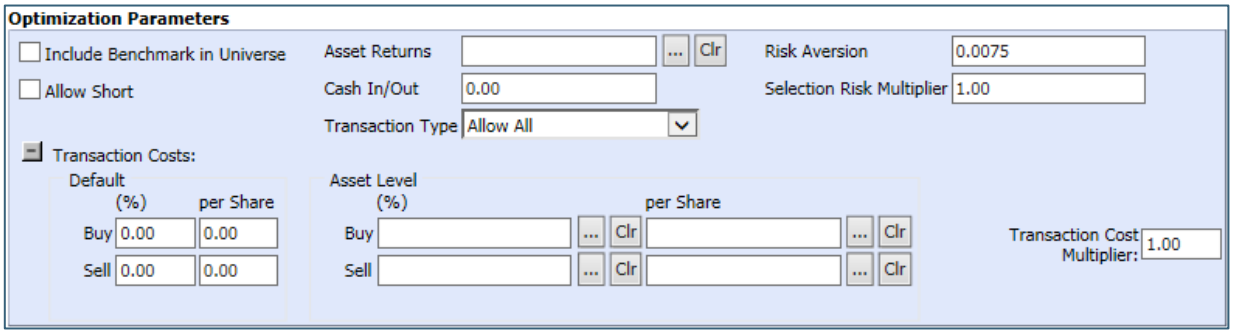
[4] The 5/10/40 rule refers to the European Community Directive on Undertakings for Collective Investment in Transferable Securities (UCITS). This constraint is used to satisfy the following conditions: the maximum weight of securities of a single issuer cannot exceed 10% of the portfolio value and the sum of the weights of all issuers representing more than 5% of the portfolio value cannot exceed 40%. The numbers are customizable.

- **Risk Target**—this optimization type is used to specify a target level of risk for the optimizer when creating an optimal portfolio. If the risk target is achievable, the optimizer will return the optimal portfolio. Otherwise, it will return the minimum risk portfolio for the return level.
- **Long/Short**—this optimization type allows specific constraints for the long and short sides. In addition to long positions, the optimizer can consider and take short positions during optimization.
- **Efficient Frontier**—this optimization type allows a series of portfolios to be generated along the efficient frontier instead of a single optimal portfolio. The user specifies the range of risk, return, or turnover the optimizer should consider when creating the efficient portfolios. Efficient frontiers allow the user to choose the portfolio that best fits the desired risk-return or utility-turnover trade-off. This optimization type can also help calibrate the risk aversion parameter.

3. Select the Optimization Type and click **OK**. In this example, we use the Standard Optimization type.

2. Specify Optimization Parameters

The BarraOne Optimizer offers a wide variety of constraints, depending on the optimization type selected. The following parameters are available with the Standard Optimization type.



