

MORE PROFIT, PRODUCTIVITY, AND COST REDUCTION – FROM OPERATIONS RESEARCH

**AN INTRODUCTION TO MODERN O.R.
FOR BUSINESS EXECUTIVES**

By Randy Robinson

informs

EXECUTIVE SUMMARY

Looking for another way to substantially boost company performance? Consider operations research (O.R).

Essentially, O.R. – “the science of better” – entails applying advanced analysis to help make better decisions. The O.R. field is a unique source of truly high-tech assistance that helps improve the information content of management information and place intelligence in intelligent operational systems. It is well enough established to have a solid, practical track record yet still new enough to offer real competitive advantage. Opportunities to move the performance dial are plentiful, for firms large and small, in virtually all industries.

This article takes you on an introductory tour of modern O.R. We’ll answer your basic questions, such as: What is O.R. all about? What bottom-line benefits does it deliver? If it’s so helpful, why isn’t it famous? What methods does it apply? Where do you find good applications? How would you get started if you’re not yet an O.R. user? An appendix discusses how the international Edelman competition – the World Series of O.R. – documents success stories.

Operations research methods and technologies have traditionally played an important role in business areas such as supply chain planning and logistics network design and operation. In the future, OR will help companies deal with a broad range of new business challenges.

WHAT OPPORTUNITIES TO IMPROVE A COMPANY’S PERFORMANCE, PERHAPS DRAMATICALLY, STILL WAIT TO BE DISCOVERED BY THE ALERT BUSINESS EXECUTIVE?

I mean notable improvements like higher revenue, lower cost, increased market share, reduced risk, greater productivity, faster turnaround, and more efficient use of limited resources.

The high-tech field of operations research offers numerous excellent opportunities to boost performance immediately. Yet time remains to skim the cream before everyone wakes up to the prospects. When most do wake up, companies that aren’t taking full advantage of O.R. will leave serious money on the table and be outflanked by competitors.

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For example, here's what former CEO Bob Crandall of AMR, Corp. (parent of American Airlines) said about one result of applying modern operations research:

I believe that yield management [method of pricing and booking seats, created by AA's OR group] is the single most important technical development in transportation management since we entered the era of airline deregulation in 1979... The development of yield management was a key to American Airline's survival in the post-deregulation environment¹.

In another example, Nick Donofrio, Senior Vice President, IBM Technology and Manufacturing, commented that

The Asset Management Tool [for supply chain management, from an O.R. team in IBM]...helps our business units identify the "optimal" supply chain strategies... [It] allows for enormous cost-saving, inventory reduction, customer responsiveness, and speed of delivery benefits...[and] has totally transformed our global operations².

After today's headline frontiers such as e-commerce become routine, operations research may well lead the next generation of vital business facilitators. To discover why, let's tour the field of modern OR, from the executive perspective.

We'll focus especially on fundamental questions: What are the bottom-line benefits? What exactly is OR? If it's really helpful, why isn't it already widely known? What methods does it employ (in plain language)? Where are the better applications? How would an organization that isn't already benefiting get started?

WHAT BENEFITS SHOULD COMPANIES EXPECT?

Reflecting on the next stage of e-commerce, Andy Grove, Chairman of Intel Corp., remarked:

Think of every enterprise, whether it is Intel or a hotel, involved in adjusted capacity-demand pricing.... If this can be done computers-to-computers in real time, you'll see another power of 10 increase in the efficiency of the work in the economic system. Now how do we get there?...Bits and pieces of it exist in decision theory and operations research³.

The OR ideal is to turn around the declining enterprise, save the project in trouble, and win the war. While typical achievements are more modest, at its best OR delivers blockbuster results.

The magnitude of benefit varies from case to case, of course. In some instances it has been striking, valued in the hundreds of millions or billions of dollars.

What are the specific benefits? They vary widely. Generally speaking, OR helps improve effectiveness. Here are some illustrative sources of effectiveness – that is, particular benefits – delivered in O.R. projects:

- Increase revenue or return on investment; increase market share.
- Decrease cost or investment.
- Gain greater utilization from limited equipment, facilities, money, and personnel.
- Assess the likely outcomes of decision alternatives, and uncover better alternatives.
- Manage and reduce risk.
- Quantify and balance qualitative considerations.
- Increase speed or throughput; decrease delays.
- Gain greater control; achieve turn-around.
- Improve quality.
- Provide a better basis for forecasting and planning.
- Demonstrate feasibility and workability, and assist with training.

These broad categories overlap, and more than one might apply in a project.

O.R.? WHAT'S THAT?

