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# International Encyclopedia of STATISTICS

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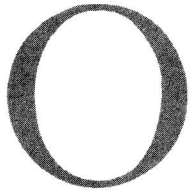

## ODDS RATIO

*See* COUNTED DATA; SURVEY ANALYSIS, *article on* METHODS OF SURVEY ANALYSIS.

## OFFICIAL STATISTICS

*See* CENSUS; GOVERNMENT STATISTICS; PUBLIC POLICY AND STATISTICS; VITAL STATISTICS.

## OPERATIONS RESEARCH

The roots of "operations research" (commonly referred to as OR) go back at least to the industrial revolution, which brought with it the mechanization of production, power generation, transportation, and communication. Machines replaced man as a source of power and made possible the development of the large industrial, military, and governmental complexes that we know today. These developments were accompanied by the continuous subdivision of industrial, commercial, military, and governmental management into more and more specialized functions and eventually resulted in the kind of multilevel structure that today characterizes most organizations in our culture.

As each new type of specialized manager appeared, a new specialized branch of applied science or engineering developed to provide him with assistance. For example, in industry this progression began with the emergence of mechanical and chemical engineering to serve production management and has continued into more recent times with the development of such specialties as industrial engineering, value analysis, statistical quality control, industrial psychology, and human engineering. Today, no matter how specialized the manager, at least one relevant type of applied science or engineering is available to him.

Whenever a new layer of management is created, a new managerial function, that of the *executive,* is also created at the next higher level. The executive function consists of coordinating and integrating the activities of diverse organizational units so that they serve the interests of the organization as a whole, or at least the interests of the unit that contains them. The importance of the executive function has grown steadily with the increase in the size and complexity of industrial, military, and governmental organizations.

The executive function in business and industry has developed gradually. The executive was not subjected to violent stimuli from new technology as was, for example, the manager of production. Consequently the executive "grew" into his problems, and these appeared to him to require for their solution nothing but good judgment based on relevant past experience. The executive, therefore, felt no need for a more rigorous scientific way of looking at his problems. However, the demands on his time grew, and he sought aid from those who had more time for, and more experience with, the problems that he faced. It was this need that gave rise to management consulting in the 1920s. Management consulting, however, was based on experience and qualitative judgment rather than on experimentation and quantitative analysis. The executive function was left without a scientific arm until World War II.

The major difference between the development of military executives and of their industrial counterparts is to be found in the twenty-year gap between the close of World War I and the opening of World

War II. Because there was little opportunity to use military technology under combat conditions during this period, this technology developed too rapidly for effective absorption into military tactics and strategy. Thus, it is not surprising that British military executives turned to scientists for aid when the German air attack on Britain began. Initially they sought aid in incorporating the then new radar into the tactics and strategy of air defense. Small teams of scientists, drawn from any disciplines from which they could be obtained, worked on such problems with considerable success in 1939 and 1940. Their success bred further demand for such services, and their use spread to Britain's allies—the United States, Canada, and France. These teams of scientists were usually assigned to the executive in charge of operations, and their work came to be known in the United Kingdom as "operational research" and in the United States by a variety of names: operations research, operations analysis, operations evaluation, systems analysis, systems evaluation, and management science. The name operations research was and is the most widely used in the United States.

At the end of the war very different things happened to OR in the United Kingdom and in the United States. In the United Kingdom expenditures on defense research were reduced. This led to the release of many OR workers from the military at a time when industrial managers were confronted with the need to reconstruct much of Britain's manufacturing facilities that had been damaged during the war and to update obsolete equipment. In addition the British Labour party, which had come into power, began to nationalize several major and basic industries. Executives in these industries in particular sought and received assistance from the OR men coming out of the military. Coal, iron and steel, transport, and many other industries began to create industrial OR.

In contrast to the situation in Great Britain, defense research in the United States was increased at the end of the war. As a result military OR was expanded, and most of the war-experienced OR workers remained in the service of the military. Industrial executives did not ask for help because they were slipping back into a familiar peacetime pattern that did not involve either major reconstruction of plant or nationalization of industry.

During the late 1940s, however, the electronic computer became available and confronted the industrial manager with the possibility of automation —the replacement of man by machines as a source of control. The computer also made it possible for a man to control more effectively widely spread and large-scale activities because of its ability to process large amounts of data accurately and quickly. It provided the spark that set off what has sometimes been called the second industrial revolution. In order to exploit the new technology of control, industrial executives began to turn to scientists for aid as the military leaders had done before them. They absorbed the OR workers who trickled out of the military and encouraged academic institutions to educate additional men for work in this field.

Within a decade there were at least as many OR workers in academic, governmental, and industrial organizations as there were in the military. More than half of the largest companies in the United States have used or are using OR, and there are now about 4,000 OR workers in the country. A national society, the Operations Research Society of America, was formed in 1953. Other nations followed, and in 1957 the International Federation of Operational Research Societies was formed. Books and journals on the subject began to appear in a wide variety of languages. Graduate courses and curricula in OR began to proliferate in the United States and elsewhere.

In short, after vigorous growth in the military, OR entered its second decade with continued growth in the military and an even more rapid growth in industrial, academic, and governmental organizations.

**Essential characteristics of OR.** The essential characteristics of OR are its systems (or executive) orientation, its use of interdisciplinary teams, and its methodology.

