Operational Research and the Social Sciences

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EFFECTIVENESS VERSUS EFFICIENCY : OPERATIONS RESEARCH IN A NEW LIGHT

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I. INTRODUCTION

Operations researchers have traditionally been concerned with well-structured problems which have one best solution or a range of acceptable solutions. Social scientists, on the other hand, deal with hard-to-structure problems in which it is very difficult to define what "best" means let alone find the best solution. Stated differently, operations research attempts to find the most efficient means of reaching a goal given a particular problem formulation. In contrast, social sciences tend to question the validity of the goal itself by treating the problem formulation not as a given but as open to challenge and revision.

The above difference can be partially traced to the difference between mathematical problem solving and real-world problem solving. In solving mathematical problems, from elementary school all the way to the postdoctoral stage, we are used to situations in which the basic facts are given, the assumptions are unnegotiable, and the problem is already structured and formulated. The only valid formulation of the problem is the one provided. To solve the problem based on a different set of givens becomes tantamount to solving a different problem. Not so in the real world. As I have argued elsewhere (Rahmatian, 1985), real-world problems exhibit a distinctly hierarchical nature. This is because problems are based on objectives, and objectives form a hierarchical ends/means chain. With assumptions questioned at one level, we move to a higher level where real goals become more manifest. We thus minimize chances of correctly solving the wrong problem; of reaching an efficient but ineffective solution.

Effectiveness and efficiency are indeed two interesting concepts which can help us understand the interplay of problems and solutions in the real world. In the next section, a conceptual analysis will be offered, challenging some of the traditional wisdom surrounding the two concepts. In section three, the outline of a theory will be sketched, while in the last section the theory will be illustrated in the domain of information technology.

II. EFFICIENCY VS. EFFECTIVENESS

Effectiveness has to do with "what" is accomplished; efficiency with "how" it is accomplished. As Peter Drucker (1974) put it, effectiveness has to do with doing the right things whereas efficiency has to do with doing things right. Another conception equates efficiency with the ratio of output over input, while defining effectiveness in terms of the difference between the actual and the desired output. With this last definition of efficiency, an interesting situation arises. Since

$$\text{Efficiency} = \text{Output}/\text{Input} ,$$

it has always made sense ("common sense"!) to regard as equivalent the following two ways of increasing efficiency :

A. By obtaining a higher level of output with the same amount of input;
B. By obtaining the same level of output with a smaller amount of input.

Are these two modes of increasing efficiency equivalent? Mathematically yes, but practically no.

First consider situation A. Take a "production process" (in its most general form) in which 10 units of input produce 100 units of output. Suppose due to technological innovations, the efficiency of this production process is increased such that with the same 10 units of input 105 units of output are now produced. This may mean slightly higher profitability and nothing more. Now suppose due to a fundamental technological breakthrough, the same 10 units of input can produce 1000 units of output. This time the qualitative impacts of this quantitative change need to be examined. Going from 100 to 1000 units of output may mean

* a larger sales force;
* a different organizational structure;
* a revised pricing/advertising strategy;
* etc.

These are all the qualitative impacts of a quantitative change, which indicate that "more" is more than merely a simple quantitative notion.

Now take situation B where we can obtain the same level of output with a smaller amount of input. With the same technological breakthrough still underway, we now consider producing the same 100 units of output but this time with only 1 unit of input. This may imply:

* less raw material;
* fewer production runs (fewer production shifts, lower labor cost);
* smaller goods-in-process inventory;
* etc.

To be noted is the difference between situations A and B in terms of goal-setting. With situation A, there is a tendency to take advantage of the higher efficiency in terms of increased levels of production. With situation B, the higher efficiency tends to affect the cost of production.

To be noted is also the similarity between situations A and B. In both we have efficiency increase to such an extent as to begin to impact effectiveness. This is again due to the difference between abstract mathematical problem-solving and concrete real-world problem-solving. In purely mathematical terms "6 times 2" and "12" are the same. In practice, buying two six packs of beer has consequences different from buying twelve individual cans of beer. With the two six packs, one ends up with two cartons, which can either translate into a problem (how to get rid of them) or an opportunity (making a toy for a child).

Effectiveness and efficiency can be separated for analytical purposes. In practice, however, they are inseparably linked. The relationship between the two will be explored in what follows.

III. TOWARDS A THEORETICAL FOUNDATION

The ideas explored in the previous section can be formalized into a theory consisting of two basic axioms.

A X I O M 1 : For every production process, there is a critical threshold point such that when the efficiency of the process increases beyond that point, then the effectiveness of the process is impacted (usually positively).

A X I O M 2 : For every production process, there is a critical threshold point such that when the efficiency of the process falls below that point, the effectiveness of the process is impacted (usually negatively).

An example may help clarify the meaning of these axioms.

