Management Science: Current Educational Trends and Jobs in the Field

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Abstract

Businesses can benefit from the use of Management Science. A variety of problems are solved every day with the help of tools from the discipline. Although this field of work is found in almost every industry, many business schools have or eliminated the Management Science course from the core curriculum. This research focuses on the current job market in the field of Management Science/Operations Research. The results indicate there are in fact many opportunities available to the practitioner in this field. This article identifies the locations, industries, salaries and other information about these positions.

Keywords: Operations Management, Production, Management Science, Business Education, Jobs, Careers, Operations Research, Opportunities.

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Management Science: Current Educational Trends and Jobs in the Field

Management Science is taught in many schools throughout the country and the world. It is also practiced in many jobs spanning numerous industries. Although there seems to be a need for practitioners in the field of Management Science, recent academic trends are showing just the opposite. Business schools are no longer required to have the Management Science course as part of the core curriculum. Fewer students are now taking the course, which leaves many without any exposure to the subject. What is the purpose of Management Science? What are the reasons for the decline of the course? What do practitioners in this field do? What types of jobs are there? This paper attempts to answer these questions and gain a further understanding of the study and current practice of Management Science. In this paper, the terms *Management Science (MS) and Operations Research (OR)* are used interchangeably.

Businesses of all sizes can benefit from the use of Management Science and Operations Research. Management Science (MS) or Operations Research (OR) is a scientific discipline devoted to the analysis and solution of complex decision problems (Camm, 2000). It is a way to analyze a specific problem and make a decision based on the results. It often uses mathematical computer models to forecast the implications of various possibilities and to guide decision makers as they choose the best alternative from available options.

OR developed as a formal study from the efforts to improve military operations during World War II. It was used to provide effective deployment of radar, search for enemy submarines, and route supplies (Chase, Aquilano, and Jacobs, 1998). After the war, the tools and techniques used by the military were soon applied to many types of business problems.

Professionals in the field of OR work in many disciplines including Finance, Human Resource Management, International Business, Marketing, Transportation, Production, Education, Health Care, and

Natural Resources among others. Firms such as American Airlines, AT&T, Citicorp, Merrill Lynch, American Express and General Motors are examples of employers with an in-house OR staff. Smaller businesses have also recognized the need for OR and have hired consulting firms to perform the OR tasks. The single largest employer of OR professionals is the United States Government. OR positions exist within the Departments of Labor, Commerce, Housing and Urban Development, Defense, Health and Human Services, Transportation and all branches of the armed services. The Institute for Operations Research and Management Sciences (INFORMS) indicates approximately 35% of its 13,000 members work in private industry, 56% in academia and 9% in government (Informs Online, 1997). Degree programs are available in Operations Research, Management Science, Manufacturing or Industrial Engineering and other related fields (see for example Bell, 1998 and Martell, 1999).

Current Trends in Education

Over 150 colleges and universities offer OR programs, yet the traditional Management Science course is on the decline in many MBA programs throughout the United States. In 1991 the AACSB, the premier agency for business school accreditation, revised its standards to exclude Management Science from its core body of knowledge; thus, many schools eliminated the Management Science requirement from their programs (Powell, 1998) to free up space to offer more popular courses and electives. Scott (2001) forecasting the future of education in the year 2025 agrees the OR community will not be proactive in designing this future.

In the past several years' schools such as Stanford, the University of Chicago, Tuck School at Dartmouth College and Harvard have either reduced or eliminated Management Science from the required business curriculum. What are the reasons for these declines? Powell (1996) suggests several possibilities and suggests the curriculum at business school is subject to cycles. The current decline is expected because of the rise of the Management Science discipline in the 1960s and 1970s. Another possibility is MBA students simply do not want

to take the course because they are not strong in quantitative skills. Another possibility suggested could be the other concentrations within the business school have incorporated Management Science into their classes, therefore eliminating the need for a separate, stand-alone Management Science course. The final possibility is that MBA graduates rarely used Management Science tools in their careers, particularly in the high growth areas of Marketing and Finance.

Thomas Grossman, (2001) a Management Professor at the University of Calgary, suggests Management Science courses are being threatened with elimination or reduction for one simple reason, there is a large gap between what is taught in the traditional business school Management Science course and the requirements of MBA programs and students. He suggests the traditional Management Science course teaches only an appreciation for the body of knowledge rather than teaching students how to utilize the Management Science concepts. He further suggests MBA programs want to produce effective leaders and competent managers but the traditional Management Science course teaches only theories and models. Grossman's final argument is MBA students want to learn practical skills and seek knowledge to enable them to advance in their careers. This contrasts with what the traditional Management Science program teaches: Mathematics, Properties of Optimality, and to be informed consumers of the work of Management Science professionals.

