



GUROBI
OPTIMIZATION

| The World's Fastest Solver

State of Mathematical Optimization Report, 2021

State of Mathematical Optimization Report, 2021

Introduction

We are pleased to present the *State of Mathematical Optimization Report, 2021*, which highlights the importance and impact of mathematical optimization in our world today.

The report – which is based on data from a Gurobi survey of 251 customers conducted in 2020* – provides insights on how companies are using mathematical optimization and showcases the business value that has been delivered by this AI technology.

You will learn how organizations today leverage mathematical optimization technologies in a wide array of off-the-shelf and custom-built applications to automatically solve their most challenging business problems, facilitate (and often automate) optimal decision making, and achieve their business goals.

We hope that this report gives you a sense of the power and pervasiveness of mathematical optimization in the business world today and that it opens your eyes to some of the possible opportunities for optimization in your organization.

**It should be noted that the Gurobi Customer Survey respondents are all commercial users of Gurobi's state-of-the-art mathematical optimization solver – the Gurobi Optimizer. Thus, their views may not be representative of the broader community of mathematical optimization users, who use the Gurobi Optimizer as well as other commercial and open source solvers in a wide variety of off-the-shelf and custom-built software applications.*

Who Is Using Mathematical Optimization Today

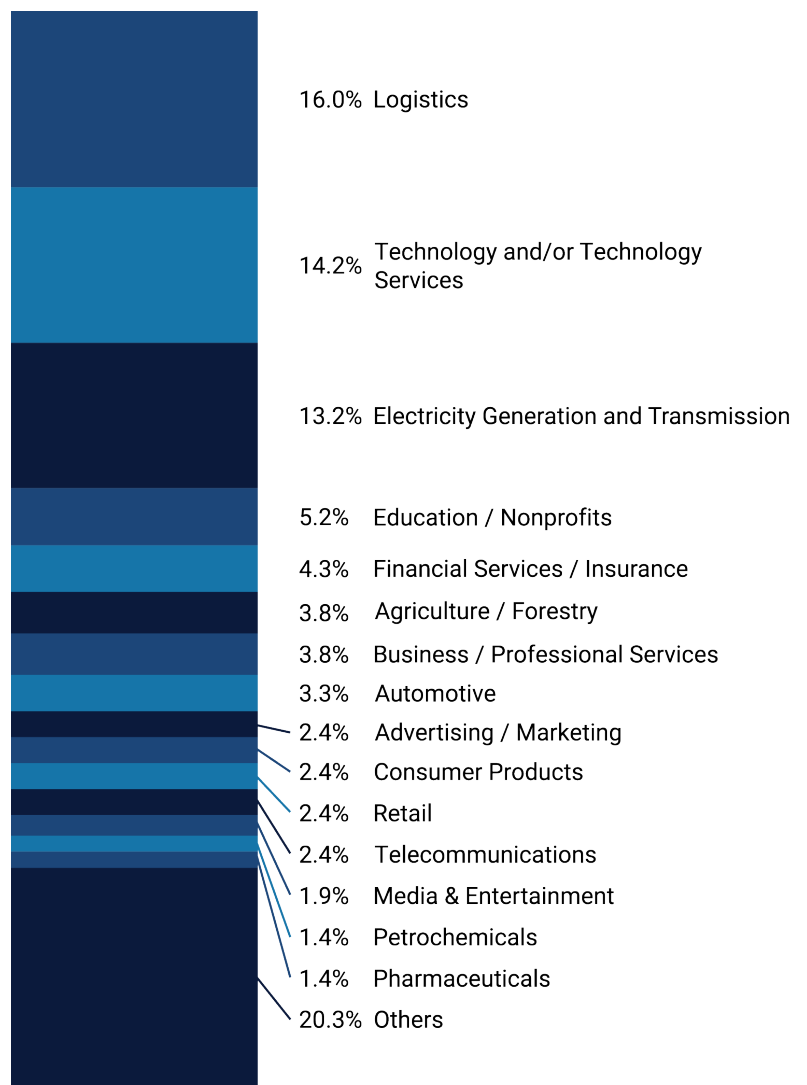
Profile of Companies

Industry

Mathematical optimization is used by companies today in virtually every sector and segment of the global economy. The pervasive presence of mathematical optimization across the economic spectrum is reflected in the wide cross-section of industries represented in our survey of commercial users of this AI technology.