*Systems approach to problems.* The systems approach to problems is based on the observation that in organized systems the behavior of any part ultimately has some effect on the performance of every other part. Not all these effects are significant or even capable of being detected. Therefore the essence of this orientation lies in the systematic search for significant interactions when evaluating actions or policies in any part of the organization. Use of such knowledge permits evaluation of actions and policies in terms of the organization as a whole, that is, in terms of their over-all effect.

This way of approaching organizational problems is diametrically opposed to one based on "cutting a problem down to size." OR workers almost always enlarge the scope of a problem that is given to them by taking into account interactions that were not incorporated in the initial formulation of the problem. New research methods had to be developed to deal with these enlarged and more complicated problems. These are discussed below.

As an illustration of the systems approach to organizational problems, consider the case of a company which has 5 plants that convert a natural material into a raw material and 15 finishing plants that use this raw material to manufacture the products sold by the company. The finishing plants are widely dispersed and have different capacities for manufacturing a wide range of finished products. No single finishing plant can manufacture all the products in the line, but any one product may be produced in more than one plant.

Many millions of dollars are spent each year in shipping the output of the first group of plants to the second group. The problem that management presented to an OR group, therefore, was how to allocate the output of the raw-material plants to the finishing plants so as to minimize total between-plant transportation costs. So stated, this is a well-defined, self-contained problem for which a straightforward solution can be obtained by use of one of the techniques of OR, linear programming [*see* PROGRAMMING].

In the initial phases of their work, the OR workers observed that whereas all the raw-material plants were operating at capacity, none of the finishing plants were. They inquired whether the unit-production costs at the finishing plants varied with the percentage of capacity in use. They found that this was the case and also that the costs varied in a different way in each plant. As a result of this inquiry the original problem was reformulated to include not only transportation costs, but also the increased costs of production resulting from shipping to a finishing plant less material than it required for capacity operation. In solving this enlarged problem it was found that increased costs of production outweighed transportation costs and that a solution to the original problem (as formulated by management) would have resulted in an increase in production costs that would have more than offset the saving in transportation costs.

The OR workers then asked whether the increased costs of production that resulted from unused capacity depended on how production was planned, and they discovered that it did. Consequently, another related study was initiated in an effort to determine how to plan production at each finishing plant so as to minimize the increase in unit-production costs that resulted from unused capacity. In the course of this study of production planning it also became apparent that production costs were dependent on what was held where in semifinished inventory. Therefore, another study was begun to determine at what processing stage semifinished inventories should be held and what they should contain. Eventually the cost of shipping finished products to customers also had to be considered.

In the sequence of studies briefly described, it was not necessary to wait until all were completed before the results of the first could be applied. Solutions to each part of the total problem were applied immediately because precautions had been taken not to harm other operations. With each successive finding previous solutions were suitably adjusted. Eventually some change was made in every aspect of the organization's activities, but each with an eye on its over-all effect. This is the essence of the systems approach to organizational problems.

*The interdisciplinary team.* Although division of the domain of scientific knowledge into specific disciplines is a relatively recent phenomenon, we are now so accustomed to classifying scientific knowledge in a way that corresponds either to the departmental structure of universities or to the professional organization of scientists that we often act as though nature were structured in the same way. Yet we seldom find such things as pure physical problems, pure psychological problems, pure economic problems, and so on. There are only problems; the disciplines of science simply represent different ways of looking at them. Nearly every problem may be looked at through the eyes of every discipline, but, of course, it is not always fruitful to do so.

If we want to explain an automobile's being struck by a locomotive at a grade crossing, for example, we could do so either in terms of the laws of motion, or the engineering failure of warning devices, or the state of physical or mental health of the driver, or the social use of automobiles as an instrument of suicide, and so on. The way in which we look at the event depends on our purposes in doing so. A highway engineer and a driving instructor would look at it quite differently.

Though experience indicates a fruitful way of looking at most familiar problems, we tend to deal with unfamiliar and complicated situations in the way that is most familiar to us. It is not surprising, therefore, that given the problem, for example, of increasing the productivity of a manufacturing facility, a personnel psychologist will try to select better workers or improve the training that workers are given. A mechanical engineer will try to improve the machines. An industrial engineer will try to improve the plant layout, simplify the operations performed by the workers, or offer them more attractive incentives. The systems and procedures analyst will try to improve the flow of

information into and through the plant, and so on. All may produce improvements, but which is best? For complicated problems we seldom can know in advance. Hence it is desirable to consider and evaluate as wide a range of approaches to the problem as possible. OR has greatly enlarged our capacity to deal with all the complexities of and the approaches to a given problem and has therefore expanded our opportunities to benefit from the use of interdisciplinary teams in solving problems.

Since more than a hundred scientific disciplines, pure and applied, have been identified, it is clearly not possible to incorporate each in most research projects. But in OR as many diverse disciplines are used on a team as possible, and the team's work is subjected to critical review by as many of the disciplines not represented on the team as possible.

