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Francisco R. Sagasti,

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MANAGEMENT SCIENCES IN AN UNDERDEVELOPED COUNTRY: THE CASE OF OPERATIONS RESEARCH IN PERU*†

FRANCISCO R. SAGASTI

University of Pennsylvania

This paper examines the development of management sciences in Peru, with particular reference to the introduction and diffusion of operations research in the 1960's. The reactions of government officials and executives in private industry to management science are analyzed. The educational and institutional aspects of the future of OR are also examined. The paper ends with a discussion of the methodological aspects of operations research work in underdeveloped countries.

1. Introduction

This paper will analyze one aspect of what are broadly called "The Management Sciences" in the context of an underdeveloped country, using the introduction and diffusion of operations research in Peru during the 1960's as an example. The paper is based on the author's personal experience and on information acquired through conversations with colleagues, managers, and government officials with whom he has remained in close contact since leaving Peru.

The general reasons for utilizing management sciences in an underdeveloped country will be reviewed first. The paper will then give a background on the development of management sciences in Peru, examining the reaction of business executives and government officials to the suggestion that they may benefit from the use of operations research. The future development of operations research in Peru will then be examined, particularly with respect to its educational and institutional aspects. The paper ends with a discussion of the methodological aspects of operations research work in underdeveloped countries.

2. Management Sciences in Underdeveloped Countries

The most important reason for promoting the use of management sciences in general, and operations research in particular, in underdeveloped countries, is that *the general lack of resources, particularly human and financial, imposes the urgent need for using them more efficiently*. While a relatively rich country may afford some measure of waste in the use of its resources, absorb more easily planning errors in investment decisions, and tolerate duplication of efforts, this is certainly not the case for the poor nations. A single mistake can have catastrophic effects that last and are felt for many years. For example, an erroneous decision to locate a fertilizer plant in the central highlands of Peru, which in addition uses the most expensive method for producing hydrogen, still has a negative impact on the Peruvian economy, even though the decision to construct the plant was made around 1959 and production began in the early 1960's. The argument may be put forward that the larger the distance that separates an underdeveloped country from the more developed ones, the greater the intensity with which the scientific method should be applied to optimize decisions that involve the use of scarce resources. Wu's [6, p. 5] reasoning supports this suggestion very strongly:

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† Based on a paper delivered at the XII International TIMS Conference in Washington, D.C., 1971.

If the economic gap between the developing and the industrially advanced countries is to be closed or even narrowed, it is obvious that the former must grow more rapidly than the latter. This is not going to be an easy task. Apart from the availability of necessary physical and other inputs, rapid progress requires commitment, sense of urgency and leadership. Assuming that all these factors for development are present, developing countries relatively will need greater administrative capabilities than were historically prevalent in the industrially advanced countries. The developing countries must be able to approach development problems with a sense of urgency required for solving emergency problems and crises. To create administrative capabilities commensurate with requirements, developing countries must be able, among other things, to use modern management techniques more effectively than in the case in the industrially advanced countries.

This is particularly true for decisions affecting government activities, which in many underdeveloped countries account for a major share of the total economy, and where development planning is acquiring new importance. Paradoxically, there where the need for modern management approaches is most urgently felt, more often than not the capability for using them is almost nonexistent. Moreover, the administrative demands imposed by planned development will tend to make whatever administrative capabilities exist insufficient and outmoded. In order to cope with the stress imposed by this disequilibrium, underdeveloped countries should consider the introduction and widespread utilization of modern management techniques, including operations research, as one of the integral parts of their development planning strategy.