Survey respondents came from more than 42 different industries. The three most common industries were logistics (16.0%), technology and technology services (14.2%), and electricity generation and transmission (13.2%), followed by education and nonprofits (5.2%), financial services and insurance (4.3%), agriculture and forestry (3.8%), and business and professional services (3.8%).

What is the main industry that your firm operates in?



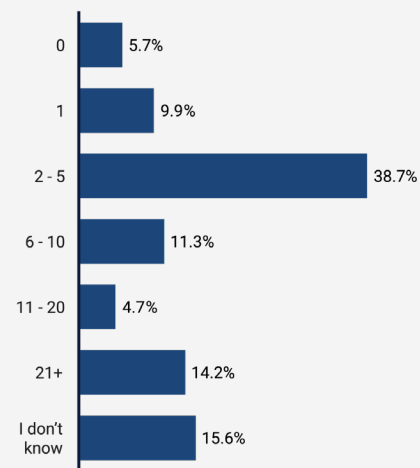
Who Is Using Mathematical Optimization Today

Profile of Companies

Mathematical Optimization Expertise

Companies of all sizes – from small start-ups to some of the world’s largest global organizations (including nearly 85% of Fortune 500 companies) – use mathematical optimization in their operations. As mathematical optimization is a sophisticated AI technology that requires having personnel with certain specialized skills (most notably, mathematical modeling), many of these companies either employ operations research professionals, advanced analytics professionals, or data scientists or engage external consultants to help implement and utilize mathematical optimization. Nearly 39% of respondents said that their company employs 2-5 operations research professionals, while over 14% of respondents stated that their company employs more than 21 operations research professionals.

How many operations research professionals does your company employ?

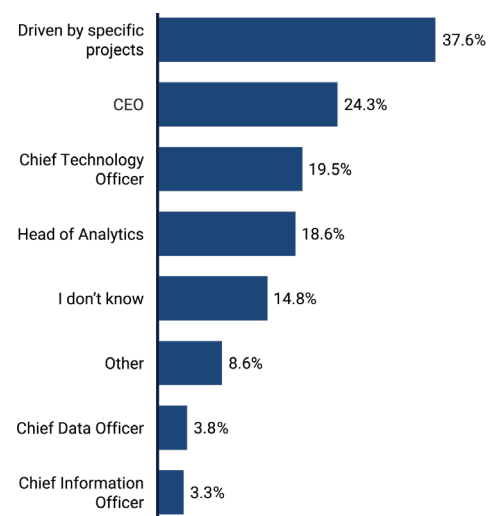


Advanced Analytics Strategy

In the past, mathematical optimization applications and other advanced analytics projects were typically not seen as a strategic priority by the C-suite and were often relegated to the IT departments of companies. Now – with the availability of huge quantities of high-quality business data and the advances in AI technologies such as mathematical optimization and machine learning – an increasing number of companies are investing in these technologies and a growing number of C-level executives are taking responsibility for developing and driving their company’s advanced analytics strategy.

The results of our survey showcase this shift, with 24.3% of respondents saying that their CEO is responsible for setting their company’s overall analytics strategy, followed by the CTO at 19.5%, and Head of Analytics at 18.6%. Almost 38% of respondents, however, said that their analytics strategy was driven by specific projects – indicating that advanced analytics technologies may not yet be a top strategic priority for some companies out there.

