

THE ROLE OF OPERATIONS RESEARCH IN MANAGERIAL DECISION-MAKING

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ABSTRACT

Managers in all organizations should take into account the qualitative aspects of the problem they face, but they should also use the solution of quantitative models as a recommendation in order to make a good decision. The field of Operations Research includes a “buffet breakfast” of analytical methods developed to solve real complex problems and to help make better decisions. Operations Research has been applied in diverse areas, such as: agriculture, aviation, construction, education, electronics, finance, healthcare, manufacturing, military, sports, telecommunications, transportation, etc. Operations Research generates powerful benefits for organizations, such as: increased revenue, increased efficiency, reduced cost, optimized resource use, improved customer service, etc. The aim of the paper is to examine the role of Operations Research in managerial decision-making in renowned organizations around the world. Applications of Operations Research in 30 organizations are presented and the annual savings are given.

Key words: managerial decision-making, operations research, analytical methods, benefits

INTRODUCTION

“I often say that when you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind; it may be the beginning of knowledge, but you have scarcely in your thoughts advanced to the state of Science, whatever the matter may be.”

– Lord Kelvin

In every organization it is the managers who make decisions, and while some of them are operational and short-term, others are strategic and long-term. In order to make a good decision in conditions of increased competition, higher client requirements, time pressures, limited resources and swift changes in technology, it is certainly a daunting task. “Operational Research (O.R.) is the discipline of applying appropriate analytical methods to help those who run organizations make better decisions. It's a 'real world' discipline with a focus on *improving* the complex systems and processes that underpin everybody's daily lives - O.R. is the 'science of better'.” (The Science of Better, 2017). Aside from the traditional term of Operations Research, a synonym used for this discipline is the term Management Science (M.S.). For the roots of the discipline of O.R., see Gass and Assad (2005). In fact, the foundation of the activity of O.R. is connected to the military services in the beginnings of World War II (Hillier and Lieberman, 2010, p. 1). During WWII, it was necessary to effectively allocate the limited resources of various military operations, so teams of scientists who were actually the first O.R. teams did research on how to manage the military operations. At that time, scientific and quantitative techniques developed, and they proved to be quite successful, so after the war ended, numerous companies in managerial decision-making and planning started to apply similar techniques (Render et al., 2012, p. 3).

The usual phases of an operations research study are the following six (Hillier and Lieberman, 2010, p. 8): (1) Define the problem of interest and gather relevant data; (2) Formulate a mathematical model to represent the problem; (3) Develop a computer-based procedure for deriving solutions to the problem from the model; (4) Test the model and refine it as needed; (5) Prepare for the ongoing application of the model as prescribed by management; and (6) Implement. These phases are described in detail in Hillier and Lieberman (2010, pp. 8-19). Regarding O.R. models, methods and their application, see: (Albright and Winston, 2016; Anderson et al., 2009; Anderson et al., 2013; Babic, 2011; Goodwin and Wright, 2014; Hillier and Lieberman, 2010; Hillier et al., 2014; Jensen and Bard, 2003; Powel and Baker, 2013; Rardin, 2016; Ravindran, 2008; Render et al., 2012; Taha, 2016; Taylor, 2016; Williams, 2008).

The developed methods and techniques, as well as the computer revolution, have contributed to the rapid growth of the discipline of O.R. Operations research methods may be applied to solve real complex problems in various areas, such as agriculture, aviation industry, education, environmental and energy issues, finance, healthcare, logistics, marketing, military, mining industry, production management, transport, sport, supply chain management, telecommunications and information technology, etc. (Cvetkoska, 2016, p. 350).

The Institute for Operations Research and the Management Sciences (INFORMS) is “the world’s largest professional association dedicated to and promoting best practices and advances in operations research, management science, and analytics to improve operational processes, decision-making, and outcomes” (INFORMS, 2017). It counts 12.500 members and it publishes 14 journals. The journal *Interfaces* is “dedicated to improving the practical application of OR/MS to decisions and policies in today's organizations and industries” (Interfaces, 2017).

Aside from the Introduction, this paper describes the synergy between operations research, management and decision-making, while special attention is paid to the application of operations research in practice, followed at the end with the conclusion.