Peru is now entering a stage in which many fundamental social and economic reforms are being instituted simultaneously. The tasks of coordinating them, managing the allocation of funds and qualified manpower to reforms competing for resources, and implementing the national plans devised to put these reforms into practice require the development of administrative skills and capabilities on a scale and order of magnitude without precedent in the history of the Peruvian government. Furthermore, not only are there many reforms being put into effect at the government level, but also there will be major modifications in the structure of private enterprise activities. The Industrial Reform Law and the Industrial Community Law both impose major changes in the nature of private industrial activities. These changes coupled to the fact that Peru has joined the Andean Sub-regional Pact,¹ which seeks to establish a common industrial policy for its members, reduce protective tariffs, and enlarge the suffocated domestic markets of each of the countries in the Pact, will have a profound effect in the management and administration of private enterprises. The need for modern management techniques will soon be felt in private industry with equal or greater strength than in the government.

3. The Development of Management Sciences in Peru

Brief Historical Background

The first efforts to rationalize management activities in Peru were made during the 1940's and 1950's, when many traditional industrial engineering techniques were introduced. Among them, motion and time study, plant layout and design, job evaluation, merit rating, and the design of incentive plans were the most popular; they were accepted by the larger and relatively modern enterprises whose managers had, in general, a more progressive outlook. However, these traditional industrial engineering techniques have not become common usage in Peru, and there is a large number of private enterprises and government organizations which have not yet applied them.

¹ The Andean Sub-regional Pact includes Colombia, Ecuador, Peru, Bolivia, and Chile.

Operations research was formally introduced for the first time in 1958–1959 when a mission of French experts visited several institutions in Peru, although the credit for generating a self-sustaining critical mass of activity in this field should probably go to Professor Miguel Colina, who in 1962–1963 began to teach formal OR courses at the Universidad Nacional de Ingenieria and other institutions.

During that period, teams from Iowa State University came to the Universidad Nacional Mayor de San Marcos, the Universidad Nacional Agraria and the National Planning Institute. They carried out research work in the areas of agricultural applications of linear programming, inter-industry input/output analysis and the development of econometric models of the Peruvian economy. Unfortunately, because of the lack of qualified Peruvian counterparts for the foreign experts, their knowledge and the results of their research were not transmitted as effectively as they could have been. Other efforts to introduce operations research and quantitative management techniques were made by the Center for Incrementing Productivity (CENIP), the Graduate School of Business Administration (ESAN), and the Peruvian Institute of Business Administration (IPAE). They disseminated operations research techniques through conferences, short courses, symposia, etc.

Initially the introduction of OR techniques was closely related to the use of computers and to the application of computer programming to industrial and economic problems. The first and second seminars on the application of computers, held at the Universidad Nacional de Ingenieria, devoted a substantial portion of their time to the introduction of OR techniques, including queuing theory, linear programming, simulation, PERT and CPM. Most of the initial OR projects that were carried out in Peru were in one form or another closely related to computers, and more often than not these projects were carried out, totally or in part, by young professionals working at computer centers. In consequence, a very important factor in the diffusion of OR techniques was the supply of standard package programs by IBM, which enjoys a virtual monopoly in the Peruvian computer market.

A Peruvian Operations Research Society was established in 1966, although it has not been very active in the past few years, mainly due to lack of funds and a limited number of members.

Most of the initial applications of operations research were circumscribed to the use of standard models and techniques which had been developed and applied elsewhere; with few exceptions the introductions of operations research into Peru was dominated by the "technique approach." Examples of early work include linear programming models for agricultural planning (crop rotation, optimizing cattle feed mixes) and industrial planning (production smoothing); the use of simulation and queuing models to study the operations at the port of Callao; the use of PERT and CPM models in the construction industry; and the use of engineering economy models for evaluating capital investments. Although most of these models and their results remained unimplemented, they served useful educational purposes and many students obtained theses from them. However, their impact on industry and government was minimal through most of the 1960's, although after 1968 the situation began to change.

At present there is a large number of Peruvian professionals with master's degrees earned abroad who have had training in operations research. To my knowledge, few Ph.D.'s in OR have been granted to Peruvians and only one of them is currently working in Peru. There are now several academic programs in engineering and management which include operations research courses (for example, a three-year course sequence at the Universidad Nacional de Ingenieria) and the supply of professionals who have been exposed to formal operations research courses is likely to continue increasing.