Imagine the very common situation in which an important document (such as a proposal for winning a competitive contract) is to be produced under considerable time pressure by a certain deadline, say Friday 4 PM. Suppose based on the expected length of the document it is estimated that it will take eight hours to type, proofread, edit, correct, and revise it. Typing must therefore begin around 8 AM.

Efficiency can be defined here in terms of the number of hours of typing (labor input) needed, whereas effectiveness can be defined in terms of the quality of the report (i.e., the extent to which it will be instrumental in winning the contract).

Suppose the regular typist (who would take eight hours to type the document) is replaced by a more efficient one who would be able to do the job in seven hours. The time (one hour) thus freed up may not be long enough to let the writers of the proposal (who wrote it under considerable time pressure) improve its quality significantly. This could be true for both operational and psychological reasons. Now suppose due to a technological breakthrough (such as word processing) efficiency increases dramatically, such that it will take only two hours to produce the same document. This means the six hours thus freed up can be spent improving the quality (i.e., effectiveness) of the proposal. This is precisely what Axiom 1 means.

Axiom 2 is easily understood in the context of the above example too. Suppose the efficiency of the process drops from its original level of eight hours (due to the typist badly injuring three fingers) to the new level of twelve hours. This means that typing must start Thursday at 1 PM (presupposing an 8-to-5 workday), which implies that Thursday evening cannot be used by the authors for working on the proposal, further exacerbating the time pressure they are under. The adverse impact this will have on quality (effectiveness) is obvious.

The proposed axioms are perhaps in some way related to the basic tenet of catastrophe theory, namely that for a certain class of events, continuous changes beyond a threshold point produce discontinuities. It would be challenging to explore the similarities between the threshold point in catastrophe theory and the one in the above axioms.

IV. APPLICATION DOMAIN : INFORMATION TECHNOLOGY

The proposed theory perhaps finds its clearest application in computer-based information technology. This type of technology was originally conceived as entirely efficiency oriented. Even today, it is being marketed primarily as a productivity enhancing force, whether in the office, the factory, or at home. To regard computers as merely (or even primarily) efficiency oriented without any consideration of their impact on effectiveness (along the lines explained in the previous section) would be just too simplistic. Computers <u>have</u> increased efficiency in many areas to unimagined levels. Indeed, in some domains, the productivity gains have gone beyond the critical threshold points hypothesized earlier. That is why computers are an excellent vehicle for allowing us to see the application of the proposed theory to the real world.

Computers are mind-amplifying tools (Rahmatian, 1987). But this is not to say that they are merely more efficient manual systems. With computers allowing dramatic increases in efficiency, many qualitative changes are bound to occur. As clerical tools, computers have found a secure place for themselves. The more recent development is using computers for strategic purposes. The two axioms explicated in the previous section can perhaps shed some light on how this shift (from computers as clerical tools to computers as strategic tools) came about. An example may help clarify the explanation.

Consider a bank which is trying to attract new patrons. Service is an important factor affecting the decision of a prospective client whether or not to open an account in this bank. An element of service is the length of waiting lines which, in turn, is partially determined by computer response time. Imagine computer response time being such that on the average six (n = 6) people wait in the line.

With computer efficiency improving such that n becomes equal to five, the perception of a shorter waiting line is not likely to be created. However with dramatic increase in efficiency causing n to equal 1 the situation may become qualitatively different. It may make the difference between "a pretty long line" and "practically no line at all". This shift in perception can make the difference in the prospective client's mind between opening and not opening an account in that bank. And <u>this</u> is a strategic, not merely clerical, issue.

It also works the other way around. With computers facing unresolved maintenance (or other) problems, the response time can significantly increase, thus making the line much longer, and the bank as a whole appear less service-oriented.

Many other examples can be provided illustrating the ways in which the effects of information technology have gone beyond pure efficiency considerations and have begun to spill over into the domain of effectiveness.

It may be advantageous to bring the paper to a conclusion by going back to the issue raised at the beginning. Social sciences, in their widest scope, attempt to understand human behavior. Human behavior can be explained in terms of purposefulness (Ackoff and Emery, 1972). Understanding human goals, their variety, and their relationships is thus an important part of social sciences. In practical problem-solving situations, it becomes even more important to understand the exact nature of the results being sought. Failure is as likely to occur due a limited or erroneous understanding of the problem as it is likely to occur due to adopting an incorrect solution. Effective problem solving then becomes a goal to strive for.

Operations research, in its widest scope, attempts to impose a mathematical structure on a given problem formulation, thereby identifying the most efficient solution to it. Armed with the latest techniques and technologies available, operations researchers are tempted to make efficient problem solving a goal to strive for.

If this paper has succeeded in explaining the relationship between effectiveness and efficiency as foci of action, then perhaps it has helped shed some light on the relationship between operations research and the social sciences as different approaches to the investigation of human behavior.

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