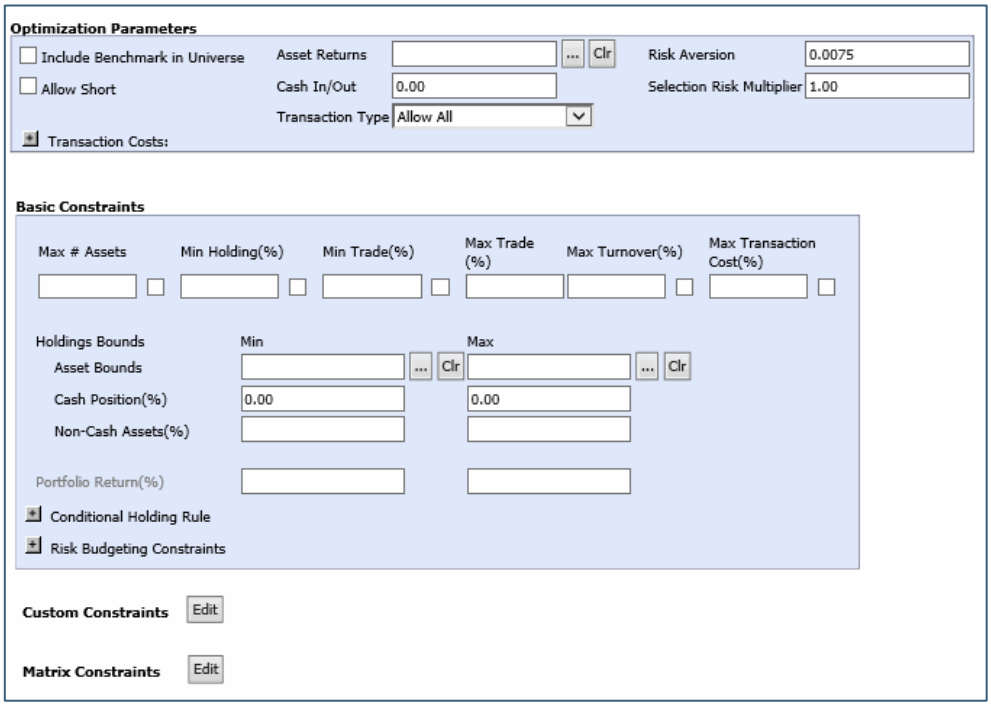
- **Include Benchmark in Universe**: By default, the universe will be the union of the assets in the initial portfolio and the selected universe. This setting can include benchmark assets in the investable universe.
- **Allow Short**: This setting allows the optimizer to short positions.
- **Asset Returns**: Asset-level returns can be specified as either a system or user attribute (formula or uploaded).
- **Cash In/Out**: This setting is used to reflect the addition or subtraction of cash flows to the portfolio. The value of the optimized portfolio will be equal to the initial portfolio value +/- Cash In/Out.
- **Transaction Type**: The user can choose the transaction types the optimizer should apply to control how the portfolio is rebalanced. For Standard, Risk Target, and Efficient Frontier optimizations, the choices are:
  - Allow All – The optimizer may buy and sell from the initial portfolio and buy from the universe portfolio.

- Buy from universe only – The optimizer may buy assets in the universe portfolio only and at the same time can sell assets in the initial portfolio. This transaction type can be used when the universe is the buy list of the use case.
- Buy none – The optimizer does not increase the number of holdings in the optimal portfolio, but may sell holdings in the initial portfolio.
- Sell none – The optimizer makes no sales and purchases can be from assets in the initial or universe portfolios.
- Sell none, buy from universe only – The optimizer makes no sales and purchases can be done from assets in the universe portfolio only.

- **Risk Aversion**: This setting is used to indicate the acceptable risk levels. This parameter is the multiplier that accounts for the impact of risk in the objective function. The higher the number, the less risk in the portfolio.
- **Selection Risk Multiplier**: This multiplier is used to calibrate the sensitivity to the asset selection risk relative to the common factor risk. For example, a value of 2 means that the investor wants to take less risk from asset selection risk than common factor risk.
- **Transaction Costs**: Transaction costs can be used in the portfolio construction process to account for trading costs. Costs of buys, sells, and shorts can be specified as % or per holding and can be implemented at the portfolio or specific asset level. The multiplier specifies the magnitude of the impact of transaction costs on the utility function.

3. Specify Optimization Constraints

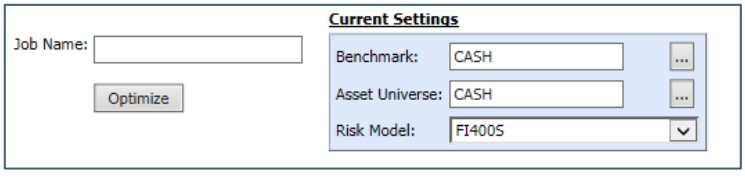
The following are the basic constraints available with the Standard Optimization type.



