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Operations Research and Ethics: Responsibility, Sharing and Cooperation

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Abstract

After a discussion on the relevance of ethics in Operations Research, two approaches to the ethical discourse, one based on rules and the other based on principles and values, are analyzed. Then, two ethical principles, which can help O.R. researchers and practitioners in their activity are discussed in some detail. The first is the "responsibility principle", proposed in a more general context by the philosopher Hans Jonas, which in our case suggests to take into account in our work not only the point of view of the "client", but also the point of view of all the "stakeholders", i.e. the ones who can directly or indirectly be affected by the results of our activity. The second, which can be called the "sharing and cooperation principle", calls for a more open distribution of the results of our research activity, whether they are ideas, algorithms or software.

1 Introduction

Science and technology are more and more intertwined: the latter motivates the former and, at the same time, new methodological developments make new applications possible and hence lead to new technological advancements.

Technology has a pervasive and every day stronger impact on society and on human life. That has led to a growing awareness that science cannot

*A first version of this paper has been presented at a workshop held on occasion of the eightieth birthday of prof. Enzo Luigi Aparo, who has taught me to value quality, sharing and cooperation in my research activity, and to whom the paper is dedicated.

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be considered above or beyond the realm of value judgments and hence of ethics. As Robert Oppenheimer put it after Hiroshima: "*scientists have now experienced sin*".

These considerations apply in a special way to Operations Research which, has as its objects methodologies and techniques for providing support in decision making processes. Hardly any area in O.R. can be considered far enough from the real world to escape from ethical considerations.

The awareness of the relevance of ethics in Operations Research has been growing in the last years. The rôle of Operations Research in addressing social issues has been advocated among others by Rosenhead [12] [13] and, more recently, by Koch [8]. Schneeweiss [15] analyzes the relations between ethics and decision processes and therefore Operations Research, thus "via the analyst or consultant, O.R., as an applied science, is part of the decision process and thus is, at least partially, responsible for keeping moral norms". A more systematic analysis of the relations between ethics and Operations Research has been performed by Brans [1], who outlines what can be considered the first ethical code for Operations Research. Note that scientific associations in fields which are contiguous to or overlap with the O.R. area, such as ACM and IEEE, already have their ethical codes [11] [4].

In this paper two ethical principle are discussed, which can help O.R. researchers and practitioners in their activities.

The first is the *responsibility* principle, along the lines developed in a more general context by the philosopher Hans Jonas [6] [7]. Applied to our field this principle suggests, for example, taking into account in our work not only the point of view of the "client", i.e. the person who pays for our research or for our professional advice, but also the point of view of all the "stakeholders", i.e. the ones who can directly or indirectly be affected by the results of our activity.

The second principle, which can be called the *sharing and cooperation* principle, calls for a more open distribution of the results of our research activity, whether they are ideas, algorithms or software. The rationale behind this principle is twofold. First, our results are not only 'ours'; in fact, they are only the tip of an iceberg consisting of a pre-existing large body of knowledge. We will have used in our work the results of the work of the scientific and professional community, and it is our duty to enable the whole community to benefit from our work. Second, we should contrast the trend to an ever increasing privatization of ideas, which is something relatively new in science, and which rather often turns public investments into private gains.

2 Values, Science and Technology

The claim that science and technology are value-neutral, which was quite common among researchers not long time ago, is now challenged more and more. It is still slow in dying and, most often, the practical behavior of people working in scientific or technological areas appears to conform to it. “Guns don't kill, people do”, the motto of those who oppose firearms control bills in the United States, is only one of the most typical expressions of the belief that problems only derive from people's behavior not from technologies, although it is not difficult to unmask the corporate interests which are behind it.

The idea of the value-neutrality of science derives from two different assumptions. The first is *methodological*: scientists must be objective, neutral observers of the subject of their study. The second is *ontological*: the object of scientific analysis must be seen as it is, or, put in a different way, the *natural laws* simply *are*; no value or purpose can be attached to them. From the above assumptions it follows that science is nature laden, *i.e.* the development of the scientific knowledge is a kind of natural process dictated by nature itself not by society. Hans Jonas, in [7], argues against the second assumption, and hence implicitly against the first one, and shows the paradox it generates: a purposeless and disinterested nature has given birth to the subjectivity of human life, whose main characteristic is to put endless questions about its purpose and its nature, that is to ‘be interested’. In other words, subjectivity cannot be explained while remaining within such a concept of nature; it is a paradox with a Gödelian flavor. However, a philosophical discussion on this matter is beyond the scope of this paper; here I will use a different argument against the neutrality of science.