SYNERGY BETWEEN OPERATIONS RESEARCH, MANAGEMENT AND DECISION-MAKING

“We are all decision makers first, problem solvers second, and creative thinkers third. We are born with the talent of automatic decision making, close to our instincts, in order to survive. Next we have to solve problems we face during survival. Creative thinking is a talent whose degree of practice distinguishes human beings from all other form of life. ... Decision making, along with creative thinking and problem solving, are three areas with which the unconscious mind is partly active.” (Saaty, 2006, p. 207).

Regardless of whether it concerns a small or a large organization, private or rather state, profit or non-profit, managers are constantly faced with the tasks of solving problems and making decisions. Moreover, making a good decision leads to the success of an organization, while making a wrong decision inevitably leads to failure, or to the worst case scenario - the closing of an organization.

The process of solving a problem covers the following seven steps (Anderson et al., 2009 p. 3): (1) Identify and define the problem; (2) Determine the set of alternative solutions; (3) Determine the criterion/criteria that will be used to evaluate the alternatives; (4) Evaluate the alternatives; (5) Choose an alternative; (6) Implement the selected alternative; and (7) Evaluate the results to determine whether a satisfactory solution has been obtained. Making a decision refers to the first five steps of the process of solving a problem, i.e. starts with identifying and defining the problem, and finishes with the selection of an alternative.

When solving the problems, it is necessary for managers to take into consideration both the quantitative and the qualitative aspects. If the manager has had experience with a problem that is similar to the present one or if the problem is relatively simple, then more emphasis can be put on the qualitative analysis, but if his/her experience with related problems is scarce or the problem is quite

complex, then the emphasis is put on quantitative analysis as a scientific approach to managerial decision-making. A clear statement should be formulated for the identified problem, a model representing a simplified picture of the problem should be constructed, with only the important aspects from reality taken into consideration, followed by data collection, then from a “buffet breakfast” of methods and techniques of O.R. the one adequate for solving the model is chosen, but if there is no such method or technique, then it is developed, and with solving the model it is expected for the best (i.e. most optimal) solution to be found, afterwards tested, the gained results analyzed, and implemented in the organization. In order for the O.R. research to be successfully applied in organizations, it is necessary for the O.R. researcher to collaborate with the management.

O.R. can largely help the managers with the specific challenges they face, such as (The Science of Better, About O. R., 2016): to decide where to invest capital in order to grow, to get more value out of Enterprise Resource Planning (ERP), Customer Relationship Management (CRM), and other software systems, to figure out the best way to run a call centre, to locate a warehouse or depot to deliver materials over shorter distances at reduced costs, to forecast sales for a new kind of product that has never been marketed before, to solve complex scheduling problems, to decide when to discount, and how much, to get more cycles out of manufacturing equipment, to optimize a portfolio of investments, to decide how large a budget to devote to Internet vs traditional sales, etc.

By using O.R., organizations can benefit differently: decrease of costs in millions, increase of profit, higher market share, better quality, improved processes, productivity, performances, etc.

OPERATIONS RESEARCH IN PRACTICE

"O.R. influences a whole range of decisions. Ours is a complicated business and O.R. thinking is critical to taking the right decisions. O.R. people often bring a different way of thinking about a problem that you don't see for yourself."

- Roger Blackburn (Head of Strategy and Business Planning, British Airways)

3663 First for Foodservice, Air New Zealand, Amazon, American Airlines, AT&T, Bank Hapoalim Group, Bank One Corporation, BMW, British Airways, British Telecommunications, Canadian Pacific Railway, Citibank, Continental Airlines, Crimestoppers, CSAV, Deere & Company, Dell, DHL, Eastman Kodak, EDS, Federal Aviation Administration, Federal Express, General Motors, Hewlett-Packard, IBM, INDEVAL, Jan de Wit, Kellogg, KeyCorp, Kimberly-Clark, Memorial-Sloan Kettering Cancer Center, Merrill Lynch, MISO, Motorola, NASA, Netherlands Railways, Nokia, Peugeot, Procter & Gamble, PSA Peugeot Citroen, Samsung Electronics, Sasol, Swift & Company, Taco Bell, Time Inc., United Airlines, Waste Management, Workers'-Compensation Board. These organizations, with headquarters in different countries, with different sizes, and belonging to various industries, have one thing in common: they all use O.R. to improve their decision-making.