- **Max # Assets**: Allows to constrain the number of assets in the optimal portfolio.
- **Min Holding %**: Sets the amount for minimum holding position. Anything below that point is considered infeasible and hence not an optimal portfolio.
- **Min Trade %**: Sets the minimum threshold that will be considered when trading assets to get to the optimal portfolio.
- **Max Trade %**: Sets the maximum threshold that will be considered when trading assets to get to the optimal portfolio.
- **Max Turnover %**: Controls the amount of turnover incurred to obtain the optimal portfolio.
- **Max Transaction Cost %**: Controls the amount of transaction costs expended to obtain the optimal portfolio.
- **Holding Bounds** - *Asset, Cash Positions (%) and Non-Cash Assets (%)*: Controls specific assets during the optimization process. For example, cash asset bounds can be set at zero to exclude a cash position in the optimal portfolio.
- **Conditional Holding Rule**: Allows application of the "P/Q/R" rule. The default values are P = 5, Q = 10, and R = 40. The weight of securities from a single issuer cannot exceed Q% and at the same time the sum of the weights of all issuer representing more than P% cannot exceed R%.
- **Risk Budgeting Constraints**: Limits the sources of risk such as currency, asset selection and common factor risk.
- **Custom Constraints**: Allows the flexibility to input constraints using system or user attributes. Attributes such as effective duration or issuers can be constrained. Constraints can be applied to the overall portfolio or to groups.
- **Matrix Constraints**: Allows constraints to be applied to a group of assets for system or user attributes. For example, restrictions can be imposed on the weight of a specific sector by country.

4. Run Optimization

After selecting all settings, specify a name for the optimization and click **Optimize.**



Appendix B: Optimization Parameters

Function to Maximize

Asset Returns: OAS – (.6 x MSCI BLM Bid/Ask)

- Favors bonds with high option-adjusted spreads and low bid/ask spreads

Sector Portfolio Constraints

- Banks: Weight less than or equal to index weight
- Optionality: Weight on callables, step-ups, fixed-to-float less than or equal to index weight
- Emerging Markets: Weight less than or equal to index weight + 3%

General Portfolio Constraints

- Tracking Error Volatility: 75 bps per annum, imposed at month-end rebalancing
- Duration: +/-.1 year of index
- Monthly Turnover: No greater than 5% of market value
- Maximum Bond Weight: Ranges from .20% to .22%
- Minimum Trade Size: Ranges from .03% to .1%
- Universe: At time of initial purchase, all portfolio securities must belong to the Index

Issuer Constraints

- Unconstrained, the initial optimization had seven issuers with a combined index weight of 1.5% contributing almost 35% of the portfolio's spread risk
- Implemented constraints on these issuers to minimize excessive concentration
- Two additional issuers were added to this list after an additional optimization identified them as contributing risk deemed to be excessive

Constrained Issuers

Portfolio weight less than or equal to benchmark weight for: Anglo American PLC, BHP Billition, Casino Guichard, Delta Lloyd, Glencore, SAS Rue La Boetie, Stichting Demeter, Valepar S.A., Votorantim.

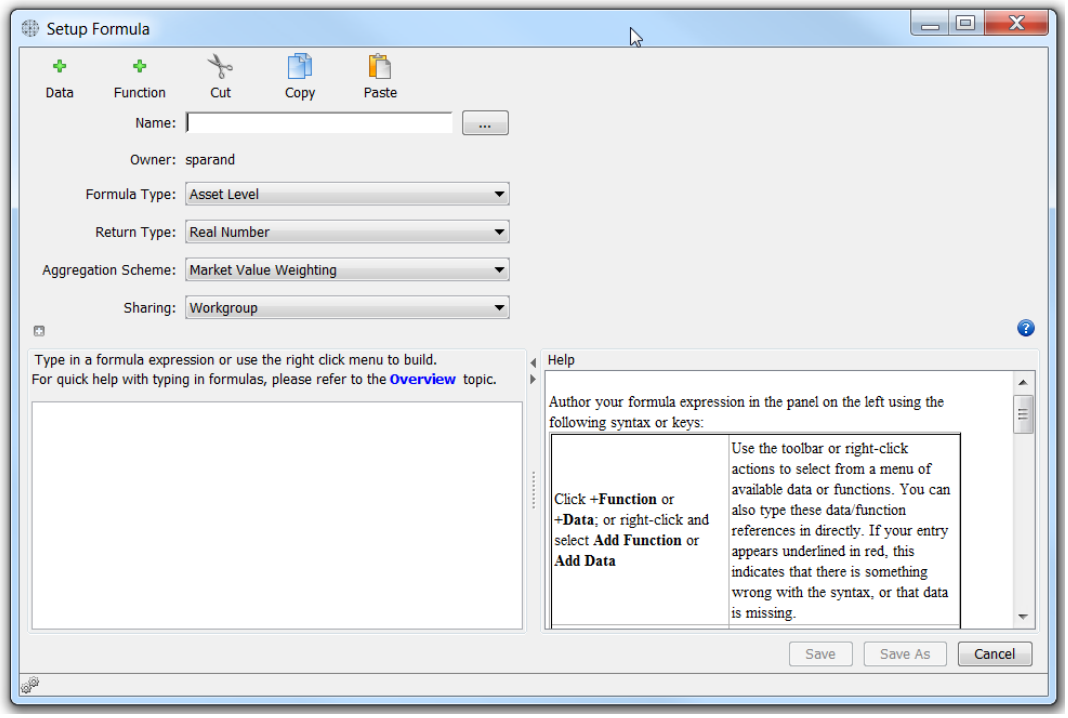
Appendix C: User attributes using Formula Builder

