

FORRESTER®

Mathematical Optimization And Machine Learning: Your Perfect AI Tech Team

How Mathematical Optimization Complements Machine Learning Models

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Accelerate AI Solutions With Mathematical Optimization

AI adoption has passed the 50% threshold at global enterprises in 2019.¹ Enterprises are using artificial intelligence (AI) and machine learning (ML) to build powerful predictive models about customers, operations, and market conditions inductively from data. This success, however, comes with a dilemma: How do firms accurately act on those predictions to boost business outcomes while conserving precious enterprise resources? The answer is found in the adjacent field of mathematical optimization (MO).

Respondents in this study indicated they use MO for work frequently, indicating a baseline of familiarity with techniques that can pave the way for using MO to drive maximum impact for every ML or AI project.

Key Findings



Firms utilize MO for major business use cases, including operational applications, business processes, logistics, and several other key business decisions like scheduling, routing, and resource optimization.



MO delivers major business benefits: Firms report MO drives operational efficiencies, increased revenues, and lowers costs — but also strengthens competitiveness, decision making, and business agility.



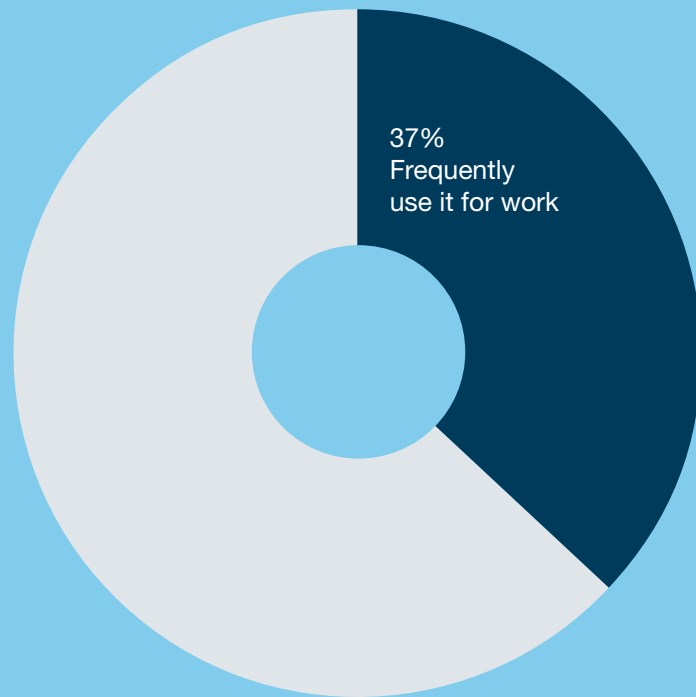
Use MO to inform AI and ML projects. AI and ML revolutionize businesses' approach to key business challenges. MO complements ML-based predictions by optimizing the decisions that businesses make.

Firms Use Mathematical Optimization To Drive Business Decision Making

Mathematical optimization is quantitative modeling and computational software that enables companies to solve complex business problems and make optimal decisions that improve their efficiency. It allows firms to model the key features of a complex real-world problem that must be considered to make the best possible decision. An optimization model – which is comprised of relevant objectives (business goals), variables (decisions in your control), and constraints (business rules) – is designed to recommend a solution that generates the best possible, mathematically-driven result. A solver is the computational engine that reads the optimization model and then delivers an optimal feasible solution.

MO allows data scientists to turn their predictions into smart actions, and it's showing signs of broad adoption as 37% of the respondents in our study say they use MO frequently for their jobs today.

“Which of the following best describes your personal background with mathematical optimization?”



Mathematical Optimization Tackles Tough Business Decisions

Firms are awash in information intended to help determine what plans to make, what actions to take, and which resources to allocate. For example, they need to use their data to answer questions like: What combination of carriers will minimize shipping costs while ensuring on-time delivery? How many SKUs are likely to be required across a brand’s brick-and-mortar footprint to match expected sales from a planned promotion?

Firms need to consider dozens, hundreds, or sometimes thousands of factors to optimize decisions about complex, core business processes. That’s what MO technology delivers for use cases including operational applications, business processes, logistics, and pricing.

“Which of the use cases do you use mathematical optimization for today?”

(Select all that apply.)



45% Operational applications



45% Business processes



43% Logistics



34% Pricing



32% Planning



31% Research and development



28% Optimizing/personalizing customer experiences



25% Supply chain planning

Firms Look To Expand MO Use Cases

MO is currently driving improvements in operational applications, business processes, logistics, and other critical functions. But respondents indicate they're considering other areas for MO adoption.