Table 1 shows 30 organizations that have applied O.R., and their annual savings, as well as the reference for each study. DHL and Hewlett-Packard annually have made a savings of 22 and 180 million dollars, respectively. Merrill Lynch and Samsung Electronics annually have made a revenue higher for 50 and 200 million dollars, respectively. PSA Peugeot Citroen annually has made a profit higher for 130 million dollars, etc.

The application of O.R. in marketing and related management problems is presented in Magee (1954). Datta and Bandyopadhyay (1994) have studied the application of O.R. in solving problems in the industry and industrialization in developed countries. The application of O.R. techniques in financial markets is examined in Board et al. (2003). Semini (2011) examines the applicability of O.R. in manufacturing logistics. A review of O.R. studies applied to healthcare is given in Fakhimi and Probert (2013).

Table 1: Applications of Operations Research

	Organization	Annual Savings	Reference
1.	Air New Zealand	\$6.7 million	Butchers et al. (2001)
2.	AT&T	\$750 million more profit	Brigandi et al. (1994)
3.	Bank Hapoalim Group	\$31 million more revenue	Avriel et al. (2004)
4.	Bank One Corporation	\$75 million more profit	Trench et al. (2003)
5.	Canadian Pacific Railway	\$100 million	Ireland et al. (2004)
6.	Continental Airlines	\$40 million	Yu et al. (2003)
7.	CSAV	\$81 million	Epstein et al. (2012)
8.	Deere & Company	\$1 billion less inventory	Troyer et al. (2005)
9.	DHL	\$22 million	Fischer et al. (2011)
10.	Federal Aviation Administration	\$200 million	Sud et al. (2009)
11.	General Motors	\$90 million	Alden et al. (2006)
12.	Hewlett-Packard	\$180 million	Ward et al. (2010)
13.	INDEVAL	\$150 million	Munoz et al. (2011)
14.	KeyCorp	\$20 million	Kotha et al. (1996)
15.	Memorial-Sloan Kettering Cancer Center	\$459 million	Lee and Zaider (2008)
16.	Merrill Lynch	\$50 million more revenue	Altschuler et al. (2002)
17.	MISO	\$700 million	Carlson et al. (2012)
18.	Netherlands Railways	\$105 million	Kroon et al. (2009)
19.	Norwegian Companies	\$140 million	Romo et al. (2009)
20.	Procter & Gamble	\$200 million	Camm et al. (1997)
21.	PSA Peugeot Citroen	\$130 million more profit	Patchong et al. (2003)
22.	Samsung Electronics	\$200 million more revenue	Leachman et al. (2002)
23.	Sasol	\$23 million	Meyer et al. (2011)
24.	Sears	\$42 million	Weigel and Cao (1999)
25.	Swift & Company	\$12 million	Bixby et al. (2006)
26.	Taco Bell	\$13 million	Hueter and Swart (1998)
27.	Time Inc.	\$3.5 million more profit	Koschat et al. (2003)
28.	United Airlines	\$6 million	Holloran and Bryne (1986)
29.	Waste Management	\$100 million	Sahoo et al. (2005)
30.	Workers'-Compensation Board	\$4 million	Urbanovich et al. (2003)

Source: Hillier and Hillier (2014, p. 13), Hillier and Lieberman (2010, p. 4)

