

**How Axioma Compares with General Purpose Optimizers**

Axioma is often asked to compare its optimization capabilities with other commercially available general purpose optimizers. This document illustrates the key differences and advantages of using Axioma.

**Underlying Optimization Algorithm:**

Axioma uses the current state-of-the-art algorithms for optimization: ***Second-Order Cone Optimization (SOCP)*** with ***Branch-and-Bound***. A few commercially available general purpose optimizers also use this approach. However, unlike these general purpose optimizers, Axioma offers a comprehensive package designed specifically for portfolio optimization. Years of experience working with portfolio managers and understanding their needs and workflow have led to a product that is efficient, easy to use, and comprehensively tested.

**1. Real World Test Cases and Algorithm Fine-Tuning**

Axioma’s engine has been heavily tested and researched using a comprehensive library of problems arising in real-world portfolio management compiled by Axioma from years of experience working with portfolio managers. Axioma had developed several proprietary reformulation and algorithmic techniques to improve the solution quality for portfolio optimization problems that are not found in general purpose solvers. Such tailored approaches can lead to significant speed or solution quality improvements, especially in the presence of combinatorial constraints. For example, Axioma includes:

* Specialized heuristics and fine-tuned branch-and-bound algorithm to find good feasible solutions quickly
* Proprietary reformulation techniques for combinatorial constraints to yield stronger relaxations

**2. Problem Set Up and Formulation**

With general purpose optimizers, the user must explicitly translate simple financial constraints into an appropriate mathematical problem statement. In contrast, Axioma allows the users to easily set common portfolio optimization constraints, without having to define additional auxiliary variables for problem reformulations. For example:

* **Long-Short Holdings**. With Axioma, users can put constraints on the long holdings and short holdings (both at portfolio level or asset level) without having to define auxiliary variables. In addition, Axioma automatically ensures that an asset is not simultaneously held long and short.
* **Relative Marginal Contribution to Risk Constraints**. Axioma handles this non-convex constraint under the hood
* **Combinatorial/Discrete/Integer Objectives and Constraints**. These are implemented without the need for users to explicitly define binary variables and the necessary logical constraints to model these business rules. The user also does not need to ensure that the mathematical representations of these business rules are the “strongest” in terms of relaxation strength. Examples of these objective terms and constraints are:
  + Threshold Holdings and Threshold Trade Constraint (if asset is held/traded, hold/trade at least a certain amount)
  + Number of Names/Trades Constraint
  + Limit Issuer Holdings Constraint (places a maximum limit on the sum of weighted holdings from a single issuer that exceeds some lower bound. This constraint can be used to address the 5/10/40 rule.)
  + Fixed Charge Ticket Cost Objective Term
* **Tax-Aware Objective Terms and Constraints**. Axioma includes tax-related objective terms and constraints including objectives on tax gains/liability and constraints on minimum holding period, tax liability, net tax losses/gains, gross tax gains/losses, etc. Axioma encodes the rules of the Internal Revenue Service so that users to do not need to model this logic into the optimization model.

**3. Advanced Innovations**

Axioma comes with advanced features developed by our research department not found in any other portfolio optimizer or generic optimizer. For example:

* **Infeasibility Diagnosis**. Infeasibility can be analyzed using our infeasibility diagnostic and overcome by using our Constraint Hierarchy that will find solutions with the least violations according to the user-defined priority of each constraint.
* **Alpha Factor**. This innovation automatically reduces the risk underestimation bias inherent in optimized portfolios using a factor risk model
* **Robust Optimization**. Users can include estimation errors in their alpha predictions (expected return) into the optimization.
* **Constraint Attribution**. This feature allows users to view the marginal impact of each constraint on the final holdings, implied alphas and returns.
* **Multi-Portfolio Optimization.** Axioma can simultaneously optimize separately managed accounts, for example, where there are constraints and objective terms that apply to the aggregate account, and each account has its own set of constraints and objective terms. This approach also allows users to target Cournot-Nash equilibrium solutions.

**4. User Experience and Workflow**

Axioma’s products have advantages over general purpose optimizers in a number of aspects specifically related to the user’s experience and workflow.