Although Management Science courses are declining in programs across the country, many professors are trying new approaches to teaching. Not only are these new approaches attempting to meet the needs of today's students, they are also attempting to meet the needs of the changing work environment. Robert Carraway and Dana Clyman, professors at the University of Virginia, agree the Quantitative Analysis course is routinely rated by students as one of the top courses in the required MBA curriculum. They think the course's success is due to its focus on managerial relevance, rather than Operations Research, Management Science or Statistics. The classes are structured to have a decision-oriented focus, raise issues

and address contexts pertinent to an informed business practitioner. The Quantitative Analysis course relates closely with functional courses like Finance, Marketing and Operations. The primary objectives of the course are to master a core group of quantitative analytical frameworks and techniques and to integrate this technical competency into the general decision making processes (Carraway & Clyman, 1997).

Ingjaldur Hannibalsson, a University of Iceland professor, incorporates interactive teaching in his Operations Management course to meet the changing demands of students. He includes spreadsheets, cases, and gaming exercises in the curriculum. He found 38 percent of students are more interested in Operations Management after taking this course (Hannibalsson, 2001). In Germany, the number of university institutes or chairs dedicated to OR is both small and decreasing (Fleischmann, 1995).

Francis Clauss, a professor at Golden Gate University, suggests educators need to break from patterns leading to a declining role for OR/MS in both academia and the corporate world (Clauss, 1997). Just because a solution is optimal in a theoretical sense does not necessarily make it a good management decision. Instead of focusing solely on the optimal solution, Clauss suggests students need to recognize where corrective actions need to be taken. OR/MS textbooks too need to elaborate more specifically on a manager's duties. For example, a manager's job is not finished just because the optimal solution is found. Therefore OR/MS texts should encourage students to prepare management-quality presentations and implementation strategies.

Stephen Powell, a professor at the Amos Tuck School of Business at Dartmouth College, suggests revisions are needed in the Management Science course to provide the background students need for success on the job. The first task taught should be how to effectively design, build and debug a spreadsheet. The second task is to teach students how to extract useful managerial insights from a model's results. Finally Powell (2002) suggests the analytical tools of Management Science should continue to be taught, but possibly at a reduced num-

ber in order to accommodate the spreadsheet and problem solving skills students need.

While the examples and proposed solutions are different, the common theme is Management Science courses taught in business school prepare students to use Management Science in the corporate world. Teaching students not only how to solve problems, but also encouraging them to think in a managerial sense seems to be the trend in teaching the Management Science course (see also Borsting, 1988 and Larson, 2002).

Skills of OR/MS Professionals

What are the skills needed to be an effective practitioner in the field of Management Science? Although the skills needed vary from industry to industry, the best practitioners have general, transferable knowledge and skills, as well as industry-specific skills. To be most effective, professionals in the field of Management Science need to have general business skills as well as modeling skills (Murphy, 2001). Harlan Crowder, a Senior Scientist at Hewlett-Packard Laboratories, states the OR practitioner should have three distinctive traits: the ability to build computer-based OR models, business and application domain knowledge, and good communication skills (Crowder, 2000). Horner quotes Raj Nigam, the leader of the internal Management Science group at Merrill Lynch, on qualities needed by OR professionals—a solid background in terms of Statistics, Finance, Mathematics. In addition, OR professionals need to be able to talk, make eye contact, listen, and communicate. You have to know how to listen to decision-makers in order to find out what's bothering them. And then you have to communicate your analysis to them in plain English to be understood (Horner, 2000).

Melnyk (2002) agrees the field of Operations Management is changing and new trends include time-based competition, mass customization, supply chain management, kaizen events, collaborative planning and forecast replenishment, advanced planning and scheduling, environmentally benign manufacturing, the Internet, lean manu-

facturing and e-procurement. Other demands and constraints have affected the theory and practice of Management including reduced lead times, greater customer demands, and the presence of a large number of demanding stakeholders within the supply chain. McKenna (1997) agrees major forces challenging the discipline are growing and include the never satisfied customer, a transformation process or total supply chain, shrinking product life cycles, more data, profit margin squeeze, technological change, management developments, and an increasing number of operational alternatives. Still other opportunities are in consulting (Askoy, 1996) and systems development (Jacobs, Ratliff, & Smith, 2000).