One reason why O.R. presents untapped opportunities is that the field frequently is invisible or, if visible, misunderstood.

In a nutshell,

operations research is the discipline of applying advanced analytical methods to help make better decisions.

To further clarify what O.R. is and what it is not, let's review an expanded definition:

Operations research is the application of scientific methods to improve the effectiveness of operations, decisions, and management. By means such as analyzing data, creating mathematical models, and proposing innovative approaches, O.R. professionals develop scientifically based information that gives insight and guides decision-making. They also develop related software, systems, services, and products⁴.

In other words, O.R. professionals specialize in doing advanced analysis to create and interpret valuable knowledge. The purpose of that knowledge is to assist management by furnishing insight and guidance. O.R. professionals, first and foremost, are experts in mathematical modeling for managerial applications.

O.R. may assist with almost any management function. For instance, it helps executives and managers make key decisions, solve urgent problems, design better multi-step operations (often called processes), set policy, plan, forecast, and measure results. O.R. serves non-managers too – say engineers or consumers – helping them improve decision-making and other functions ordinarily performed by managers. You will find applications of O.R. in diverse types of organizations, at diverse organizational levels.

O.R. professionals also develop software systems, including the large decision-support systems that perform make-or-buy jobs in some companies. And they develop new products and services that depend on O.R. methods.

To sum it up, O.R. helps take advantage of the latest analytical and computer-system methods to improve bottom-line results. It provides the highest-tech management consulting on the planet. It develops decision-support systems and managerial command-and-control systems. It develops modern products and services that embody advanced decision-making methods. The analysis O.R. can deliver is vastly more powerful than non-O.R. analysis – such as projections of accounting reports and other standard spreadsheet studies. The beneficial results of O.R. analysis may be substantial – company rescuing in some instances.

IF O.R. IS SO FAR REACHING AND VALUABLE, HOW HAS IT AVOIDED THE SPOTLIGHT?

Despite sixty years of solid accomplishment, the operations research world remains largely unheralded. Several reasons explain this. O.R. operates ordinarily behind the scenes. And its professionals tend to be doers, not promoters. In many cases they have shied away from publicity. Furthermore, many older-generation executives, the early prospective customers for O.R., were content with far-less-than-cutting-edge analysis to support decisions. Some older executives also felt an aversion to computers and mathematics.

Another significant reason for the O.R. community's low profile is that they never completely "branded" their field. Consequently operations research is practiced under many names. These alternative names include the near-synonyms management science, decision technology, decision support, policy science, system analysis (where the applications are related to management and decisions), management technology, and management analytics. Other aliases, adding to the confusion, apply to special subjects. Examples are operations analysis in manufacturing and the military, financial engineering in finance, marketing engineering in marketing, rocket science in Wall Street, and a recent arrival, focused on a few of the analytical methods, complexity science.

As if that weren't enough, yet another source of confusion is that most traditional branches of engineering and of applied mathematics practice O.R. within their own fields. For instance, O.R. methods are employed, and O.R. applications worked on, at times by aeronautical, chemical, civil, electrical, industrial, and mechanical engineers (to name a few), and by statisticians, actuaries, and other applied mathematicians. Even that isn't all. The same is true of miscellaneous other applied scientists, notably economists and their close colleagues the corporate finance specialists.

Despite such an embarrassment of riches in names, and despite being practiced often by those who prefer the banner of another field, O.R. is O.R. is O.R. The name operations research, while misleading (neither is it research in the popular sense, nor is it limited to the subset of activities called operations), is far and away the best established name.

The bright side of O.R. being carried on under all those different names, and within all those different professions, is that it underscores the fact that operations research is a wide-ranging, influential subject with staying power. It's no passing fad.

LARGE NUMBER OF HIGH-TECH METHODS

An O.R. professional, like a medical doctor, is expected to select from the total array of the latest technology whatever promises to do the most good in the task at hand. This technology includes methods that might be found in any branch of mathematics, any of the sciences including the social sciences, and any branch of engineering.

Over the years members of the O.R. community have invented important new methods, and significantly advanced existing methods. But the O.R. professional should select among all helpful techniques, not just those created within the O.R. family.

Because of the breadth and depth of the growing collection of pertinent methods, combined with the breadth and depth of the fields of application, O.R. like medicine is divided into specialties. The generalists may call in specialists and work in teams.

When first encountered, methods commonly used in O.R. seem obscure. This impression is fostered by technical labels such as multicriteria decision analysis, linear and nonlinear programming (nothing to do with computer programming), discrete-event simulation, queueing and other stochastic process modeling, conjoint analysis, and neural networks.