Some Reactions of Government Officials and Business Executives to Operations Research

I shall make use of archetypes to illustrate and typify the reactions of government personnel and executives in industry to the possible introduction of operations research in their areas of activity. On the whole these reactions were to proposals made by operations researchers to the executives or government officials. Thus, the initiative was on the OR man's side.

The reactions of government officials can be classified into two categories:

Archetype G1. "Government institutions are rather complex and the bureaucracy is very slow. There are many political problems involved, we are doing the best that is possible to do given the circumstances, and because they will not change we do not need OR. Furthermore, even if we had an OR capability we would not be able to use it."

Archetype G2. "We know about OR, we need it, and we would like to use it. However, we could not implement the results because of the complexity of the present situation, and we do not have funds to afford consultants or to hire our own personnel. Furthermore, the lack of relevant data would render them ineffective."

These two archetypes, encountered in practically all discussions with government officials, reflect a generally negative attitude towards the use of operations research. Most of the officials interviewed knew very little about OR, and those who knew something about it tended to confuse operations research with the technique of linear programming. Their conservative approach could probably have been explained in terms of their lack of familiarity with the subject of OR.

In the years that have passed since the bulk of the interviews were carried out, the general attitude of government officials has apparently changed. A program to introduce operations research through the use of simulation, econometric models, computer programming in general and mathematical programming techniques for the selection of development projects is being implemented by one of the most important planning agencies. This reversed a trend prevailing a few years ago, when a group of professionals who proposed the introduction of OR were given a budget large enough to keep them working for the government, but small enough so that no substantial impact could result from their efforts. The change in government in 1968 appears to have increased the opportunities for applying operations research and modern management techniques to government operations.

Before this possibility becomes a reality it will be necessary to change the attitudes of government officials and to set up an organization or institution capable of doing OR work *within the government*. The first could probably be achieved through training programs for government officials and the second through the establishment of an agency with the function of promoting and carrying out OR projects. If these two conditions are not satisfied, the application of operations research to government activities is most likely to proceed in a scattered way without gaining the critical mass that would make it effective.

In industry the archetype reactions identified were slightly different, although they were also generally negative. Here I found a larger variety of attitudes than in government, although most of them fit into three categories.

Archetype I1. "Oh yes. I know all about operations research, and I also know that I do not need it. My enterprise is doing fine and if it were not for one or two technical problems we would be operating perfectly."

This response archetype was found in a handful of firms directed by what could be

called "classical entrepreneurs." One of the managers whose response can be classified within this archetype was the most successful businessman in the Peruvian fishing industry. Another was the executive vice-president of the Peruvian subsidiary of a large Swiss manufacturing firm. He had managed to maintain a 40% annual rate of growth during the preceding five years, and his objective was to do better and become more profitable than the Brazilian subsidiary of the same firm, which was the largest in South America.

Few arguments could be given to persuade an executive with this attitude that he could benefit from OR. He is convinced that because he does better than everybody else, he is doing the best that is possible. The concepts of opportunity costs and errors by omission would probably be the only ones that may convince him to use OR, that is, if he needs it at all.

Archetype I2. "I am very interested in operations research. I think it could help me a great deal, but I am not sure. Give me a guarantee that you will solve my problems using OR, and I will introduce it in my firm."

This second archetype was the characteristic attitude of executives from medium-size enterprises facing a general lack of resources. They were, in general, very conservative, avoided any kind of risks, and were not prepared to "gamble" (as one of them put it) in operations research projects. They wanted a guarantee that their investment in OR would yield savings and benefits of a specific and pre-defined order of magnitude.

In one case the executive interviewed mentioned that he would only invest in an OR project if he knew beforehand exactly the payoffs that would result from it, and furthermore, if he were to use external consultants he would demand that they do not work for their competitors at any time in the future.

