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5 Essential Ingredients for Mathematical Optimization Success

Management Paper



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For many people in the business world, there is something mysterious and almost magical about mathematical optimization. The way it works is actually quite amazing:

- You have a highly complex, real-world business problem with an astronomical number of possible solutions.
- You feed your data into a mathematical optimization application, which automatically processes that data and spits out the best solution to your business problem.
- You use that solution as the basis for your business decisions—which boost your operational efficiency and overall profitability.

That's all it takes to rapidly transform your data into optimal decisions! For those who have never utilized mathematical optimization technologies, this process may seem miraculous or maybe just mind-bogglingly sophisticated and complicated – simply beyond their range of understanding or area of expertise.

But in reality, there's no magic to mathematical optimization—all it requires is a handful of essential ingredients.

So, what does your company need to successfully implement and use mathematical optimization technologies?

In this management paper, we reveal the five essential ingredients that your company must have in order to achieve success with mathematical optimization.

Ingredient #1: The Right Type of Business Problem

Mathematical optimization is, at heart, a problem-solving technology. It gives you answers to your business problems and it also gives you the confidence that you can use those answers to make the best business decisions.

So, naturally, in order to conduct mathematical optimization, you first need to have a business problem—but not just any business problem. It is imperative that you identify the right type of business problem—one that is suitable for mathematical optimization.

The question is: What is the right type of business problem for mathematical optimization?

Although mathematical optimization is being utilized in a vast array of applications by [thousands and thousands of different companies](#) across more than [40 different industries](#), there are certain common features that characterize all mathematical optimization problems.



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On a fundamental level, a mathematical optimization problem involves a decision about:

- How your company can most efficiently utilize scarce, but critical resources (such as skilled workers, raw materials, equipment, energy, investment capital, transportation, and inventory),
- In order to achieve certain business objectives (such as maximizing customer satisfaction and profits, or minimizing operating costs),
- While adhering to your company-specific business rules (such as capacity, cost, or time constraints).

Mathematical optimization technologies enable you to rapidly solve such problems and make optimal (and often automated) decisions about how to most efficiently use your precious resources to meet your business objectives (while taking into account your unique business rules).

Although the nature of a mathematical optimization problem may vary – from a shipment routing problem to an investment portfolio allocation problem, an energy distribution problem, a product marketing problem, a supply chain network design problem, or a resource allocation problem, and many, many more—it must possess the underlying characteristics highlighted above.

Ingredient #2: Accurate, Timely, and Complete Data

Data is the fuel on which mathematical optimization (as well as other advanced analytics technologies such as machine learning) runs.

In order to successfully utilize mathematical optimization, you must have access to accurate, timely, and complete data that captures the current state of your operations (including all the activities competing for your critical resources) and the future demand for these resources.

Mathematical optimization technologies automatically process your data (including real-time and historical data as well as forecasts, projections, and even [machine learning-based predictions](#)) from various sources (including ERP, MES, PoS, cloud, and other systems as well as IoT devices) and utilize this data to drive optimal, automated decision making.

With mathematical optimization, you can unlock the true business value of your data by using it to solve your complex business problems and decide on the best courses of action in order to optimize the utilization of your resources and achieve your business goals.



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Reason #3: A Well-Formed Objective Function

The third essential ingredient that you need in order to successfully use mathematical optimization is a well-formed objective function (or business objective). In other words, you must be able to clearly define what you are trying to optimize.

Every mathematical optimization problem has an objective function that needs to be maximized or minimized. It could be, for example, maximizing revenue, on-time and in-full (OTIF) delivery performance, or resource utilization, or minimizing risk, excess inventory, or costs.

In order to define this objective function, you must first be able to formulate a statement that crystallizes—in the most precise manner possible—what your business problem is (including the decisions you have to make, the metrics you use to evaluate those decisions, and the business rules you have to satisfy).

Typically, defining your business problem and your objective function is an iterative process that involves getting input from all relevant stakeholders and decision-makers in your organization. This exercise is well worth the time it takes—as it is absolutely crucial to ensure that you are accurately stating your business problem as well as your business goal.

If you don't clearly define the objective function that you are aiming to achieve, your mathematical optimization application might end up missing the mark.



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Reason #4: Basic Mathematical Programming Skills

It should come as no surprise that mathematical optimization requires some basic mathematical programming skills, which you need in order to formulate your real-world business problem as a mathematical optimization model.

Many companies these days have this mathematical programming expertise in-house: they have operations research (OR) specialists, computer scientists, or [data scientists](#) in their organization who have the capability to build mathematical optimization models.

If your company doesn't have this expertise in-house, there are many [consulting firms specializing in mathematical optimization](#) out there that would be willing and able to work with you.

The bottom line is that you need a person or people on your team with the ability to systematically state your business problem (including its decision variables, business rules or constraints, and objective function) in mathematical form and ensure that you have the right input data for your mathematical optimization application. It's important to note that this process of formulating a mathematical optimization model is an iterative process, as the modeler must get input from all relevant stakeholders and then test, deploy, tune, and maintain the model over time.

Indeed, to successfully utilize mathematical optimization technologies, your company must have the capability to correctly capture the key features of your business problem as a [mathematical optimization model](#)—and this requires some mathematical programming proficiency.

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Reason #5: A State-of-the-Art Mathematical Optimization Solver

The last essential ingredient that you need is a state-of-the-art mathematical optimization solver—which reads your mathematical model, processes all available data, and rapidly generates a globally optimal solution to your real-world business problem.

A mathematical optimization solver is an absolutely astonishing piece of technology that—out of the box, without any sort of customization of code—can be used to solve virtually any mathematical optimization problem.

There are [many options in the market to choose from](#) (including open-source and commercial solvers), but if you want to ensure that you get the fastest performance and best results, you should choose a [best-of-breed solver like the Gurobi Optimizer](#).

With such a state-of-the-art mathematical optimization solver, you can automatically generate globally optimal solutions to your business problems—and utilize those solutions to fuel optimal decision making and operational efficiency.



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Conclusion

As you can see, there's nothing magical about mathematical optimization—all it takes is a handful of essential ingredients: the right type of business problem; accurate, timely, and correct data; a well-formed objective function; basic mathematical programming skills; and a state-of-the-art mathematical optimization solver.

With these five essential ingredients, your company can successfully implement and utilize mathematical optimization and realize significant business benefits.

By combining these ingredients, your company can unleash the power of mathematical optimization and use it to tackle your complex business problems, make optimal decisions, and achieve the best possible business outcomes.

