A 2013 finalist for the Edelman Prize, Kroger and its O.R. team are known for innovation.
Source: INFORMS and Kroger (inset)

Operations research at Kroger

Changing the game at a 134-year-old retail company where innovation enjoys a long tradition.

By Matt Sias, Greg Noble and Pooja Singh

Back in 1883 when Barney Kroger invested his life savings of $372 to start his first store, the second purchase he made was a horse and carriage so he could deliver goods to his customers. One could make the argument that Barney knew the importance of delivery before Domino's, Amazon or Blue Apron ever existed. Innovation has long been a tradition at Kroger. In the early part of the 20th century, Kroger was the first grocery store to include a bakery so customers didn't have to travel to two stores, the first to introduce self-shopping and the first to surround its stores with parking lots. As technology evolved, it became the first company to test electronic scanners in the 1970s and one of the first to formalize consumer research. In the 1990s, it was one of the first stores to test self-checkouts, and by the start of the 21st century, it had spawned an industry-leading loyalty program.

All About the Roundtable

The Roundtable consists of the institutional members of INFORMS with member company representatives typically the overall leader of O.R. activity. The Roundtable is composed of about 50 organizations that have demonstrated leadership in the application of O.R. and advanced analytics. The Roundtable culture is peer-to-peer, encouraging networking and sharing lessons learned among members.

The Roundtable meets three times a year. Roundtable goals are to improve member organizations' OR/MS practice, help Roundtable representatives grow professionally and help the OR/MS profession to thrive. Further information is available at http://roundtable.informs.org.

The Roundtable also has an advisory responsibility to INFORMS leadership. According to its bylaws, "The Roundtable shall regularly share with INFORMS leadership and advise the INFORMS Board on its views, its suggested initiatives and its implementation plans on the important problems and opportunities facing operations research and the management sciences as a profession and on the ways in which INFORMS can deal proactively with those problems and opportunities." The Roundtable Board meets with the INFORMS Board each spring to discuss topics of mutual concern.

This series of articles aims to share with the INFORMS membership at large some information and insights into how O.R. is carried on in practice today

The Kroger Co. is a 134-year-old retailer servicing more than 9 million customers every day. It is also in the business of manufacturing, distribution, finance, pharmacy, health services, fuel, real estate, jewelry, grocery, general merchandise, digital and delivery to name a few. The company's operational footprint spans more than 2,800 locations in 35 states and Washington, D.C., and with every new business line entered, every additional facility opened and each new customer served, these operations continue to increase in complexity and scale. In this fast-paced environment the operations research (O.R.) team at Kroger must harness both technological innovation and an exponentially increasing amount of data in order to help our leaders make better, more informed decisions.

While the company made its foray into advanced analytics in marketing and merchandising in the early 2000s with the establishment of dunnhumbyUSA, with a 50 percent stake, a team dedicated to O.R. didn't begin at Kroger until January 2007. The O.R. team came on the heels of the establishment of the R&D department within Technology under the leadership of Brett Bonner, vice president of R&D. When he asked Kroger's CIO for help identifying and contacting the O.R. team, he received a pat on the shoulder, a small wink and the words, "You're it." Soon after, Doug Meiser was brought into R&D to establish an O.R. team, which has flourished under his leadership.

O.R. Team Structure and Goals

Doug Meiser started as the first O.R. analyst in R&D and slowly began to build out a team of associates, consultants and academics. Meiser, now the director of Operations Research, leads a team of 20+ associates collaborating extensively with professors and Ph.D. recipients from local universities on a variety of projects touching nearly every business line in the company. Due to the diverse nature of the projects with which O.R. is now engaged, the backgrounds of the team's analysts cover a variety of skill sets that allows them to build, test, manage and scale solutions to an enterprise level. While several of the team members came internally from Kroger with various technology backgrounds, Meiser also expanded with several new hires in the areas of statistics, applied mathematics, industrial engineering, data and systems architecture and machine learning.