Careers in OR/MS

OR/MS has had a significant impact in almost every sector of corporate America. Larson (2000) agrees businesses cannot afford to ignore OR because it either means more profits or better customer service, and usually both. Examples of industries using OR are profiled and include e-business, telecommunications, airlines, the management of forest fires, energy production and financial services.

E-Business – Opportunities for Operations Research are becoming more abundant in the e-business era (Geoffrion & Krishnan, 2003a, 2003b, and Swaminathan & Taylor, 2003). Success in areas including financial services, electronic markets, network infrastructure, packaged OR-software tools, supply-chain management and travel related services are becoming more prominent. Two kinds of managerial opportunities exist for OR in connection with information goods and services: to help design and operate e-business processes and to analyze new, unique business issues (Geoffrion & Krishnan, 2001). OR can be useful in assessing the potential of e-business models (Hayes & Finnegan, 2005). Makatsoris and Change (2004) agree e-business technologies have provided new ways of working and suggest an emerging area of e-business focus is that of collaborative supply-chain planning and fulfillment systems across multiple, distributed enterprises.

Telecommunications – One part of the telecommunications industry is the call center. Call centers exist in many industries including airlines, banks, credit card, rental cars, hotels and shipping companies. OR is used in call content analysis to answer questions such as: How many calls will we get? How many people do we need to staff? When/how should these agents be hired, trained and scheduled? What will this cost? To answer these questions, OR professionals use a combination of mathematical modeling skills, database aptitude and organizational/business processes (Mehrotra, 1997). Recent telecommunication applications include transportation infrastructure and routing decisions (Labbe, Laporte, Rodriguez, & Gonzalez, 2005), designing cellular networks, determining cell location and demand, and modeling revenue potential in various geographical areas (Kalvenes, Kennington, & Olinick, 2005), expansion costs of wireless cellular network substations (Chamberland, 2004) and designing telecommunication networks to minimize costs and reduce failure (Ouveysi, Wirth, Yeh, and Oguz, 2003).

Airline – OR/MS skills are extremely valuable in the airline industry. OR/MS models are used in airline safety, crew scheduling, pricing decisions, air traffic control, workload distribution, communication and data transfer. The airline industry has invested heavily over the past three decades to solve crew-scheduling problems (Cappanera & Gallo, 2004). The main reasons for their investments have been to reduce aircrew costs, reduce solution time, and increase compliance and to reduce costs to construct and maintain the crew scheduling process (Ryan, 2000; Freling, Lentink & Wagelmans, 2004; Sohoni, Johnson, & Bailey, 2004; and Boschetti, Mingozzi & Ricciardelli, 2004). Examples of opportunities for research in airline safety include development of an information infrastructure for collecting, analyzing and disseminating aviation safety information, development of technology for cockpits and ground control systems for pilot error reduction, development of a computer program to study the errors of airline maintenance workers and determines solutions, and an examination of the opportunities and challenges of global airline mergers and alliances

(see also Vanchieri, 2000 and Mcfadden, 1997). Other OR research has enhanced the capacity of the air space available while satisfying Air Traffic Control constraints and airlines' requests to optimize their operating costs (Barnier & Brisset, 2004).

Forest Fire Management - Forest fire management poses many challenges and opportunities for operations researchers. Fires create threats to public safety, timber production and other human endeavors. However, because fires are a natural process to the forest ecosystem, fire managers must balance the threat to humans with disrupting natural processes. OR models have been developed to evaluate initial attack system alternatives and support the purchase of firefighting equipment. This is often accomplished through a deterministic simulation model of previous forest fires. Simulations have been developed to decide how fire fighting services should be allocated according to the development of a particular fire (Dimopoulou & Giannikos, 2004). Models have also been used to help evaluate where air tankers should establish their home base as well as how to deploy the air tankers to fight fires on a daily basis (Martell, Tithecott, & Ward, 1999) and to model fire spread rates (Butler, Finney, Andrews & Albini, 2004 and Stocks, Alexander, & Lanoville, 2004).

Energy Production – OR professionals are needed in the energy field for efficiency and emissions reduction. Since energy cannot be stored in large quantities, production and demand must be met on a minute-by-minute basis. To achieve the highest efficiency, energy production must be carefully scheduled. The OR challenge professionals is to design and develop efficient software systems to integrate decision-support functionalities and e-commerce capabilities. This is accomplished with techniques including stochastic programming, non-linear programming with mixed 0-1 variables, controlled Monte Carlo simulation, artificial neural networks and cluster analysis (Escudero & Pereira, 2000). Recent market simulation OR models in the domain of electricity have expanded the agent-based models to include both short-term and long-term delivery approaches as well as including regulatory agent's decisions (Czerrohous, Fichtner, Veit, & Weinhardt, 2003).