Lonnstedt (1973) has examined the use of O.R. in 12 companies quoted on the Stockholm Stock Exchange. The most common areas of use are identified and they are coordination and production problems. Also, the following O.R. techniques were identified as frequently used: simulation and network planning. The degree to which quantitative methods (methods involving strategic planning, formal decision-making methods and operations research methods) are used in management in Serbian companies is examined in Nikolic et al. (2010). The research was conducted through a questionnaire consisting of 12 questions, and the sample was comprised of 30 respondents (senior managers). Based on the obtained results, the average degree to which quantitative methods are used in management in Serbian companies was determined. It was additionally determined that operations research methods (linear programming, transportation problems, network planning techniques, supply management, etc.) are used more often than methods involving strategic planning (SWOT analysis, portfolio analysis, ABC analysis, etc.) and formal decision methods (ELECTRE, PROMETHEE, AHP, TOPSIS, VIKOR, etc.). Time constraints and lack of knowledge are the main issues in the use of quantitative methods at management levels in Serbian companies. Cvetkoska (2016) gives an analysis of using O.R. in making decisions in micro, small and medium-sized enterprises in Macedonia. The survey was conducted via a questionnaire distributed electronically to 100 managers of micro, 100 managers of small, and 100 managers of medium-sized enterprises. It was completely filled in by 93, 73, and 71 managers of micro, small and medium-sized enterprises, respectively. According to the obtained results it was determined that quantitative operations research models for supporting the decision-making process are used by 10% of managers of the micro, 22% of managers of the small, and 45% of managers of the medium-sized enterprises. The benefits achieved in using quantitative models in decision-making are cost reductions, successful coverage of costs, revenue growth, forecasting of sales, predicting fluctuations in expected income, increased exports, production optimization, determining the optimal inventory level, better planning of activities, more efficient allocation of staff, reduction of customer complaints, and improved customer satisfaction. Most of the respondents believe that students at all levels of studies at the Faculties of Economics should study O.R. models and methods and therefore use the acquired knowledge in organizations.

CONCLUSION

Numerous well-known organizations around the world make million-dollar savings annually because they apply O.R. in their operating. The problem that has been identified is clearly defined, a model is developed, the needed data is collected, and a solution which is developed, tested and analyzed, it is implemented in the organization. The solution from the O.R. model should serve as a recommendation to the managers for making better solutions in the organizations.

Decreasing costs, increasing revenues and profit, improving quality, productivity and performances, increasing market share as well as client satisfaction, are only some of the benefits for organizations that use O.R. Lack of knowledge regarding the benefits of using O.R. in the working of the organizations and its methods and techniques are the largest reason why this discipline is not applied in companies in Macedonia at a satisfactory level. The management in companies should have trainings organized for them, through which they will acquire the needed knowledge and skills for applying O.R. in their work, while at the Faculties of Economics this discipline should be taught at every study cycle in order for the students to be prepared for their application in companies.

