RIVERLOGIC

PRESCRIPTIVE ANALYTICS

FOR BUSINESS LEADERS

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PRESCRIPTIVE ANALYTICS **FOR BUSINESS LEADERS**

BY PETER BULL, CARLOS CENTURION, SHANNON KEARNS, ERIC KELSO AND NARI VISWANATHAN

EXPLORE:

- THE DIFFERENT APPROACHES TO PRESCRIPTIVE ANALYTICS
- THE TRANSFORMATIONAL VALUE IT BRINGS TO BUSINESS LEADERS
- HOW TO DETERMINE IF YOUR COMPANY IS READY FOR PRESCRIPTIVE
- A STEP-WISE APPROACH TO FINDING YOUR FIRST USE CASE AND GETTING STARTED
- SOME REAL-WORLD, CROSS-INDUSTRY APPLICATIONS

FOREWORD

FOREWORD BY ***ANDRE BOISVERT***

With over 35 years in the technology industry, leadership roles at IBM, Oracle and SAS Institute, Inc., and a co-founder of the world's most popular commercial open source business intelligence platforms (Pentaho Corporation), Andre Boisvert is a thought-leader in the business analytics space. He serves on multiple boards, including servings as River Logic's Board Vice Chairman and Senior Advisor.

More and more, business leaders are becoming responsible for understanding how to appropriately leverage business analytics to drive value, both within their business unit as well as companywide. Simply being familiar with the types of business analytics is no longer enough, however; leaders must familiarize themselves with the kinds of problems for which each type of analytics is best suited. Prescriptive analytics is no exception to this.

A recent report by Gartner stated the following:
"Prescriptive analytics is moving beyond its core community of operations research and management science professionals and becoming increasingly embedded in business applications." (Hare, J., Swinehart, H., Woodward, A., Forecast Snapshot: Prescriptive Analytics, Worldwide, 2017, Gartner Inc., May 3 2017.)

Deemed the most transformational form of advanced analytics, it's crucial that business leaders understand the value that can be drawn from prescriptive analytics and take responsibility for driving initiatives. Many might steer clear of prescriptive initiatives, believing it's the responsibility of the Information Technology Department, too complex of an endeavor to prove reasonable Return on Investment (ROI) or deciding that other advanced analytics initiatives should take priority. However, those that rise to the top will be those who take an initiative to appropriately inform themselves about the category.

The ROIs we see from prescriptive analytics alone are enough to peek anyone's interest, with many organizations seeing numbers ranging from 10-15%. Then, when we consider the projected market growth of the category (adoption is expected to more than double over the next four years), it's easy to understand why prescriptive analytics is quickly becoming necessary to achieve a competitive advantage.

Many of the most successful companies in the world are already leveraging prescriptive analytics — companies that span all sizes and industries. Though this might not be the right time for every organization, now is the time to get informed and understand where prescriptive will fit in your advanced analytics roadmap.

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Peter is Chief Technology Officer of River Logic and is responsible for the technology leadership, strategy, development and delivery of River Logic products. Prior to joining River Logic, Peter held a number of wide-ranging roles in the software and technology industry, including work with Tibco, in which he led the mobile analytics product team, and Extended Results (which was acquired by Tibco), in which he pioneered a leading mobile business intelligence product.

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INTRODUCTION

ABOUT **THIS BOOK**

At only 6% market penetration as of this year (2017), it's no surprise that many business leaders have never heard of prescriptive analytics or, if they have, are still hesitant to define what it means for their role and their business.

Even those who are familiar with prescriptive struggle with unanswered questions and confusion around the subject. Our goal with this book is to introduce the topic of prescriptive analytics to business leaders in order to empower them to make the most informed decisions around leveraging advanced analytics.

> "The prescriptive analytics software market will reach $1.57 billion by 2021, with a 21% CAGR from 2016. Technology strategic planners must understand the market opportunities for prescriptive analytics when planning their business strategy to build and market their data and analytics offerings."
>
> Gartner®
>
> Hare, J., Swinehart, H., Woodward, A. Forecast Snapshot: Prescriptive Analytics, Worldwide, 2017, Gartner Inc., May 3, 2017

If you're unfamiliar with prescriptive, our hope is that this book gives you a clear idea of what it is, how it can be applied and the type of value it can drive. If you're already familiar with the topic, our hope is that this book allows you to take a deeper dive into understanding how to successfully implement prescriptive analytics solutions within your organization. We also hope to clear up some common misconceptions around 1) the different approaches to prescriptive analytics and 2) the barriers to adopting it that exist in the marketspace today.

BEYOND **THIS BOOK**

IF YOU'RE INTERESTED IN ADDITIONAL INFORMATION ON PRESCRIPTIVE ANALYTICS, WE SUGGEST THE FOLLOWING:

- Reach out to Gartner or another analyst research firms with questions
- Explore our 60+ articles on prescriptive analytics (blog.riverlogic.com/topic/prescriptive-analytics)
- Talk to one of our partners who have vast experience implementing prescriptive solutions (https://www.riverlogic.com/partners/)
- Contact our leadership team, some of whom have been working in the prescriptive space for 25 years

01 AN INTRODUCTION TO **BUSINESS ANALYTICS**

THE BUSINESS
ANALYTICS MARKET

The analytics market is traditionally divided into three types of analytics:

- Business Intelligence
  - Description: What happened?
  - Diagnostic: Why did it happen?
- Predictive: What will happen?
- Prescriptive: What should I do?

Recently, the research firm Gartner added a fourth form of advanced analytics to the spectrum: cognitive and artificial intelligence, defined as insights and recommendations based on self-learning or natural language processing capabilities.

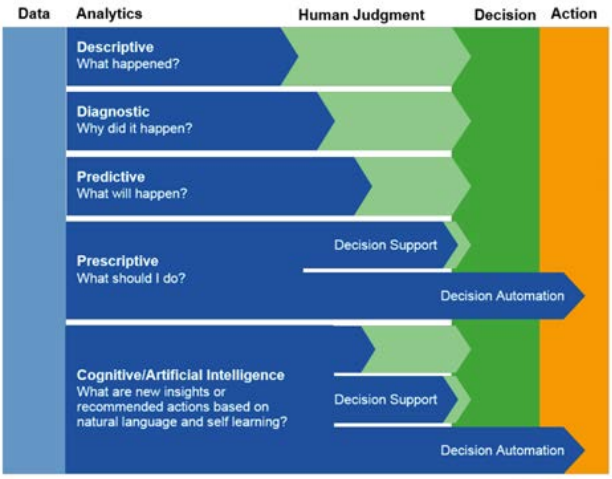


Figure 1. Types of analytics techniques (Gartner, 2017)

A plethora of content exists that defines BI, predictive, and prescriptive analytics. This book is not meant to regurgitate existing content. Rather, it's meant to help business leaders understand how they can apply prescriptive analytics as a form of decision support for enabling them to answer their most pressing problems.

Instead of using the highly technical definitions that already exist in the marketspace, we're going to talk about the kinds of questions and decisions that are supported by each form of analytics by walking you through a real-life example.

BUSINESS ANALYTICS THROUGH THE **EYES OF A BUSINESS LEADER**

Let's assume we have Barry, a business analyst who works within the Marketing function of a consumer packaged goods (CPG) company that manufactures several hundred products. Barry is in charge of all business analytics activities. He's tasked with compiling dashboards and grabbing data that answers his boss's, Vice President (VP) Mary, most pressing questions.

BUSINESS INTELLIGENCE

Several years ago, VP Mary was struggling with reviewing her budget, so she asked Barry how she could guarantee she adhered to her budget. Barry decided the best option was to create a report for Mary that updates, in real time, what is being spent on promotions, paid advertising, trade shows, and any additional spend categories. He used Tableau to compile a series of dashboards that provided VP Mary ad-hoc insights into her spend and sent her notifications when she was nearing her pre-defined monthly budget limits in each category. Barry's Tableau dashboard is an example of descriptive analytics — it's a collection of historical events that are compiled into easy-to-digest dashboards, often reflecting events as they occur.

Because Barry is an exceptional Marketing Analyst, he also grouped Mary's spend in simple categories that allowed Mary to drill down to specifics, so she could identify exactly where she went over budget from within her

dashboards. He also created charts and visuals that correlated Mary's real-time spend data with historical data and spend targets, allowing Mary to understand how she's doing compared to her past performance. Enabling these drill-downs and correlations is the diagnostic piece of BI. It involves grouping data appropriately in order to understand why something happened (i.e., identifying deviations from the target or identifying certain outliers).

PREDICTIVE ANALYTICS

Thanks to Barry's dashboards, Mary was finally able to stick to her predefined budgets. She was able to pinpoint which campaigns, lead personas, and channel initiatives had driven the most revenue for her company. However, she quickly realized that having these insights wasn't enough to streamline her marketing efforts. Sales remained irritated at receiving only "lukewarm" leads, some of her campaigns that she thought would be successful weren't resonating, and her Client Success Managers were frustrated with seemingly unpredictable customer churn.

When she brought this problem to Barry, he knew exactly what to do. "Simply describing our data isn't enough anymore — we need a form of analytics that will help us predict the likelihood of all these things like customer churn, deal close, etc. occurring," he said.

Over the next several months, Barry began compiling relevant marketing and sales data. This included information about deal closes and losses, social media, website engagement, detailed customer behaviors, brand engagement, and campaign information. He then used a variety of statistical modeling approaches to include regression analysis, forecasting, multivariate statistics, pattern matching, predictive modeling, and forecasting to correlate the data and predict the likelihood of outcomes that he and Mary knew had a significant impact on their Marketing performance.

Mary was thrilled with the outcome of Barry's work. She could now understand how likely her Marketing leads were to turn into customers (this satisfied the Sales team). She was able to segment the data by detailed persona characteristics, engagement metrics, campaigns and more in order to better target different

market segments. She could also now predict the likelihood of customer churn, so her Client Success team could step in before churn occurred. Lastly, she was able to improve her messaging by understanding how likely a message was to resonate with her audience segments across websites, social channels, and emails. Over the next year, the company's average profit margin per customer and customer lifetime value both doubled — all thanks to Barry's predictive modeling.

PRESCRIPTIVE ANALYTICS

Despite the fact that Mary saw drastic improvements in her metrics since she began leveraging predictive insights, she still noticed gaps in her Marketing Plan (as did her boss — CEO Sara — and many of her higher-level colleagues). All this was impacting her promotion in the company.

Mary continued to struggle with unanswered questions. Not only were they unanswered, but they seemed to be the most important questions she needed to address to drive the most impact organization wide and get the promotion she wanted. She wondered:

- "I know Google Adwords drives the most revenue, but I want to understand how much I should put toward all my forms of paid advertising across my different audience segments. How do I know where to put my advertising dollars in order to drive the most profit, and how much should I allocate to each channel and segment?"
- "I run a lot of product campaigns, but I don't know the exact dollar amount to put toward the product campaigns, especially when our business has so many constraints around product promotions already. Which product should I promote, when, and how much should I spend so I can optimize our overall profit?"
- "I'm getting pressure from my CEO to promote to new audiences. I have data around the messages that resonate and the channels they like, but I have no idea how much money I should put into each marketing channel so that I minimize cost while still maximizing income."

