The Role of Statistical Consultant in the Complex World : A Systems Approach

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Table of Contents

1. Introduction

Information requirements never seem to get smaller in the complex world. Management of business is the process of data to make decisions. Recently restructuring of organization for efficiency is the most interested issue under the circumstances of high labor and financial cost. As a method of changing the organization, experimental design may be required as a necessary factor. However, in the experimental design, there might be many statistical and non-statitical problems which should not be disregarded. Experimental statistics that requires a lot of information or the flow of data may observe the fragmentation only. Without observing the whole system, the solution of a part may cause another problem. A system should be considered as a part of the total system. Many authors stress the importance of total system specially in the field of open system [1], [13], [14].

This paper considers the relationship between statistician and the users of statistical

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result for decision making(Client) in the experimental design. The concept of general systems theory is applied to understand the system. Here, the system is defined as the problem which shoud be solved by the statistical experimental design.

After Fisher first introduced statistical principles of experimental design, this statistical method has been used in all fields of study either to discover something about a particular process or to compare the effect of several factors on some phenomena. However, Designing an experiment, in the complex world, is not a matter of statistics only, it is a matter of how to collect the data. In any experiment, the results and conclusions that can be drawn depend to a large extent on the manner in which the data were collected. Furthermore, experimenter may not an expert in both statistics and the area involved in the investigation. Occasionally, the statitical consultant and the client must work together. Much of the statistical literature emphasize the importance of planning stage, and the importance of cooperation between the statistician and the client [2], [4], [5], [6], [7], [14]. However, Few authors have discussed methods for obtaining important inforamtion during the initial stages of research project. Statistical consulting and experimental design in the real world is a complex activity that requires statistical and non-statistical skills.

The purpose of this paper is to provide general guidelines for the statisticans who consult statistical problems, specifically in the experimental design. Since once the problem has been defined correctly, the rest of procedures is only an application of statistical methods. However, if the problems were ill - structured, the statistician might commit the third errors : right answer to the wrong problem. This is the reason that many authors emphasize the importance of planning stage. Thus, this paper focuses on the planning stage of the experimentation, and the systems approach was applied to define the several steps that statistician can follow in the initial planning stage of the experimental design.

1.1 The Planning stage of the experimental design

Gerald Hahn[7] says that "Statistician make their most valuable contributions if they are consulted in the planning stage of an investigation. Proper experimental design

is often more important than sophistcated statistical analyses ··· , Results from a well - planned experiment are frequently evident from simple graphical analyses. The best statistical analyses, on the other hand, cannot rescue a poorly planned program". Kimball[10] introduced some type of error which resulted from different situations that arise frequently in practice. The defined errors of the third kind in the statistical consulting as the error commited by giving the right answer to the wrong problem.

Many authors have discussed the importance if initial planning stage not to commit the third kind of errors. Then, what are the factors to be considered by the statistical consultant in the initial stage of the experimental design. How can a statistician collect information that he may regard as crucial to a good design.

Bishop[2] says that "important information can be obtained through the construction of logic diagrams that outline the proposed tasks in the experimental program ··· , Researchers and statisticians should take advantage of their combined skills in developing the overall logic of experimentation".

However, he did not explain the methods of constructing the logic of diagrams. It is not easy to draw a logic diagrams when the problems are in the complex world.

1.2 The Systematic view

Systematic view of planning stage of experimental design may provide a concrete framework for effective experimental design. The premises of the systematic view of experimental design is that in order to understand the systems, there are four important areas in the application of the systems approach to organization that require our particular attention [1].

① Defining the boundaries of the whole system and of the environment.

② Establishing the system's objective.

③ Determining the program structure and the programs - agents relationships.

④ Describing the system's management.

Once the characteristics of the above four aspects has been defined with respect to the planning stage of the experimental design. The result will become guidelines that the statistician can follow when they are planning the experimental design. Another

words, when we look at the problems from the systems approach, guidelines that the statistician must follow can be identified.