*Methodology.* Experimentation lies at the heart of scientific method, but it is obvious that the kind of organized man–machine system with which industrial, military, and governmental managers are concerned can never be brought into the laboratory, and only infrequently can such systems be manipulated enough in their natural environment to experiment on them there. Consequently, the OR worker finds himself in much the same position as the astronomer, and he takes a way out of his difficulty much like that taken by the astronomer. If he cannot manipulate the system itself, he builds a representation of the system, a *model* of it, that he can manipulate. In OR such models are abstract (symbolic) representations that may be very complicated from a mathematical point of view. From a logical point of view, however, they are quite simple. In general they take the form of an equation in which the performance of the system, $P$, is expressed as a function, $f$, of a set of controlled variables, $C$, and a set of uncontrolled variables, $U$:

$$P = f(C,U).$$

The controlled variables represent the aspects of the system that management can manipulate, for example, production quantities, prices, range of product line, and so on. Such variables are often called decision variables since managerial decision making may be thought of as assigning values to these variables. The uncontrolled variables represent aspects of the system and its environment that significantly affect the system's performance but are not under the control of management, for example, product demand, competitors' prices, cost of raw material, and location of customers.

The measure of performance of the system may be very difficult to construct since it must reflect the relative importance of each relevant objective of the organization. This measure is sometimes called the criterion or objective function since it provides the basis for selecting the "best" or "better" courses of action.

Limitations or restrictions may be imposed on the possible values of the controlled variables. For example, in preparing a budget a limitation is normally placed on the total amount that may be allocated to different departments, or there may be legal constraints on the decision-making activities of managers. Such restrictions can usually be expressed mathematically as equations or inequalities and can be incorporated in the model.

Once the decision maker's choices and the system involved have been represented by a mathematical model, the researcher must find a set of values of the controlled variables that yields the best (or as close as possible to the best) performance of the system. These "optimizing" values may be found either by experimenting on the model (i.e., by *simulation*) or by mathematical analysis. In either case the result is a set of equations, one for each controlled variable, giving the value of that controlled variable relative to a particular set of values of the uncontrolled variables and other controlled variables that yields the best performance of the system as a whole [*see* SIMULATION].

If the problem is a recurrent one, then the values of the uncontrolled variables (for example, demand) may change from one decision-making period to another. In such cases a procedure must also be provided for determining when values of the uncontrolled variables have undergone significant change and for adjusting the solution appropriately. Such a procedure is called a solution-control system.

The output of an OR study, then, is usually a set of rules for determining the optimal values of the controlled variables together with a procedure for continuously checking the values of the uncontrolled variables. It must be borne in mind, however, that a single, unified, and comprehensive OR study is seldom possible in an organization of any appreciable size. Rather, what usually occurs is a sequence of interrelated studies, each of which is designed to be adjustable to the results of the others.

Ten years of constructing and working with models of managerial problems in industry have shown that, despite the fact that no two problems are ever exactly alike in content, most problems fall into one, or a combination, of a small number of basic types. These problem-types have now been studied extensively so that today we have considerable knowledge about how to construct and solve

models that are relevant to them. Adequate definitions of these problem-types require more space than is available here, but the following brief characterizations indicate their nature.

*Inventory* problem—to determine the amount of a resource to be acquired or the frequency of acquisition when there is a penalty for having either too much or too little available.

*Allocation* problem—to determine the allocation of resources to a number of jobs where available resources do not permit each job to be done in the best possible way, so as to do all (or as many as possible) of the jobs in such a way as to achieve the best over-all performance, given criteria for measuring performance.

*Queuing* problem—to determine the amount of service facilities required or how to schedule arrival of tasks at service facilities so that losses associated with idle facilities, waiting, and turned-away tasks are minimized.

*Sequencing* problem—to determine the order in which a set of tasks should be performed in a multistage facility so as to minimize costs associated with the performance of the tasks and delays in completing them.

*Routing* problem—to determine which path or route through a network of points or locations is shortest (or longest), has maximum (or minimum) capacity, or is least (or most) costly to traverse subject to certain limitations on the paths or routes that are permissible.

*Replacement* problem—to determine when to replace instruments, tools, or facilities so that acquisition, maintenance, and operating and failure costs are minimized.

*Competition* problem—to determine the rule to be followed by a decision maker that yields the best results when the outcome of his decision depends in part on decisions made by others.

*Search* problem—to determine the amount of resources to employ and how to allocate them in seeking information to be used for a particular purpose so as to minimize the costs associated with the search and with the errors that can result from use of incorrect information.

**The future of OR.** OR has been primarily concerned with the executive's decision-making or control process. There are, of course, other approaches to improving the performance of organizations, for example, selecting better personnel, providing better personnel training, better motivating personnel, accelerating their operations through work study, changing equipment and materials, modifying communications, changing organizational structure. This multiplicity of available approaches presents the executive with the additional problem of selecting which approaches to pursue. He seldom has an objective basis for doing so. Clearly it would be desirable to develop an integrated and comprehensive approach to organizations, one that rationally selects from or combines different points of view. OR and other systems-oriented interdisciplinary research are taking steps to develop such an over-all approach to organizational problems. This is leading to mathematical descriptions of organizational structures and communications systems, thus providing the ultimate possibility of integrating studies of organizational structure, communication, and control.

Precise solutions of some limited problems of organizational structure have already been found. For example, given an organization's over-all objective and a description of its task and environment, it is possible to determine the number and types of units into which the organization should be divided and the objectives to be assigned to these units so as to minimize inefficiency arising from the organization's structure. This is a problem in structural design. Or, given an organization that has an inefficient structure, it is possible to determine the types of decentralized control to be applied to decentralized decision making so as to minimize inefficiency. This is a problem in structural control.

Such developments are leading to an integrated theory of, and generalized methodology for, research on organized systems. Since all of these systems are, in some sense, social systems, the participation of the social scientist in these interdisciplinary efforts is essential.