Perhaps the only way to introduce OR to these firms, either by means of consultants or in-house teams, would be, once again, through a change in the attitude of managers and executives. If an OR study is considered as something that has to pay for itself, with the managers watching the projects and the results from outside, it will almost certainly be a failure. Peruvian executives (as well as government officials) have not yet understood that the success of an OR study is a function of the activities of the operations researcher as well as the activities and the degree of participation of key management personnel.

Archetype I3. "Operations research might be a very useful thing, but you know nothing about my business. If I who know it well cannot do better, how could you improve my performance without knowing as much as I do?"

The third archetype was found in small enterprises, generally family concerns, in which things had been done in the same way for many years. As a rule these executives and managers lacked formal training and relied entirely on their own experience, intuition and judgment. Most of these enterprises had a long way to go before OR would become an attractive alternative to the use of simpler and less sophisticated approaches and techniques.

These five archetypes cannot be considered as irrational responses of managers who were given the opportunity of introducing OR in their organizations. Government officials and industrial managers were probably justified in their skepticism and their attitude toward the introduction of operations research for it represented a novel, and as yet unproven, approach to the solution of their management problems. This was aggravated by the "technique" orientation of early OR work, which put many basic concepts and ideas outside the reach of the majority of executives in Peru.

The contrast between the spread of "academic" operations research, defined in terms

of students exposed to formal courses, and the generally negative attitude of potential users, expressed in terms of these response archetypes, points out that the capability for doing work in this area has grown faster than the effective demand for operations research projects. It would seem necessary to develop the "OR absorption capacity" of government and private enterprises, while continuing to prepare more and better qualified operations researchers. These observations can be summarized as follows:

(a) The capability for doing OR work in Peru has developed at a rapid pace during the 1960's. The number and scope of projects have been increased many times over since the early 1960's.

(b) The managerial capability for using operations research effectively has remained relatively low. Projects have had a poor rate of implementation, and OR has not been generally accepted by Peruvian managers.

4. Educational and Institutional Aspects of OR Work in Peru During the 1970's

Education for Operations Research

The development of educational OR programs during the next decade should be characterized by a shift away from the technique orientation that prevailed during the 1960's. Operations research courses and programs should become more problem-oriented, stressing methodological rather than manipulative or computational aspects. An examination of the content of a course sequence at the Universidad Nacional de Ingenieria showed a listing of operations research techniques all the way from allocation algorithms to zero-sum games. There was little emphasis on problem formulation, the process of modeling, interpretation of results, and on implementation problems. Furthermore, apparently there was no conscious effort to study and analyze the successful and unsuccessful applications of OR made in Peru, with the aim of transmitting this experience to the students. A movement in the direction of problem-oriented teaching, with extensive student involvement in case studies, would give a better balance to academic OR programs. These observations are even more important for programs at the graduate level.

This shift in emphasis will probably require a change in teaching methods. Lectures on operations research techniques should be replaced by active involvement of students in case studies and projects, particularly for advanced students at the graduate level who may later be in charge of OR projects. Project leaders in operations research cannot be prepared through traditional classroom methods, they should be trained primarily by using the "apprenticeship" method, in which a small group of students participates in real operations research projects under the direction of an experienced OR man who, in addition to conducting the project, takes the responsibility of training his junior staff. If this approach is taken, it is unlikely that traditional university structures will be able to adapt to the demands imposed by project-centered teaching methods. New institutional forms may be required to implement them.

Turning now to the education of potential OR users, it is possible to say, on the basis of the experience gained in the last decade, that any efforts to promote operations research in Peru will have little effect unless the education of managers and government officials becomes their focal point. This implies that training in the management sciences and operations research should be emphasized in business schools and also that short courses, lectures, seminars and conferences should be arranged to expose managers to the basic concepts and ideas of operations research, informing them on the potentialities and limitations of OR, as well as making them aware of what they can expect and demand from a team of operations researchers.

Shakun [4, p. 4] reached the same conclusion in his study of operations research in India. In his view:

Specifically, there is need for education of management—managers should understand how their activities can be viewed as a type of inquiry and how OR scientists can work with them. This education should lead, through understanding, to increased use of OR.