Science and technology are strictly intertwined, to such an extent that it is often hard to make a distinction between the two. There is a kind of reinforcing loop in which scientific results foster the development of new technologies, and, at the same time, new technologies push forward the frontiers of scientific knowledge. On the one hand, technologies are a driving force of economic development and are within the realm of economics and of corporate interests no less than within the scientific realm. On the other hand, they have a deep influence on society and on its dynamics and are at the same time influenced by social forces. As the development of new technologies or the improving of old ones is today one of the main motivations of scientific research, one can say that science itself is dependent on social forces and economic interests and is shaped by them. As Deborah G. Johnson puts it: “Even those who resist these claims insofar as they apply to scientific method, recognize that when it comes to topic choice and funding, science is shaped by social forces”[5]. In fact, it is this very connection and interdependence of the two, science and technology, which, instead of making the latter value-neutral, makes the former value dependent.

Operations Research is itself a kind of microworld in which scientific and technological activities proceed together, each pushing forward and stimulating the other. New problems lead to the formulation of new models which require new and more efficient algorithms (the technology), but the design of new algorithms requires and motivates new theoretical work. The loop is closed because new and more advanced theories and more efficient algorithms enlarge the area of tractable problems suggesting the possibility of new applications. We have again a typical, self-reinforcing loop.

Operations Research, as the science which claims to provide tools for helping decision making processes, may, more than many other scientific disciplines, have an impact on people's lives and hence on society at large. Almost any solution provided by O.R. methodologies, when (and if) applied, do affect people, whether workers of a company, customers of a service or investors in the stock market. Hence, the arguments which apply to any other sector apply, possibly more strongly to O.R., making it subject to ethical considerations. This is the main thesis of Tom Koch in his paper "We Live in the City Not in a Study"[8]: the O.R. practitioner, when analyzing a problem, cannot limit himself/herself to the specification of the problem provided by the customer; he/she must make an effort to analyze the context in which the problem is placed and to understand the consequences of its solution on the people affected and on the environment. The typical answer Koch says he has received, when asking the speakers in a section of an O.R. Conference "what does this mean to you as a citizen?", was "it is not in the study's parameters". We can easily assume that the people who designed and carried out the highly efficient logistical organization which allowed the Nazis to exterminate millions of people in their camps would have given the same answer. This parallel may be considered unfair, and it is certainly an extreme example, but not that extreme, at least in the light of the revelations about the rôle of IBM machines in the nazi logistics. Moreover, in some cases the difference may be considered more a matter of quantity rather than of quality.

These last considerations lead us to a question: "who is our real customer?". Is it only the agency or the corporation that has employed us? or do we have to put in the picture other customers? But before answering such a question we have to answer a more fundamental one: "what is the meaning of ethics and of ethical behavior?". I will try to give an answer to these questions in the next section.

3 Rules and principles

What do we mean when we talk of ethics? This is a fundamental question which I will not address from a philosophical point of view, as that would goe far beyond the objectives of this paper. I will try to give a practical answer, perhaps a simplistic one, but one which may help us to analyze the relations between ethics and Operations Research.

We cannot talk of ethics without talking of liberty: the two go together. There is no room for ethics nor for ethical responsibility where there is no freedom of choice. It is the possibility of choosing between different alternatives which makes us subject to moral judgment. The fact that we can choose does not mean that the choice is always an easy one; in fact, often it is not. Sometimes it might appear that there is no choice. Still, there is good argument for saying that there is always a choice, although it may happen that some alternatives do not conform to what are perceived as the common behavioral rules of the community we live in.

An ethical discourse can be developed at two levels. The first (and lower) one is the level of *rules* or *ethical norms*; the second (and higher) one is the level of *principles* or *values*.