RUSSELL L. ACKOFF

[*See also* Gochman 1968; Kaplan 1968; Mitchell 1968; Parsons 1968; Rapoport 1968.]

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## OPINION POLLS

*See* ERRORS, *article on* NONSAMPLING ERRORS; PUBLIC POLICY AND STATISTICS; SAMPLE SURVEYS; STATISTICS AS LEGAL EVIDENCE; SURVEY ANALYSIS.

## OPTIONAL STOPPING

*See* SIGNIFICANCE, TESTS OF.

## ORDER STATISTICS

*See under* NONPARAMETRIC STATISTICS.

## ORGANIZATIONS: METHODS OF RESEARCH

*This article was first published in* IESS *with four companion articles less relevant to statistics.*

A formal organization consists of a set of people who are engaged in activities coordinated by the relatively consistent expectations that these people have about one another and about the purposes of the organization. Such expectations define a set of organizational statuses or offices, each status with a set of roles linking it to the other statuses with which it interacts. Organizational research examines how people behave in their organizational roles and how organizations behave as collective units. Here we will consider the types of data collection and measurement, and research design and analysis used in organizational research.

### Data collection

Organizational research uses three main sources of data: qualitative observation and interviewing, surveys of organization members, and institutional records. Qualitative methods of data collection are described elsewhere (see Powdermaker 1968). Surveys within organizations take three forms: surveys of one stratum only; surveys of two or more strata within the organization (for instance, workers and management, or students and faculty); and "relational surveys" of linked pairs or sets of role partners. In surveys of two or more organizational strata ("multistratum surveys") individuals are usually sampled at random within status groups and are identified only by the general status each one occupies. In "relational surveys" each individual is identified by the specific others with whom he interacts, and the sample is set up to include these role partners. When a sample of individuals is asked to provide the information on their role partners, who are not themselves interviewed, we have a "pseudo-relational survey."

Institutional data include records made by organizations for their own use; information from directories, which can be turned into "data banks"; and "institutional questionnaires," sent to samples of organizations, to be filled out by one or more key informants in each organization.

### Measurement

The formal aspect of measurement that is most significant for organizational research is the relation of the units from which the basic data are gathered to those which are characterized by the measurement. Information can be gathered on the organization as a whole or on component parts of it, such as individuals, interacting pairs and sets, and subgroups of members. Data on component parts can be aggregated in various ways to characterize the organization; and data on the organization can be considered as a "contextual characteristic" of the members. The following types of characteristics of collectives and their members have been distinguished by Lazarsfeld and Menzel (1961), and further discussed by Barton (1961, pp. 2–3 and appendix 1).

*Integral* or global characteristics of a unit do not derive from aggregation of members, pairs, or sets within that unit, but from properties of the

unit as a whole. In the case of an organization, examples of such properties are its physical equipment, formal rules, budgets, programs, collective events, and collective outputs.

*Relational* characteristics derive from information concerning the relationship between a unit and other units. In the case of an individual, they include popularity, measured by number of choices received on sociometric questions; participation in an occupational community, measured by the number of friends who belong to the same occupation; supportiveness of political environment, measured by the proportion of his associates who vote the same way as the respondent; cosmopolitanism, measured by the number of extraorganizational contacts he has; and so on. For collective units, relational characteristics would include the amount of communication between one unit and various others in its environment, the frequency of cooperation or conflict with other units, the volume of economic transactions between them, and so on (Levine & White 1961; Litwak & Hylton 1962).

The underlying model for relational data is a "who-to-whom" matrix showing the value of the relationship for each pair within a group. There may be different types of relationships (who likes whom, who gives orders to whom, who talks shop with whom, etc.), each of which generates a matrix [*see* SOCIOMETRY]. Summary scores for individuals are found in the marginal totals of each matrix. Other operations can give us the number of second-order and higher-order connections which an individual has (through his immediate partners) and the characteristics of his interpersonal environment. Organizations likewise have higher-order connections and an interorganizational environment.

*Aggregate* measures characterize a collective in terms of distributions of data concerning its members. The simplest aggregate measures are additive properties, such as rates and means. Thus the morale of army units may be measured by the proportion of their men who feel strong loyalty to the unit; the political climate of a college by the proportion of its faculty members who are liberal; the ability level of a school by the mean IQ of its students. In these cases, as we would expect, there is a simple correspondence between the individual and the collective properties; relationships true on the individual level are duplicated on the organizational level. However, this kind of correspondence does not always exist, as discussions of the "ecological fallacy" have shown (Robinson 1950; Duncan & Davis 1953; Goodman 1953). Additive measures can also be used as indicators of more complex organizational characteristics that are not simply the sum of individual traits: for example, the proportion of an organization's total personnel that is in administrative positions may indicate how bureaucratized the organization is.

A peculiar type of aggregate property arises when researchers ask samples of members for their perceptions of the organization or parts of it, and add up their answers to obtain a kind of aggregate perception. For example, an army company may be classified as having authoritarian leadership if a large proportion of members report that the leader behaves in an authoritarian way (Selvin 1960). A problem here is that different groups within an organization may evaluate the same behavior differently: Halpin (1956) found school principals reporting themselves as high on "consideration" for teachers; the school boards agreed with them, but the teachers themselves did not.

