Bullet Holes in Bombers

Operations Research and Management Science Applied to Marketing

by Jerry W. Thomas

Operations research achieved acclaim during World War II as a multidiscipline, scientific approach to solve war-related operational problems. An operations research team might be made up of a psychologist, a medical doctor, a mathematician, and a historian, for example. Operations research investigations followed rigorous scientific protocols and used mathematical concepts and methods. One famous story of operations research success during the war involved an analysis of Allied bombers returning from bombing missions over Europe. The military analyzed the location of shrapnel damage and bullet holes in returning bombers, to identify where to place additional armor on aircraft. Operations researchers were brought in at the last minute to do a "confirmatory" analysis, but they recommended that additional armor be placed on bombers everywhere except the places with damage or bullet holes! The operations researchers realized that analyzing damage to returning bombers involved a sampling error. It was the bombers that did not return that needed extra protection—and they needed it in the most vulnerable places (the places not damaged on the returning bombers). The power of this multidiscipline, scientific attack on problems was proven again and again during the war.

After the war, the promise and practice of operations research moved into industry. Ford Motor Company hired 10 young U.S. Army Air Force officers to bring advanced operations methods to Ford. This group, led by Robert McNamara (later U.S. Secretary of Defense), soon earned the title of "Whiz Kids" within Ford. This team transformed the managerial systems and methods at Ford and helped publicize the benefits of operations research and quantitative analysis. During the 1950s and 1960s operations research (and management science, a synonymous term) methods spread rapidly throughout U.S. industry, primarily in very large corporations. In the 1980s and 1990s operations research and management science (OR/MS) continued to grow, fueled by smaller, more powerful computers, the increasing availability of relatively low-cost software, and the profusion of analytical methods and models.

However, despite the great promise of advanced quantitative methods, the ultimate potential of OR/MS methods has never been fully realized. Corporate budget cutting over the years, lack of senior management understanding and support, and corporate emphasis on short-term tactical decisions over long-term optimal solutions are some of the reasons. The utilization of OR/MS methods sinks to its nadir in the marketing domain, despite the development in recent decades of a branch of OR/MS devoted to marketing (i.e., marketing science).

Before exploring the application of OR/MS to marketing, some definition and explanation might be useful. Most analysts define OR/MS to mean the application of the scientific method and advanced analytics to the solution of business problems. OR/MS almost always involves building a mathematical model of some business process or system. There is an **objective function**; that is, a mathematical definition of the object or thing to be optimized (to maximize profits or sales revenue, or minimize costs, typically). Mathematical formulae are developed to define the relationships among the variables. Algorithms and heuristics are used to seek optimal solutions.There are probabilities and probability distributions of relevant events. Stochastic processes (or random variations) are incorporated into these models, and often constraints or limits are imposed on some variables and/or solutions. Virtually all OR/MS methods can be characterized as optimization techniques, and many involve simulation methods. The goal is to find optimal solutions, given a set of variables, constraints, and probabilities.

OR/MS offers a varied and robust analytical toolkit. Some of the widely used OR/MS techniques include linear programming, nonlinear programming, dynamic programming, integer programming, Markov chain analyses, structural equation modeling, Monte Carlo simulations, network flow models, transportation models, inventory models, decision tree analyses, queuing theory, game theory, and Bayesian statistics. These models and methods can answer profound marketing questions. Some examples:

1. Optimal Restaurant Density. Let's suppose a restaurant chain (or some other type of retail chain) would like to know "the number of units (retail stores) to build in a particular DMA (designated marketing area) to maximize return on total investments within that DMA." At first this might seem like a simple, straightforward task, but an optimization model would need to consider the following variables across DMAs:

a) Warehousing, distribution, and supply chain costs

b) Managerial efficiency, overhead, and related costs

c) Operating costs (labor, utilities, taxes, etc.)

d) Advertising efficiencies (the more restaurants, the bigger the ad budget)

e) Media advertising costs

f) Positioning, marketing strategy, and advertising themes and messages

g) Promotion efficiencies (the more restaurants, the bigger the budget)

h) The breadth and type of menu (wearout considerations)

i) The size and seating capacity of each restaurant and unit sales

j) DMA economic variables (employment, discretionary income, etc.)

k) Competitive variables (number and mix of competitive restaurants)

l) Demographic variables and trends

m) Pricing power and price elasticity

n) Real estate and construction costs

o) Employee training and sharing efficiencies among the restaurants

p) Liquor laws and liquor consumption

As the number of possible variables above suggests, deriving the maximum return on investment (ROI) solution for a given DMA is complicated. The relevant variables must be identified and quantified. All of the data must be organized into a pristine analytical database, across multiple DMAs, with several years of historical data. This data must be analyzed to derive formulae and build algorithms, and then the ultimate model must be assembled, calibrated, tested, and applied to determine the number of units that would maximize return on total investment for each DMA.

In the example above, a nonlinear integer programming optimization model with stochastic and dynamic components would most likely be recommended, but many other quantitative approaches are available. Once implemented, such a model could add millions of dollars to the bottom line of a major restaurant chain (or other type of retail chain).