- "We do about 30 trade shows a year across different geographies, and every year I waste a large amount of money. How can I best allocate my tradeshow funds and understand how much I should spend in the first place to achieve the lowest customer acquisition cost?"

Once again, Mary approached Barry with her problems and, again, Barry found a solution.

"Want to know what all these questions have in common, Mary? They all ask 'what should I do'? And see, predictive analytics can tell you about likelihoods and probabilities, but it can't tell you where to allocate your marketing dollars, and it certainly can't tell you exactly how much to put and where to put it. What you need is prescriptive analytics."

Barry started working on developing a prescriptive model that represented Mary's end-to-end marketing business. Of course, he first had to find new software — his BI/predictive tool certainly wouldn't do the trick.

While we'll get into the "how" of prescriptive analytics later on, essentially what Barry did was create a model that describes how their CPG business works — he considered account business rules, business processes, objectives, constraints, preferences, policies, best practices, boundaries, revenue, and costs. He then used that model to provide his prescriptive system (the math piece) with the business intelligence to analyze their data and suggest the optimal way forward.

With a nice User Interface (UI) on top, Mary was able to ask her questions (what-if scenarios — we'll get into those later as well) and understand the financial impact of very specific decisions on her predetermined objectives.

Finally, she had a trusted companion that guided her business decision-making process and gave her the best plan forward. She had actionable insights!

Mary used her prescriptive dashboards for everything:

- She created monthly plans that allowed her to see the expected Return on Investment (ROI) she'd get; and she was able to track her progress against those plans.
- She was able to understand which target markets and campaigns she should invest in. She even threw out ones she'd previously thought were the most profitable.
- She used it to run scenarios in order to prepare for sudden market shifts so she could plan, on the fly, the best way to react.
- She used them for more long-term, strategic planning around what new market/audience segments they might penetrate, how their budget was expected to grow, and what new products they might look into manufacturing and selling.

Prescriptive analytics turned Mary into a strategic business partner, and she finally got that promotion to Chief Marketing Officer she'd always wanted. Mary saw transformational value across the business, such as:

- A 15X ROI on her marketing initiatives
- Increased trust in her marketing plans, helping win the confidence of Sales, Finance, and Operations
- Increased ability to quickly respond to market shifts in optimal ways
- 4% of the company's annual Marketing-related revenue in additional profit

And, of course, Barry got a huge promotion!

SUMMARY

In this section, we defined the three main types of business analytics: BI, predictive analytics, and prescriptive analytics.

BUSINESS INTELLIGENCE

- Nearly 100% of businesses today use some form of BI. Several of the most common applications are:
- Compiling customer or seller profiles
- Assessing the success of product promotion campaigns
- Conducting performance reviews based on pre-defined metrics

PREDICTIVE ANALYTICS

The market penetration for predictive analytics is around 20%, and this number will continue to grow rapidly over the next several years. Common applications of predictive analytics are:

- Assessing the likelihood of customer churn based on levels of engagment and other relevant factors
- Feeding targeted product promotions to website visitors based on previous website activity
- Determining if a lead is sales-ready based on certain characteristics and engagements (i.e., lead scoring)

PRESCRIPTIVE ANALYTICS

Currently, at 5% market penetration, prescriptive analytics is expected to grow to 35% penetration by 2020. Section VII offers a deep-dive into common applications of prescriptive analytics, but here are a few more examples.

- Optimizing product mix or machine/resource allocation
- Optimizing bed capacity and overtimes shifts in a hospital
- Risk mitigation for future scenarios

While Mary's example may have given you an idea of what prescriptive analytics is, we're going to dive deeper into the category by looking at its progression over the last century.

"COMPANIES LIKE PEPSICO ARE ALL WORKING ON MOVING FROM THE TRADITIONAL DESCRIPTIVE AND DIAGNOSTIC ANALYTIC CAPABILITIES TO PRESCRIPTIVE ANALYTICS. ADOPTING PRESCRIPTIVE IS CRITICAL FOR SUPPLY CHAINS TO GAIN A COMPETITIVE ADVANTAGE NOW AND IN THE FUTURE."

LESLIE KEATING
FORMER SVP SUPPLY CHAIN, FRITO-LAY

DEFINING
PRESCRIPTIVE ANALYTICS

CONFUSION IN THE MARKETSPACE

To understand the progression of the prescriptive analytics category, let's revisit Mary and Barry's story. When Mary brought her problems to Barry, she had no idea Barry could solve them — she'd never heard of anything like prescriptive analytics! Further, while Barry knew it, he hadn't seen any consistency in the marketspace on a clear way to apply it in an actual business sense. In fact, one colleague of Barry's in the IT department told him it would be impossible for him to solve Mary's problems in the best way possible without adding a full-time programmer — what he called an "Operations Research Ph.D."

This problem of misinformation and lack of awareness isn't isolated to Mary and Barry. It's a problem that exists globally across almost every industry. To help dispel some of the false information and appropriately educate people within a business unit on prescriptive, let's walk through the history of prescriptive analytics.

If you search Google trends today, you'll see that interest in the topic "prescriptive analytics" has grown significantly since Google began collecting this data in 2004. The real boom began in 2013, and we've seen rapid growth in interest since then. It's worth noting that there is no sign of the trend curve flattening out, as it continues to grow each year.

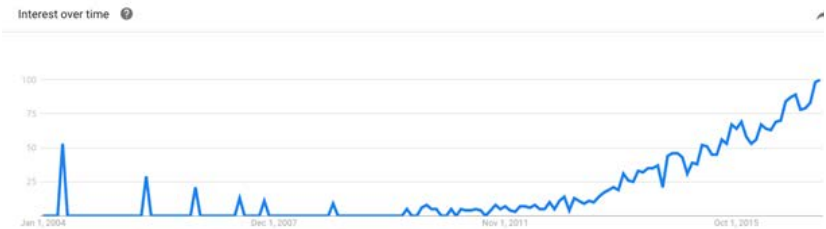


Figure 2. Interest in prescriptive analytics from 2004 to today

In early 2011, prescriptive analytics first appeared in Gartner (renowned global technology research firm). Since then, we've seen a rapid increase in interest in prescriptive analytics.

A BRIEF INTRODUCTION TO PRESCRIPTIVE ANALYTICS

The major mathematical-based disciplines of prescriptive analytics include Operations Research, Machine Learning, Natural Language Processing, and Applied Statistics.

To further complicate things, each discipline is made up of many sub-disciplines and variants. For example, Operations Research includes various disparate techniques like Simulation, Decision Analysis, and Optimization. It's no wonder there's confusion in the marketspace!

Our goal with this book is to simplify things — tell you what you need to know so you can make the most informed decisions around applying prescriptive analytics within your business. Therefore, we've outlined the concepts we feel are essential for you to know in order to begin using prescriptive analytics.

Research firms, vendors, consultants, and market leaders have trended toward dividing prescriptive analytics into two different approaches: Heuristics-based automated decision making and optimization-based decision support. We'll dive deeper into these two approaches in the next chapter, but below are some basic definitions to get you started.

OPTIMIZATION

To solve operational problems, such as route optimization and logistics planning, Operations Research professionals traditionally applied optimization. With the advent of new technologies making it possible to model larger, enterprise-wide problems and provide broad support for what-if analyses, optimization now enables a new class of decision support analytics.

Advanced optimization models combine the value chain (including key constraints) with financials, providing higher quality information than what's

possible with single predictive or BI models. This also ensures internal data consistency and identifies infeasible outcomes. These models support unique analyses, such as contribution margin, activity-based costing, and Pro-forma financial statements to help users make the best possible business decisions.

Optimization is typically used to solve complex problems that involve numerous (20+) constraints, objectives, and trade-offs. Applying prescriptive analytics through optimization enables users to wade through all these factors and find the path that meets the most objectives given the defined business.

The "math" used in optimization is complex. The most important thing to note is that it uses mathematical algorithms that maximize or minimize one or more objective functions while still respecting business realities, thus always producing feasible plans.

HEURISTICS-BASED DECISION AUTOMATION

Rules-based decision automation is different. It means that when something happens, the system will decide what to do on the fly, given a set of predefined rules that have been plugged in. Mind you, these rules are typically determined by humans using gut feel and "best practices," not by using math.

Unlike optimization, this approach cannot provide an answer outside of what has been predetermined. Further, the "math" is very different from the math used in optimization. It typically uses a form of statistics and applies algorithms to find the answer.

The most important takeaway from this section is that different methods of applying prescriptive analytics exist, and — while it's not crucial for business leaders to dive deep into the "math" — they do need to understand the value that each approach can bring to an organization.

Earlier, we mentioned the kind of transformational value VP Mary saw from applying prescriptive analytics to help support her decision-making process. This is arguably the most important thing to know about prescriptive analytics: It truly transforms the impact one or more business units have on the entire company.

THE TRANSFORMATIONAL VALUE OF **PRESCRIPTIVE & WHY BUSINESS LEADERS SHOULD CARE**

Prescriptive analytics has been around for a long time. However, it's typically been used to solve highly complex, niche problems like scheduling, routing, and staffing — activities that are highly complex where the problem definition is stable, and have historically involved Data Scientists rather than people within a business unit. Now, however, we're seeing the application of prescriptive analytics move out of the hands of Information Technology (IT) or Data Scientists and into business units. This shift has shown that prescriptive analytics is most beneficial to the organization when it's understood and accessible to business leaders.

PRESCRIPTIVE ANALYTICS BELONGS IN THE HANDS OF BUSINESS LEADERS

Four key factors have caused a shift from using optimization to solve operational problems to using it to solve more strategic, cross-functional problems that business executives regard as important to their success.

1. We not only have more data, but it's better and more diverse data.
2. Prescriptive analytics technology is becoming significantly less black box, allowing business users to draw insights without the dependence on Data Scientists or Operations Research experts within IT Departments.
3. Business leaders understand the most pressing problems they need to address.
4. More and more organizations are doing it, so it's no longer a "nice to have," rather, it's a must have.

THE TRANSFORMATIONAL VALUE OF PRESCRIPTIVE ANALYTICS IN BUSINESS

Though it may be hard to believe, our VP Mary's story is a real example of the transformational value of prescriptive analytics, and the benefits she saw have been replicated across dozens of industries and hundreds of use cases.

The typical value realized from prescriptive analytics is 10-20X ROI. While the exact ROI depends on the specific approach to prescriptive analytics and the type of problem addressed, it's clear that prescriptive analytics offers the most significant improvement of any of the other forms of analytics...by far!

Further, the impact can become transformational when applied end-to-end across business functions, especially when it affects the core business metrics such as operating income or return on invested capital (ROIC). Let's look closer at the value business leaders have seen from prescriptive analytics.