The first level corresponds to the rather common idea that ethics means mainly *rules*, a set of behavioral rules. Such rules are given from outside, and depend on the particular cultural, social and political reality in which the individual lives. No society can live without a set of accepted rules, which represent the minimal set of rules on which there is a general consensus. Often we acknowledge different sets of rules, one set sometimes in contradiction with another) depending on different aspects of our life. Here we are mainly concerned with professional activity. The codes of ethics of professional society are, typically, sets of rules, sometimes well defined and sometimes rather generic. As an example the code of ethics of *The Institute of Electrical and Electronics Engineers* (IEEE) consists of 10 points, some very precise, like the 3^{rd} (*to be honest and realistic in stating claims or estimates based on available data*) or the 4^{th} (*to reject bribery in all its forms*), others are more general, like the 1^{st} (*to accept responsibility in making engineering decisions consistent with the safety, health and welfare of the public and to disclose promptly factors that might endanger the public or the environment*) or the 10^{th} (*to assist colleagues and co-workers in their professional development and to support them in following this code of ethics*). If our ethical discourse remains at the level of rules, we face the risk of fragmentation in our lives: "There is a growing body of literature and research indicating that the ethical standards applied by individuals at work may be different and probably significantly lower than those they follow in situations outside the business environment" [10].

At the second level a further step is taken with respect to a rule based ethics. Here the guidance is provided not by a set of rules, which are always somehow external and which limit our freedom, but by principles and values which are the result of our self-comprehension as human beings, as members of a society, as nodes in a network of relations connecting ourselves to other fellow human beings, to past and future generations, to nature. These are principles and values that give sense to our life and that collocate us in the realm of liberty. Here, every choice becomes a step in a wider *sense-seeking* process (we are in a never ending quest for sense), a process of making unity in a life which is always threatened by the risk of fragmentation. This is what Koch seems to have in mind when he says [8] that, when tackling a problem, the O.R. analyst "must see it first as a citizen involved in a social context and then as a specialist who will insist upon addressing the problem and its context together".

Following, among others, Hans Jonas [6] [7], I think that the following priciple can be chosen as the basis of our ethical discourse: *Responsibility* towards the *Other* (the value), be it humankind (past, present and future generations) or nature. In addition to the responsibility principle, I suggest a principle which can be stated as follows: *knowledge, in all forms, must be shared and be made available to everybody; cooperation rather than competition should be at the basis of research activity.* This is what can be called the *sharing and cooperation* principle. These two principles are distinct although strictly correlated, and, as will be pointed out, relate to different aspects of the activities perfomed by practitioners and researchers in the operations research area.

4 Responsibility

The responsibility principle finds its application mainly in the relations between the operations researcher and the external world, in his/her activity of analyzing and modelling systems, of solving problems and of providing counseling and support to decision processes.

The applications of the responsibility principle are different depending on the different contexts. As an example, Rosenhead [12] [13] advocates a larger involvement of Operations research in public policy issues and a reinforcement of the experience of *community operations research* which was started by the *Operational Research Society* in 1986. This latter idea came from the observation that the "perspective which has dominated operational research has been a managerialist one" and that in societies in which conflict is endemic, "working for the strong will often further disavantage the weak, and indeed put operational research in a morally dubious position". Explicit reference to the responsibility toward the society when developing operations research activities is made also by Brans [1] and Gallo [3].

Interesting suggestions for applications of the responsibility principle can also be derived from what Thomas A. Kochan and Saul A. Rubinstein write in a recent paper [9]. "Should maximizing shareholder wealth continue to be the singular purpose of American corporations, or should they be designed to accommodate and be held accountable for meeting the goals of multiple stakeholders?". Starting from this question, Kochan and Rubinstein analyze the possibility of developing a *stakeholder theory of the firm*. Some of their conclusions have much to say to us as operations researchers, in particular what they say about *goals* and *governance*.

As for the *goals*, the key distinction between shareholder wealth maximizing models and stakeholder models is "that a stakeholder firm has multiple objectives rather than a single superordinate goal"[9]. On the one hand, this suggests the need to extend the use of multi-objective optimization techniques; on the ther hand, it warns against leaving the decision about the objective function only to the customers and leaving unquestioned their assessment of the weight to give to the different interests at stake. Aside from the ethical considerations about our responsibility towards the different stakeholders, there are also practical reasons in favor of considering their points of view: hardly any decisions can be effectively implemented without the collaboration of all those who are to some extent involved.

As for the *governance*, "while in a shareholder firm the critical task is one of ensuring control [...] the critical governance tasks in a stakeholder firm are to ensure effective negotiations, coordination, cooperation, and conflict resolution to maximize and distribute the joint gains among multiple parties of interest"[9]. Again, this fact suggests a methodological shift, from classical models and algorithms, mainly based on optimization theory and techniques, to ones which are more flexible, although probably less easy to formalize. We, as operations researchers, have developed very sophisticated and powerful tools for addressing the decision problems arising in highly centralized organizations, but have done less work on decentralized systems, and are almost absent in areas such as 'conflict resolution', where there is no lack of interesting and challenging decision problems.