Who in your organization sets the overall strategy for analytics? (Select all that apply)



Who Is Using Mathematical Optimization Today

Profile of Users

Background

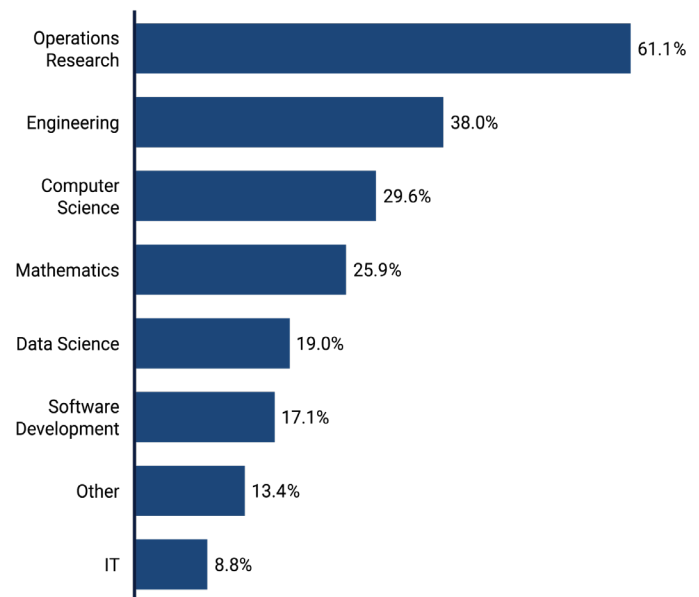
Users of mathematical optimization technologies come from many different fields. Traditionally the exclusive domain of operations research specialists, mathematical optimization is gaining traction among professionals with formal training in a number of different areas including data science, computer science, and engineering. Additionally, professionals who are trained in mathematical optimization or mathematical programming are looking to branch out into related advanced analytics and data science fields, and are undergoing training in those areas.

Reflecting these trends, our survey respondents – who are all commercial users of mathematical optimization – reported that they have had formal training in a wide range of fields beyond operations research including computer science (29.6%), engineering (nearly 38%), and data science (almost 19%).

It should be noted, however, that the majority (61.1%) said that they had formal training in operations research – demonstrating the enduring importance of this field in the mathematical optimization space.

Interestingly, the number of respondents indicating that they have formal training in data science rose by around 17% compared to our 2019 customer survey – suggesting that a growing number of data scientists are starting to use mathematical optimization.

Your formal training was in which field?
(Select all that apply)



Who Is Using Mathematical Optimization Today

Profile of Users

Role in the Company

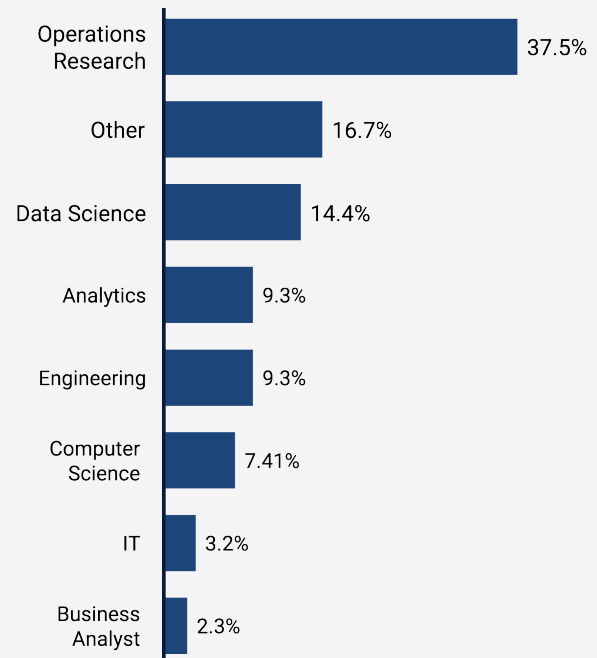
In the past, operations research professionals were the primary users of mathematical optimization applications – but this dynamic is changing. With the introduction of applications with more user-friendly interfaces, we are seeing a wider range of individuals across various business functions utilizing mathematical optimization technologies.