The first seminar on operations research for executives in Peru was held in 1966 under the sponsorship of the Peruvian Institute of Business Administration (IPAE). Unfortunately, partly because of the mathematical orientation of the seminar, it was rather unsuccessful and did not convey to the managers the idea that they could derive potential benefits from the use of OR. At the end of the seminar many of them did not even understand what operations research was about. With this experience in mind, the organization of seminars and conferences for executives should focus on basic concepts and on case studies, rather than on descriptions of mathematical techniques.

The Institutionalization of Operations Research

The fundamental shortcoming that characterized OR work in Peru during the 1960's was the poor rate of implementation. Leaving aside considerations regarding the low receptivity of managers, this shortcoming could be explained in terms of the lack of institutions involved in OR work. Apart from a short-lived consulting firm, a two-man team at the National Planning Institute and a small independent group of university professors, there have been no institutional arrangements whose main task was to carry out operations research projects.

There are four institutional modes for organizing OR activities of particular relevance to underdeveloped countries. They are described in order of importance for the Peruvian situation.

The first mode is that of *OR groups established within government organizations*, having the functions of promoting, disseminating and carrying out OR projects. These groups could range from a two-man team organized to identify and formulate OR projects, to a full Public Decentralized Enterprise with many operations researchers at various levels doing work for one or more government dependencies. The groups would probably have to be closely linked to computer operations and installations, for they constitute the natural point from which to start building an OR capability within the government. A team following this institutional mode has been recently established within the National Telecommunications Enterprise (ENTEL). It is formally ENTEL's Division of Computers and OR, but it is doing work for the Ministry of Transport and Telecommunications as well as other government dependencies. The OR team gathered at ENTEL is one of the best in the country, and constitutes the first attempt to establish an OR capability in large scale within the government.

A second institutional mode could be the establishment of what Trist [5] calls "*Research-Application*" institutions. These are organizations centered on a domain of inquiry which undertake research on some generic problem, or group of problems, but at the same time seek to apply and put in practice the results of their research. Because of the methodological problems found in the application of OR in underdeveloped countries (some of which are discussed below) and the need to incorporate the social sciences within the scope of OR work, the methodological research content of many OR projects is likely to be very high. A Research-Application institution would provide a natural way of combining the utility characteristic required in OR work with the research activities that are necessary to improve the effectiveness of operations research in underdeveloped countries. If the method suggested for training project leaders

through the apprenticeship model were adopted, Research-Application institutions would probably be the best suited to house this type of academic programs.

A third possibility for institutionalizing operations research is through the *consulting mode*. An organization of this type would provide services on a consulting basis, employing experienced local project managers and also using foreign personnel through collaborative arrangements with other consulting firms. This mode has been tried with moderate success, although if project managers come from abroad it becomes necessary to provide qualified counterparts for them in order to obtain the maximum benefits from their participation.

The fourth possible mode for institutionalizing OR activities is the *Cooperative Research Organization* mode. Several private enterprises and/or government departments could join efforts and, instead of each having a small OR group, set up a larger institution capable of providing services to all of them. A variant of this mode would be to establish several OR groups in different organizations, which would have their own junior staff, but share their senior staff. In this way, experienced project directors would be used more effectively in carrying out OR projects and training junior staff. However, in view of the attitudes displayed by executives and government officials, which were described in §2 of this paper, many difficulties can be anticipated in establishing a cooperative OR service group for unrelated organizations.

Notice that universities have not been mentioned in any of the institutional modes through which operations research could be applied during the 1970's. This is because tradition has kept Peruvian and many other Latin American universities away from any kind of institutional participation in applied work, and also because the constraints imposed by law on university activities, particularly in state universities, make it almost impossible to organize groups that could apply OR directly through university channels.

These institutional modes should be considered complementary, for they are oriented to provide services to different clients and carry out operations research activities in different areas.