I do not want here to ignore the importance and the historical rôle of 'Optimization' within the O.R. field. Aside from its theoretical relevance and mathematical elegance, Optimization had and still has an essential practical rôle to play in our field. What I want to say is that, like all technologies, mathematical methods too (a soft type of technology) are not value free: in fact they contain embedded values. Behind the development of *optimality* as a fundamental principle in the analysis of economic activities and in taking decisions related to such activities, there are two ideas which have relevant ethical implications: self-interest as the only motivation behind individuals' economic choices, and the utility function to be maximized as the formal way to model the individual's behavior.

The utility maximizing paradigm has two implications which are relevant from the ethical point of view. The first is that, remaining within its boundary, there is no room for value judgments, nor are there ways to make interpersonal comparisons, which are needed if we want to go beyond Pareto optimality, to include equity as a measure of welfare. A critical analysis of the contradiction between an ethical perspective and the utility maximizing paradigm in economic analysis has been developed by Amartya Sen [16].

The second relevant implication of the idea that a single utility function can be used to catch the complexities of human motivations is the too widely accepted assumption that everything can be measured in monetary terms. If we accept that, by applying the proper rate of substitution, everything can be traded for everything else, then the consequence is that everything can be assigned a monetary value. This is something which we would not accept in our private life, but which is rarely challenged outside the private sphere.

5 Sharing and cooperation

So far I have addressed the ethical aspects of the relations between the operations researcher and the outside world, be it the customer, the stakeholders, society or nature. Here I want to focus more on the way operations researchers work to develop the tools and the knowledge needed for their activity, and on their relations with fellow operations researchers. Here the *sharing and cooperation* principle enters into the picture.

Research activity has been traditionally characterized by substantial openess in the dissemination of information and of results. The research community could be seen as a *extended academic community* in which information was freely distributed, new discoveries and results were made public as soon as they were obtained. Usually researchers did not wait for the final result, intended for publication in journals, to distribute information about their research. Partial results were usually communicated in scientific conferences. Everybody, at least in principle, could have a fairly accurate and up-to-date idea of the state of art on any particular subject, and from that they could start their research, free to use everybody's else results.

Of course, the picture given above is a generalization to which there are many exceptions: economic interests, jealousy and competition between different research groups or within the same group has often led to uncooperative behavior and to secrecy about the research activities.

This substantially cooperative attitude used to extend beyond the area of pure research, involving also more technical aspects, such as algorithms and software. In the early days of the development of operations research, discussions about algorithmic and implementation aspects of codes were quite open even for codes with a high commercial value. A typical example is the SIGMAP Bulletin special issue on "Recent and Future Development of Math Programming Systems" [17] of April 1980 where one can find many implementation details on the main *linear programming* codes of the time. It must be said that at that times the main commercial linear programming codes were produced by large companies such as IBM, UNIVAC and CDC, whose core businness was hardware not software; software came with the machines which were the real source of revenue.

With time things have changed mainly with regard to algorithms and their implementation. That is part of a trend common to many scientific areas. In some cases security reasons prevent the dissemination of information. A typical example is the area of cryptography considered particularly sensitive by the US Government. But most often commercial interests are the main motivation for an uncooperative attitude which is gaining ground in the scientific community. This is true in general, and is also true, although possibly to a lesser extent, in the operations research community.

The effect of this trend is that the quality of research itself might worsen. Research has always benefitted from openess and cooperation. Every researcher knows that his/her work depends strongly on the availability of information, and that the results he/she can obtain are always built upon previous results; if such previous results are not fully and promptly known because commercial rea sons prevents the authors from disclosing them, the work of the whole research community is impeded or at least delayed. "New ideas are tipically produced from a recombination of existing ideas (in the phrase coined by Martin Weitzman), so environments rich in ideas produce chain reactions of innovation. But as with nuclear reactions, a critical mass of ideas and technology is needed first" [14], and no such critical mass can be built without a wide and free flow of ideas.

If theoretical research is still characterized by a relatively high degree of cooperation, that is less true for algorithms, at least for those algorithms which have significant potential use, and is definitely not true for software. Although it that cannot be considered very common, in some cases algorithms have been patented, as is the case for some variants of Karmarkar's algorithm in 1988. It is not rare for software developed within some research project, possibly made public funds, to end up as a closed commercial code.