The *variance* of the distribution of member data may also be used to characterize the collective. Thus the range or standard deviation of the incomes of an organization's members can be used as a measure of the organization's equalitarianism, and the same measures, when applied to the ability levels of a high school class or the values of members of a union local, can indicate the degree of heterogeneity in the class or of value consensus in the union. Equality, homogeneity, and consensus are emergent properties on the collective level, without individual counterparts.

Finally, the *correlations* between variables within a collective can be used as aggregate measures. For instance, the correlation of values with rank in the American army indicates its degree of "value stratification" (Speier 1950). Similarly, the correlation of military rank with external social status measures the degree of ascription as compared with achievement in the organization's promotion system.

The members of the collective from which data are aggregated need not be individuals; they may be smaller collectives within the larger one. Thus an aggregate measure of the degree of local democracy within national unions might be the proportion of locals within a union that had contested elections.

When we have data from several status groups within a number of organizations, we can obtain aggregate measures for each stratum. An organization might thus be characterized as having high morale in the upper strata but low morale among the rank and file, as having authoritarian top managers and democratic foremen, and so on. The *differences* between different strata, in rates or mean scores on various attitudes, behaviors, back-

ground data, etc., are actually a form of correlational index.

*Relational-pattern* measures (sometimes termed *structural* or *sociometric* measures) are aggregations of relational data on the members of a collective unit. Group cohesion is often measured in this way by the ratio of in-group to out-group choices when each member of a group is asked whom he chooses or would choose as a close friend; group integration may be indicated by the over-all frequency with which group members communicate with one another (see Schachter 1968). More complex measures would include the extent to which relations within a group form self-contained cliques. Patterns of relationship among subunits—for example, the amount of conflict between subgroups in an organization—can also characterize a collective. Just as relational characteristics of individuals are indicated by their row or column scores in a who-to-whom matrix, relational pattern measures for a collective derive from the matrix as a whole—that is, from the distribution or patterning of pair relations.

*Contextual* measures arise when we characterize a member by the properties of the collective of which the member is a part. Being dissatisfied is an integral property of the individual; being a member of a work group where a high proportion are dissatisfied is a contextual property, derived from the aggregate of individual properties of members. Being a member of a conflict-ridden organization is a contextual property derived from a relational-pattern property of the collective; attending a college with a large library is a contextual property derived from an integral property of the collective.

In a multistratum survey of many organizations, contextual data can also be derived from different strata. For example, aggregate data on university faculty are contextual for students, and characteristics of foremen are contextual for the workers under them.

Organizations, too, have contexts, such as the larger organization of which they are part or the industry or community in which they are located. Locals may be part of a "democratic" or an "undemocratic" national union; business firms may be located in communities with growing or shrinking populations, or belong to competitive or concentrated industries.

In summary, individual members of an organization have integral, relational, and contextual properties. Collectives likewise have integral properties, relational properties (with regard to other organizations), and contextual properties (those of larger collectivities of which they are members). But in addition, collectives have aggregate properties derived from their members' integral characteristics, and relational-pattern properties derived from their members' relationships.

## Research designs

We have distinguished five main sources of data: qualitative observation, one-stratum surveys, multistratum surveys, relational surveys, and institutional data; this is the first of three dimensions on which research designs can be classified. A second dimension is the number of organizational units studied: "case studies" of one organization, "comparative studies" of two or several organizations; and "large-sample studies" of enough organizations to make statistical analyses with organizations as units of analysis. (Either a whole organization or a formal subunit can be the focus of study; a study of 100 work groups within a large corporation would be a "large-sample study" of work groups.) The third dimension is whether data are gathered for one point in time or whether comparable data are gathered for each of two or more time periods. Studies over time permit analysis of change and inferences of causal relationships.

A typology of designs for organizational studies is generated if we run these three dimensions against one another (see Table 1, in which each row of six cells derives from a different source of data).

## Analysis of data on organizations

The different types of research design outlined in Table 1 permit several basic types of analysis, some qualitative and some quantitative. Each type of analysis can be performed for units at different levels of aggregation—for individuals, for linked sets of individuals, or for organizations. We will examine each type of analysis in turn, indicating its limitations as well as the problems that it permits us to study.

**Ideal-type comparison.** A study of one organization at one point in time, using qualitative methods, provides a very limited scope for analysis. Such analysis usually involves comparing the case at hand with a theoretically derived ideal type—Weber's model of bureaucracy, for instance, or the economists' model of a firm composed of rational economic men. Thus, an analysis of bureaucratic patterns in the navy officer corps describes a number of striking behavior patterns (avoiding responsibility, ritualism, insulation from the outside world, and ceremonialism) and concludes: "The military variant of bureaucracy may thus be viewed