The results of our survey demonstrate this “democratization” of mathematical optimization across the professional spectrum – nearly 63% of respondents have job titles other than “operations research.” Around 14% of respondents stated that their role is “data science,” while around 9% said that their role is “analytics” and “engineering.” Other respondents had C-suite positions – including CEO and CTO – indicating the presence of mathematical optimization users at the highest levels of organizations today.

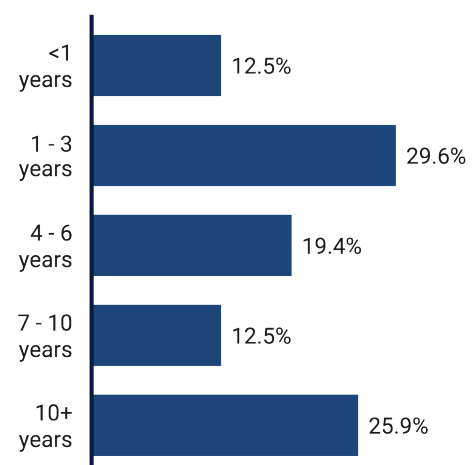
Years of Experience Using Mathematical Optimization

Once companies have successfully implemented mathematical optimization technologies and begin to use them in mission-critical applications in their organizations, they typically end up using these technologies for a significant amount of time. The users of these applications build up years of experience with mathematical optimization, often becoming experts in the area. This phenomenon is illustrated by the results of our survey, which show that almost 58% of commercial users have four or more years of experience with mathematical optimization, while nearly 26% of commercial users have been using this AI technology for 10 or more years.

My role in my company is:



How many years of commercial experience do you have working with mathematical optimization?



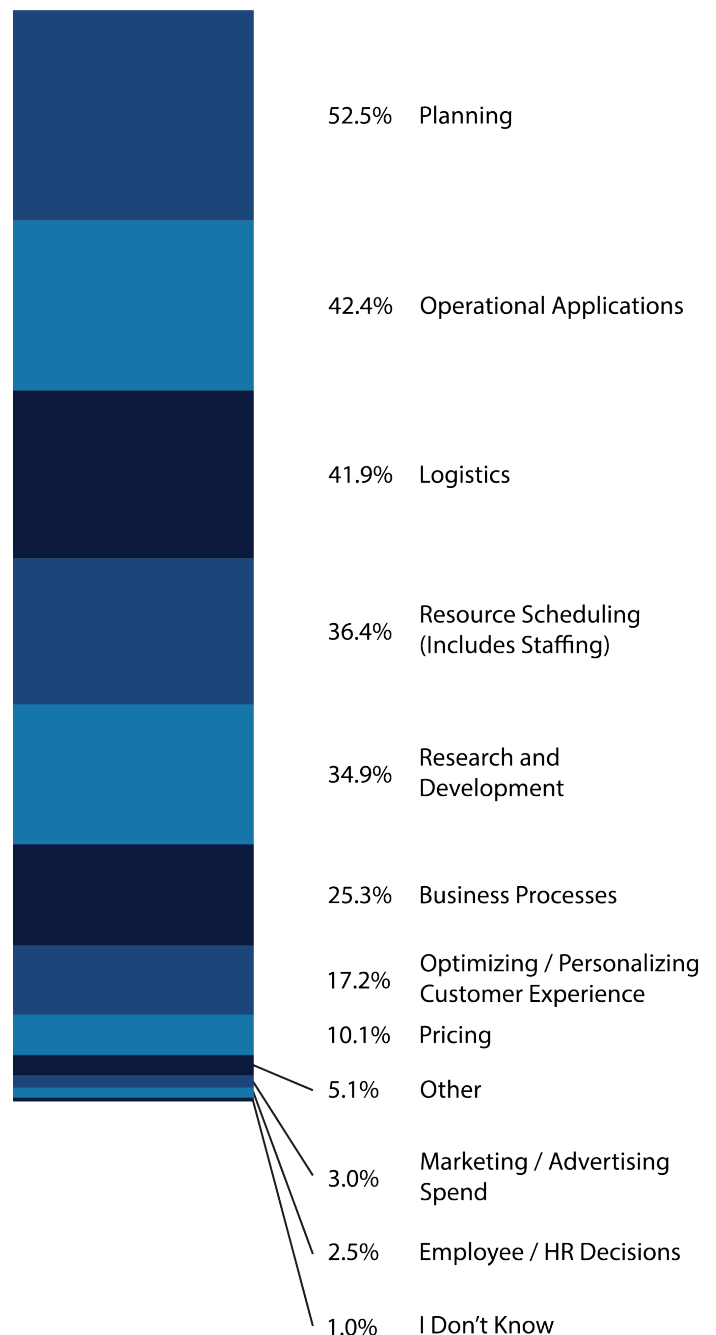
How Companies Today Are Using Mathematical Optimization