I am insisting on software because of its fundamental rôle both in applications and in research. The typical activities which are developed within the O.R. community have many different facets: analysis of systems and construction of appropriate models; development of new theories; analysis and design of new tools, typically algorithms; implementation of new software; skillful use of existing software. Most often the activity of a single operations researcher is a mix of some of these activities. Those working in academia will more often be involved in theoretical work and/or in the development of new algorithms and of new software, while practitioners will be more likely to develop skills in analyzing complex systems, building models and solving them by means of existing software. The availability of efficient and powerful software is a crucial component in almost all the O.R. activities. Take as an example the *linear programming* codes. A *LP* solver is needed not only to solve problems which can be formulated as straight linear programs, but also to solve subproblems of more complex problems (in this latter case the *LP* code is a component in more sophisticate algorithms), or as a tool to perform experiments needed to develop new theories and methods. The same can be said for many other codes.

There are two main models of software development. The first, the *open* model, is one in which the software produced is made widely available within the community; everybody can use it, and make changes to improve it or to adapt it to his/her needs, provided that this is done on a reciprocal basis. This does not exclude software from being sold and software developers getting paid for their assistance to the customers and for adapting the software to customers' needs. The second model, the *closed* one, is one in which software is a commodity, a highly sophisticated one, produced by specialized companies: an industrial product rather than an hand-crafted product. Software produced this way is sold in closed form, that is, the user does not know what there is inside, nor it is allowed to know: "the recently enacted U.S. Digital Millennium Copyright Act (DMCA) [...] prohibits the development and use of technologies designed to circumvent protection measures employed by rightholders to control access to information distributed digitally" [2]. That means that users cannot fix the bugs (to have the bugs fixed they may have to wait for the next release, possibly at a cost), nor they can modify the software to adapt it to their needs.

The situation in the early days of the development of operations research was more near to the first model than to the second. Then the process of 'commodification' of software has made the second model the most common. The advocates of this model claim that without a strict enforcement of property rights (copyright and patents) incentives to innovation will end, and that the creator of software has the right to receive appropriate benefits for his/her work. In fact, there is no evidence supporting the first claim: a lot of innovative products and of software in particular has been produced under regimes of weak property right enforcement, and the experience with the open source and free software movements and the development of software like *Apache*, *GNU-Linux*, *Emacs*, *Tex*, to name just a few, suggets that the quality and innovation content of software produced under the open model can be as good as and often higher than that of closed industrial software. As for the second point, the benefits to the creators and developers of software are often higher with the open model than with the closed one, where usually they are just employees without any right to the results of their work, and the substantial part of the benefits go to the employer company together with the rights on the software produced.

There are other reasons which suggest that the open model is superior to the closed one. Open software may have a propulsive effect on operations research practice. Cheaper and more easily available software will help the diffusion of operations research techniques in small and medium size companies on which the rather high initial investment needed to buy a specialized code, which may not necessarily be useful, has a strongly discouraging effect. Moreover, open software gets more people involved in software production, improvement and maintenance, increasing the number of people with the right skills to apply operations research techniques to real world systems. The two things might set up a reinforcing loop to the benefit of all the operations research community.

A connected point is relative to the inequalities at world level. In spite of all the hopes that technology, and especially the new information and communication technologies, would have opened a new era of wealth and development for third world countries, technologies have widened the divide between rich and poor countries. "A small part of the globe, accounting for some 15% of the earth's population, provides nearly all the world's technology innovations" [14]. The stronger and stronger assertion and enforcement of intellectual property rights has contributed to increasing global inequalities. The old aphorism which said: "*if someone is hungry, don't give him a fish; give him a fishing rod*" has been changed into "*if someone is hungry, don't give him a fish; give him your patented fishing rod and collect the royalties*". Using the words of Jeffrey Sachs, "rich countries should exercise restraint in the use of property rights. Rich countries are unilaterally asserting rights of private ownership over human and plant genetic sequences, or basic computer codes [...]. These approaches are of dubious legitimacy and will worsen global inequities."

Finally, a last consideration. By making the relations among researchers and practitioners less open and cooperative, and by stressing competition rather than cooperation and mutual help, the overall quality of life within the professional community worsens. A few win in this race to the top, and (wrongly) believe that their lot has improved, but loneliness and stress has become a standard condition, making everybody's life worse. If it is true that the goal of our activity in any field is to make human life better, that quality matters more than quantity, and that that must be true for everybody and not only for a minority, then the sharing and cooperation principle suggests a direction in which it may be worth moving.

activity is no more important that the process which has lead to it. Quote Simon when he talks of the planning activity.

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