ACHIEVE HIGHER CONFIDENCE IN PLANS PLUS LOWER RISK

The foundation of a solid, effective plan is having confidence in it. Optimization-based plans are, by definition, feasible. Plans based on heuristics may or may not be feasible, depending on how simple the problem is and how well the rules are set up.

With optimization based decision making, because the operational and financial flow of the business is appropriately represented, there is a higher likelihood that the results can be achieved than if the company was using rules or Excel-driven hypotheses. This includes both the ability to deliver a plan and the understanding of required actions to implement the plan. Further, it provides an understanding of the operational and financial impacts of analyzed decisions on overall objectives. A manager that produces a plan with high confidence gains respect and the ability to affect further change in the business.

IMPROVE PERFORMANCE

Prescriptive analytics uncover unique insights that can lead to better financial and operational performance, especially when deployed across functions that were previously supported through tools relying on user intuition (i.e., Excel, BI). Different types of impact include:

- Improving the effectiveness of the business against one or more objectives (i.e., operating income, net income) — for example, in the application of integrated planning across demand, supply, and finance. Typical impact can

range from 2-5% of revenue in additional profit.

- Increasing the efficiency of an operation (i.e., do more with same resources, achieve the current outcome with fewer resources) — for example by improving the use and allocation of personnel and resources to best meet a set of tasks. Typical impact includes 15-20% higher throughput or 10-15% reduction in addressable cost.

- Maximizing the return from altering the design of a system, subject to a defined maximum risk — for example optimizing the allocation of investments. Typical impact ranges from 25-100% better NPV than Excel or heuristics-based solutions.

ESTABLISH HIGHER AGILITY IN THE ORGANIZATION

Difficult decisions take weeks or months to make, often taking up a lot of personnel time and occasionally the use of external consultants. Routine decisions that are made weekly often don't get the same level of scrutiny or scenario analysis, as there is not enough time to manipulate and analyze so much data. Prescriptive analytics increases the organizational knowledge of how different functions impact one another and recommends a path forward, thus increasing the ability to evaluate more scenarios and delivering a faster approach to making trade-decisions.

MITIGATE RISK

Risks are often quantified in either operational or financial term, but usually not in a way that truly mirrors how the business operates. Prescriptive analytics helps identify and better quantify the risk associated with both short and long-term decision-making and develop potential risk mitigation strategies.

EARN A HIGHER RETURN ON EXISTING ASSETS

Prescriptive analytics enable businesses to showcase how to leverage their prior investments in tools like Electronic Resource Planning (ERP) software that helps provide companies with clean, fresh data. Leaders can utilize that data for actionable insights while also guiding them on where they

might be missing quality data. Lastly, because prescriptive provides the best path forward, employees can have a true impact on overarching business objectives and quickly progress their status within a company. Employees are thus motivated to continue using prescriptive analytics solutions.

ADDRESS NEW PLANNING CHALLENGES USING THE BEST METHOD POSSIBLE

Prescriptive analytics can address questions that other forms of analytics simply cannot. Further, it often helps uncover transformational opportunities across businesses that business leaders may even think are impossible to solve.

Table 1 shows a few of the most common examples of applying prescriptive analytics across various industries.

Table 1. Real-Life, Cross-Industry Applications of Prescriptive Analytics

INDUSTRY	SOLUTION
Financial Services	Cash Management Mortgage Services Strategy Portfolio Optimization
High Tech	Integrated Business Planning
Aerospace & Defense	Service Contract Profitability Modelingn
Healthcare (Providers)	Health Plan Benefit Design Optimization Staff, Service and Resource Optimization
Utilities	Operational Planning (weekly planning to 25+ year long-range planning)
Consumer Packaged Goods	Trade Promotion Optimization IBP/Sales and Operations Planning (S&OP)
Oil & Gas	Logistics Optimization Commodity Trading Optimization
Retail	Price and Promotion Optimization
Chemicals	IBP/S&OP CAPEX
Government	Army Recruiting
Natural Resources	Network Optimization IBP/S&OP CAPEX
Metals	Product Mix and Supply Planning
Mining	Supply Chain Planning Blend Optimization
Public Sector	Personnel Training Optimization
Telecomm-unications	Optimization of Channel Allocation to Spectrum

SUMMARY

Hopefully, after reading this chapter, you understand:

- How prescriptive analytics is different from BI and predictive analytics
- The types of approaches to prescriptive analytics and how they differ
- The importance of putting prescriptive analytics in the hands of business leaders versus Data Scientists and Operations Research PhDs
- The transformational value prescriptive analytics can drive

This is an exciting and opportune time in the prescriptive analytics market. Businesses are beginning to understand what they need to be successful — and the data is quickly becoming available (if it isn't already). By 2020, we expect 35% market penetration in this category. Ask yourself: do you want to fall behind?

02 HOW DOES **PRESCRIPTIVE ANALYTICS WORK?**

A DEEPER LOOK INTO **PRESCRIPTIVE ANALYTICS**

The prescriptive analytics market consists of two categories of algorithms: heuristics (rules) and exact.

- Heuristic algorithms do not guarantee the best answer. If designed well, they can offer a short-cut approach to finding good answers in a reasonable amount of time.
- Exact algorithms guarantee the best answer. However, for difficult problems, the time to solve for the best answer can increase exponentially compared to the size of the problem.

For the remainder of this section, we will refer to exact algorithms as optimization. We make this distinction because any approach designed to find the best answer (optimization) must use a computational algorithm based on a proven scientific technique. An approach designed just to find a good answer (heuristics) does not require the same mathematical proof. For some heuristics, it's impossible to know if it can provide the best answer.

By definition, a prescriptive analytics solution must rely on rules or optimization. It's possible but less uncommon for a prescriptive analytics solution to use both simultaneously. One approach isn't always better than another; rather, business leaders and analysts need to understand when to apply each type (or when to apply both).

Below, we've listed some important criteria to consider when determining the appropriate approach to prescriptive analytics:

- TYPE: Some problems are naturally better for heuristics, while others are better for optimization. There are lists below citing examples of each.
- COMPLEXITY: How difficult is the problem? There are well known problems — e.g., traveling salesman — that can be difficult to find the best answer using optimization. In some cases, finding a good solution quickly using rules might make sense compared with optimization.

- PERFORMANCE: How long are you willing to wait for an answer each time you solve the problem? If an answer must be found as soon as possible, a heuristic might be a better choice. If time is not a major concern, optimization might be a better choice.
- FREQUENCY: How often must the problem be solved? If a new decision must be made frequently, maybe hundreds, even thousands, of times each day, then heuristics is likely to be a better choice over optimization.

HEURISTICS **(RULES)**

HOW IT WORKS

Heuristics are a set of problem-dependent rules. They are best used when the problem can be narrowly defined and operational in nature, rather than tactical or strategic. Additionally, they can be a good choice when the same decisions must be made hundreds, thousands, even millions of times per day.

Heuristics use highly specialized techniques designed to take advantage of particular aspects of a problem. They typically require developing either a set of mathematical functions (e.g., f(x) = y); a set of instructions (e.g., "If this… then do this"); or both. Here is an analogy:

Imagine you are driving in a car in a city you don't know, trying to reach a destination that you have never been to. The only instructions you have been given are "head west until you reach a certain hill on the horizon." You begin driving…

Without GPS, a map, or a specific set of instructions, you must rely on a rules-based approach — knowledge of local traffic laws plus intuition and experience — to help guide you. You might not take the shortest route (in distance or time). You might end up driving an extra 10 kilometers and take 20 minutes longer than was necessary. You might not get to your destination at all without additional information. This approach is a good proxy for a heuristic. Since a GPS system can provide the best answer based on an exact algorithm with specified parameters (i.e., "I want the shortest distance"), it would meet the test of an optimized approach.

Excel is a common tool used to make business decisions. By using features like IF statements, lookups, and functions, Excel-based rules can be defined by making a hypothesis about a potential answer. Then, when values are entered, the answer is immediately returned. Unless an optimization approach is used, there is no means to know if this is the best answer.

EXAMPLES

As mentioned above, certain decisions are better suited to heuristics rather than optimization.

Examples of circumstances where optimization is not required and "rules of thumb" are sufficient:

- RAW MATERIAL PURCHASES: e.g., purchase the cheapest source of raw material first regardless of quality
- CAPACITY ALLOCATION: e.g., assign capacity to line 1 first, then line 2 second, and so on, regardless of operating efficiency or costs
- `MARKETING: e.g., offer customers promotional opportunities based on a website search or prior purchase
- DEMAND FULFILLMENT: e.g., Tier 1 customers must always have their service level met at the expense of lower tier customers

PROS

- Better for decision automation, because it provides an instant output
- Better for difficult problems, such as scheduling or inventory economic order quantity (EOQ)
- Can be easier to learn, configure, and implement — many rules-based decisions are built into existing features in business process management (BPM), inventory management, and other software

CONS

- Limited benefits for holistic decision-making across functions (e.g., Integrated Business Planning) with a low ROI
- Highly likely forfeiture of additional profits (or fewer costs)
- "Good enough" answers are not guaranteed optimal (and often no mathematical proof)
- Won't analyze every possible scenario
- Although rare, it can fail to find a good solution if instructions don't allow it
- Requires customized solutions for narrowly-defined, specific problems
- May result in infeasible plans, for example, using Excel for tactical or strategic decision making
- Rules are difficult to maintain or may become obsolete

OPTIMIZATION

HOW IT WORKS

Optimization is a combination of mathematical modeling and exact algorithms used to find the optimal answer. A problem is defined by writing math equations using a model building platform. Once the model is created, it is sent to a highly specialized algorithm used to solve the problem. More information is provided later on

An optimization problem consists of the following parts:

DECISIONS TO BE SOLVED FOR

- Commonly referred to as decision variables
- These are the business questions to be answered. Complex problems can range from 100K to 10 million+ individual decisions.

Examples

- How much raw material to purchase?
- How many hours to run each line?
- How much product to sell to certain markets?

DATA TO BE INPUT

- Commonly referred to as coefficients
- Depending on the problem can be costs, prices, BOMs, or yields
- The shorter the planning period, the more granular the data should be

Examples

- How much does each ton of raw material cost?
- What does it cost to run each line?
- What is the recipe for SKU #123 at Plant A?
- At what price is the product sold in each market?

BUSINESS REALITIES/RESTRICTIONS THAT MUST BE ADHERED TO

- Commonly referred to as constraints or bounds
- These can include but are not limited to physical laws or company policies

Examples

- How much raw material is available to purchase?
- How many hours does each line have available?
- What is the maximum amount of demand for each market?

To achieve an optimal answer, an objective must be stated to either maximize or minimize a metric (e.g., profit, costs, personnel utilization, volume). The user can specify how precise they want the answer and how long they are willing to wait. The optimization algorithm then finds the best answer.

EXAMPLES

Optimization is used to solve numerous problems that are generally too complex for a heuristics-based approach.