***Table 1 — A typology of designs of organizational studies***

| TIME PERIODS | NUMBER OF UNITS STUDIED | | |
|---|---|---|---|
| | One | Several | Many |
| 1 | *Qualitative case study*<br>Davis 1948 | *Qualitative comparative study*<br>Coser 1958<br>Form & Nosow 1958 | *Many qualitative case studies*<br>Udy 1959 |
| 2+ | *Qualitative case study over time*<br>Selznick 1949<br>Gouldner 1954<br>Roethlisberger & Dickson 1939 | *Qualitative comparative study over time*<br>Guest 1962 | *Many qualitative case studies over time*<br>——— |
| 1 | *One-stratum one-unit survey*<br>Walker & Guest 1952 | *One-stratum comparative survey*<br>Katz & Hyman 1947 | *One-stratum survey of a large sample of organizations*<br>Lazarsfeld & Thielens 1958<br>Bowers 1964 |
| 2+ | *One-stratum one-unit panel survey*<br>Stouffer et al. 1949 | *One-stratum comparative panel survey*<br>——— | *One-stratum panel survey in a large sample of organizations*<br>——— |
| 1 | *Multistratum one-unit survey*<br>Stouffer et al. 1949 | *Multistratum comparative survey*<br>Georgopoulos & Mann 1962<br>Illinois, University of 1954<br>Mann & Hoffman 1960 | *Multistratum survey of a large sample of organizations*<br>——— |
| 2+ | *Multistratum one-unit panel survey*<br>Newcomb 1943<br>Lieberman 1956 | *Multistratum comparative panel survey*<br>——— | *Multistratum panel survey of a large sample of organizations*<br>——— |
| 1 | *One-unit relational survey*<br>Weiss 1956<br>Kahn 1964<br>Stogdill et al. 1956 | *Comparative relational survey*<br>——— | *Relational survey of a large sample of organizations*<br>Kahn & Katz 1953<br>Gross et al. 1958 |
| 2+ | *One-unit relational panel survey*<br>W. Wallace 1964<br>A. F. C. Wallace & Rashkis 1959 | *Comparative relational panel survey*<br>Morse & Reimer 1956 | *Relational panel survey of a large sample of organizations*<br>——— |
| 1 | *Case study using one-time institutional data*<br>——— | *Comparative study using one-time institutional data*<br>Harbison et al. 1955 | *Study of a large sample of organizations using one-time institutional data*<br>Faunce 1962<br>Douglass 1926 |
| 2+ | *Case study using institutional data over time*<br>Brown 1956 | *Comparative study using institutional data over time*<br>Haire 1959 | *Study of a large sample of organizations using institutional data over time*<br>Lipset et al. 1956 |

as a skewing of Weber's ideal type by the situational elements of uncertainty and standing by" (Davis [1948] 1952, p. 384). Similarly, the authors of the famous Western Electric study (Roethlisberger & Dickson 1939) sought to discover, by means of qualitative interviewing and observation, whether factory workers behaved like a set of discrete and rational economic units and concluded, when faced with such phenomena as group production norms and informal leaders, that they did not.

Single case studies thus can disclose the existence of phenomena that raise problems for the theories from which ideal types have been generated. Such studies therefore inspire further research of more complex design to find the conditions under which the ideal–typical or the deviant phenomena occur.

**Multivariate comparison of a few cases.** When we have data on two or several organizations—whether these data are qualitative, aggregated from surveys, or compiled from institutional records—we can use some form of "quasi-experimental" analysis (also known as "quasi-correlational" analysis). The simplest form is "strategic paired comparison," a method that calls for two organizations that are formally similar but differ strongly in one respect. The presumed consequences of this difference are then explored in detail. Thus Coser (1958) com-

pared a medical ward with a surgical ward in the same hospital; the wards, though formally similar, presented many differences in the actual exercise of authority and the informal relations of doctors and nurses. Mann and Hoffman (1960), using a survey of top managers, foremen, and workers, compared an automated power plant with a nonautomated one. Treating the results as a "quasi-experiment," they suggest that automation increased the men's sense of having an influence on plant operations, as well as their interest and satisfaction, but also aggravated tensions related to the job.

In these two examples, the researchers translated a gross institutional characteristic (medical versus surgical, automated versus nonautomated) into several more general sociological characteristics (time pressure on decision making, job enlargement, interdependence of components), which were capable of explaining the observed differences in the dependent variables in terms of general sociological propositions (for example, when there is more time pressure on decision making, there will be less group consultation). Having only two cases, however, they could not test the relative effects of the several proposed explanatory variables or control for the effects of other variables.

When researchers have somewhat more cases, they can locate each organization in a multidimensional classification of explanatory variables. Thus a study of six organizations' responses to disaster found seven characteristics that differentiated the more effective from the less effective ones; each organization represented a particular pattern of these seven attributes (Form & Nosow 1958). Such an analysis is suggestive but not conclusive, since there is only one case per cell.

**Qualitative study of change.** Most qualitative case studies that go beyond description of formal structure necessarily examine time sequences of the behavior of organization members. These may disclose the "microprocesses"—the exercise of informal pressures, the ways of getting around rules, the immediate causes of deviance—that maintain normal equilibrium in the organization. Many examples of such microprocesses were observed in the Western Electric study. A worker who went beyond the group norm of output was ridiculed or "binged" on the arm by fellow workers. A researcher entering the room was mistaken for a time-study man, and everyone slowed down. Changes in production often followed off-the-job personal problems (Roethlisberger & Dickson 1939). More recently, it was found that episodes of patient disturbance in a mental hospital followed staff disagreements on the patients' treatment (Stanton & Schwartz 1954).

The logic of sequence analysis is *post hoc, ergo propter hoc;* but this kind of reasoning can be misleading in the absence of experimental or statistical controls to eliminate accidental or spurious factors. Researchers therefore try to test their interpretations by observing as many repeated sequences as they can and by locating changes precisely in the time sequence. This procedure can become a qualitative form of time-series experiment [*see* EXPERIMENTAL DESIGN, *article on* QUASI-EXPERIMENTAL DESIGN; *see also* Campbell & Stanley 1963].