Common Use Cases

One of the key strengths of mathematical optimization is its versatility. Mathematical optimization solvers – the algorithmic engines that make every application run – are embedded in a vast and ever-expanding array of applications to address a broad range of complex, real-world business problems and enable optimal decision making and business outcomes.

The results of our survey showcase the versatility of mathematical optimization in the business world today, with respondents stating that they use or plan to use mathematical optimization to tackle a wide range of business problems. The most popular use cases of mathematical optimization among respondents are planning (52.5%), operational applications (42.4%), logistics (41.9%), and resource scheduling (36.4%).

Which use cases do you use or plan to use mathematical optimization for? (Select all that apply)



How Companies Today Are Using Mathematical Optimization

Type of Development

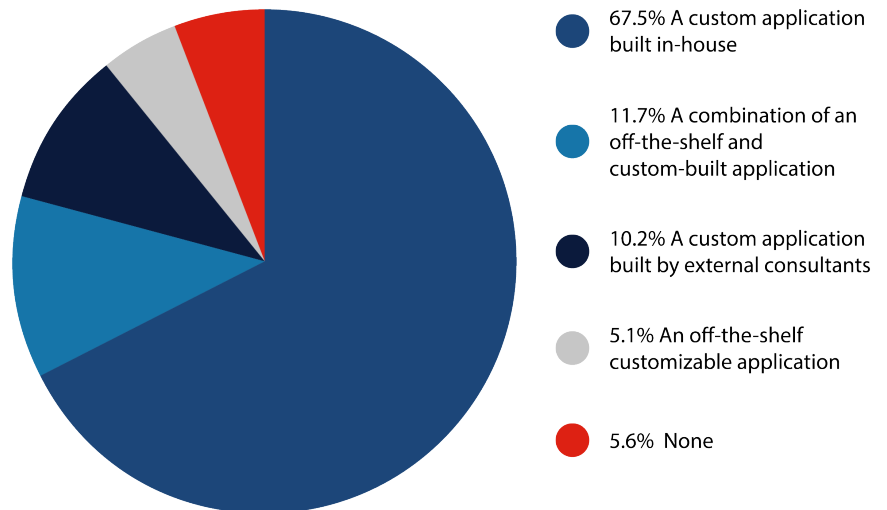
Broadly speaking, there are two different ways that companies can implement and use mathematical optimization solvers:

- 1) They custom build an application (using in-house operations research specialists and data scientists or external consultants) and embed the solver in it.
- 2) They purchase an off-the-shelf, customizable software application, which is built by a third-party software vendor and has the solver embedded in it.

Although both approaches are common today, the majority (77.7%) of respondents to our survey indicated that they custom built their applications, while a minority (16.8%) said that they use an off-the-shelf application or a combination of an off-the-shelf and custom-built applications.