We can clarify O.R. techniques despite their labels, however, because most projects apply one of three broad groups of methods, which may be explained readily:

- With simulation methods, the O.R. professional develops simulators that give clients (executives, managers, front-line workers) the ability to dry run different approaches, on a computer, to search for improvements and to test improvement ideas.
- With optimization methods, the O.R. professional enables clients to search among possible choices – often where thousands or millions of choices are feasible, or where comparing choices is complex – to locate the very best.
- With data-analysis methods, the O.R. professional helps clients detect patterns and connections in data, useful in numerous applications including forecasting and data mining.

Within each of those groups, many probabilistic methods give the advantageous ability to assess risk and uncertainty.

WHERE ARE THE APPLICATIONS?

Because operations research can make and has made contributions in virtually all industries, in almost all managerial and decision-making functions, and at most organizational levels, the list of past and prospective applications is prodigious. To sample from the application universe, let's briefly look at O.R. in major business functions (finance, production, and so on), and then consider some applications that cover multiple functions (such as revenue management and supply chain management).

This sampling of applications won't try to go industry by industry. All industries contain many good opportunities to benefit, including industries that might at first seem unlikely clients – e.g., agriculture, health care, broadcasting, entertainment, and sports.

Here are selected business functions, with a few comments about O.R. applications in each:

Board room and senior executive offices

Top-level, high-impact policy-setting and decision-making offer companies especially great potential to gain competitive advantage. The power of O.R. to reveal the implications of different courses of action, and to find a preferred course of action among numerous possibilities, goes far beyond that of ordinary spreadsheet analysis.

Senior-executive applications include, for example, mergers and acquisitions, major expansions, divestitures, valuation of companies or operating units, facility location, and redesign of the entire supply chain. In companies that operate through large contracts, the ability of O.R. methods to help them with price setting and risk reduction in competitive bidding are keys to gaining an edge.

O.R. techniques make it possible to quantify risk, always vital information but seldom quantified in executive offices. O.R. methods also can quantify and balance other qualitative aspects normally thought to be beyond the reach of analysis. In addition, some O.R. methods help with gathering and displaying inputs from different executive participants, and with building buy-in to the final decision.

Many excellent applications come to the top-executive level. Even a slight percentage improvement beyond what the ordinary analysis discloses will produce a significant payoff for the company. Often the improvement is so substantial that it makes a critical difference.

Manufacturing and service operations, distribution, transportation, telecommunications

The “operations” in operations research suggests that this application category is the original home of O.R. That’s not quite correct, because the name comes from military operations, not business operations. Nevertheless it’s true that O.R. successes in contemporary business pervade manufacturing and service operations, logistics, distribution, transportation, and telecommunications.

The myriad applications include scheduling of all kinds, routing, improvement of work flow and elimination of bottlenecks, inventory control, business process reengineering, site selection, greenfield facility planning, and general operational planning. Two growing applications that are distinguished by their use of several methods to cover several functions – revenue management and supply chain management (both discussed below) – are in this realm.

Manufacturing companies make heavy use of simulation. Transportation and telecommunication companies make heavy use of optimization. In fact, most O.R. methods are well exercised throughout this arena.

The names operations analysis and operations management often appear as synonyms for O.R. in operations.

Finance and control

The core financial applications occur in investment, lending and borrowing, financial planning, and insurance. Financial institutions have these, as well as applications in their operations. In a manufacturing or service company, the applications are those within the domain of the chief financial officer.

Mathematical models, signatures of O.R., have become common in finance. Much publicity surrounds the investment applications, especially in connection with newer investment media like financial derivatives. The index fund was invented by O.R. people. So were key advances in investment performance measurement. But past and prospective O.R. successes cover a much wider range, including company financial projections and forecasts, valuation of companies and product lines, selection of corporate borrowing vehicles, hedging, foreign currency analysis, treasury operations, analysis of taxes, asset and liability management in commercial banks, and credit approval.

The name financial engineering is popular these days. That name typically serves as a synonym for O.R. in finance. The Wall Street version of the name rocket science usually means O.R. in investment.

Marketing

As in finance, in marketing the opportunities to gain a competitive edge through quantitative analysis are multiplying. Those opportunities arise, first, in strategic marketing. Strategic applications include general planning, sales forecasting, market selection, market measurement, segmentation and targeting, and product portfolio analysis. Other opportunities present themselves in tactical marketing. They include decisions about pricing and promotion, salesforce sizing and deployment, location of distribution facilities, advertising, and product design.