Companies now consider the environmental impacts when making decisions regarding energy development and regulation because of the National Environmental Policy Act of 1970. These laws offer incentives to reduce pollution. This incentive-based approach to environmental regulation gives management more flexibility but at the same time creates more options and complexity. This is where the skills of OR professionals come in. Models are used to simulate the impacts of different policies upon global environmental conditions (Hobbs, 1996) and calculate recycling rates (Reuter, Boin, Rem, & Yang, 2004). Other models aid in allocating energy grants for low-income households to states (Kaiser & Pulsipher, 2004).

Financial Services – Within the financial services sector, OR professionals are primarily employed by the large institutional buyers and sellers in the major capital markets. They study and model the risks and returns in the instruments traded. Examples of areas in which Operations Research is useful are fixed income investments, term structure models, prepayment modeling, and portfolio optimization. OR also aids in data mining in the financial services industry (Chang, Chang, Lin, & Kao, 2003) as well as model process performance in financial services (Safizadeh, Field & Ritzman, 2003). For a career in Finance, OR skills should be diverse to allow effectiveness in a variety of projects combined with strong computer programming skills (Venkatakrishnan, 1997).

Health Care – OR Models have assisted health care providers determine unused hospital bed capacity, more efficiently allocate space, and examine relationship between surgery wait times and length of patients' stay (Akkerman & Knip, 2004). Other solutions in health care integrate hospital planning and multi-objective decision support to include decisions on the location and size of medical departments in a hospital network, for example (Stummer, Doerner, Focke, & Heidenberger, 2004).

Methodology

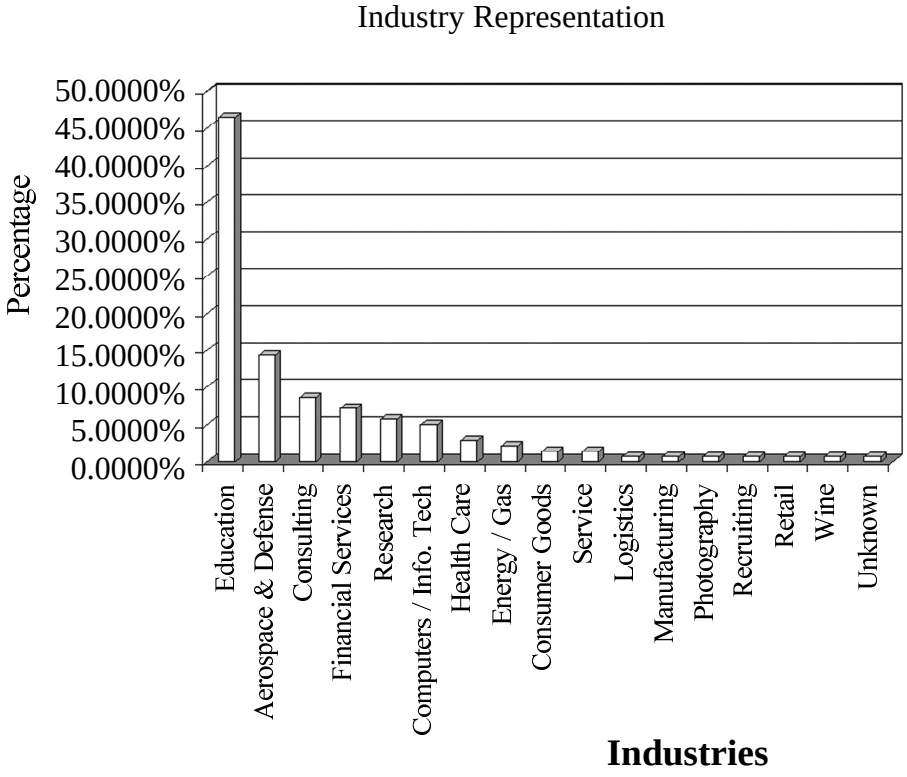
The skills needed to be successful in OR/MS are well understood and there are numerous industries that employ these skills. To find information regarding job openings currently posted in the field of OR/MS, research was performed through the use of the Internet. The information gathered included the company posting the position, industry, and job title, location of the position, degree required, experience desired and salary. A total of 140 different job postings were found during a four-month period in fall 2002. The source of the information came from four national job search websites as well as two OR websites. The websites where postings were found were Flipdog.com, Hotjobs.com, Monster.com, BrassRing.com, OR/MS Today and DecisionSciences.org. The only criterion for the inclusion of the postings was that it had to be in the field of OR/MS and listed as such.