Historically, problems solved using optimization were for a specific business function:

- TRANSPORTATION: shipping goods from supply to demand points at minimal cost
- EQUIPMENT REPLACEMENT: determining the optimum point in time to replace equipment
- ASSIGNMENT PROBLEMS: assigning staff to equipment
- GASOLINE BLENDING: for aviation fuels

Over the last two decades, businesses have learned to use optimization to tackle cross-functional problems. Some of the less traditional yet significantly more valuable applications are:

- Customer profitability and pricing
- Asset investment planning

- Product mix, blending, and substitution
- Treatment path optimization
- Workforce planning and training
- Commodity trading

Further on in this book, we dive into sample applications of optimization across four different industries.

PROS

- Provides an optimal answer with opportunity values
- Great for making complex decisions and yields better insights and higher feasibility
- Proven techniques established many decades ago
- Established software industry for building and solving models

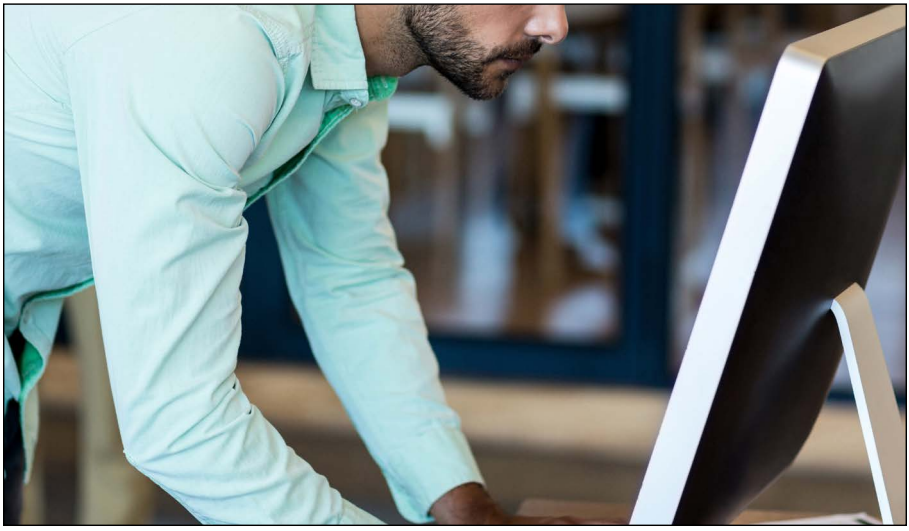
CONS

- Challenging problems can take significant time to find the best answer.
- Older generation software packages require specialized knowledge to write math equations.
- In the old days, people saw optimization as a black box as equations were difficult to manage.

SELECTING THE **RIGHT APPROACH**

In this chapter, we provided brief descriptions of heuristics versus optimization. We also cited a few examples for each approach as well as pros and cons. There are many things to consider when making a choice:

- Whatever approach and technology you choose, it must allow for flexibility to do what-if scenario analyses.
- As you read through the pages, try to envision what you will ask of it.
- Consider not just your current decisions, no matter how critical they are, but all possible important decisions you might need to make in future years.
- Look for approaches and technologies that allow for a great deal of flexibility in both model scope and in changes over time.



03 DETERMINING IF YOU'RE **READY FOR PRESCRIPTIVE ANALYTICS**

FINDING YOUR **FIRST USE CASE**

Most likely your organization uses a form of prescriptive analytics, but it's embedded deep into a function supporting a niche decision that is repeatedly made, like picking routes for your product delivery. There is always a case to extend these into broader problems. Additionally, if you have complex decisions supported by tools such as Excel, then you may have a strong business case. The first question you need to answer is how prescriptive analytics may apply to your business. In other words, how do we identify the top use cases?

Organizations should consider several factors in defining prescriptive analytics use cases with the highest likelihood of success. They include:

- The applicability of optimization to the business problem(s), such as constraint-based modeling/optimization
- Where to look first
- Requirements for successful adoption

APPLICABILITY OF OPTIMIZATION **TO THE BUSINESS PROBLEM(S)**

In other words, can we define the problem as a constraint model that can be optimized? Furthermore, can we identify the differentiated value/insights that can be generated? There are four core considerations in defining an optimization use case:

- DECISION SPACE: What decisions, trade-offs, and interactions between possible decisions (i.e., can you define a complex decision tree) are required to solve the problem?
- DEFINABLE OBJECTIVE(S): What are the objectives we are trying to maximize, minimize, or meet? These may include maximum profit, minimum cost, maximum throughput or volume, maximum ROIC, and a target blend quality.

- LIMITATIONS: Can we quantify the constraints impacting the value of the solution, for example, HR policies, resource capacities, marketing budgets, the number of marketing messages into an audience within a period of time, or blending targets for coal? Remember, recognizing business realities is critical in defining marginal versus average profitability.
- MINIMUM LEVEL OF COMPLEXITY: How complex is the decision? Would it be easier to write an Excel model? Problems with a minimum of 20+ decision variables are good candidates for optimization. For example, consider a decision that includes four products, two resources, and three customers. It faces 24 decision variables. In addition to these, additional dimensions may include time, inventory, channels, marketing events, inputs, and working capital policies.

Table 2 below serves as a guide to help you determine the complexity of your problem. It's a starting point to help you think through the problem, but you would need to multiply the number of variables for all rows to estimate the size of your problem:

Table 2. Determining the complexity of your problem

CATEGORY	OPTIONS	NUMBER OF VARIABLES
Products	Brand, SKU, promoted group, etc.	Number of brands or SKUs
Customers	Segment, channel, location, customer, etc.	Total number of combinations
Time	Quarters, months, weeks, days	Total periods to plan for
Resources	Labor, assets, machines	Which ones affect decision
Delivery	Service delivery centers, logistics (flow paths and DCs)	Alternatives to deliver product or service
Inputs	Suppliers, raw materials	Inputs that affect decision
Policies	Budgets, managerial Key Performance Indicators (KPIs)	Set boundaries on decisions

A tried and true approach to spotting good candidates for optimization is to ask your colleagues if they are supporting decisions with overly complex Excel spreadsheets or, even better, multiple Excel spreadsheets that work in parallel or sequence. Occasionally, companies also use planning engines that rely on rules to make decisions and these can also be good candidates (for example, as in most supply planning tools or tools that allocate capital investments).

WHERE TO **LOOK FIRST**

From a business standpoint — and while not an exhaustive list — Table 3 suggests some typical situations that are tell-tale signs of the need for optimization.

Table 3. Symptoms that indicate a need for optimization

SITUATION	SYMPTOMS	EXAMPLES
Policies that guide behavior	Decisions are made out of habit or people fail to make decisions	• Sourcing products from a specific plant to serve a specific market • Prioritize customers based on volume and revenue • All our surgeries start at 6:00 am because that's how we've always done; • On oncology clinic opens from 8:00am-5:00pm based on historical analysis and no-one has recently analyzed why
On-going Complex Planning Processes that are treated sequentially today or that are made in isolation	Decisions driven by silo thinking—tactical and strategic decisions involving resources, product/service mix, and marketing that are made solely within the function	• Sales and operations planning, where decisions about sales/marketing manufacturing, procurement, distribution, and finance are made sequentially. • S&OP where different tools or spreadsheet models are used for planning
Highly dynamic situations	Input/product prices change constantly and regulations evolve	• Commodities Industries • U.S. Healthcare Industry • Chemicals • Oil and Gas • Finance
High difference in average versus marginal decision making	There can be up to 100% difference in average versus marginal profitability for the same products	• Multiple constraints, volume contracts, and output price differentials • These are ideal situations because prescriptive analytics automatically identifies and considers these differences on the margin

REQUIREMENTS FOR **SUCCESSFUL ADOPTION**

This is a broad category that includes all the required components for implementing a prescriptive analytics solution for the identified problem. The main objective at this point is to understand the feasibility and effort required to drive user adoption and deliver the full value proposition such that the initiative delivers a strong ROI.

Below is a high-level "checklist" of items that should be considered to maximize the potential for success.

ORGANIZATIONAL READINESS

Is the organization in a state where an initiative like this could be undertaken? Ask yourself the following questions to determine whether your organization or business unit is ready to undertake such a problem:

- What would your vision be?
- Where would you focus a Proof of Concept (POC)?
- Who would be the right executive sponsor(s)? (note: it is often more productive to involve the business and finance)
- Could you have access to the personnel and budget to undertake even a POC?

DO YOU NEED A MODEL OR A FULL SOLUTION?

Often, prescriptive analytics deployments are limited to a model and one or few expert users. In contrast, some of the end-to-end use cases that bring more transformational value require multiple business users to interact with each other, collaborate on scenarios, and track performance against plan. What type of solution will be required to solve the business problem and ensure the right level of adoption? Conduct a high-level mapping of the "to-be" planning process to help define the components required:

- Where would the inputs come from? Is there a need for integration with other systems? Would the problem require statistical inputs such as demand

forecasts, currency movements, or asset breakdown variability?

- Is there a need for users to enter, validate, and approve certain inputs? How would the users need to visualize these inputs? Do we need to track who approved the inputs and when?
- What kind of scenario analysis is required, if any? Are the scenarios standard and on a set frequency vs. ad-hoc? Is there a need to automate running of the scenarios? Will different users need their own private sand box to run the scenarios? Is there a need for strong collaboration across users?
- Will senior management need to see the scenarios or plans? What kind of visualization would be required for this? Do users need the ability to define their own reports?
- Does the process require tracking and comparing an official plan (i.e., a budget) against the latest plan and actual performance?

DO YOU HAVE ACCESS TO THE DATA YOU NEED?

A crucial step in understanding if you're ready to address a problem using prescriptive analytics is to determine if you have access to the data you need. If you don't or you only have some of it, determine how difficult it would be to develop/cleanse the data you need. Typical data used for prescriptive analytics includes:

- MASTER DATA: Defines the structure of the organization, including products/services (i.e., product hierarchy), customers, personnel/ resources (i.e., assets, BOMs, routings, throughput rates), supplier contracts and financial reporting structure.
- OPERATIONAL VARIABLES: Define the specific situation. Examples include demand (orders/forecasts for service/product including quantity, price, and location), starting inventories, input availability, and costs. It is important to define not only how the business works, but also how it incurs revenue and costs.
- OBJECTIVES AND CONSTRAINTS: These are important as they define the key limitations and business objectives. Note that sometimes they are two sides of the same coin. For example, a user may want to see the maximum revenue possible subject to a minimum amount of profit, while

another may want to maximize profit subject to a minimum service level.

- DECISIONS: In addition to well-defined decisions such as where to make a certain product, it's often useful to identify activities that are currently not being done, but that could be undertaken. This is an area where data creation often leads to significant new insights and value for the business.

INVESTMENT AND ROI

The last step you need to understand if you're ready is to determine the kind of investments you will need to make and the likely return on those investments. At this point, it is important to understand orders of magnitude.

- Include here personnel, external consultants, and software that might be needed, bearing in mind the next step is a POC that would yield a more accurate estimate of both the investment and estimated value (Refer to Chapter IV: Getting Started with Prescriptive Analytics). Nevertheless, note that total implementation time ranges from 12-20 weeks for a team of 2-5 people depending on the scope.