5. Methodological Aspects of Operations Research in Underdeveloped Countries

Underdeveloped countries like Peru have many characteristics differentiating them sharply from the more advanced countries, where operations research has been mostly applied and where the majority of techniques have been developed. In consequence, a mere transposition of OR techniques and approaches from developed to underdeveloped countries is bound to encounter many difficulties and produce results that may be largely irrelevant. When applying the scientific method to the solution of the real problems associated with economic and social development, which is what OR in these countries should be about, it will be necessary to take into account explicitly the particular conditions of the environments in which OR projects are to be carried out, leaving aside preconceived ideas and models developed elsewhere.

Although the scientific methodology, which constitutes the core of the operations research approach, is basically one, the distinctive characteristics of underdeveloped countries will tend to modify the types of OR work and the customary methodological procedures prevailing in the more advanced countries. These modifications will take the form of shifts in emphasis in the variables to be considered, the types of models to construct, and the criteria for deriving solutions. According to Ghosal [3, p. 45]:

The most important thing about the application of OR is to bear in mind the environments under which the proposed solution is sought. Consequently, the approach of prob-

lems is likely to be different in different conditions. In other words, there cannot be any ready-made solution to any problem faced by the client because the solution to a similar problem faced in countries like the U.S.A., U.K., etc., may be completely unsuited for a country like India or any other developing country.

In the paragraphs that follow some of the environmental conditions in underdeveloped countries, and Peru in particular, will be examined, pointing out their methodological implications.

Management Scientists as Change Agents

The first factor that could modify the methodology followed in OR work refers to *the active role that operations researchers must play as change agents* while working on projects and attempting to improve decision making by business executives and government officials. Playing this role adequately requires an understanding of the behavioral aspects of the problem situation and of the social and psychological characteristics of individuals and groups related to it. This is to say, the social science content of operations research activities in underdeveloped countries should be very high.

Shakun [4], in his paper on OR in India, points out that a knowledge of the social sciences could be put into two main uses by operations researchers: (a) learning how to incorporate behavioral variables in OR models and (b) considering explicitly the implementation of OR work as an integral part of the project. This second aspect has also been suggested by Abrams [1] who considers the implementation of OR "A Problem in Sociology," and by Wu [6] for whom a close relation between the social sciences and operations research would lead to higher implementation of project results.

Simple vs. Complex Operations Research Models

It has been frequently argued that operations researchers should concentrate on constructing simple models and use the simplest tools of OR in order to deal with problems that arise in underdeveloped countries. However, if the problem situations found in these countries are to be solved adequately, it is necessary to use methods and models that are at least as complex as the problems being tackled. This is but another expression of Ashby's Law of Requisite Variety, which states that controlling systems must match the variety of the controlled ones, if effective control is to be achieved at all. According to Wu:

... While most developing countries do not have the trained personnel to undertake use of sophisticated techniques, their problems do require more than simple techniques. From the standpoint of need, the development problems of such countries are complicated and difficult, and they should have effective problem-solving techniques which are no less complex than the problems themselves. [6, pp. 5-6]

From the preceding comments a second observation of methodological character can be derived: *any efforts to simplify OR approaches and techniques with the intention of putting them within reach of personnel with little knowledge about OR are not likely to produce models and results commensurate with the problems they attempt to solve.*

Some of the factors that generate complex problem situations in developing countries have been identified in [6]. Among the most important ones is the nature of changes taking place in these countries. In addition to being erratic, they often proceed at a very rapid pace, leaving little time for stabilizing forces to act before a new wave of changes is introduced. Referring to Wu [6, p. 10] once again:

Related to the tempo of change is the erratic nature of change. Scientific and technological changes seem to take place in great spurts while the social and human organizations

seem to be slow in adjusting to them. The result is the introduction of random components in human decision making, which do not seem to lend themselves to dependable prediction and scientific treatment by modern management techniques. The proportion of random components is particularly great in the developing countries

The unpredictable elements, in short, remain a major vexing problem in rational decision making in developing countries. Our question is *how to adapt OR to situations in developing countries where the tempo of change tends to be fast, uneven, erratic and difficult to anticipate.* (his emphasis)

The Peruvian situation as we enter the 1970's fits considerably well Wu's description of changes taking place in a developing country. As mentioned before, many reforms are being put into effect simultaneously, and changes follow changes without leaving time for things to settle. The methodological problems involved for OR work in such situations, especially at the national planning level, appear to be formidable.