REFERENCES

- Albright, C., & Winston, W. L. (2016). *Practical management science. Revised 5th ed.* Boston: Cengage Learning.
- Alden, J. M., Burns, L. D., Costy, T., Hutton, R. D., Jackson, C. A., Kim, D. S., Kohls, K. A., Owen, J. H., Turnquist, M. A., & Vander Veen D. J. (2006). General Motors increases its production throughput. *Interfaces*, 36(1), 6-25.
- Altschuler, S., Batavia, D., Bennett, J., Labe, R., Liao, B., Nigam, R., & Oh, J. (2002). Pricing analysis for Merrill Lynch integrated choice. *Interfaces*, 32(1), 5-19.
- Anderson, D. R., Sweeny, D. J., Williams, T. A., & Wisniewski, M. (2009). *An introduction to management science: Quantitative approaches to decision making.* London: Cengage Learning EMEA.
- Anderson, D. R., Sweeny, D. J., Williams, T. A., Camm, J. D., Cochran J. J., & Fry M. J. (2013). *Quantitative methods for business. 12th ed.* Mason: South-Western a part of Cengage Learning.
- Avriel, M., Pri-Zan, H., Meiri, R., & Peretz, A. (2004). Opti-money at Bank Hapoalim: A model-based investment decision support system for individual customers. *Interfaces*, 34(1), 39-50.
- Babic, Z. (2011). *Models and methods of business decision making.* Split: University in Split, Faculty of Economics Split. (On Croatian)
- Bixby, A., Downs, B., & Self, M. (2006). A scheduling and capable-to-promise application for Swift & Company. *Interfaces*, 36(1), 39-50.
- Board, J., Sutcliffe, C., & Ziemba, W. T. (2003). Applying operations research techniques to financial markets. *Interfaces*, 33(2), 12-24.
- Brigandi, A. J., Dargon, D. R., Sheehan, M. J., & Spencer, T. III (1994). AT&T's call processing simulator (CAPS) operational design for inbound call centers. *Interfaces*, 24(1), 6-28.
- Butchers, E. R., Day, P. R., Goldie, A. P., Miller, S., Meyer, J. A., Ryan, D. M., Scott, A. C., & Wallace, C. A. (2001). Optimized crew scheduling at Air New Zealand. *Interfaces*, 31(1), 30-56.
- Camm, J. D., Chorman, T. E., Dill, F. A., Evans, J. R., Sweeney, D. J., & Wegryn, G. W. (1997). Blending OR/MS, judgment, and GIS: restructuring P & G's supply chain," *Interfaces*, 27(1), 128-142.
- Carlson, B., & 12 co-authors (2012). MISO unlocks billions in savings through the application of operations research for energy and ancillary services markets. *Interfaces* 42(1), 58-73.
- Cvetkoska, V. (2016). A survey of the use of operational research in decisions made by micro, small and medium-sized enterprises in Macedonia. *Croatian Operational Research Review*, 7, 349-365.
- Datta, S., & Bandyopadhyay, R. (1994). Applications of operational research in industry and industrialization in the developing countries: A Review. *Omega*, 22(2), 173-184.
- Epstein, R., & 14 co-authors (2012). A strategic empty container logistics optimization in a major shipping company. *Interfaces*, 42(1), 5-16.
- Fakhimi, M., & Probert, J. (2013). Operations research within UK healthcare: A review. *Journal of Enterprise Information Management*, 26(1/2), 21-49.
- Fischer, M., Giehl, W., & Freundt, T. (2011). Managing global brand investments at DHL. *Interfaces* 41(1), 35-50.
- Gass, S. I., & Assad, A. A. (2005). *An annotated timeline of operations research: An informal history.* Boston: Kluwer Academic Publishers.
- Goodwin, P., & Wright, G. (2014). *Decision analysis for management judgment. 5th ed.* Chichester: John Wiley & Sons Ltd.
- Hillier, F. S., & Lieberman, G. J. (2010). *Introduction to operations research. 9th ed.* New York: McGraw-Hill Education.