- To calculate the initial ROI, compare the resource cost against the value expectations. Keep in mind that typical ROIs from prescriptive analytics initiatives return anywhere from 5x-20x investment in the first full year of use.

SUMMARY

At this point, you should have the following items clearly defined

- Your problem definition
- A rough idea of how to approach solving the problem
- The estimated range of value expected from solving the problem
- A perspective on the likelihood of success from such an initiative

It is entirely acceptable to have some gaps and ranges, as the objective at this point is to articulate a vision and recruit the champions to help you go to the next step.

04 GETTING STARTED WITH **PRESCRIPTIVE ANALYTICS**

Launching a prescriptive analytics initiative may seem daunting. However, if you've followed the key steps laid out in Chapter III: Determining if You Are Ready for Prescriptive Analytics, you should have a solid foundation to move forward. This section outlines the key steps and decisions necessary to minimize the risk from such an undertaking while ensuring the organization gets the maximum value possible. The key components in this section include:

1. Establishing a vision
2. Outlining key process steps from evaluation through adoption
3. Skillsets you'll need on your team

Addressing these questions will help you decompose the problem into manageable steps. We have attempted to embed as much wisdom as possible into each decision to help you understand the key areas you need to consider as you move forward.

ESTABLISHING **A VISION**

In relation to prescriptive analytics, a vision is a summary of the overall opportunity. It includes a high-level "from-to" definition of how the organization will make decisions in the future, the impact on performance, and a roadmap on how to get there. The roadmap includes the key steps the organization will follow to execute on the vision — see #2 below.

Because prescriptive analytics is a relatively new development, senior management — who often see it as a niche area and is relegated to Operations Management PhDs — poorly understand it. It is, therefore, important that education is included in this vision, to help senior leaders understand how it works, the potential it brings, and that it is complementary to other forms of analytics they might be using — such as BI, predictive, and machine learning. Refer to the next chapter to understand more about how prescriptive complements these other approaches.

OUTLINING KEY PROCESS STEPS FROM **EVALUATION THROUGH ADOPTION**

There is a well-defined path to moving from vision through the enterprise-wide adoption of prescriptive analytics. This approach starts by building momentum for the initiative, enables organizational learning while balancing risk, and ultimately results in maximum value to the organization. Below are the key steps:

1. TEAM ASSIGNMENT

All the standard roles that you would see in a transformation initiative apply here — a senior level sponsor, initiative lead, steering committee, etc. It is critical that the business leads and closely supports the initiative. In the next section, we define the roles and skills that are uniquely required to making a prescriptive analytics initiative successful.

2. VALUE DISCOVERY

Normally, this step works in parallel with and informs the overall vision. It consists of a series of interviews and workshops with subject matter experts to define the problem, envision the solution, and estimate the value opportunity. A Value Discovery step is necessary for each prescriptive analytics application.

3. PROOF OF CONCEPT (POC)

Once the team is in place, the next step is to identify a subset of the problem to run a POC.

a. POCs typically have three primary objectives:

- To establish a more accurate estimate of the value potential to the organization
- To understand the full requirements for implementation – solution components, data, etc. These may require different com — onents to be enabled in the POC
- To educate the organization about prescriptive analytics and the opportunities that it brings

b. Based on the objectives/priorities and the type of solution that might be required, a POC may contain one or more of the following:

- A prescriptive analytics model properly scoped with enough complexity to demonstrate the value while minimizing unnecessary data management tasks at this point. This model may be partially or fully validated to a relevant time period, and it is typical that during a POC it will support analysis of multiple scenarios.
- Scenario analysis and visualization components that enable users to run optimizations and interpret results easily
- A high-level business process map that illustrates the planning and performance management process to be adopted with the implementation
- A solid understanding of the effort, a work-plan, cost and target ROI from the implementation

c. POCs typically last anywhere from 2-6 weeks depending on the scope and availability of personnel and data.

4. IMPLEMENTATION

Deployment of the first application leverages the work in the POC to enable the full planning process powered by prescriptive analytics. The following components are present in an implementation:

a. DESIGN: In this phase, the problem definition is confirmed, the model requirements are established, and the full scope of the application is defined including the business planning process. This phase typically includes a walk through, interviews/workshops with SMEs, and a data review. It concludes with a presentation to the steering committee to approve moving into the next phase.

b. MODEL BUILD AND VALIDATION: In this phase, the model from the POC is finalized. The key steps include:

- Complete a model build, including a one-time data load. There may be a need for targeted data development in this phase – if there is, it will inform the data management step later in the process.
- Validate the model against a relevant time period. This can be historical

or Pro-forma depending on the nature of the solution. This step is critical in educating the organization about prescriptive analytics and establishing credibility in the model.

- Run selected scenarios. This step not only helps test the model, but it also informs the types of visualization and reports that will be necessary. Finally, it serves as good education on the potential value of the initiative.
- For prescriptive analytics, it is critical that the power users and subject matter experts be very involved in the modeling phase.

5. SOLUTION CONFIGURATION

Once the model is structured, the team will know what data is required and can then move into the solution phase.

a. DATA MANAGEMENT: This includes the data transformation required to use data from other systems, any new data development, and the integration with source systems.

b. WORKFLOW: To align with the planning process, sometimes it is necessary to enable a business process. This includes ensuring data contributors, approvals, scenario collaboration sequences, tracking performance against actuals, and overall process tracking.

c. USER INTERFACE: In this step, the data input, scenario creation, and visualization interfaces are configured to support the particular needs of the application.

d. TECHNICAL TESTING: Ensure that all the components work as intended.

e. USER ACCEPTANCE TRAINING: Once the solution is configured and tested by the implementation team, it is time to enable the key users. Best practices include education about the underlying prescriptive analytics model, and running one or two planning cycles together to ensure all the key learnings are passed on and that the model and screens can be refined as needed.

f. IMPLEMENTATION: This takes anywhere from 8-20 weeks depending on the scope, data availability/cleanliness and how much progress was made during the POC.

6. EXPANSION/ROLL-OUT

In this phase, the emphasis is on leveraging the initial win, capturing the learnings, identifying the next areas of need, and potentially a more aggressive schedule. The key consideration should be given to establishing a Center of Excellence that includes expertise in prescriptive analytics, planning, and finance.

SKILLSETS YOU'LL NEED

While a typical initiative has all the standard roles required, such as an Initiative Lead, Steering Committee, or Project Manager, this section focuses on the skills that are relatively unique to deploying prescriptive analytics.

- MODEL CONFIGURATION: Qualified personnel that can translate use cases into prescriptive analytics models and are capable of delivering during projects and implementations. With the technologies available today (that de-emphasize formula management and include embedded knowledge), it is not necessary to have a Data Scientist/Operations Research Ph.D in this role (although if they are available, great). Rather, a business analyst that understands business and is capable of writing complex Excel spreadsheets should work very well. Ideal backgrounds include Engineering, Economics, Math, Accounting, Actuarial, and Business Operations Management.

- PROBLEM DEFINITION: Expertise in the subject matter, including how the business works and the business problem at hand. These are experienced practitioners that can describe the problem in detail, understand the data, and help define a vision for the solution, to include the business planning process and data sources. They tend to be planners, analysts, or FP&A professionals.

- APPLICATION DESIGN: This role is responsible for embedding the prescriptive analytics model into a broader application that supports the business planning process. The activities supported include data management/transformation, data integration, workflow configuration, and User Interface (UI) configuration. Usually, a solution architect is a great starting point. If the UI requirement is complex or requires unusual expertise, it is also good practice to enlist a BI Expert who can help configure UIs and reports.

- FINANCE: While this role is optional, prescriptive analytics projects with transformational ambitions should include a finance professional. This person should be focused on ensuring the model represents the financials as the business incurs them, including managerial (i.e., cost accounting, marginal contribution) and financial accounting (i.e., P&L, cash flow)

05 UNDERSTANDING THE **AVAILABLE TECHNOLOGY**

OVERVIEW

This chapter discusses important considerations when purchasing prescriptive analytics technology. Some of these are tough questions you must ask of your organization. Is your company capable of successfully adopting prescriptive analytics?

Whether rules or optimization-based, there are two primary technology approaches for prescriptive analytics: packaged applications and optimization platforms.

A packaged application is a fully functional program developed by the vendor that requires an installation or subscription plus configuration, but no additional coding. The answers provided can be either rules or optimization-based. Some configuration can be required, such as choosing which components or modules are installed. Sometimes, you can customize parts of packaged applications to meet specific requirements.

Software companies with packaged applications in the prescriptive analytics marketplace sell targeted solutions focused on well-defined business areas. The vendor has decided ahead of time what problem you want to solve, what data you need, what reports you want to see, and so on. Llamasoft's Supply Chain Guru, which focuses on network optimization and JDA's Manufacturing Planning solutions, are two such examples.

An optimization platform is used to create applications and requires customization. Most platforms still run in Windows or Linux and require a license. Whereas a packaged application might be marketed explicitly for inventory management, an optimization platform can allow you the ability to create your own applications for inventory, capacity, demand, and various other uses.

Platform software can require you to create the math. Advanced Interactive Multidimensional Modeling System (AIMMS) and IBM's CPLEX Optimization Studio are two such programs. Other software, such as River Logic's Enterprise Optimizer, have a drag and drop visual user interface, where you draw a picture to define the problem.

Both optimization-based packaged applications and platforms rely on highly specialized algorithms, called optimization solvers, to find answers. IBM's CPLEX, Gurobi, and FICO's Xpress are examples of market leading solvers. In a packaged application, the use of a solver might not be visible in the user interface. For this reason, we include the discussion of solvers below with optimization platforms, since all platforms must interact with solvers explicitly.

The figure below highlights the difference between the two approaches. The two boxes on the left comprise some of the vendors who sell optimization modeling platforms and solvers. The box on the right lists a few primary business-related subject areas served by packaged application software.

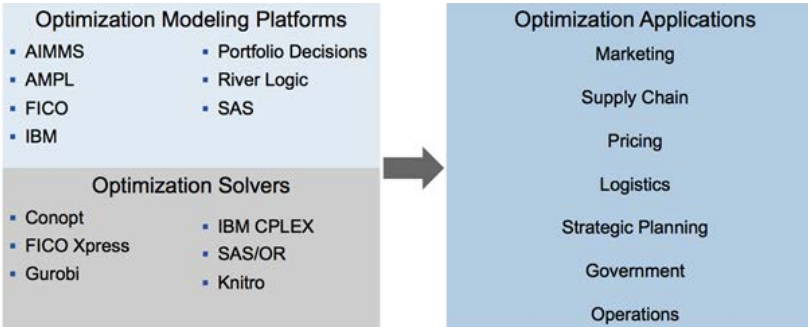


Figure 3. Optimization solvers, platforms and applications (Gartner, 2017)

As you read the following pages, keep in mind that modeling platforms and solvers are used to create applications, whereas the packaged applications are programs where the software vendors have already done most of the work for you. The best choice for you depends on many criteria. In the following pages, we explore in-depth the fundamental differences as well as provide examples, pros, and cons of each option.