For example, 38% say they may apply MO to optimize customer experience (CX) or foster greater personalization. Forrester has been tracking the inroads AI has been making to various aspects of CX — from improving customer service to offering hyperpersonalized customer journeys and products to the overall customer analytics stacks that drive modern customer experience practices.² MO applications into CX will help ensure that firms can couple powerful ML-derived predictions with MO-supplied next best courses of action.

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“Which of these use cases do you want to use mathematical optimization for in the near future?” (Select all that apply.)



Base: 153 US managers who are responsible for or influence their organizations' data science or execution strategy
Source: A commissioned study conducted by Forrester Consulting on behalf of Gurobi, December 2019

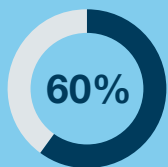
Mathematical Optimization Drives Business Benefits

Firms that deploy MO today see improved performance and business outcomes, and firms are looking into new applications for MO to bolster critical business functions.

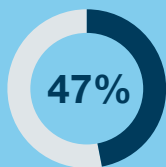
Additionally, MO can help firms improve competitiveness — in areas such as agility, profitability, and market share. Firms are also able to make more accurate decisions with fewer errors based on rigorous, data-driven decision making. Finally, improvements in business agility point to MO's role in helping firms more quickly and accurately respond to shifting market forces.

Increased revenues and lowered costs contribute to overall operational efficiency.

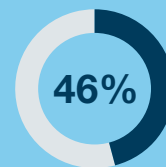
“Which of the following benefits has your organization realized/do you expect to realize as a result of applying mathematical optimization for tasks like scheduling, sourcing, route planning, resource optimization, etc.?”
(Select all that apply.)



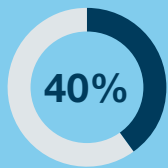
Operational efficiency



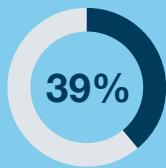
Increased revenue



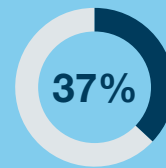
Reduced cost



More ability to be competitive



Better/more accurate decisions



More business agility

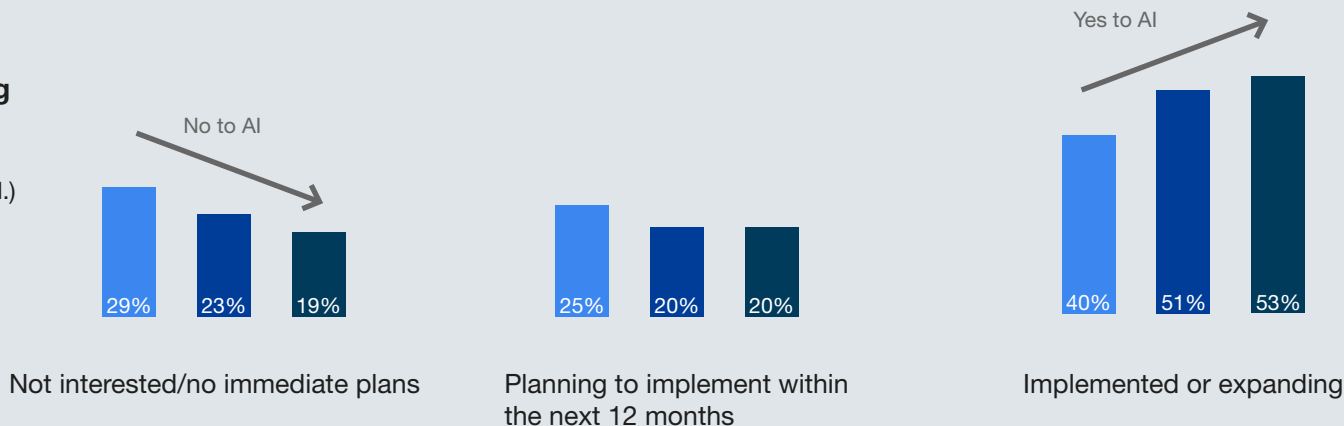
Machine Learning Adds The Power Of Prediction To Business Decisions

AI technologies such as ML represent the frontier of business decision making. By analyzing large amounts of data, machine learning algorithms can uncover patterns that add the power of prediction to decisions. It's no wonder that more than half of data and analytics decision makers plan to implement, already have implemented, or are expanding their use of AI.

As the fundamental building block of AI, enterprises' capabilities with building ML models will fuel this shift. Enterprises will surely have to build custom ML models, and they will also need to buy ML-enabled solutions. That means they'll have to understand how to make data science teams as productive as possible with the latest ML solutions and how to show decision makers the most efficient paths forward.