**Business Problems Expressed Directly.** Axioma’s user interface (both API and GUI) allows user to easily formulate their business strategy as objectives and constraints, without explicit formulas. Business rules are converted by Axioma’s products into mathematical formulations that make use of specialized algorithms. For example:

* **Holdings and Trade Constraints**. Users can easily set constraint on the (weighted) holdings and trades, either at the portfolio level, classification (e.g., sectors, industry, style factors) level or asset level
  + - **Nonlinear Market Impact Costs.** Users can set quadratic, 3/2-power or 5/3-power market impact cost models by simply choosing the exponent and the asset-specific coefficients
    - **Risk Objective and Constraints.** User can load any factor risk model and create risk objectives and constraints simply by choosing the desired risk model.

**An Extensive Toolbox of Objectives and Constraints.** Axioma’s products accommodate all the objective and constraint types that commonly arise in portfolio optimization. The vast library of preconfigured objectives and constraints make model specification faster and easier to maintain, compared to generic optimizers that often impose strict problem structure formats.

**Objective Term Library Includes:**

* + - Linear term (net holdings, short holdings, long holdings)
    - Tax term (tax gains, tax liability)
    - Risk (standard deviation, variance)
    - Expected Return (including robust)
    - Trading Cost (fixed charge cost, fixed charge buy cost, fixed charge sell cost, linear transaction cost, linear sell cost, linear buy cost, short sell cost, market impact cost, piecewise linear transaction cost)

**Constraint Term Library Includes:**

* Holdings (net holdings, long holdings, short holdings, absolute holdings, threshold holdings, weighted average holdings, long/short ratio, limit issuer holdings, etc)
* Trading (net trade, buys, sells, turnover, threshold trades, short sell, transaction cost)
* Risk (standard deviation, relative marginal contribution to risk)
* Number of Names (# of names held, # of longs, # of shorts, # of total trades, # of buys, # of sells)
* Tax (minimum holding period, tax liability, net/gross tax gains, net/gross tax losses)
* Robustness (robust, probabilistic)

In addition, Axioma can often model constraints and objective terms that are not directly covered using additional modeling techniques.

**An Extensive Library of Portfolio Analytics.** On top of our optimizer, Axioma contains a vast library of portfolio analytics so that the user does not need to compute these on their own. Besides typical analytics such as expected return and total/active risk, examples of other analytics item include:

* Risk decomposition (both traditional standard deviation breakdown and covariance-distribution breakdown)
* Marginal contribution to total/active risk
* Transfer coefficient
* Implied alpha
* Implied beta

**Interaction between API and GUI.** Axioma’s C++ API, Java API, and GUI tools seamlessly communicate with each other. A rebalancing session in the C++ API can be persisted to an XML file that can be opened in the Java API or the GUI. We have many users who are predominantly C++ API users, who occasionally open the XML file in the GUI for further analysis and error diagnosis. This transparency enables the users to always choose the tool which is most convenient for the task to solve.

We also have clients consisting of a technical group that prefer our C++ API and another group that is more comfortable with a graphical user interface. Our flexible interface facilitates collaboration and communication across both teams.

**Customer Support.** Axioma prides itself on its support team. Our dedicated support team includes:

* + - **Support Help Desk**. The support team responds to client inquiries on a timely basis, supporting issues ranging from installation, licensing, data loading, strategy building, and troubleshooting.
    - **Subject Matter Experts**. Axioma has a team of Ph.D. level specialists to assist in advanced modeling issues and solution analysis. This team has expertise in finance and optimization, and can provide insights into best practices in portfolio construction.

On top of our Customer Support team, clients have exposure to our product and research teams:

* + - **Product Team**. Our flexible development environment allows Axioma to quickly deliver product updates incorporating enhancement requests from clients.
    - **Research Team**. Our research department is available to discuss our latest innovations and is always on the lookout for new ideas. Axioma actively seeks out dialog with our clients about decision problems faced by finance practitioners. We are eager to learn more from them about issues particular to the domain so that our solutions can be further tailored to meet those needs.