Applying prescriptive analytics to manufacturing network challenges
Manufacturers, including a leading maker of building concrete, are using a new class of analytics tools to help make difficult choices in markets filled with irregular constraints.

If manufacturing supply chains were regular and free of constraints, the task of planning networks and capacity would be easy. Plant executives could simply pick a software tool that provides a one-size-fits-all solution, and then, with very little effort, serve their customer demands at the lowest possible cost.

In the real world, however, manufacturing supply chains are bound by numerous constraints, both universal (skewed demand profiles, delivery-time requirements) and unique to individual manufacturing subsectors (automotive, household appliances, building materials or others). Many of today’s off-the-shelf analytics tools are far too generic to handle the challenges of real-world capacity planning.

In addition, many planning tools offer only predictive analytics, when what’s needed for many strategic decisions is prescriptive analytics. What’s the difference? Predictive analytics forecast future patterns and capacity based on patterns observed in the past. By contrast, prescriptive analytics apply optimization techniques to help managers make the best strategic decisions for their businesses.

For example, prescriptive analytics could be used to help answer these types of questions: Given our organization’s constraints and requirements, where is the best location worldwide for a new factory or warehouse? And what steps do we need to take now to best serve a new market while also earning the maximum possible revenue?

These kinds of decisions are not only strategic but — in contrast to tactical decisions made on a frequent, even daily basis — are also typically made only infrequently. Similarly, while tactical moves can be revised with relative ease and speed, changing these sorts of strategic decisions, especially once implemented, is typically quite difficult, costly and time-consuming. As a result, a different type of analytical tool is required.

Concrete solution

For an example of how prescriptive analytics can help with real-world strategy, consider a recent project completed by DXC Technology for one of our clients, a major manufacturer of concrete.

The company needed to answer a single strategic question: What factory locations and capacities would best serve our customers over the next 10 years while also minimizing our total cost to serve (TCS)?
Although concrete may be a relatively simple product, the company’s business constraints were anything but. Answering that seemingly simple question involved approximately 200,000 variables and 14,000 constraints. These included:

- **Product categories.** The company offered its customers no fewer than 920 types of concrete, based on a long list of characteristics, including relative strengths and aggregates.

- **Time pressure.** After concrete is formulated, it must be delivered to the customer and used within 90 minutes. Any longer, and the concrete sets and becomes useless.

- **Daily demand periods.** Many of the company’s customers, including construction firms, work early in the day. Therefore, the company’s peak period of demand was weekdays from 7:00 a.m. to 9:00 a.m.

- **Seasonal demand periods.** Construction activity can vary not only by the season but even by the day. During the winter, the company’s activity could be reduced, as concrete is difficult to work with when outdoor temperatures drop below freezing. But construction work could also be halted during warm months, typically in the event of hazardous weather such as lightning storms and high winds.

- **Customer locations.** Geographically, the company’s customers were widely dispersed. As a result, planning delivery schedules, including customer grouping, was complex.

**Developing key drivers**

We first reviewed available off-the-shelf solutions for supply-chain network design to determine whether any could meet the company’s needs. Unfortunately, the generic nature of these solutions quickly became apparent. We realized they would be unable to incorporate the company’s real-life business constraints, including skewed demand profiles and constrained delivery times.

As a result, we decided to create our own custom solution. The first step toward solving this complex challenge was to join company executives for several brainstorming sessions. The goal: define and agree on the company’s key drivers of manufacturing capacity and network costs.

During these meetings, we quickly identified two types of drivers facing the company: those based on supply-chain networks and those based on transactions. The supply-chain network-based drivers included possible plant locations, product categories and customer locations. And the transactional drivers included 10-year demand projections and a long list of cost parameters, including fixed, variable, material and transportation costs.
Data analysis and modeling

Next, we needed to begin the massive task of analyzing the company’s data and then modeling that data for prescriptive analytics. This project was large enough that we organized it into six subprojects:

- **Database creation.** The company needed a database of its driver values. To create this database, we used historical reports from internal and external sources. We then developed these same values for the future, using the consumer price index (CPI) and arranging future demand locations by customer and product category.