It is important to note that this split is most likely a reflection of the fact that the survey respondents are Gurobi customers (who typically purchase, embed, and use our solver in their custom-built applications), while the other main user group (those who use mathematical optimization through an off-the-shelf application) are underrepresented in this survey. In the business world today, there is a more balanced mix of the two types of deployment.

Where does the mathematical optimization solver live?
(Select all that apply)



How Companies Today Are Using Mathematical Optimization

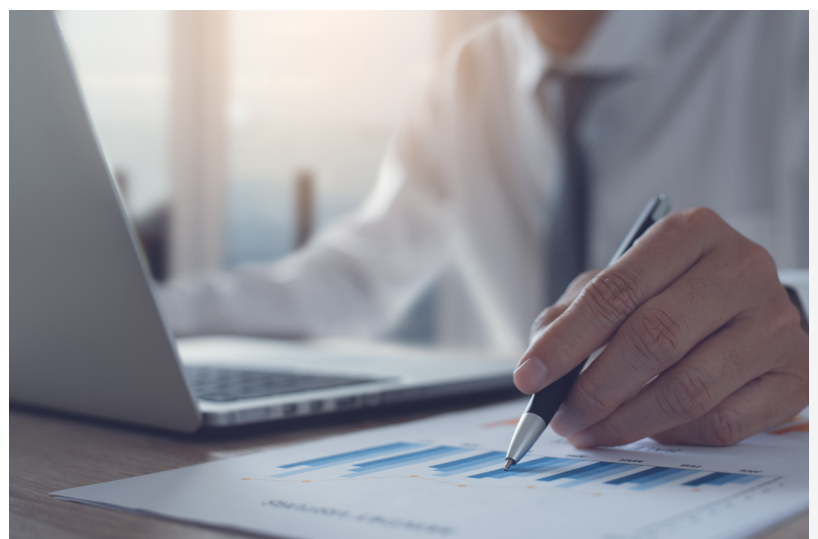
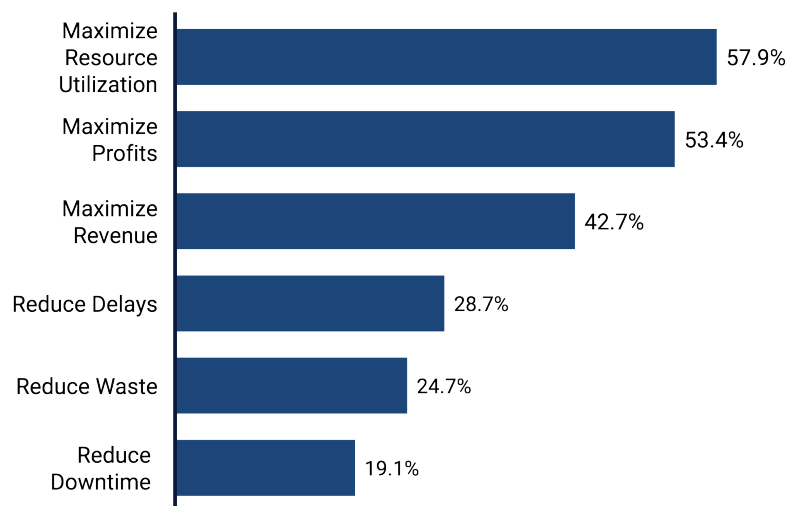
Business Benefits Achieved

Mathematical optimization is a proven, powerful AI technology that has delivered tremendous benefits in terms of efficiency and profitability for companies around world and across numerous industries. Indeed, using mathematical optimization, companies have realized billions of dollars in cost savings and revenue growth.

One of the unique features of mathematical optimization is that in your company's application you can specify which business objectives you want to achieve, and then use the application to help you achieve them. You may, for example, want to minimize operating costs or employee overtime hours or machine downtime, or maximize on-time delivery performance or risk-adjusted investment returns or revenue growth. No matter what your business objectives are, if you can define them in mathematical terms in your application, then mathematical optimization can help you reach them.

