GUROBI
OPTIMIZATION

Solving Complex Challenges in Banking & Financial Services:

Portfolio Optimization

Is your portfolio construction process enabled by your optimization engine, or hindered by it?

Optimization Expertise

At Gurobi Optimization, we focus on [mathematical optimization](). It's all that we do.

Since our founding in 2008, our clients have benefitted from the convergence of two powerful trends: first, our sustained R&D investment has driven order of magnitude improvements in Gurobi's 'speed-to-solve,' along with an ever-broadening array of mathematical formulations and features.

And second, advances in compute power have led to a reduction in compute cost, making optimization a practical solution for an ever-widening variety of complex business problems. Together, this convergence has introduced thousands of clients to Gurobi and the power of optimization, establishing us as the market leader across 40+ industries and around the globe.

Opportunities for Optimization

Banking and Financial Services firms use mathematical optimization to address a variety of customer-facing and back-office functions. Here are some of today's most common applications:

Asset management (maximize return or minimize risk)

- Portfolio Construction
    - Asset Allocation
    - Portfolio Index-tracking
    - Scenario Back-testing
- Payment Netting
- Systemic Risk Management

Operations management (maximize revenue or contain costs)

- Retail Loan & Credit Card Offerings
- Liquidity & Cash Management
- Collections Management
- ATM & Branch Network Location Determination
- ATM Cash Transfer Efficiencies
- Field Service Scheduling
- Workforce Scheduling

Your view of the investing world changes all the time; your portfolio construction modeling environment must be ready to respond.

Gurobi: A Leader in Portfolio Optimization

Portfolio optimization (PO) is perfectly suited to the speed and robustness of Gurobi, which at its essence, is an advanced numerical library of sophisticated algorithms. PO is a specific example of mathematical optimization (MO). The power of MO is its ability to incorporate any sort of investment requirement, as long as it can be expressed as a mathematical formula—a process referred to as 'modeling.' The portfolio manager (PM)'s mathematical models precisely reflect the full set of business rules behind their portfolio construction logic, and as such, each model can grow to become very complex. The PO modeling process starts with the PM's objective of balancing return maximization and risk minimization.

The PM works with their modeling experts to define the series of variables (e.g., fundamental data, alternative data, market data, etc.) and constraints (e.g., leverage, factor, holdings, etc.), layering dependency upon dependency, until the PM's investment strategy is properly represented. As the PM's thinking evolves, so too must the mathematical model that reflects it. This evolution is known as extensibility; high-quality commercial optimization tools give the PM the power to continuously adapt the model to changing requirements without having to redevelop a given model from scratch.

Complimented by Machine Learning Trade Execution Algorithms

Whereas optimization is king in the portfolio construction process, machine learning (ML), optimization's sister technology under the Artificial Intelligence umbrella, is leader in the resulting trade execution process.

ML takes in data, processes it through the data scientist's ML algorithm, and outputs a model. These output models are predictive, presenting the liquidity-seeking, trade execution quantitative analyst with a range of possible strategies.

Order-routing decisions depend upon streaming real-time market and trade data. As a result, optimality is not know-able in advance, and it's rarely achieved in the trading room. The execution quality of an ML model is measured as a post-mortem analytic that compares an actual result to a benchmark. That gap is called 'slippage,' and the pre-trade gap prediction is called 'estimated market impact.'

Minimizing slippage in the trade execution process is important to the post-trade 'execution quality' assessment.

In contrast, PO is a system that takes in a model, processes it through the appropriate Gurobi algorithm, and produces, as an output, a transparently defendable and optimal asset re-allocation decision in accordance with the PM's objective.

Traditionally, factoring for the risk of adverse market impact has been handled differently by the PM versus the ML quant responsible for executing the trades.

In the PO process, this type of risk factor is applied generically, across all symbols regardless of order size, ADV, liquidity available by venue, etc. The quant's ML models have a short, intra-day time horizon and work to reduce slippage on a symbol-by-symbol basis with the more trade-relevant streaming data.