Formula builder is a BarraOne tool that allows the creation of formula-based user attributes that can be used during the portfolio construction process. For this credit value strategy, we used attributes from Formula Builder to specify asset returns, custom constraints, and asset-level bounds.

Asset Returns

Follow these steps to create formula-based asset-level returns:

1. Select **Data Admin** > **Attributes** > **Formula builder** to open Formula Builder.



2. Create a formula to derive the asset-level returns from scaled OAS to treasury [OAS div 100] and the Bid Ask imputed [Average bid-ask spread 30 days] as described:

    a. **Name** – specify a name (OAS_BLM Return in this strategy)

    b. **Formula Type** – Asset Level

    c. **Return Type** – Real number

    d. **Aggregation Scheme** – Market Value Weighting

    e. Type the **required** formula for the asset-level returns:
    `[OAS div 10000]-([Bid_Ask Imputed 30 day]*.6/10000)`

    where, `[OAS div 10000]` and `[Bid_Ask Imputed 30 day]` are attributes created through Formula Builder.

Attribute Name	Aggregation	Formula
OAS div 10000	Spread Duration Weighting	[AssetAttribute::OAS To Treasury (bp)]/10000
Bid_Ask Imputed 30 day	Market Value Weighting	IF([AssetAttribute::Average Bid-Ask Spread 30 Days]='N/A',55,[AssetAttribute::Average Bid-Ask Spread 30 Days])

Custom Constraints

In the credit value strategy, custom constraints are used to limit issuer exposure and concentration on certain types of bonds. Follow the same steps to create asset attributes for custom constraints. All these attributes are based on return type as real numbers; the aggregation scheme is market value weighting.

Attribute Name	Formula
Fixed-to-Float	IF([AssetAttribute::Coupon Type]='Fixed To Float',1,0)
Callable	IF(([AssetAttribute::Yield To Best (%)]=[AssetAttribute::Yield To Worst (%)])AND([AssetAttribute::Coupon Type]='Fixed'),0,1)
Step-up	IF([AssetAttribute::Coupon Type]='Stepped',1,0)
Anglo American PLC	IF([AssetAttribute::Ultimate Issuer Name]='ANGLO AMERICAN PLC',1,0)
BHP Billition	IF([AssetAttribute::Ultimate Issuer Name]='BHP BILLITON LIMITED',1,0)
Casino Guichard	IF([AssetAttribute::Ultimate Issuer Name]='CASINO GUICHARD-PERRACHON S.A.',1,0)
Delta Lloyd	IF([AssetAttribute::Ultimate Issuer Name]='DELTA LLOYD N.V.',1,0)
Glencore	IF([Ultimate Issuer]='GLENCORE FINANCE (DUBAI) LIMITED',1,0)
Sas Rue La Boetie	IF([AssetAttribute::Ultimate Issuer Name]='SAS RUE LA BOETIE',1,0)
Stichting Demeter	IF([AssetAttribute::Ultimate Issuer Name]='STICHTING DEMETER INVESTMENTS',1,0)
Uniqa Insurance Group	IF([AssetAttribute::Ultimate Issuer Name]='UNIQA INSURANCE GROUP AG',1,0)
Mexico States	IF([AssetAttribute::Ultimate Issuer Name]='MEXICO (UNITED MEXICAN STATES)',1,0)
Valepar S.A.	IF([AssetAttribute::Ultimate Issuer Name]='VALEPAR S/A',1,0)
Votorantim	IF([AssetAttribute::Ultimate Issuer Name]='VOTORANTIM S.A.',1,0)

Asset-Level Bounds

Asset-level bounds are used in all the optimization profiles in the credit value strategy discussed here. The bounds are designed to prevent issuer and bond concentration, ensure a portfolio of at least 450 bonds and reduce the amount of monthly trades.