Findings

Industry Representation

The 140 job postings were spread across a variety of industries. The industry with the largest percent of the market share was education. Of the 140 job postings, 65 (46%) were in education, as was expected. The second largest representation was in the field of aerospace and defense. There were 20 job postings (14%). Other industries posting OR jobs were in consulting, financial services, research and computers/information technology. The remaining fields including health care, energy/gas, consumer goods, service, logistics, manufacturing, photography, recruiting, retail, and wine industries, had only a few postings each. One posting did not list the industry.

Although this data shows the majority of current job openings in the field of OR/MS are in education, it also shows that OR/MS professionals are needed in a wide variety of industries. Individuals looking for career opportunities are not limited to education, but can find opportunities in many different, challenging areas. Table 1 profiles the various industries with job postings in the field of OR/MS shown in descending order of jobs available by industry.



Location

The locations of the job postings span across the United States as well as several countries. By far, the state with the highest percentage of job postings was California, with 24 of the 140 postings (17%). The locations with the next highest percentages of job postings were New Jersey (6%), DC and Michigan (5.7%) and New York and Pennsylvania (5%). In all, job postings were found in 30 states as well as Ontario, British Columbia, Denmark, Singapore and Hong Kong. Five of the postings had unspecified locations. The findings are shown in the Table 2. The majority of the job postings are located in the North or Northeast section of the United States. The second largest section was the West mainly because of the number of jobs in

California. When looking for OR employment opportunities, it is helpful to search in regions where OR/MS jobs are more prevalent but it is also important to note OR/MS jobs are not limited only to these areas.

Table 2: OR Job postings by State and country

State	# Postings	Percentage	Region	Percentage
CA	24	17.14%	North/N. East	49.29%
NJ	9	6.43%	Central	2.14%
DC	8	5.71%	South	17.86%
MI	8	5.71%	West	19.29%
NY	7	5.00%	Unknown	3.57%
PA	7	5.00%	Other	7.85%
TX	6	4.29%		
FL	5	3.57%		
OH	5	3.57%		
ON	5	3.57%		
unknown	5	3.57%		
VA	5	3.57%		
CT	4	2.86%		
SC	4	2.86%		
DE	3	2.14%		
GA	3	2.14%		
MA	3	2.14%		
MN	3	2.14%		
NC	3	2.14%		
CO	2	1.43%		
IL	2	1.43%		
IN	2	1.43%		
MO	2	1.43%		
Singapore	2	1.43%		
WI	2	1.43%		
AL	1	0.71%		
AZ	1	0.71%		
BC	1	0.71%		
DN	1	0.71%		
HI	1	0.71%		
Hong Kong	1	0.71%		
IA	1	0.71%		
MD	1	0.71%		
MS	1	0.71%		
NH	1	0.71%		
WA	1	0.71%		

Education and Experience

Within the 140 job postings, various levels of education were required. There were seven categories of educational levels: (1) Bachelors, (2) Bachelors required, masters preferred, (3) Masters, (4) MBA, (5) Masters required, Ph.D. preferred, (6) Ph.D., and (7) Not specified. Fifty percent of the job postings required a Ph.D or advanced graduate degree, including five non-educational jobs. A bachelor's degree was the minimum required for only 10% of the positions as shown in Table 3. Overall, this information shows that the workforce in the field of OR/MS is highly educated. A graduate degree is the norm.

Table 3 OR Degree Requirements

MBA	2	1.43%
Bachelors req., Masters pref.	7	5.00%
Masters req., Ph.D. pref.	8	5.71%
Masters	13	9.29%
Bachelors	14	10.00%
Not specified	26	18.57%
Ph.D.	70	50.00%

The levels of experience were grouped in eight categories: Yes, 0-3 years, 3-5 years, 5-10 years, 10-20 years, Military, None, and Not Specified. The results are shown in Table 4. The employers were interested in job experience. There were 80 job postings requiring past experience in the field of OR/MS. The number of years was not identified, just that experience was necessary. Of the postings specifying a certain amount of years, the next highest was in the category of zero to three years (8.5%). There was only one posting where experience was not necessary. Thus, experience is vital. Experience while in college, through a part time job or internship, could provide the minimum experience an employer is seeking.