What if the ML liquidity-seeking execution algorithm could be used as an input to the PO process? In fact, this is a recent industry development. It may not deeply affect the PM's list of securities to be traded on a given day, but information is power. At a minimum, it's an approach that better aligns intra-day alpha, the dominant trading room performance metric, with the longer performance measurement lens of the portfolio manager, and this is good start.

Prepare For The Future

If you began your journey modeling in an Excel spreadsheet that became too complex, or with a heuristic, or an open-source solver that doesn't deliver the required performance, or perhaps suffers from instability, lack of documentation, or support—for many firms, the decision to use a state-of-the-art commercial portfolio optimization engine often begins with the question:

> **"If the solver is the most critical component of my portfolio construction IT stack, why would I not use the best?"**

Models evolve, and portfolio management strategies that today may be solved by a simple continuous non-linear formulation may tomorrow require a complex combination of quadratic, non-linear, or mixed integer constraints. Gurobi's library of optimization algorithms was built on the premise that our clients need not be concerned with what sort of solver algorithm is required—that determination is Gurobi's.

Make Smarter Decisions Faster

> **Would faster iterative back-testing cycles improve the daily performance of your portfolio?**

Evaluating alternative datasets is a vital component of many quantitative investment strategies, and their rise in popularity presents new challenges for portfolio managers.

How many new alternative data sets do you care about? How often do you acquire and normalize a sample dataset to your master data model, re-configuring your existing optimization models to accommodate multiple combinatorial approaches, creating and running your back-testing scripts—only to wait too long for the result?

An optimization model reflects a specific perspective on the objective, constraints, and variables in the underlying decision problem. For systematic quantitative approaches to portfolio management, back-testing complex portfolio strategies and performing historical simulations is critical. Iterating millions of 'what if' scenarios with highly compressed time series data, fast, requires a solver that excels at speed-to-solve performance.

The firm that can experiment with the largest number of new datasets in any given month's back-testing scripts, maximizing the scope of optimization scenarios to be tested while minimizing the speed to complete each iteration, may gain a performance competitive advantage in production.

Gurobi Optimizer
A Mature Enterprise-Grade Commercial Solver

The world's fastest solver – backed up by brilliant innovators and expert support
Our founders created Gurobi Optimization with a single, simple vision: To build the world's fastest and most powerful mathematical optimization technology. And that's exactly what they did.

Unmatched performance
Public benchmarks consistently show that Gurobi finds both feasible and proven optimal solutions faster than competing solvers.

All major model types
Solve a complete range of problems—including LP and MILP and convex and non-convex QP, MIQP, QCP, and MIQCP, as well as SOCP and bi-linear problems.

Numerical stability
Trust Gurobi in the correctness of results, scalability with problem size and difficulty, and solve time consistency over a full range of model instances.

Easy-to-use features for streamlining model implementation
Gurobi provides tools to easily incorporate multiple objectives, use non-linear functions, perform scenario analyses, troubleshoot infeasible models, and more.

Lightweight programming interfaces
Work in the language you know best—GAMS, AIMMS, AMPL, MATLAB, R, Java, C++, .NET, and importantly, our Python API. Python users may also take advantage of our seamlessly incorporated matrix-based modeling environment.

Parallel and distributed optimization
Distribute your computational load across several processing units, shortening your solve time.

**Flexible licensing to satisfy your architectural requirements**
Whether you choose to run Gurobi Optimizer on a local machine, submit jobs to the Gurobi Compute Server, develop containerized applications to be deployed in the cloud, or embed it in an enterprise application, Gurobi gives you a full range of options.

> " It was not a difficult decision to switch over to Gurobi after seeing these impressive numbers. The Gurobi interfaces set themselves apart in that they are simple and intuitive to use, and the application works well with large models. The Gurobi technical support team is available to help answer all of our questions, which is an extra time-saving benefit, in addition to the solver's performance and the quick implementation process.