2. The Model of Planning Stage on the Experimental Design

2.1 Environmental aspects

The environment is the set of entities and conditions outside of the system boundary that affects the system or is affected by it. The entities in the environment may be affected by the system, but are not controlled by it. System thought emphasize the need to take a holistic view in order to explain why an object is structured as it is, or how it should be structured[13]. Thus the system study starts from the outside, identifying the environment in which the object exist and the way it impacts that environment.

One of the tasks of the statistician is determing the current state of affairs with respect to the specific problem and overall situation. The environment of the problems must be clearly and throughly described.

Although Bliss[3] propose a careful identification of the situation before applying any statistical problems with the client, it is not simple to develop a clear and generally accepted statement of problems. In order to describe the problems properly, the statistician may think about the following aspects.

What is the statistical problem? Is it concerned with ensuring that the client can solve the problems without statistical procedure? What is the impact of the statistical results? What are the uncontrolled and the controlled variables? The response variables are measurable? What method of data analysis should be used? The budgeted size of the experiment is appropriate? The deadlines can be met? What are the assumptions of the problem? What are the expected results? etc.

Since the purpose of the initial planning stage of the experimental design is to describe the problems well in order to build the models appropriately, many of these questions should be satisfactorily answered, and both the statistical consultant and the client must fully understand the problems.

2.2 Definition of the goal.

The objective of a systematic represents its intended impact on its environment. It specifies which services the system is supposed to deliever and what its goals are. It also provides the basis for evaluating the system and thus should be specified in terms that are amenable to measurement[13].

Montgomery[11] defines the objective of the experiment as either be confirmation (verify about the system) or exploration (study the effect of new conditions on the system). If the environment of the system has been well described, defining appropriate goals are feasible. Thus, the first thing to check is that the situation is clearly and throughly described. The defined goals should be clear enough to which experimental design is applicable. If both client and statistician had enough understanding of the problems and they were satisfied with the definition of the environment, defiend goal would be satisfied by them. Zahn and Isenberg[14] cautioned that "the most difficult issue occurs when either when the client's data do not appropriately address the research objectives or when statistical consultant's theory is not clearly enough thought through to define appropriate research objectives".

2.3 Determination of the components and consultant - client relationship

The components of the system are the identifiable elements within the system boundary. These components represents the functional building blocks of the system. Division of labor relates to the ability to perform effectively a necessary task[13].

This step is to determine what actions will be taken. If situation and goals are clearly defined, it would be also clear what the consultant should do, and what the client should do. This part much related with implementation part. Mutual understanding between them is necessary in order not to commit errors. Errors of the third kind may be caused by inadequate communication between the consultant and the client. Statistician's specialized knowledge of statistical theory enables him to see which parts are statistical. He must designates, in the planning stage, which part of the work will belong to the statistician, and which to the client. They can divide their jobs by discussing each other. Edwards Dening[6] specified the responsibilities of the statistician and the client. We can infer the division of labor between the statistician

and the client from his examples.

The statistician's responsibilities may be summarized as follows.

① to formulate the client's problem in statistical terms.

② to lay out a logical division of responsibility for the client, and for the statistician, suitable to the investigation proposed.

③ to explain to the client the advantage and disadvantage of various frames and possible choices of sampling units, and of one or more feasible statistical plans of sampling or experimentation that seem to be feasible.

④ to furnish statistical procedures for the investigation - selection, computation of estimates and standard errors, tests, audits, and controls as seem to be warranted for detection and evaluation of important possible departures from specifications, various between investigators, non - response, and other persistent uncertanties.

The Responsiblities of the client may be summarized as follows.

① The type of statistical information to be obtained.

② The methods of test, examination, questionaire, interview, by which to elicit the information from any unit selected from the frame.

③ Approval of the probability model proposed by the statistician, statistical procedures, scope and linitations of the statistical inferences that may be possible from the results.

④ The decision on the classes and areas of tabulation; the approximate level of statistical precision or protection that would be desirable in view of the purpose of the investigation, skills and time available, and costs.