The results of our survey reflect the positive impact that mathematical optimization has had in helping users realize a variety of business outcomes. The three most common business objectives achieved among respondents were maximizing resource utilization (57.9%), maximizing profits (53.4%), and maximizing revenues (42.7%).

Which business objectives does Gurobi help your company achieve? (Select all that apply)



How Companies Today Are Using Mathematical Optimization

Increasing Importance Across the Enterprise

As mathematical optimization is being used in an expanding array of mission-critical applications by business today and has delivered such significant business value, it is no surprise that this AI technology is gaining traction among decision makers within these companies.

The results of our survey highlight the increasing importance of mathematical optimization across enterprises today: 58.9% of respondents indicated that mathematical optimization is gaining traction internally, while 37.2% said that mathematical optimization is retaining its importance in their organization.

With the footprint of mathematical optimization expanding across the enterprise, the future is bright for this AI technology.

Combining Mathematical Optimization and Machine Learning

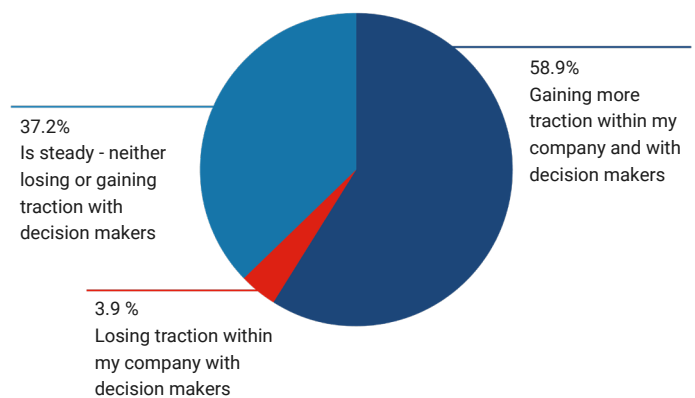
Mathematical optimization and machine learning are complementary, and a growing number of companies are building and deploying applications that combine these two AI technologies.

Nearly half (46.1%) of survey respondents stated that they use mathematical optimization and machine learning together today.

There are many different ways that mathematical optimization and machine learning can work together: machine learning predictions can serve as input for mathematical optimization solutions, mathematical optimization solutions can serve as input for machine learning predictions, and mathematical optimization can actually be used to generate optimal solutions to classification, prediction, and other problems that are usually solved with machine learning.

Today's data scientists and operations research professionals are just beginning to discover all the possible ways to integrate and utilize these two powerful AI technologies together.

How much do you agree with this statement?
Mathematical optimization is:



46.1%
of those surveyed use
mathematical optimization in
concert with machine learning.

Conclusion

Mathematical optimization has firmly established itself as an essential AI technology for companies today. In this report, we highlighted numerous key trends that illustrate the increasing importance of mathematical optimization in our business world:

- **Impact across industries:** Companies across more than 40 different industries (including electrical power, logistics, financial services, and telecommunications) use mathematical optimization in their operations.
- **Expanding user base:** A broad range of professionals from various fields (including operations research, engineering, computer science, and – more and more – data science) and various functions and levels across the enterprise are using mathematical optimization technologies today.
- **A vast array of applications:** Companies are embedding mathematical optimization solvers in a wide variety of off-the-shelf and custom-built applications to address a whole host of business problems. Increasingly, companies are building applications that combine mathematical optimization and machine learning.
- **Proven business value:** Companies that utilize mathematical optimization technologies are consistently able to achieve their business objectives such as minimizing costs and maximizing resource utilization and revenue.
- **Growing power and presence across the enterprise:** Businesses today are continuously developing and deploying new, mission-critical mathematical optimization applications, and this AI technology is gaining traction among decision makers across the enterprise.

To learn more about how mathematical optimization could benefit your business, visit [Gurobi.com](https://gurobi.com) or contact us at sales@gurobi.com.

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