Table 4 OR Position Experience Requirements

Experience	# Postings	Percentage
Yes	80	56.74%
0 - 3 years	12	8.51%
3 - 5 years	8	5.67%
5 - 10 years	8	5.67%
10 - 20 years	3	2.13%
Military	3	2.13%
No	1	0.71%
Not Specified	26	18.44%

Sources for OR Jobs

Several different websites were used to find job postings. Five of the websites were national job search services and two were OR/MS specialty online sources. OR/MS Today had the greatest number of postings with 55 of the 140 (39%). The majority of the postings in this website were for education jobs. The second largest number of postings was from Monster.com. This website had postings from a variety of industries and included postings from staffing firms as well as individual companies. The complete list of sources is shown in Table 5.

Table 5 OR Sources of Jobs

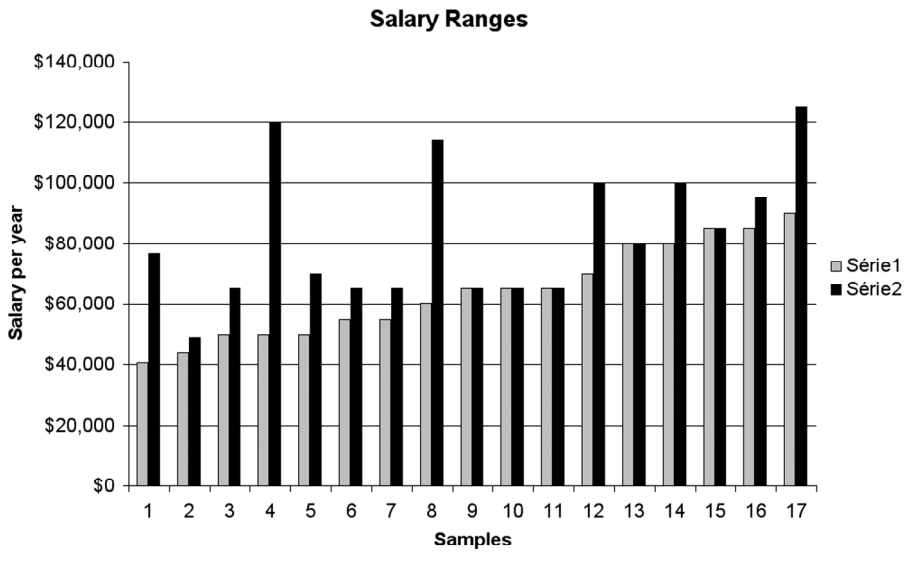
Source	# Postings	Percentage
OR/MS Today	55	39.29%
Monster.com	26	18.57%
DecisionSciences.org	23	16.43%
BrassRing.com	12	8.57%
Hotjobs.com	12	8.57%
Analytic Recruiting	7	5.00%
Flipdog.com	5	3.57%

OR/MS Today and DecisionSciences.org would be the best source for postings in the field of education and research. The other national online job searches would be the best source for postings outside education. When looking for career opportunities within the field of OR/MS, all of the sources would be helpful.

Salary

Of the 140 job postings identified, only 17 listed a salary or salary range. The average salary range was $64,111 to $82,632 per year. The lowest salary found was $40,579 and the highest was $125,000. These salaries are based on experience within the industry. The salaries found are shown in Table 6. According to the *Wall Street Journal*, the national average for a position in operations research is $52,064. The low is $37,460 and the high is $63,007. The salary ranges found in the sample are at the upper end of the national averages.

Table 6 Salary Ranges



Conclusion

Career opportunities are available in the field of OR/MS. These data show the field of OR/MS is very strong. There remains a need for individuals with OR/MS skills to fill these positions. Career counselors, college professors, and advisors need to convey this information to current and prospective students.

The limitations of this research include the time frame used and the limited sample of job posting locations. Further research could examine trends in job composition and availability on longitudinal bases and determine what variables are correlated with job availability and to review trends in job location. Further study is also needed to compare OR/MS business curriculum courses and content and to explore the need to re-emphasize OR/MS in graduate business training. Other research should seek to differentiate the industry definitions and usage in practice of the terms MS, OR, Decision Sciences, OM (Operations Management), and IE (Industrial Engineering). Expanded research on job availability could also include other search engines, the Internet in general, and newspapers including the *Wall Street Journal* and the *New York Times.*

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