To create the asset-level bound attribute, select Formula Type as asset level, Return Type as real number, Aggregation Scheme as market value weighting, and type the desired level in the formula section (i.e. 0.002 to specify a 0.2% bound).

For more information about using Formula Builder, see Using Formula Builder.

Appendix D: Risk Aversion and Other Parameters

Portfolio managers have specific requirements in the optimized portfolio such as amount of turnover, tracking error or number of assets. To achieve these requirements and to construct an optimal portfolio aligned with the investment expectations, portfolio managers need to specify constraints and parameters for the Barra Optimizer.

Risk aversion is a fundamental parameter used in mean-variance optimization. It is the multiplier that allows the optimizer to understand and balance returns and risk during optimization. As the risk aversion parameter increases, more risk is penalized during optimization indicating that the investor is willing to take less risk. As the risk aversion parameter decreases, the less influence the risk term will have in the objective during optimization. Risk aversion is an important input that requires calibration aligned with the portfolio manager's expectations. To read more about risk aversion, see Liu and Xu (2010).

Usually risk aversion should be calibrated once to reflect investor's general tolerance for risk. In the case study discussed in this paper, we are setting the risk aversion levels to correspond to an optimal active risk of 75 basis points. The values of risk aversion range between .23 and .05.

Asset-level bounds, turnover constraint, minimum trade size constraint and maximum holding weights constraint help to accomplish other implicit objectives in this use case. The targeted number of bonds in the portfolio ranges between 500 and 600. The number of trades should not be extremely high and we consider a range between 50 and 150 trades per optimization is a reasonable amount to achieve all objectives while avoiding excessive trading. The maximum holding of a bond is set to range from .2% to .22%to prevent issuer and bond concentration. This constraint also ensures a portfolio with at least 450 bonds. Although the goals are similar for each rebalancing, the constraints need to be adjusted. The maximum holding constraint, for example, is gradually increased to reduce the amount of monthly trades. The following table indicates the actual values.

Date	Risk Aversion Parameter	Active Risk	Specific Risk	OAS	Active OAS	Maximum Holding Weight (%)	Portfolio Turnover	Minimum Trade Size (%)	# of Assets	# of Trades
Jan -16	0.1	0.75	0.07	210	74	0.2	n.a.	n.a.	516	n.a.
Jan-16	0.23	0.75	0.09	236	79	0.205	5.0%	0.07	522	65
Feb-16	0.23	0.74	0.1	250	79	0.205	5.0%	0.03	535	126
Mar-16	0.15	0.75	0.07	212	71	0.21	5.0%	0.05	530	83
Apr-16	0.1	0.74	0.06	196	68	0.21	5.0%	0.05	527	74
May-16	0.05	0.75	0.06	205	69	0.21	5.0%	0.07	545	80
Jun-16	0.15	0.76	0.08	216	68	0.21	5.0%	0.05	533	113
Jul-16	0.12	0.76	0.06	189	67	0.215	5.0%	0.1	542	64
Aug-16	0.07	0.77	0.05	180	67	0.215	5.0%	0.1	551	67
Sep-16	0.07	0.76	0.06	189	68	0.215	5.0%	0.07	571	95

Date	Risk Aversion Parameter	Active Risk	Specific Risk	OAS	Active OAS	Maximum Holding Weight (%)	Portfolio Turnover	Minimum Trade Size (%)	# of Assets	# of Trades
Oct-16	0.06	0.74	0.06	182	67	0.215	4.8%	0.07	544	104
Nov-16	0.1	0.77	0.07	203	72	0.215	5.0%	0.04	526	104
Dec-16	0.05	0.75	0.07	199	71	0.215	5.0%	0.03	516	138
Jan-17	0.05	0.75	0.07	197	70	0.215	5.0%	0.05	522	85
Feb-17	0.05	0.75	0.07	202	70	0.215	5.0%	0.03	520	124

BOFA Merrill Lynch Index Data

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