Just as there are many different solutions to the same problem, there are many different flavors when it comes to how O.R. practitioners are structured throughout a company. In Kroger's case, the O.R. team grew organically from within R&D with the initial goal of helping to simulate and validate new technology opportunities that would create a sustainable competitive advantage. As some of the first R&D projects were spun up, these goals evolved to include helping manage and measure these new solutions through the systems development lifecycle into production. Soon O.R. was fielding requests to take on additional projects outside of R&D with the goal of helping business partners solve some of their most complex problems. O.R. analysts are now being embedded into projects throughout the enterprise, collaborating with Kroger business partners to improve operational performance.

Early Successes

This first big success for R&D and the O.R. team involved developing and deploying the retail industry's first real-time, front-end prescriptive analytics solution for queueing that Kroger calls QueVision. What began as a button-labelled "Dynamic Lane Planning" in a discrete event simulation of a store's front-end helped Kroger answer the question, "What if we could open another lane the moment queueing conditions required it?" The results of that simulation led to a system of sensors above each entrance and register that measures the number of customers walking into Kroger stores, as well as the number of customers standing in line at each lane. Combined with a real-time transactional feed from the POS system it was now possible to make predictions on the number of customers arriving at the front end by day of week and time of day.

The system informs front-end managers on a big screen hanging above the registers how many lanes are open, how many lanes should be open now, and how many should be open in 30 minutes, in order to proactively meet the rush of customers about to arrive. This journey both defined the

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Source: Kroger

O.R. arm of the newly formed R&D department while improving one of the most significant customer experience metrics in retail: wait time at checkout. Kroger was able to measurably decrease average wait times across the organization from an average of four minutes to about 30 seconds. The company also significantly improved queueing standards with no additional impact to front-end labor. Along with being featured in *The Wall Street Journal* and *Popular Science*, this solution garnered The Kroger Co. the No. 3 spot in *Information Week's* Elite 100 in 2014.

The O.R. team soon moved beyond the realm of R&D with successful projects revolving around warehouses, inventory and new POS (point of sale) solutions. Commodity Aligned Delivery was a project that reorganized every warehouse in the enterprise to facilitate building more aisle-friendly pallets for stores based on the proximity of product in adjacent aisles. This allowed a pallet of product to be taken directly to the floor and stocked, instead of being broken down in the back room and loaded onto U-boats, reducing the time it takes a store to unload and stock each truck by an average of three hours.

In 2013, Kroger was honored to be recognized as a Franz Edelman finalist for the O.R. team's solution for Pharmacy Inventory Optimization. This was an innovative analytical approach to inventory control that combines simulation and optimization to set Min/Max re-order points for the ordering system. This solution reduced annual out-of-stocks by 1.7 million prescriptions, reduced annual inventory costs by $120 million, increased annual sales by $80 million, while reducing annual labor spent on ordering by roughly $10 million.

As part of the project aimed at improving store ordering, the simulation/optimization being leveraged in the pharmacy solution was modified to identify minimum re-order values for each shelf-stable SKU at the store level, as well as products in our fresh departments. This approach seeks to minimize the total cost by taking into account factors such as out-of-stocks, inventory costs, restocking costs, potential shrink and presentation value by simulating order movement at various minimum points in order to find the optimal solution.

In Kroger's "Scan, Bag, Go" program, where customers can scan and bag items as they shop in order to decrease the time it takes to checkout, O.R.

developed an intelligent order verification algorithm that can assess every shopping session. Certain risk factors associated with the shopping trip are then evaluated (similar to credit score models). Working closely with Loss Prevention and the MAX Team, this real-time mathematical model determines if order verification is warranted for a specific transaction.