MATTHIAS WYSS
HEAD OF IMPAQT CONSULTING AT SWISSQUANT
A European ISV focused on Risk Modeling & Analytics, Trading & Risk Management, and Hedging & Procurement
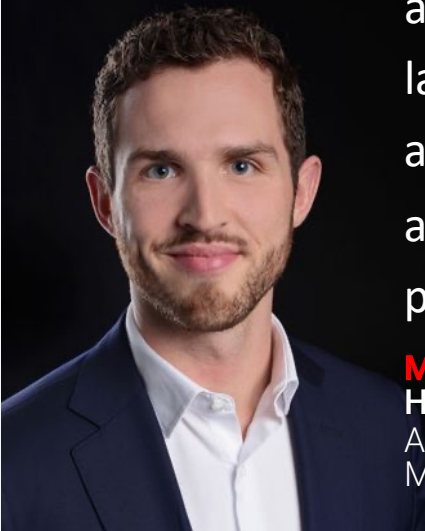
Gurobi Experts
Technical Advisory & Support Team

Our Experts Team is 15+ strong and has over 150 years of aggregate experience in optimization—with 88% having earned a PhD. Put simply, our team is passionate about helping customers succeed with optimization.

Gurobi experts are on the frontlines with you, directly available without call triage. We extensively measure our client customer satisfaction results and are proud of our 98.5% rating; the team maintains a median response time of 27 minutes from when a help request ticket is first opened.

Whether you are migrating from a different solution or starting a new project, our experts are happy to answer your 'how to' questions, point you to the right resources, and get you set up for success. Typical areas of assistance include:

Using Gurobi APIs
Using our optimization libraries the 'right way' can make a significant impact. Our experts will help you use our APIs efficiently, thereby reducing the time required to construct and interact with your models.

Helping with performance tuning
Gurobi is pre-configured with settings that generally work well across a broad set of models. However, it is possible that for a specific set of models, our experts can help you find those specialized settings that will allow them to perform even better.

Model troubleshooting
The Experts Team can help identify and troubleshoot unexpected problems, such as slow performance or code failure.

As you develop your optimization application, you may have questions like why the solver behaves in a certain way, or how a change to the model leads to a particular outcome. The Experts Team can help you understand exactly what is happening.

Providing guidance on architectural deployments
Whether you are building a new optimization application or updating an existing one, our experts can review your architectural deployment, make sure you are comfortable with any migration processes involved, and assist during upgrades to reduce the risk of service interruptions.

VIEW BROCHURE

Expert Advice and Technical Support
Work with Gurobi in the manner that suits you best.

In addition to live advisory calls with our Experts Team, our multi-channel educational support offering includes online technical documentation, a community forum, knowledge-based articles, and bi-annual in-person 'Gurobi Days' training sessions.

GUROBI COMPASS
Our Capstone Advisory Offering: Customized, Expert-Led Training and Workshops
Let our experts come to you! With our live, hands-on workshops and pre-recorded videos, your team can receive the training they need, in the format that works best.

NEED MORE?
Our Gurobi Alliance network of trusted partners and professional services firms can help you develop and execute your optimization strategy, delivering on both short- and long-term optimization engagements.

Prepare for Optimal Impact

With Gurobi's optimization technology, you can make confident business decisions in seconds. In over 40 industries and around the globe, over 1,200+ direct customers and Independent Software Vendors (ISV's) run on Gurobi, including half of the Fortune 10 and 70% of top US banks.

In Banking and Financial Services, from portfolio management to commodity trading to hyper-personalized retail bank marketing and many other use cases in between, Gurobi Optimization is here to help identify your optimal course of action, efficiently and reliably.

Thank You

> The business problem may be yours, but the science of decision intelligence is Gurobi's. Let us help you solve it.

It Starts with a Conversation.

Try Gurobi free for 30 days.
Our Sales and Technical Account Management teams
are here to help you get started with the appropriate type of
evaluation license, including full access to our world-class Experts Team.

For more information, please contact **sales@gurobi.com** or visit
gurobi.com/free-trial to get started.

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