Qualitative studies over long time periods, particularly if they cover major organizational changes such as succession, growth, and reorganization, permit derivation of relationships between organizational variables. Such studies also test hypotheses about the functions of various parts of the system by observing what happens when one part of it is changed. For instance, McCleery (1957) studied the process of change in a prison from an authoritarian to a more liberal regime. His main argument was that the arbitrary behavior of the old regime created such insecurity that the inmates accepted an exploitative elite of "old cons" who interpreted and negotiated with the authorities, and who controlled disorderly inmate behavior that might have jeopardized their own special privileges. At the same time, this administrative arbitrariness made the inmates hostile to the official programs of rehabilitation. When the new administration created fairer procedures and more communication with the inmates, this hostility was reduced, but the power of the inmate elite was reduced still faster, so that an outburst of disorder resulted. A new equilibrium was finally achieved without an exploitative elite and with more rehabilitative activity.

Several operations can be distinguished here: identifying the "anatomy" of the system—the major formal and informal status groups; identifying the key variables characterizing each group; reporting the values of these variables at several stages in the process of change; deriving causal relationships among them; and locating these causal relationships in a functional model of the whole system (see Figure 1). This model can be analyzed to account for the initial equilibrium, the sequence of changes, and the final equilibrium (Barton & Anderson 1961).

That such a system of relationships was found to exist in a single case is hardly conclusive evidence that it exists in all such cases. Comparative study of several organizations can begin to provide checks against alternative possibilities and to spe-

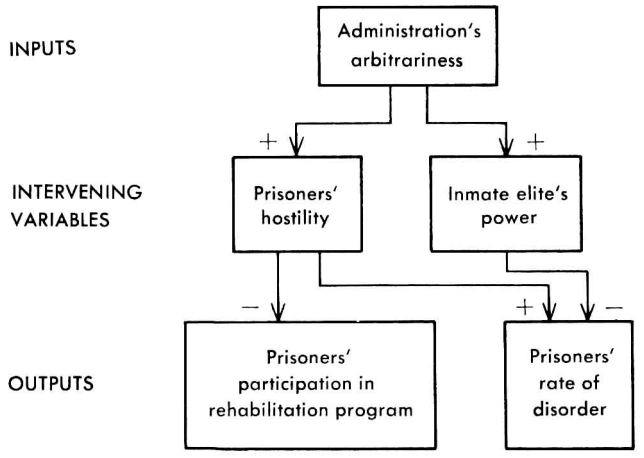


***Figure 1 — Causal relationships in prison disorder***

Source: Adapted from Barton & Anderson 1961.

cify conditions under which the relationships hold. Thus, Guest (1962) compared two studies of succession of a top manager and proposed no fewer than seven variables in an effort to explain why the two men adopted opposite policies.

**Multivariate analysis of individuals.** A survey of individual attitudes and behavior within a single organization can analyze the correlates of job satisfaction, productivity, mobility aspirations, or any other organizationally related attitudes and behaviors, in exactly the manner of ordinary public-opinion studies, except that detailed information on organizational status and activities can be added to the usual limited background data. For instance, Stouffer and his colleagues (1949) analyzed the relation of rank, combat experience, length of service, and similar organizational-status variables to morale, mobility aspirations, etc., for the army as a whole and for various components.

**Multivariate analysis of linked sets.** Analysis of characteristics of pairs or sets of role partners is made possible by relational samples. This is easiest when the role set corresponds to an organizational subunit—as in studies of the correlation of supervisor behavior with worker morale or productivity (see, for instance, Kahn & Katz 1953). In Hall's study (1955) of 40 air crews, behavior of each commander was described for three variables by the aggregate perceptions of his crewmen; each crew's role prescriptions for their commander were measured for the same three variables; and a measure of the conformity of commander behavior to crew prescriptions was derived. His conformity could then be correlated with other attributes of his crew, such as its cohesion and degree of consensus.

Where the role set does not correspond to an organizational subunit, "snowball sampling" can be used. For example, Kahn and his associates (*Organizational Stress . . .* 1964) took 53 managers as "focal persons" and interviewed two superiors, two subordinates, and three pairs of each. Tensions of the focal person could then be related to characteristics of his role set. The variety of measures that can be created with such samples is shown by a study by Stogdill and his colleagues (1956), who surveyed 47 role sets of a superior and one or two subordinates in a research agency, measuring role expectations and perceived role behavior for self and other for each of 45 role elements. From these basic data they derived measures of each pair's consensus on role expectations, conformity of behavior to own and partner's expectations, agreement on perceptions of behavior, and differentiations or division of labor between the two statuses, both perceived and expected.

**Multivariate analysis of organizations.** Whenever we have data on a large number of organizations or subunits within organizations, it is possible to apply the same methods of analysis that are used in survey analysis of individual data. The organizational data may derive from a large set of qualitative studies containing comparable data, from surveys that have sufficient samples within a large number of organizations to provide aggregate data, or from institutional data derived from records, "data banks," and surveys of informants by means of institutional questionnaires. Thus Udy (1959) classified 82 production organizations, using data from anthropological monographs compiled in the Human Relations Area Files. He found a high correlation between the degree of complexity of their technology and the number of levels of authority (see Table 2).