PACKAGED **APPLICATIONS**

DEFINING A PACKAGED PRESCRIPTIVE ANALYTICS APPLICATION

Upon seeing a packaged application, you should be able to quickly and easily understand what the product is (i.e., which problem does it solve), how you would use it, and what kind of output analysis you should expect.

Since the prescriptive analytics market for packaged applications is relatively new, most are cloud-based. Major advantages of software-as-a-service (SaaS) or platform-as-a-service (PaaS), include only paying for the hardware and software that you consume and having the software installed and maintained by the vendor. Typically, customers have immediate access to the latest release. Implementation time from kickoff to user acceptance should be measurable in days or weeks, not months or years.

Most knowledge transfer from a vendor or consultant to your organization should occur through established training programs, either in an online knowledge base, within the product itself or in a classroom. Ideally, there are example models and other documentation that resemble your company's issues.

Only a "reasonable" amount of configuration, integration, training, and support should be necessary to start. Configuration can include setting up user accounts and defining master data. Integration can also include using vendor provided templates and doing whatever work is necessary to upload data files.

Some applications allow for direct connections to other data sources needed for

data input (i.e., ETL using Microsoft SSIS) and to other programs dependent on the output for analysis (e.g., BI tools like Microsoft Power BI). This can be an issue if your organization doesn't allow data outside your company's firewall.

If it appears to require a high degree of customization, including writing math equations, it probably does not meet the definition of a packaged application. A packaged application using optimization will never require a user to write math. Consequently, vendors of packaged applications will rarely make their proprietary code available to customers. Sometimes, potential customers decide that they don't like the "black box" aspect of packaged software, but it can work quite well because each customer directly benefits from all other customer's experience.

PACKAGED SOLUTIONS ON THE MARKET TODAY

This list includes applications identified as meeting the criteria for packaged applications. We cannot guarantee; however, that is always true. What can appear as a relatively simple packaged application might require a substantial amount of effort to get working.

As for costs, most packaged technologies, especially web-based, require subscriptions to access the software. This is usually done per user or by the enterprise with each user's access to features determined by the type of role they are assigned. Subscription fees can range from several hundred dollars per month, per user to millions of dollars per year, per enterprise license.

Most web-based packaged applications to date are focused on consumer packaged goods and retailers, which is primarily due to companies having the necessary data and the real need to optimize their complete customer acquisition and retention strategy and operations:

Table 4. Typical Packaged Solutions

VENDOR	DESCRIPTION	WEBSITE
Angoss	Marketing optimization	www.angoss.com
JDA	Solutions for manufacturing, retail and service industries	www.jda.com
Llamasoft	Network optimization	www.llamasoft.com
Manthan	Customer analytics solution	www.manthan.com
Profitect	Retail solutions	www.profitect..com
River Logic	A Microsoft Azurebased platform for building prescriptive analytics applications without writing code	www.riverlogic.com
Rockwell Automation	Prescriptive maintenance solutions	www.rokeellautomation.com
Zilliant	Pricing optimization	www. zilliant.com

PROS

- Good for well-defined problems — e.g., airline pricing
- Good for large industries with many companies — e.g., retail
- SaaS (web) based applications don't require installation; can get up and running within hours or days, not weeks or months
- No requirement to write math equations (math embedded in application)
- Limited need for company IT resources
- Easier collaboration

CONS

- Fewer applications exist for smaller industries
- Fewer applications exist for complex problems
- Might not perfectly meet your requirements
- Can be difficult to understand how answer was found
- Must rely on the software vendor to fix bugs and add critical enhancements

OPTIMIZATION **PLATFORMS**

Optimization platforms consist of two types of software: modeling platforms and solvers. A modeling environment is a software used to write the mathematics needed to define the problem. This step can either be done by coding in a language or with a drag and drop user interface. Solvers are specialized software programs designed to provide an exact solution.

DEFINING A MODELING PLATFORM

A modeling platform software is used to define problems. It can require writing math equations or use a drag and drop visual interface. Program names typically contain words like developer, modeler, studio, toolbox, or similar variations of those. Most modeling software requires installation

on computers running Windows or Linux operating systems. Licenses are frequently required, which can be tied to a specific user, machine, or for use by an organization. Established around 30 years ago, there are approximately 50 such products on the market today.

DEFINING A SOLVER

An optimization solver is a software designed to solve problems using one or more exact algorithms. Problems defined in a modeling environment are combined with data and then input to a solver. The solver then uses various techniques to arrive at an answer. The quality of the solution is highly dependent on problem definition, data quality, and the user's willingness to allow the solver to find the best possible answer.

MODELING PLATFORMS AND SOLVERS ON THE MARKET TODAY

The costs of modeling software and commercial solvers vary greatly. Algebraic modeling software can range from free for trial/academic use to hundreds of thousands of dollars for enterprise licenses. Commercial solvers can range from a few hundred dollars per machine on the low end; to millions of dollars per year for unlimited use across a large enterprise.

We have grouped all vendors into a single list, including free/open source and proprietary. Some vendors sell only modeling environments, some sell only commercial solvers; and some sell both:

Table 5. Typical Optimization Platforms

VENDOR	DESCRIPTION	WEBSITE
Advanced Interactive Multidimensional Modeling System (AIMMS)	Modeling language and development environment. Includes limited dashboard building capabilities	www.aimms.com
A Mathematical Programming Language (AMPL)	Algebraic modeling language and development environment	www.ampl.com
Computational Infrastructure for Operations Research (COINOR)	A popular open source software	www.coin-or.org
FICO Xpress Optimization Suite	Modeling development environment and solver	www.fico.com
Frontline	Solver for Excel. Widely used by students. Extensions for industrial-sized problems	www.solver.com
General Algebraic Modeling System (GAMS)	Modeling system for mathematical programming problems	www.gams.com
Gurobi	Solver, with integration with many modeling languages	www.gurobi.com

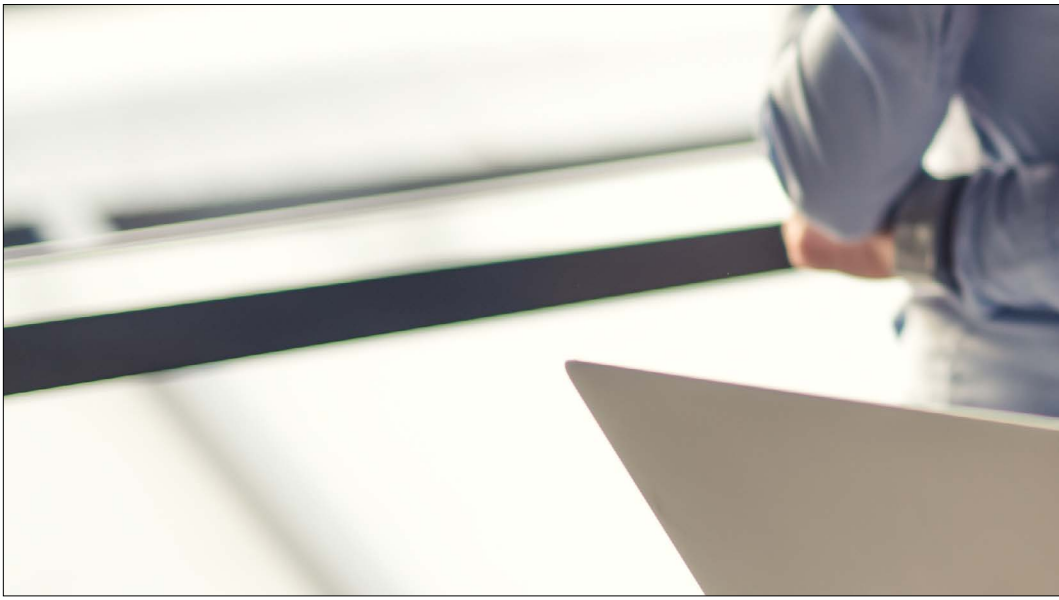
IBM CPLEX Optimization Studio	Algebraic modeling language and development environment and solver	www.ibm.com
LINDO	Algebraic modeling language and development environment. The "What's Best!" Excel add-in uses LINDO	www.lindo.com
Mathematica	One of the early pioneers of symbolic computational mathematics	www.mathematica.com
MATLAB	Optimization toolbox includes many algorithms and techniques	www.mathworks.com
MOSEK	Solver for largescale problems	www.mosek.com
OptaPlanner from RedHat	A heuristicsbased open source constraint solver	http://www.optaplanner.org
River Logic	Code-free, dragand- drop modeling environment	www.riverlogic.com
Statistical Analysis System (SAS)	High-performance optimization modeling environment	www.sas.com

PROS

- Good for highly customized solutions
- Good for highly specialized companies
- Good for difficult to solve problems
- Good for companies with IT policies that require everything behind the company's firewall
- Mature technology—most vendors have been in existence 20 to 30+ years

CONS

- Can require an OR expert to write math
- Most platforms don't have end-user interfaces. You must build your own
- Commercial solver market has relatively few good choices

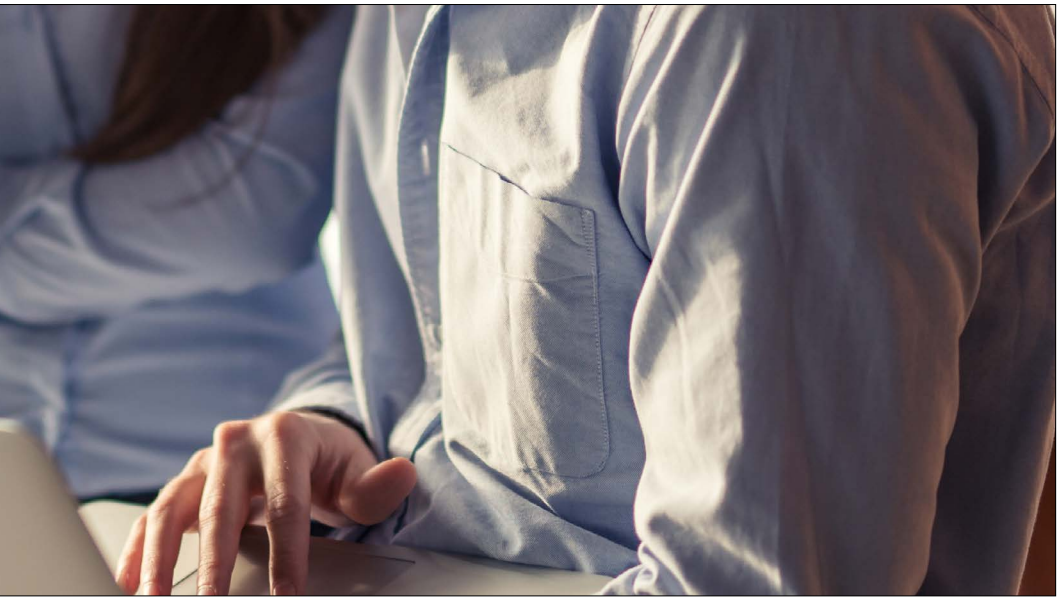


THINGS **TO CONSIDER**

The technology needs to support and enhance the organization's ability to maximize attainment of the objectives while minimizing the risk. It is, therefore, important to articulate the needs not only for the first use case, but also more broadly to support a longer-term vision for how prescriptive analytics will support Planning and Decision Making needs. The key areas that should be considered include Modeling, User Interface, Data Management, and Architecture.