Today, O.R. best practices and methodologies are expanding throughout the enterprise and redefining the way Technology scales and architects new solutions, how Finance prioritizes capital allocations, how Merchandising plans vendor promotions, and how our stores manage their inventory and ordering systems. Machine learning is now driving key business processes, while O.R. continuously measures and reports how the algorithms are performing against manual changes introduced by associates.

Technology and Data

The amount of data being produced by Kroger systems has been growing exponentially in the past few years. With the push into digital, the company now has online ordering and pickup, as well as delivery in some markets. In addition, Kroger has the largest deployment of the ZigBee protocol mesh network throughout its stores with more than 50,000 access points, and Kroger continues to develop new sensors and integration points that allow its associates to be more customer-centric, focusing their time on more value-added tasks.

Take for example temperature monitoring. This used to be a tedious process where an associate would go to every cooler, bin and freezer in the store each hour with a thermometer and check the temperature manually. These temperatures were then recorded with pen and paper. R&D was able to design a temperature monitoring tag that allowed Kroger to autonomously measure every cold bin in the store every 15 minutes with a higher degree of accuracy. The system could also alert management and facility maintenance to failing infrastructure so it could be proactively addressed before the equipment broke down and product was lost. Food safety is pinnacle at Kroger, and this solution helps enable that metric.

Kroger's loyalty program has been an industry leader for more than a decade and highlights the largest source of highly advanced analytical talent in the company, which is wholly-owned subsidiary 84.51°. The amount of customer insight that 84.51° is creating represents a treasure trove that would make any of the giant technology companies salivate. This information is used to improve the customer shopping experience, which is evident in our customer's loyalty and sales. The data is also being leveraged to define better store layouts, optimize promotions, derive product assortment and target discounts to Kroger's most loyal customers.

With 84.51°'s success in designing and executing the loyalty program and using that data to drive complex business decisions, they had already validated the value of advanced analytics to the organization. When the science and approaches developed by O.R. were called into question, 84.51° became a great partner in validating the work being put forward. As such, the O.R. team has developed a close partnership with 84.51° to promote and spread the cultural embrace of data-driven decision-making.

This partnership includes peer reviews of projects to foster healthy debate, new ideas and an exchange of knowledge. An annual analyst conference focuses on analytics and data sciences. Combined training classes are held throughout the year on a variety of topics, coding languages and advanced methodologies. Hackathons with local non-profits provide pro-bono work opportunities for associates, and the chance to work on problems outside of the realm of grocery retail. At a recent conference, Kroger teamed up with Cincinnati Children's Hospital and Cradle Cincinnati to look at the impact of shopping habits on infant mortality rates within Hamilton County.

The New Kroger Way

The Kroger Co. has a long tradition of innovation and managing change in a fast-paced industry with razor thin margins. Often when attending conferences or having other retailers/vendors come in for a demonstration, we hear, "We had no idea you guys were working on stuff this advanced. You wouldn't expect this from a grocery chain." However, Kroger is much more than your average "grocery store." It is a customer-focused, Fortune 25 company with more than $115 billion in annual sales (2016) and 134 years of retailing experience. The convergence of disruptive technology and data has created a paradigm shift in both the way we connect with our customers, as well as how they consume our services. O.R. and innovation are nothing less than table stakes in the years ahead for any company that wants to remain successful. ORMS

Greg Noble *is the O.R. team lead for Inventory Solutions at Kroger. Noble earned a B.S. and M.S. in industrial and systems engineering and a Ph.D. in engineering from Wright State University. He joined the Kroger O.R. team in 2013.*

Pooja Singh *serves as O.R. team lead for Strategic Systems. She joined Kroger's O.R. team in 2013. She has 14 years of analytics and leadership experience. She earned an MBA and a master's degree in quantitative analysis from the University of Cincinnati.*

Matt Sias *serves as O.R. team lead for Productionalization and Support at Kroger. Sias joined the R&D group in 2009 and moved into an operations research role in 2012. He graduated from the University of Cincinnati with a degree in information systems.*

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