You'll find these applications in manufacturing and service companies. Comparable applications are found in pure marketing firms, including ad agencies and market research companies.

Paralleling the name financial engineering is the currently popular name marketing engineering, which ordinarily means O.R. in marketing.

Information technology

The impact of O.R. on IT is growing. The top IT job in most companies soon may require a strong background in O.R.

For many years computer-vendor executives have been saying that the real payoff from computerization is the ability of computers to produce crucial management information. O.R. is the field dedicated to creating the content of management information. O.R. brings the best methods to bear on deciding what input data to collect, how to convert raw input data into valuable, decision-guiding information, and how to present that information for greatest managerial usefulness.

O.R. is behind a growing number of IT buzzwords. Among them are decision support systems (DSS), online analytical processing (OLAP), and optimization components (along with other analytical components) of enterprise resource planning systems (ERP) and of e-commerce systems. Generally, O.R. furnishes the expertise needed to develop management oriented software-and-communication systems with analytical content, such as shop floor planning and scheduling systems, data mining systems, intelligent pricing (revenue management) systems, supply chain management systems, and real-time command and control systems.

Because O.R. work is so closely connected to computers and data communication, O.R. and IT professionals often become partners in projects.

Human resources

The military services apply O.R. extensively for personnel planning and related HR purposes. While not as many HR applications in business have been made known outside client organizations, the opportunities, where choices are made in complex situations, are increasing. The most likely topics include analysis of retirement plans and other benefit plans, compensation studies and compensation planning, compliance with regulations, and reduction of travel expenses.

Legal

A classic O.R. application is deciding how best to proceed in a large-dollar legal action. The O.R. method called decision analysis is perfect for sorting out and correctly weighing the many uncertainties and contingencies in this situation.

O.R. professionals also may provide the expert analysis of quantitative data sometimes needed to prepare for court cases.

Engineering

Such O.R. techniques as decision analysis, the analytic hierarchy process, and mathematical programming, can assist with engineering decisions – for example in making choices in design and in testing.

The engineering professions make heavy use of linear and nonlinear programming, developed by the O.R. community. For example, those optimization methods are commonly employed to help manage oil refineries.

Research and development -

The classic R&D application is selecting the research portfolio – that is, deciding how much to invest in each of the possible R&D projects.

Revenue management

Turning now to a different view of applications, let's consider some that involve multiple functions (and often multiple O.R. methods). We'll begin with a currently hot topic: revenue management.

Also called yield management (praised by former CEO Bob Crandall of AMR, above), revenue management entails accurately forecasting demand and then adjusting prices over time to more profitably allocate fixed capacity. You might term this super-intelligent pricing. It shares much in common with the application of competitive bidding. Developed originally for pricing and booking of airline seats, the approach has spread to hotels, rental car firms, broadcasting, and more recently to manufacturing.

Supply chain management

Supply chain decisions dictate the who-what-when-where all the way from purchasing and transporting materials and parts, through manufacturing products, and finally distributing and delivering products to customers. The prime management goal might be to reduce overall cost – very large in many companies – while filling customer orders even faster than before.

The power of O.R. methods makes it possible to examine this complex chain comprehensively, and to search among a huge number of combinations for those that seem most beneficial.

Data mining

As interest in the analysis of customers and buying behavior grew, along with the ability to accumulate data in extremely large databases, this application became a major force. O.R. methods give the means to find in any large collection of data (not just customer data) those patterns, trends, and connections that will assist management.

Complex scheduling

O.R. brings the latest techniques, and decades of experience, to the scheduling of resources in complex situations. Applications abound, especially in manufacturing, service, and transportation industries.

Intelligent real-time systems

Modern decision support systems respond in real time, and draw analytical capabilities from a combination of mathematical and artificial-intelligence/expert-system methods. Already important in the military, these O.R.-developed systems are likely to become important in business too.

MAKING EFFECTIVE USE OF MODERN O.R.

Perhaps a company wants to try O.R. for the first time. Or perhaps it wants to strengthen an O.R. activity in place. How should it proceed?

Any exploration in O.R. inevitably surfaces the question: How do you recognize qualified help? Look first at the usual dimensions – working track record, personal qualities, and academic training. What may assist you further is to be aware that the O.R. field, through collective experience, has arrived at unwritten but widely known practice guidelines the professionals follow. My interpretation of those guidelines, in a nutshell, is:

- Take a system view, often across departmental boundaries. O.R. is famous for investigating the management question or problem under study in a broad enough way to learn what really makes it tick, and to avoid “suboptimizing.” This frequently requires working with multiple departments and functions.
- Unearth the real problem. O.R. is there to get practical results. If the initial diagnosis of the client’s need and corresponding initial O.R. approach are wrong, the O.R. professional is expected to figure that out and promptly tell the client what they judge to be the correct diagnosis and approach.