MODELING

This section guides you on whether to use a modeling platform or a packaged application (which has a hard-coded model inside) and helps you understand what the platform/packaged application needs to support. Here are some questions that may help make the best determination:



QUESTIONS **TO CONSIDER**

Can the problem be expressed in the platform or application?

Pay close attention to the key constraints that must be respected to get a feasible/optimal outcome — especially if the solution requires ratios, blending, financial ratios, special ordered sets, or conditional minimums

Does the technology have the flexibility to support future changes in the business? Can it add new constraints and objectives?

Pay close attention to the key constraints that must be respected to get a feasible/optimal outcome — especially if the solution requires ratios, blending, financial ratios, special ordered sets, or conditional minimums..

How well does the technology support financials as both inputs and outputs?

Make sure the financial modeling includes the managerial side (i.e., financials modeled as incurred by the business, like fixed costs, variable cost/ unit, variable cost/hour, variable cost/customer, base revenue, revenue associated with discounts, etc.). Make sure it is also expressed in financial accounting terms, as many of the organization's constraints and targets are reflected through P&L, Cash Flow statement, etc. (think of working capital, debt to equity ratios, net income as an objective, etc.)

How easy/fast is it for personnel to learn, configure and deploy models? Is it a visual, drag-and drop language or do you need to write/ manage thousands of equations? Does it require an Operations Research Ph.D. or can an astute business analyst handle it?

Note that it is customary these days for prescriptive analytics technology to embed expert knowledge and be configurable in days/weeks by a business analyst. Try to avoid the situation where you become dependent on an expert modeler who is the only person able to edit/manage a "black box" model that contains thousands of equations

.Is error checking included out of the box, or does it need to be added in?

Think of variable definitions, data gaps, material balances, financial auditing, etc. This can add significant work — as many as four to eight weeks — to the development of even a medium complexity model

USER **INTERFACE (UI)**

In 99% of the cases, there is more than one person who can/should interact with and benefit from the prescriptive analytics model. These users are normally business people who have multiple tasks and cannot devote too much time to using a "raw" model. Therefore, there is a need for them to interact with the model through an interface. Below are some key considerations for the interface:

IS IT INTUITIVE AND EASY TO LEARN?

- Does it support entering information and visualizing inputs? Think of identifying exceptions, spotting outliers, and entering information at different levels of aggregation (for example at an SKU/product/brand level).
- Can a user define, configure, and run optimization scenarios? Beyond simply running a scenario (say from the web), does it enable the right level of scenario management and collaboration? This may include running scenarios in private, sharing scenarios with colleagues, managing parent/child relationships, and simulating multiple scenarios.
- Are the reports capable of supporting the right visualization? Do they have a filtering capability? Can end users edit the reports? Can it be xported into Microsoft Office?
- Is the UI configurable or does it require programming to deploy?

DATA MANAGEMENT

The prescriptive analytics model usually requires a significant amount of data, some of which needs to be cleaned up and approved before use. Key areas of focus include:

- Does the platform have tools to bring data in? Can it transform the data for use? Can it run checks to identify missing data?
- Does it support a proper workflow, where data comes in, a user reviews/edits it, another user approves it, etc.?
- Is the data available for use by other applications? Does the solution have APIs?

ARCHITECTURE

While IT professionals likely have an extensive list of checks, here we focus primarily on applying a business lens. As such, you might consider the following questions:

Is the offering Cloud-based? And what would I need to install on premises, if anything occurs? If Cloud based, you would save time to install, require less knowledge to manage and reduce the hardware requirements. Plus — if the application is truly elastic — you will have more scalability. On the converse, make sure the vendor has set up the proper security levels.

Where will the data be stored? Is it in a standard database such as Microsoft's Structured Query Language (SQL) Server, or does the vendor have a proprietary database that may create a longer-term dependency and risk? If the data is very sensitive, does the vendor support a hybrid model where the data can reside on-premises yet the organization can still benefit from Cloud-based features such as scalability and user interfaces?

CONFIGURE **OR OUTSOURCE?**

The value from prescriptive analytics can be transformational, so delaying the initiative due to lack of resources may create too large an opportunity cost for the organization. The good news is that service providers (i.e., consultants) are increasingly investing in prescriptive analytics capabilities and they are a great source of talent to get an initiative launched.

The key considerations include personnel availability, skills, knowledge, cost, and risk. While personnel availability is straight forward, skills and knowledge are not always so. If you have a service provider with deep knowledge in Prescriptive, it may be better to have them help you even if over time you transition the project to internal resources. This approach may be more costly, but it can greatly enhance the knowledge in your organization while reducing the risk. Some service providers will also take "at risk" contracts where their upside is completely aligned with yours — this is a great way to maximize the return on that critical first project.

Finally, consider analytics as a service offering from service providers. These services may include just the development and management of the models or can also include configuring, maintaining, and even running the full application. Service providers have deep expertise in making these systems work. Nevertheless, make sure that you have an opportunity to learn and that you can bring the capability into your organization at the right time.

CONFIGURE YOUR OWN

PROS

- You can get exactly what you want
- Answer performance and result can be highly tuned
- Your organization retains the knowledge
- You work directly with software vendors, who often have specialized knowledge to help you get up and running fastest — remember their interest is in your adopting and getting value from the software

CONS

- Requires a software subscription, although now with cloud vendors, there is a limited need for IT resources and installation
- You might need to hire someone with specialized modeling skills depending on the software you choose
- It may take you time to find the resources if they aren't already in your organization

OUTSOURCE

PROS

- You can get exactly what you want — depending on the service provider, it may require some education on the use case.
- A good service provider brings knowledge and best practices in the space.
- Your organization won't need to hire the expertise directly, so you can potentially move faster.
- Service providers are good at change management to help you adopt and receive value from the initiative.
- You can onboard the resources from the service provider when you are ready to do so.

CONS

- You become reliant on another company's expertise
- Despite claims of confidentiality and internal "Chinese walls," there is a chance your unique knowledge will become part of industry best practices over time.
- It may cost you more than using internal resources.

06 APPLICATIONS OF **PRESCRIPTIVE ANALYTICS**

MINING AND RESOURCES **BLENDING CASE STUDY**

COMPANY OVERVIEW

- Top Russian producer of thermal coal – annual production volume ~100m tons
- Complex supply chain
  - Production: 30 mines, 30 coal enrichment plants, 40 coal storage areas, 150 finished goods SKUs, and 80 production BOMs
  - Transportation and delivery: 25 railway stations, 35 ways to road transport between storage sites, and 4 modes of delivery
- Diverse customer base
  - 500+ domestic clients purchasing in a mix of contract and spot with opportunities for product substitution
  - 300+ export clients (~40% of volume) requiring specific qualities across 15 types of export blends with constraints on 4 qualitative characteristics

KEY CHALLENGES

- Production, sales, and financial plans are created in sequence, making it impossible to meet all relevant restrictions and requirements
  - **First**: Production plan (only tons) developed by the Production unit in consultation with the Commercial and Financial blocks
  - **Second**: Sales and Delivery plans (tons, transport costs, and revenues) developed by the Commercial department in accordance with the Production plan and consultation with the Financial unit
  - **Third:** Financial forecasts (P&Ls, intercompany transfer prices) calculated by Finance after the Sales and Delivery plans were approved
- Limited ability to holistically optimize plans or create and analyze what-if scenarios

- Long, arduous effort to balance production and sales plans
  - Consuming FTEs
  - Limiting business agility and increasing the possibility of error in the planning process

SOLUTION

- Enable the use of optimization in planning activities to improve the profitability of sales and production decisions 3 to 18 months out
- Transition to an integrated model allowing productions, sales, marketing and finance plans to be created and analyzed simultaneously (vs. sequentially)
- Reduce the planning cycle while improving the level of insights, opportunity analysis and comparison of multiple production and sales plans
- Ensure involvement of all key stakeholders (e.g., Sales, Production, Finance) in the planning process

PROJECT IMPACT

- PROFITABILITY: $250m USD annual margin increase (4% of revenue)
- CUSTOMER SATISFACTION: 100% customer satisfaction
- PLANNING AGILITY: Improved ability to quickly react to unplanned circumstances and events
- RESOURCE TIME: 200% reduction in required resource time
- FORECAST ACCURACY: Production, Sales, Delivery, and Financial plans are the result of an integrated business model

CONSUMER **PACKAGED GOODS**

COMPANY OVERVIEW

This packaged goods company is a Fortune 1000 manufacturer of consumer products that owns several well-known consumer brands and serves most segments of the North American market. It's relatively integrated and develops, manufactures, and distributes most of the products it sells.

KEY CHALLENGES

The company has experienced significant growth in the last 10 years under the current management team; however, fast growth has also made it more difficult for executives to make the best decisions. Even after examining the best products from ERP, supply chain management, and analytics software providers, management believed these products would not give them the competitive advantage they sought.

COMMON UNANSWERED QUESTIONS INCLUDED:

- How can we maximize the profitability of the product portfolio?
- Where should we add or subtract capacity to maximize ROIC and profits (e.g., plants, production lines, distribution centers, etc.)?
- What manufacturing plants should make which products?
- What is the inventory strategy that yields the highest cash flow while maintaining acceptable levels of inventory turns?

SOLUTION

In 2004, the company's Chief Planning Officer was introduced to River Logic's Optimization and Modeling Solution by a business school professor. He quickly selected River Logic as the preferred modeling and planning solution for the company. Recently, they have built and deployed five River Logic models to drive their business.

THE COMPANY BUILT FIVE MODELS WITH RIVER LOGIC:

- A long-range planning model to evaluate strategic issues (e.g., capacity, capital expenditures, and product portfolio)
- A medium-range planning model to determine inventory strategy and tactical issues, including which plants should make which products
- An operational planning model to define production sequencing and shift scheduling
- A distribution model to determine the optimal distribution strategy
- A truck loading and handling model to maximize efficiency and minimize costs

IMPACT

To date, the medium-range and loading models have enabled the company to capture significant quantitative and qualitative benefits, resulting in an ROI of 1,000% to 2,000%. Qualitatively, the models have resulted in better and faster decisions and insights that transformed the way the company makes decisions. For example, management now understands that only a system-wide view of financials and operations — one that includes business constraints — yields the best decisions.

PUBLIC SECTOR **USE CASE**

COMPANY OVERVIEW

- Public company with a $15.4 billion annual budget and over 45,000 employees
- Need to continually train 'Technical Operations' staff across 100+ facilities that did all the airport maintenance at these facilities including a variety of things, from cutting the grass to making sure Air Traffic Control machines are functioning properly.