- Hillier, F. S., Hillier, M. S., Schmedders, K., & Stephens, M. (2014). *Introduction to management science: A modeling and case studies approach with spreadsheets*. 5th ed. New York: McGraw-Hill Education.
- Holloran, T. J., & Bryne, J. E. (1986). United Airlines station manpower planning system. *Interfaces*, 16(1), 39-50.
- Hueter, J., & Swart, W. (1998). An integrated labor-management system for Taco Bell. *Interfaces*, 28(1), 75-91.
- INFORMS, Discover, available at <https://www.informs.org/Discover> (13 May 2017)
- Interfaces, available at <https://www.informs.org/Publications/INFORMS-Journals/Interfaces> (13 May 2017)
- Ireland, P., Case, R., Fallis, J., Van Dyke, C., Kuehn, J., & Meketon, M. (2004). The Canadian Pacific Railway transforms operations by using models to develop its operating plans. *Interfaces*, 34(1), 5-14.
- Jensen, P. A., & Bard, J. F. (2003). *Operations research: Models and methods*. Hoboken: John Wiley & Sons, Inc.
- Koschat, M. A., Berk, G. L., Blatt, J. A., Kunz, N. M., LePore, M. H., & Blyakher, S. (2003). Newsvendors tackle the newsvendor problem. *Interfaces*, 33(3), 72-84.
- Kotha, S. K., Barnum, M. P., & Bowen, D. A. (1996). KeyCorp service excellence management system. *Interfaces*, 26(1), 54-74.
- Kroon, L., Huisman, D., Abbink, E., Fioole, P. J., Fischetti, M., Maroti, G., Schrijver, A., Steenbeck, A., & Ybema, R. (2009). The new Dutch timetable: The OR revolution. *Interfaces* 39(1), 6-17.
- Leachman, R. C., Kang, J., & Lin, Y. (2002). SLIM: Short cycle time and low inventory in manufacturing at Samsung Electronics. *Interfaces*, 32(1), 61-77.
- Lee, E. K., & Zaider, M. (2008). Operations research advances cancer therapeutics. *Interfaces*, 38(1), 5-25.
- Lonnstedt, L. (1973). The use of operational research in twelve companies quoted on the Stockholm Stock Exchange. *Operational Research Quarterly*, 24(4), 535-545.
- Magee, J. F. (1954). Application of operations research to marketing and related management problems. *Journal of Marketing*, 18(4), 361.
- Meyer, M., & 11 other co-authors (2011). Innovative decision support in a petrochemical production environment. *Interfaces* 41(1), 79-92.
- Munoz, D., Lascrain, M. de, Romeo-Hernandez, O., Solis, F. Santoz, L. de los, Palacios-Brun, A., Herreria, F., & Villasenor, J. (2011). INDEVAL develops a new operating and settlement system using operations research. *Interfaces* 41(1), 8-17.
- Nikolic, M., Savic, M., & Jovanovic, D. (2010). Implementation of quantitative methods in the management of Serbian companies. *Multitarts*, 1(1), 3-9.
- Patchong, A. Lemoine, T., & Kern, G. (2003). Improving car body production at PSA Peugeot Citroen. *Interfaces*, 33(1), 36-49.
- Powell, S. G., & Baker, K. R. (2013). *Management science: The art of modeling with spreadsheets*. 4th ed. Hoboken: Wiley.
- Rardin, R. L. (2016). *Optimization in operations research*. 2nd ed. London: Pearson.
- Ravindran, A. R. (2008). *Operations research and management science handbook*. Boca Raton: CRC Press.
- Render, B., Stair, R. M. Jr., & Hanna, M. E. (2012). *Quantitative analysis for management*. 11th ed. Harlow: Pearson Education Limited.
- Romo, F., Tomasgard, A., Hellemo, L., Fodstad, M., Eidesen, B. H., & Pedersen, B. (2009). Optimizing the Norwegian natural gas production and transport. *Interfaces* 39(1), 46-56.
- Saaty, T. L. (2006). *Creative thinking, problem solving & decision making*. Pittsburgh: RWS Publications.
- Sahoo, S., Kim, S., Kim, B.-I., Krass, B., & Popov, A. Jr. (2005). Routing optimization for Waste Management. *Interfaces*, 35(1), 24-36.
- Semini, M. (2011). Applicability of operations research in manufacturing logistics. Doctoral Thesis at NTNU, ISSN 1503-8181. <http://www.divaportal.org/smash/get/diva2:477533/fulltext01.pdf> (01 September 2016)
- Sud, V. P., Tanino, M., Wetherly, J., Brennan, M., Lehky, M., Howard, K., & Oiesen, R. (2009). Reducing flight delays through better traffic management. *Interfaces* 39(1), 35-45.
- Taha, H. A. (2016). *Operations research: An introduction*. 10th ed. London: Pearson.
- Taylor, B. W. III. (2016). *Introduction to management science*. 12th ed. Harlow: Pearson Education Limited.
- The Science of Better, About O.R., available at <http://www.scienceofbetter.co.uk/about-or> (10 July 2016)
- The Science of Better, available at <http://www.scienceofbetter.co.uk/> (13 May 2017)
- Trench, M. S., Pederson, S. P., Lau, E. T., Wang, Ma, H., & Nair, S. K. (2003). Managing credit lines and prices for bank one credit cards. *Interfaces*, 33(5), 4-21.
- Troyer, L., Smith, J., Marshall, S., Yaniv, E., Tayur, S., Barkman, M., Kaya, A., & Liu, Y. (2005). Improving asset management and order fulfillment at Deere & Company's C&CE division. *Interfaces*, 35(1), 76-87.
- Urbanovich, E., Young, E. E., Puterman, M. L., & Fattedad, S. O. (2003). Early detection of high-risk claims at the workers' compensation board of British Columbia. *Interfaces*, 33(4), 15-26.
- Ward, J., & 20 co-authors (2010). HP transforms product portfolio management with operations research. *Interfaces* 40(1), 17-32.
- Weigel, D., & Cao, B. (1999). Applying GIS and OR techniques to solve Sears technician-dispatching and home-delivery problems. *Interfaces*, 29(1), 112-130.
- Williams, T. (2008). *Management science in practice*. Chichester: John Wiley & Sons, Ltd.
- Yu, G., Arguello, M., Song, C., McGowan, S. M., & White, A. (2003). A new era for crew recovery at Continental Airlines. *Interfaces*, 33(1), 5-22.