Criteria for Model Building

Another factor of considerable methodological importance arises from the fact that *the criteria used for constructing OR models in underdeveloped countries may be rather different from those customarily used in the developed ones*, where most OR techniques, models and methods were originally developed. As an example we may mention the well-known differences in capital availability, investment risks and profit margins between developed and underdeveloped nations. While capital is relatively abundant in developed countries, so that there are generally little investment risks and profit margins are rather small, in underdeveloped countries capital is relatively scarce, investment risks are high and profit margins are also comparatively high. Clearly, the types of models to be constructed for capital investment decisions must reflect the conceptual and structural differences between the two situations. Furthermore, most of the operations research techniques that are available are best suited to short- and medium-range tactical problems, whereas the problems of underdeveloped countries involve primarily strategic and long-range planning considerations.

Instability in Funding Levels

Another observation which has methodological implications for OR work in underdeveloped countries refers to the lack of funds to conduct OR studies in large scale and with continuity. This imposes real limitations on the type of OR efforts that will be economically feasible and effective. A possible approach to circumvent this problem consists in *carrying out OR projects in a modular fashion, with each subproject, or project module, producing results that are directly applicable and which could be linked to other projects that may be carried out in the future.* This requires the conceptualization of several projects as an integrated system and careful planning of the OR activities in order to select the best sequence in which to carry them out.

Lack of Data

The lack of statistical data that would render operations research models operative should not represent, by itself, a serious limitation to operations researchers. As Salib (cited in [2, p. 51]) has pointed out:

A great number of people think that elaborate models cannot be worked out successfully because of a lack of statistics. This is a negative attitude that will leave our level of knowledge static; the field cannot develop at all if this objection is frequently raised. In fact, statistical machinery has never been thought of except as the tool to supply research workers with as many observations as they require. I do not underestimate the strain put upon this machinery, but it should, no doubt, develop in parallel with needs.

It is also the case that OR models can be used in order to determine which data are relevant or important in a given situation. A recently developed financial model for the Peruvian Educational Reform is being put to such use by making a series of sensitivity tests and finding out which of the parameters and variables of the model have major influence in the total costs of the Educational Reform. With this information on hand it will be possible to detect where data gathering efforts should be refined and improved.

The last observation regarding the methodology of OR work in underdeveloped countries can be derived from all the preceding comments in this section. If there are so many problems of methodological nature in the conduct of OR work in these countries, it is extremely important that *the process of carrying out OR projects should shed light onto the ways of improving on it*. This is to say, it is necessary to conduct research into the operations research process itself, seeking to identify the conditions for augmenting the quality of research work and the relevance of results produced. This research into the OR process should become an integral part of future OR work in Peru and other underdeveloped countries.

6. Conclusion

In this paper we have examined the development of operations research activities during the 1960's in Peru, commented on the reactions of government officials and business executives to the suggestion that they should use OR, and also made remarks on the institutional and educational aspects of operations research work in Peru during the 1970's.

Many of the comments that were made with reference to Peru may be equally applicable to other underdeveloped countries. For example, I do not expect the reactions of government officials and business executives in other Latin American countries to differ widely from those found in Peru. Moreover, the imbalance between the relatively high capability for doing work in the management sciences and the low absorption capacity of government and private enterprises appears to be a general characteristic of underdeveloped countries.

The operations researcher in an underdeveloped country must be aware of the methodological implications of operations research work that were sketched in §5. My experience with foreign OR project managers and with Peruvians returning with degrees in the management sciences obtained in the United States or Western Europe has been that only those who were able to challenge, discard, and renew their acquired habits of thought in response to the differences in environmental conditions were successful to any degree.

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