KEY CHALLENGES

- The company needed to understand how to optimally staff each facility so they could continually train enough staff to maintain all the equipment within their constrained resources:

» Limited number of instructors for courses

» Limited number of classroom seats for each course

» Limited budget to fund all of the training

- Current processes for capturing training requirements from the field through the creation and submission of training plans are inefficient, unnecessarily burdensome, and not conducive for accurate identification and prioritization of training needs at the System Support Center (SSC) level.
- The roles of First Level Managers (FLMs), Program Support Specialists (PSSs), and others involved in the identification and capture of training requirements needed to be more clearly delineated, consistent with each one's actual level of visibility and responsibility.
- Quota management processes for identifying and validating training requirements were time consuming and dependent largely on manual processes that do not fully utilize training requirements information available in FAA data systems.

- Decisions related to quota allocation and course scheduling were partly based on subjective determinations, and are made without the support of analytical tools or models to assist in determining most efficient outcomes to maximize training coverage based on prioritization criteria and to ensure the best use of available capacity.
- Systems failed to communicate course prioritization at the facility and district levels effectively.

SOLUTION

- The solution enabled them to determine which courses to offer in which weeks in the upcoming year and which staff from which facility would get seats to those courses.
- It allowed them to create and analyze what-if scenarios around more/less budget, external instructors, and higher/lower staff attrition.

IMPACT

- A 10% increase in the total number of staff trained without increasing teachers, classrooms or budget was realized within the first year of implementation.
- Ongoing work is being done to build out a full solution that enables the company to update the training schedule on a more frequent basis quickly and expand the use to other related decisions — e.g., hiring and new equipment planning.

UTILITIES

COMPANY OVERVIEW

Key characteristics of organization:

- £900m Turnover/yr
- 2000 vendors & 3000 employees
- 50+ Reservoirs
- 70 Water treatment works
- 60,000 km distribution pipes
- 1 billion liters of water delivered daily to 5 million Customers
- 1.6 billion liters waste water treated daily across 50,000km sewers
- 5 million tons sewage sludge yearly
- 630 Sewage treatment works

KEY CHALLENGES

- Assist in determining the most optimum outperformance tactics in AMP planning
- Understand the best trade-offs available considering regulatory incentives and penalties and assist the support of targeting the metrics that should, can or should not be allowed to fail in order to maximize the incentives to be obtained from the regulator; subject to financial and operational constraints
- Understand the systemic effect of the realization of risks, which will then inform the amount of self-cover versus insured cover

TYPICAL UNANSWERED QUESTIONS WERE:

- What is the long-term sustainability strategy? Should we only invest assets, or is it more sustainable to invest in catchments, conservation, and demand

management initiatives and if so to what extent?

- How do we manage the surrounding environment (e.g., peat bogs, grasslands)? What is the impact on sustainability and carbon emissions from the activities of the organization?
- How much Capex to deploy in AMP6 and where and what is the impact on Opex? How can we determine the optimum blend of Capex and Opex such that Totex of the model horizon is minimized?
- What are the key risks (e.g., climate change, asset criticality, and failure analysis) and their potential financial risks as well as operational impact? What are the optimal prevention and response strategies?
- What are the right metrics and strategic targets for the company?

SOLUTION

An integrated operational and financial model of the business can identify optimal plans and risk mitigation strategies.

IMPACT

- Improved return for shareholders while managing the risk of long-term delivery of regulatory targets
- Management of catchments to gain potential energy cost reductions of 3%
- Minimization of carbon emissions to offset potential carbon taxation proposals
- The realization of outperformance targets more than the previous AMP
- A new perspective on long term asset investment approach.

07 WHAT LIES AHEAD FOR **PRESCRIPTIVE ANALYTICS?**

OVERVIEW

Where are we headed with prescriptive analytics? What can we expect in the next few years? Will it be disruptive in the workplace; will it lead to more or fewer opportunities and jobs? One thing is for sure, the digitalization of business and organizations, and the way we interact with the everyday world is well underway. Prescriptive analytics, artificial intelligence (AI), machine learning (ML), Internet of Things (IoT), and Big Data are fundamental aspects of digitalization.

Currently, information and content in organizations and businesses are being digitized. We are collecting and converting increasingly more information and "raw" data in a digital format. This gives us the opportunity to apply analytical techniques to:

- Identify the patterns of (business, organization, customer...) behavior; Big Data, IoT, Data Science
- Learn and understand the patterns of (business, organization, customer...) behavior; AI and ML
- Prescribe and optimize the patterns of (business, organization, customer...) behavior; prescriptive analytics, AI, and ML

This, in turn, will enable business and organizations to:

- Improve and optimize their existing operations
- Identify and realize the best opportunities they have

MACHINE LEARNING AND **ARTIFICIAL INTELLIGENCE**

To understand how the workplace may change, we can look at our current everyday environment, where we are becoming more and more reliant on ML and AI. Take the advanced driver assistance system that now comes standard in just about every new car: parking assistance, anti-collision assistance, and lane change monitoring assistance. These ML and AI systems aid the driver in all sorts of day-to-day situations making driving safer and easier. Fundamentally they help and supplement the decision-making of the driver.

The assistance in day-to-day decision-making is how we are and will see, ML and AI affecting the workplace more and more including the following examples:

PRODUCT INTELLIGENCE

- Identifying, presenting, and recommending relevant products
- Quicker, more informative product success/lack of success insights
- Predictive/preventative maintenance
- Product success/failure diagnosis

PERSONAL/CUSTOMER INTELLIGENCE

- Learning individual (customer) preferences and behavioral characteristics
- Predicting individual behavior and behavior
- Personal/collective sentiment analysis
- Intelligent segment, cohort identification

AUTOMATION

- "Smart" services, such as customer service, travel, buying, home/business automation
- Financial fraud and identity detection and alerting
- Logistics processing
- Monitoring Overall Equipment Effectiveness (OEE)

HOW PRESCRIPTIVE FITS IN **WITH EMERGING TRENDS**

The above are example use cases that demonstrate how AI and ML are impacting organizations and businesses. The emergence of prescriptive analytics, harnessing AI and ML, to drive the best (optimized) decision-making across the breadth of an organization and business provides important, tangible value. Delivered on scalable cloud computing platforms means leading organizations and businesses are already utilizing prescriptive analytics and generating significant insights and value that have previously been out of reach.

But tension and concern exist with the potential impact of prescriptive analytics, AI, and ML for replacing jobs and roles in organizational processes. This tension and concern come down to the distinction between prescriptive analytics, AI, and ML for Process and Decision Automation compared with prescriptive analytics, AI, and ML for Augmented Decision Making. In this context, Process and Decision Automation is the potential replacement of human jobs and roles with technology, while Augmented Decision Making is about aiding people in decision making and making them more productive. There is an analogy for the AI/ML/decision automation that exists within self-driving car technology and the advanced driving assistance that are still used by human drivers. Although technically self-driving cars are advancing in their capability, the human concerns and acceptance of the user experience are significant and one of the major barriers to the rapid scale adoption.

What the self-driving car will deliver is a (fundamental) change in the car driving experience. Likewise, the impact of prescriptive analytics, AI, and ML in the workplace will change the work experience and redefine the jobs and roles. In organizations and business, we will see the growing presence of Augmented Decision Making through more informed, prescriptive analytics that helps and guides decision-makers to examine and determine the best course of action. Focusing prescriptive analytics, AI, and ML on use cases that add value to people's capabilities and performance as well as process value is essential to successful organizational adoption.

The technological revolution that is underway will fundamentally change the way we live and work. AI and ML are already becoming more relevant in our day-to-day lives (beyond the driving assistance in cars). Alexa, Cortana, and Siri, as AI Assistants, are now commonly used and referred to. One important aspect of the AI Assistant adoption has been the User Experience (UX) developed to make them natural and normal to use.

Advancements in prescriptive analytics, AI, and ML need to make people's jobs more productive and simpler from a UX perspective. The challenge for businesses in progressing prescriptive analytics is twofold:

- The limitation of handcrafting (programming) prescriptive analytics, ML, and AI algorithms
- Developing a UX that encourages widespread adoption and usage above and beyond traditional enterprise software tools

THE LIMITATION OF **HANDCRAFTING (PROGRAMMING)**

The challenge for developing prescriptive analytics, AI, and ML is beyond writing the code. The scope requires fundamental integration of other subject matters including advanced mathematical concepts, sophisticated algorithms, and deep data analytics and learning. Developing prescriptive analytics from scratch (handcrafted coding) is time consuming and limiting.

Moving forward, we are seeing the emergence of "smart" prescriptive analytics solutions that self-generate the complex algorithms and inject the domain expertise to overcome the human programming limitations. This approach enables non-technical, business and subject matter people to define and articulate the scope and application of prescriptive analytics. The need, therefore, is a UX approach that encourages and engages people in using prescriptive analytics systems. By exposing prescriptive analytics systems to more users, the system can learn and become more intelligent and smarter.

DEVELOPING A UX THAT **ENCOURAGES WIDESPREAD ADOPTION**

To encourage and enable widespread adoption, a UX approach is needed that is distinct from the traditional enterprise software tool and personal productivity application where significant time and investment is needed for users to learn and be trained. The UX approach needs to be grounded in basic concepts:

- Product design aesthetics that utilize visual, touch and voice interactions
- Modern prescriptive application experience distinct from traditional software tool experience
- Device ubiquity and preferences that support "always connected"
- Web/Search immediacy — the simplest, quickest approach

Through these UX concepts, the prescriptive analytics experience enables:

- People to have up-to-date, prescriptive, relevant information in context without being overloaded with detail
- People to make more informed decisions sooner through the presentation of tailored, real-time, reality-based, and prescriptive information in social contexts in which they can collaborate
- People to have more realistic and relevant simulations tailored to the specific needs of the context they are in.
- Consequence analysis, i.e., decision making is improved through an understanding of the consequences of action based on current choices and information available

THE FUTURE IS POWERED **BY PRESCRIPTIVE**

The growth and adoption of prescriptive analytics, AI, and ML are being fueled by more scalable and powerful cloud computing. AI and Ml are proliferating the need for Big Data at an accelerated rate. The IoT is delivering more connected devices increasingly as sources of data.

Prescriptive analytics demands more complex algorithms and mathematical modeling capabilities. Alongside the scaling of cloud computing, raw computing power is also increasing significantly. On the horizon is the advent of Exascale computing delivering over one exaflop (1 billion) calculations per second, over 50 times the performance of current 20 petaflop-capable systems that are now among the fastest in the world. Alongside increasing traditional computing power, the initial availability of commercial quantum computers is increasing. Both Exascale and quantum computing will add processing capabilities that will power prescriptive analytics, AI, and ML even more dramatically. More complex and wide-ranging prescriptive analytics will enable more and more interactions into real-time.

Prescriptive analytics, AI, and ML will become more prominent in organizations and business. The augmentation of decision-making will enable optimal outcomes to be determined and scaled across the breadth and depth of organizations and will be explicitly tied into the overall business outcomes.