- **Product categorization.** The company’s extensive inventory of concrete products served its customers well, but from a prescriptive-analytics perspective, it created far too many variables. To simplify matters, we cleansed the product data and then segmented all 920 products into a far more manageable number of only 18 groups. Each of these groups was organized by products with similar attributes and required plant capacities.

- **Customer location-mapping.** Given that concrete must be used quickly after processing, the location of the company’s customers remained a vital factor for planning. Any new plant would need to be close enough to customers to deliver concrete in less than 90 minutes. We used text mining to generate shipping addresses from historical forms, then fed that data into the Google Maps API to obtain associated postal codes and latitude/longitude. Finally, we grouped the customer locations by proximity.

- **Optimization modeling.** For this activity, we wanted to answer an important question: How much capacity would any new plant need to fulfill customer demand for the next 10 years? The answer required us to consider multiple dimensions of factors, including demand variability, construction lead times, product categories, customer location groupings and even the changing cost of capital. Our modeling approach and architecture for this challenge are shown in Figure 1.
• **Demand profiles and scenarios.** Here we sought to answer another of the company’s important questions: Given daily and seasonal fluctuations in demand, how much capacity would each concrete plant need? To devise an answer, we first created a demand profile (Figure 2). This was then used to determine whether the planned capacity for an individual plant would be sufficient. Finally, we analyzed scenarios designed with seasonality indices as “choice points” to determine how much capacity a plant would likely need.

![Normalized seasonality](image)

Figure 2. Demand profile generated for a typical plant

• **Delivery-time optimization.** Given the short, 90-minute useful life of processed concrete, the company needed to understand the distance its delivery trucks — starting from a proposed new plant location — could reach in less than that time. We used the haversine formula (a method of determining the distance between two points) and latitude/longitude data to calculate straight-line distances between plants and customer locations. Then we used a model to factor in the distance a truck could actually travel in under 90 minutes.

• **“Productization.”** The total solution needed to be combined in an integrated package that could not only be used easily by the company, but also shared with others. Toward that end, we packaged the solution using several off-the-shelf components. These included HPE Vertica, a big data analytics database; GAMS, an optimization solver; and TIBCO Spotfire, an analytics platform with built-in data wrangling. We also created a generic template for future applications (Figure 3). This features an interactive user interface that lets users explore as-is and recommended manufacturing networks, locations and products.

![Screenshots from the optimization tool](image)

Figure 3. Screenshots from the optimization tool
Final results

After our solution was packaged and ready, the company was able to run the software and get its recommendations. Using our system, we were able to recommend a manufacturing plant network that should reduce the company’s TCS by two to five percent year over year. We also recommended that the company close as many as five current plants over the 10-year period while upgrading the capacity of several other plants.

Could this prescriptive analytics approach be applied to other types of manufacturers, or even companies in other industries with highly constrained variables? Certainly. For example, a movie theater chain could use prescriptive analytics to determine the best schedule for optimizing revenue given the propensity of customers to attend movies mainly in the evenings and on weekends. An airline could use analytics tools to determine how many planes it might need to serve a new route. And a shipping company could use prescriptive analytics to design the lowest-cost routes to serve customers.

When it comes to making strategic decisions in highly constrained industries, the future is with prescriptive analytics.

Ready to learn how prescriptive analytics could help your organization? Visit us today at www.dxc.technology/analytics.

About the author

Rajesh Kumar is a data science manager in DXC Data Labs. He has over 13 years of experience spanning the high tech, retail, business consulting and automotive industries. At DXC Technology, and previously at Hewlett Packard Enterprise, he has executed and managed a number of projects involving data science, supply chain and analytics. A supply chain expert, he holds a degree in mechanical engineering and a master’s in supply chain management from Indian Institute of Science Bangalore.

rajesh.kumar7@dxc.com

Learn more at www.dxc.technology/analytics

About DXC Technology

DXC Technology (DXC: NYSE) is the world’s leading independent, end-to-end IT services company, helping clients harness the power of innovation to thrive on change. Created by the merger of CSC and the Enterprise Services business of Hewlett Packard Enterprise, DXC Technology serves nearly 6,000 private and public sector clients across 70 countries. The company’s technology independence, global talent and extensive partner network combine to deliver powerful next-generation IT services and solutions. DXC Technology is recognized among the best corporate citizens globally. For more information, visit www.dxc.technology.