- Live in the application environment to learn the subtleties. One way or another, including living on the front line for a while if appropriate, the O.R. professional should develop a close knowledge of the working environment of the assignment.
- Check onsite that the data are accurate. When important data come from a remote source, the O.R. professional goes to the source to confirm that the data are accurate.
- Advocate correct logic. The O.R. professional ensures that the general logic underlying an analysis is correct.
- Propose creative alternatives. An O.R. professional should not be satisfied to apply a method to the obvious managerial alternatives. He or she also should search for creative additional alternatives that might give the client an even better solution.
- Help the client move from a general idea to a detailed plan. Software programmers often want to start with the “user’s requirements,” meaning a detailed blueprint of what the envisioned program should do. O.R. fills a void by specializing in helping clients go from a general idea (perhaps vague idea) of what’s wanted to a detailed specification. This is true whether or not the end product is a computer program.
- Have a deep interest in the client’s situation and needs. The O.R. professional brings a sincere interest in the business background of the assignment, and in understanding the client’s need.

Another question is whether to seek O.R. expertise outside, or to staff an O.R. function inside, or a combination. You know what fits best within your own organization. I’ll just make this comment. Successful O.R., in my experience, takes teamwork between the client and the O.R. professional or professionals, usually with company members close to the client participating. Great O.R. success almost always comes from great teamwork.

A third question arises in the event you want to staff O.R. inside the company: Where to position it? If you form a single O.R. group for your company, I believe they should go where they can report to an O.R. champion in senior management, and where they can serve clients unobstructed by chain-of-command problems. In my view, most companies eventually will discover that O.R. is sufficiently valuable to merit distributing it to the various units and departments, as IT, accounting, and marketing are distributed, for example. Then the independent O.R. specialists will do better if they have a dotted-line corporate home base, comparable to corporate home bases for IT, accounting, and marketing.

To the foregoing, I add two bits of thumbnail advice to prospective clients who want O.R. to help them arrive at better decisions or policies. Never follow an analytically based recommendation that doesn't feel right. And be aware that the analytical backup you get will not in every case produce a radically original, counterintuitive answer; sometimes it serves to confirm what seemed best at the outset (but lacked analytical support).

If you decide that you want an impartial referral to outside assistance, try the O.R. resource databases at www.scienceofbetter.org, a service of the nonprofit Institute for Operations Research and the Management Sciences (INFORMS®), the O.R. professional society.

APPENDIX: BILLIONS IN BUSINESS BENEFITS

Good operations research creates competitive advantage. So companies rarely advertise their O.R. benefits. We can get a glimpse, nevertheless, from an international competition called the Franz Edelman Award for Achievement in Operations Research and the Management Sciences, in which the contestants present their work and discuss its estimated impact as endorsed by management.

Relatively few organizations become finalists each year – six or seven. And not all are from business, because O.R. is practiced widely in government and the military.

Still, over the thirty-three years of the competition, business firms reported priced-out benefi

level, for vehicles where testing is not simple, to determine how many prototypes to build, which tests to assign to particular prototypes, and when to schedule tests and test facilities.

The cost of building a single prototype vehicle can range from \$250,000 to \$500,000, and a complex vehicle program may require from 100 to 200 prototype vehicles. The O.R. work done at Ford facilitated a more-than-\$250-million annual reduction in prototype costs.

While this figure of \$250 million saved per year conveys major impact, it shows only part of the benefit picture. Other gains that resulted from O.R. included a complete revamping of Ford's prototype management procedures, to become "global best practices." Particularly important to Ford, beyond the foregoing, was that they were able to reduce the time required for prototype planning from months to weeks. Moreover, the success in this project inspired other Ford O.R. projects whose benefits were not summarized in the competition.

Ford's highly effective effort addressed improving one management function in one industry. Throughout its life the competition has attracted contestants from many different industries, reporting on projects to improve many different management functions.

Nor is O.R. confined to large companies. In the same Edelman competition, Jeppesen Sanderson, a smaller firm that produces maps and charts for airline pilots, disclosed how O.R. rescued their company from possible failure.

The Edelman Award competition is conducted by the Institute for Operations Research and the Management Sciences (INFORMS®) and its practice subdivision CPMS. Various of the past Edelman projects are described as O.R. success stories at www.scienceofbetter.org.

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