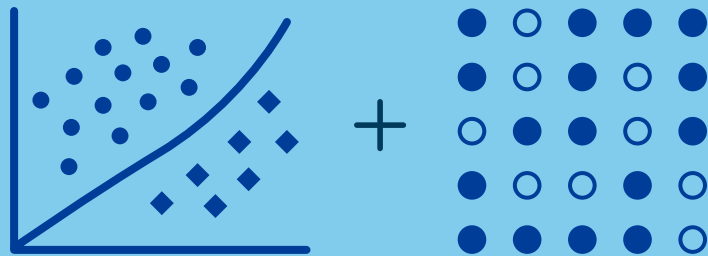
“What are your firm’s plans to use the following analytics technologies (artificial intelligence)?”
(Don’t know responses excluded.)

● 2016 ● 2017* ● 2018†



Your Perfect AI Tech Team

MO and ML are different but complementary technologies necessary to maximize operational efficiency, make smart decisions with scarce resources, and reduce risk. MO helps enterprises make the best possible decisions based on numerous and often complex business constraints such as resources, schedules, and costs. ML creates predictive models about business variables based on historical data where uncertainty is the norm. Enterprises can use these ML-predictive models to infer constraints that are uncertain but needed by MO to arrive at the best decision. Likewise, ML-predictive models are mono-predictive, or only able to make simple decisions based on a single prediction. MO can integrate predictions into systems of decision making that put predictions in the context of business and allow executives to act. In a nutshell: Where ML models generate predictions, MO can be leveraged to take action on those predictions and make decisions.



ML
(Predict)

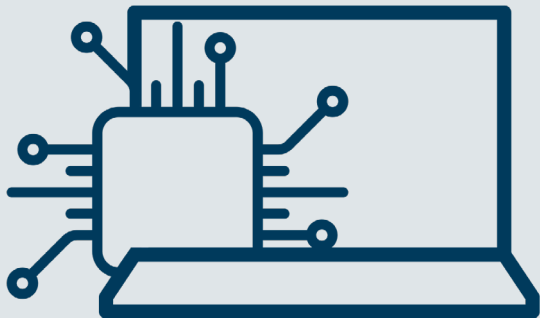
+

MO
(Decide)

Use MO To Inform Decisions For Every ML Or AI Project

Firms should utilize of MO in every ML or AI project to make fully informed decisions based on optimizing all relevant variables. The result is a system of ML models being integrated and applied in the most efficient way possible. Respondents report that they use MO frequently for work, which indicates that a baseline of familiarity and expertise is in place to pursue ML- and MO-aligned applications.

For instance, ML can help firms predict what supply chain issues might arise for them, then MO can help them decide the least costly way to reroute shipments. Security professionals can use ML to predict where the next cyberattack will come from before it happens, then have MO help decide which investigators to assign based on their skills and the potential damage from an attack. ML can help manufacturers predict machine failure, while MO shows when to shut down production for maintenance to minimize costs and production disruptions.



Let MO Become AI's Steady Hand

MO already drives significant benefits for firms when implemented on its own. With AI and ML adoption on the rise, MO is also poised to become the decision-making executor for ML solutions that press into service-precious enterprise resources. To do so, firms should bear in mind that:

- MO addresses complex combinatorial optimization problems. Enterprises need MO solver software that can solve business optimization problems in seconds or minutes versus hours or days.
- MO should be accessible to data scientists in the tools they already use or have tools data scientists can use. Solvers can be deployed complementarily with ML models.

Project Director:

Nicholas Phelps, Senior Market Impact Consultant

Contributing Research:

Forrester's Application Development And Delivery research group

Methodology

This Opportunity Snapshot was commissioned by Gurobi. To create this profile, Forrester Consulting supplemented this research with custom survey questions asked of data science decision makers at US firms. The custom survey began in May 2019 and was completed in December 2019.

ENDNOTES

¹ Source: "Predictions 2020: Artificial Intelligence," Forrester Research, Inc., October 30, 2019.

² Sources: "New Tech: Conversational AI For Customer Service, Q2 2019," Forrester Research, Inc., May 23, 2019; "The Future Of Machine Learning Is Unstoppable," Forrester Research, Inc., April 25, 2019; and "Come Together (Right Now) To Deliver The Next Best Experience," Forrester Research, Inc., April 3, 2019.

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Demographics

GEOGRAPHY

US: 100%

ANNUAL REVENUE

\$250M to \$499M: 17%

\$500M to \$999M: 35%

\$1B+: 47%

ROLE

IT: 47%

Operations: 18%

Finance: 16%

Other: 19%

JOB LEVEL

C-level executive: 18%

Vice president: 14%

Director: 39%

Manager: 30%



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