2.4 Implementation

The purpose of statistical consulting is to get the scientific (or statistical) support on the problems. The result of statistical analysis might change the policy in the future. Experimental design is a kind of implementation, which is involved by both consultant and client. Montgomery[11] states that "the experiment is almost always an intervention or change in the routine operation of a system, which is made with the objective of measuirng the effect of the intervention". Statical performance in

the field of experimental design is mostly a collaborative venture between statistician and experts. However, cooperation between the colsultant and the client is not a simple question, because they have different view points on the problem. The general problem may comes from the client's misunderstanding about the statistics, or the consultant's inefficient knowledge about the specific field.

The statistician and the client typify the two parties involved in the implementation process. The statistician is working in an improvement of and innovation which he thinks can be used by the client. This implementation theory can be applied to the initial planning stage of the experimental design. The only assumption is that statistician is an expert as a statistical consultant.

Churchman and Schainblatt[13] have laid out a matrix which explains the type of confrontation that takes place at the scientist - manager interface. The relationship between scientist and manager are replaced as a statistical consultant and client in this paper. Four types of ralationships represented by the four cells of the matrix as follows.

	B	B'
A	Mutual Understanding	Communication
A'	Persuation	Separate Function

No authors have discussed how statistical consultant cope with differnet clinet, what factors are critical in decision making. The client or the experimenter has different educational background. One clinet wants all of the statistical work done by the consultant including a substantial amount of programming, coding, and key punching, the other can communicate with statistical consultant in scientific language. If we apply this theory in the planning stage of the experimental design, statistical consultant can be classified into four groups with respect to his roles in the project, because statistical consultant may be a self - employer or a employer of the consulting company. Also the client can be classified in terms of his level of statistical education as well as his characteristics. If he or she belong to the separate function group, statistical consultant and client can divide their jobs and roles so that major gaps between them can be reduced.

The characteristics of each position of the above matrix in terms of relationship between the statistical consultant and the client can be explained as follows.

① Separate function

This position represents the approach which consider that it is the statistical consultant's responsibility to represent and improvement with detailed instructions on how to implement it[13]. Churchman further defines this position as "the design of the new method must be adequate and through to allow the manager to apply it without further communication or interpretation". This position may be appropriate when the statistical consultant is an experimenter, and the client is an expert in the area involved in the investigation. But the client may or may not have statistical knowledge. Statistical consultant and the client have separate responsibility on their own jobs with detailed instructions.

② Persuassion position

According to Churchman[13], this position holds that implementation rests to a great extent on the skill of the statistical consultant in understanding the problems of the client, to persuade him of the advisibility of adopting the client's personality to overcome his resistence. Statistical consultant must take all steps from sampling to analyzing data. He must also understand the area involved in the investigation. The success of research depends on whether the client agree with the statistical possible results.

③ Communication position

The problem of implementation could be resolved if the client were to understand the language of the statistical consultant. The position holds that the solutions suggested by the client are not understood them. In order to do so, the client should be trained to understand the language of statistics[12]. Thus this position assume that the client must understand statistics, or at least he must have willingness to work with the statistical consultant. Another assumption is that the statistical consultant may not have knowledge about the area involved in the investigation. He can draw some crucial information from questions to the client. Therefore, interpersonal relations

and communication skills might be critical factors. After work is done, and if the client has the similar problems in the future, he will have ability to do it without the consultant's help.

④ Mutual understnading

This position is not known well with various interpretation of its meaning. In this category, implementation is a function of the type of relationship that exist between the two parties[13]. Thus trust between two groups should be provided. Without trust, each parties do not have faith in each other's recommendation. The consultant can help the client formulate statistical analyses, and the client may want to know what consultant is doing and why.

3. Conclusion

The purpose of this article was to discuss general guidelines and critical factors that can be used during initial planning stage of experimental design in the complex world. There may be several methods of approaching problems and infinite number of factors to be considered in the complex world for successful application of statistical research. However the statistical result is not important for the statistician, the result is very important for the users of statistical result. Since the client who has not much statistical knowledge, he or she may not have the ability of assessing the result, so that he or she observe the result without careness no matter what the result is good or not. This is the reason why the statistician needs more carefulness when they apply statistics to real world.

The discussion in this article has tended toward being a general guidelins for the statistician in terms of the procedure of solving the statistical problems. The guidelines that statistical consultant can follow would be useful, if consultant had some practice with it. However, realistically experience might be the most important factors of success in the research.

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