2. Optimal Distribution System. Let's suppose a coffee company wants to create a distribution system that maximizes profitability within given DMAs. The coffee company can deliver directly to the store (DSD, direct store delivery) or ship coffee to the food retailers' warehouses that in turn move the product from warehouse to retail shelves (i.e., warehouse distribution). What are the major variables to consider across DMAs?

a) Out-of-stocks. What level of out-of-stocks is associated with DSD versus warehouse distribution?

b) What is the shelf space (number of facings) and shelf position implications of DSD versus warehouse?

c) What warehouses, trucks, employees, and infrastructure is required to support DSD versus warehouse distribution, and what would be the comparative costs?

d) What is the tradeoff between spending more of the budget on media advertising with warehouse distribution versus better in-store merchandising and control with DSD?

e) What is the relative cost of media advertising?

f) Does DSD provide a product freshness (or product quality) advantage, and is this advantage significant enough to positively affect market share?

g) Does the same solution apply equally to all markets, or are some markets better for DSD and some markets better for warehouse distribution?

h) If DSD is the preferred distribution method, then what is the optimal way to route trucks and service accounts?

As before, this is a complex set of questions. Time would be spent riding trucks, visiting warehouses, and conducting depth interviews with warehouse and store employees, DSD truck drivers, and executives at the coffee company and their retail customers, to develop an understanding of the key variables and the probable relationships among the variables. An analytical database would be assembled and studied. The work would include product testing, measurement of out-of-stocks, and brand share analyses. Transportation models, inventory models, and advertising response models would be used to help derive the final solutions.

3. Optimal Product Line. Let's suppose an automotive manufacturer wants to create an optimal product line to help it succeed over the next 20 years. What variables might be considered in creating an OR/MS optimization model?

a) What is the range of market conditions (scenarios) the manufacturer might face over the next 20 years?

b) What are the probabilities of these market conditions or states?

c) What are the long-term trends in fuel prices? Fuel types? Technological probabilities?

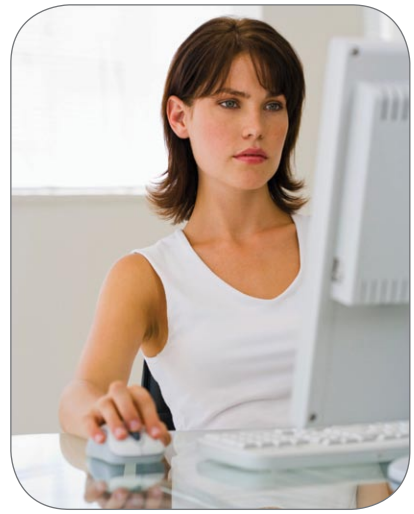
d) What are the boundaries of consumer acceptance, given extreme scenarios?

e) How much variation in product line is permissible before brand image begins to weaken? That is, what are the practical limits of brand elasticity?

f) What is the optimal mix of cars, trucks, and other types of vehicles, given different scenarios?

This project is challenging because it involves long-range forecasting of the economy and future technologies. Econometric models would be part of the solution, as would forecasts of demographic trends. Depth interviews and surveys would be conducted among industry experts and executives to identify new technologies and the future probabilities of each. Choice modeling would be used to measure consumers' "product line" preferences and elasticities, given different market conditions. Lastly, all of this would be pulled together in an integrated model to identify optimal solutions.

4. Optimal Positioning and Advertising Messaging. What if an Internet dating service wants to optimize its television advertising? Communicating in an optimal way with the target audience via a particular media is a very complicated problem because the communication partially defines the audience, and the audience partially defines the communication. An optimal solution would involve some of the following variables:



a) What is the architecture of target-audience possibilities? Demographic? Attitudinal? Behavioral?

b) What are the strategically viable positionings?

c) What are viable themes, messages, and taglines?

d) What imagery and colors correspond to the various positionings?

e) What sounds and music best reinforce the advertising themes and messages?

f) What characters and voices best support the messaging?

g) What are the interaction effects among the variables?

h) What contextual variables moderate the influence of particular positionings, themes, and messages?

i) What mix of advertising media optimizes profits?

In this example, some good old-fashioned qualitative research would be used to help define the range of possibilities (positionings, themes, messages, taglines, colors, imagery, etc.). Survey research would be employed to provide a first approximation of target-audience definition. The final optimization model would involve choice modeling experiments among the broadly-defined target audience to identify a set of optimal solutions, which would also precisely define corresponding optimal target audiences.

Other types of marketing applications for OR/MS methods include:

- Route or delivery system optimization
- Promotional optimization
- Package design optimization
- Product features optimization
- Pricing optimization

The ultimate goal of operations research is to create a mathematical model that simulates real world processes and systems so that optimal solutions can be found.

- Industry and category forecasting
- Inventory optimization
- Retail category optimization
- Store design optimization

The Team

The concept of a multidiscipline team in OR/MS has tended to fade away over the years as the glitter of advanced quantitative techniques has garnered most of the attention. Despite all of the mathematical advances and software improvements, the multidiscipline team approach should not be forgotten. The value of different educational and experiential backgrounds and different viewpoints in solving complicated problems is time-tested and proven. Marketing research is a member of the team and plays an important role in bringing new information and new perspectives into the modeling process. Depth interviews, focus groups, ethnography, and surveys can bring the experience and knowledge of customers, truck drivers, shelf stockers, warehouse workers, store managers, and senior executives into the analyses and modeling, and lead ultimately to much better and more accurate OR/MS solutions.

The Challenge

The great challenge facing marketing executives at all levels is how to make better decisions (i.e., decisions that maximize the long-term returns on marketing investments). Rarely are these major decisions simple and obvious, even when they appear to be. As the examples in this article suggest, many complex and interacting variables must be understood and modeled to find the ultimate answer. OR/MS methods, combined with marketing research, can be a valuable ally in the search for long-term optimal solutions. So, strap on your parachute, put on your goggles, and fly your business on the right course at the right altitude—with armor in the right places.

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