Blau and his colleagues (1966) studied a large sample of public bureaucracies with an institutional questionnaire which measured size, division of labor, professionalization, and centralization of authority. Quite complex conditional relationships were found; for example, in organizations with few professionals, division of labor was positively related to centralization of authority, while in highly professionalized organizations the relationship was the reverse.

***Table 2 — Authority and technological complexity in 82 organizations***

| | INDEX OF TECHNOLOGICAL COMPLEXITY | |
|---|---|---|
| Number of levels of authority | High | Low |
| 3 or more | 28 | 3 |
| 2 or less | 5 | 46 |

Source: Udy 1959, p. 584.

Very large samples of organizations can be studied by using published directories, data banks of institutional information, or questionnaires to informants in each unit. Thus, Faunce (1962) studied 753 union locals by passing out a questionnaire at the U.A.W. convention, and Douglass (1926) studied 1,000 city churches by using informant questionnaires.

**Contextual analysis of individuals.** When we have drawn samples of individuals within several or many organizations, contextual analysis becomes possible. The simplest form of this is an examination of the relationship between individual attitudes or behavior and the attributes of the organization of which the individuals in question are members. Thus, students report more cheating at colleges that are large, have many students per faculty member, have most students living off campus, have easy admissions policies, and are coeducational (Bowers 1964). Moreover, it can be shown by means of three-variable "contextual tables" that the relationship between two individual attributes is different in different organizational contexts, and thus that there is an organizational factor influencing the processes of individual behavior. For instance, Lipset and his colleagues, in a study of a large local in the International Typographical Union, surveyed two strata: chapel chairmen and rank-and-file members. Over-all, the chairmen were more interested, knowledgeable, and active in union politics than the rank and file were. However, when union members were separated according to size of the shop, it was found that this difference between chairmen and rank and file appeared only in the larger shops (Lipset et al. 1956, pp. 176–182). Similar effects were obtained in a study of three prisons by Berk (1966).

**Contextual analysis of linked sets.** Relationships between characteristics of pairs of role partners or between those of whole role sets may be modified by their organizational context. To study this requires comparing relational surveys in a number of organizations—for example, examining the relation of informal contact to consensus between role partners in organizations of different degrees of bureaucratization.

**Contextual analysis of organizations.** The larger setting—type of community, industry, or society—may affect the characteristics of organizations or the interrelations among them (Udy 1965). Cross-national comparisons show, for instance, that the ratio of supervisors to workers may be 1 to 15 in an American steel plant and 1 to 50 in a similar German steel plant (Harbison et al. 1955; see also Evan 1963). Presumably the relationship between plant size and the supervisor–worker ratio is also different in each case. A complex contextual effect is exemplified by the finding that the relationship between secular orientation and effectiveness is positive for YMCAs at nondenominational colleges, but negative for those at denominational colleges (Lucci 1960).

**Time-series analysis.** When information is available on several variables within one organizational unit for many points in time, it is possible to search for causal relationships by examining the sequence of changes in these variables. Brown (1956) examined union records covering a period of 50 years. Indicators of intraunion conflict—number of resolutions for constitutional change, challenges to convention delegates, failure of officers to be re-elected, jurisdictional disputes between locals—were found to be inversely related to size year by year during a cycle of growth, decline, and new growth. Tsouderos (1955) used time series of income, expenditure, capital, membership, and number of administrative employees to study the process of growth, bureaucratization, and decline in ten voluntary organizations. His finding was that loss of members after a period of growth led to increased administrative staff, which led to maintenance of income and activities but further loss of members and to eventual decline.

Time series could also be provided by survey data on several organizational strata repeated over many periods. Some large corporations collect data of this kind as a "morale barometer," but it does not seem to be systematically analyzed in the way that public-opinion time series have been.

**Panel analysis of individuals.** A design that obtains information on a sample of organization members at two or more points in time permits a much clearer isolation of causal relationships among individual characteristics than does a one-time survey. For instance, Stouffer and his associates found that higher-ranking enlisted men were more often in good spirits, accepted the soldier role, were more satisfied with their army job, and thought the army was well run. To test whether these conformist attitudes were a cause of promotion or only a result of being promoted, samples of privates were surveyed when newly recruited and subsequently followed up after several months during which some had been promoted. Those with more conformist attitudes early in their army careers were more likely to be promoted later on. The difference held good when various background factors related to both promotion and attitudes were held constant (Stouffer et al. 1949, vol. 1, pp. 147–154).

Another study dealt with workers who became foremen or shop stewards, repeating on them and on matched control groups a set of attitude questions given a year previously to all workers in the plant. A third wave was done two years later, when some of the foremen had been demoted because of layoffs and some of the stewards had been replaced in office. Many attitudes had changed considerably in response to changes in status (Lieberman 1956).

A panel study that included many organizations would permit comparison of social processes in different settings. Such studies do not appear to exist. (See, however, Miller 1958 for an example of a "pseudo-panel" study which compares students in different years of college for different types of institutions, suggesting major differences in the socialization process.)

**Panel analysis of linked sets.** If, as is often said, organizations are systems of interacting parts, the best design for studying them is a relational panel, since this would permit analysis of changes among related individuals and groups over time. But studies that make use of such panels are remarkably rare. We have mentioned the qualitative analysis by Stanton and Schwartz (1954) of patient disturbance and staff disagreement in a mental hospital. One quantitative panel study of staff and patients found no such relationship (Wallace & Rashkis 1959), but another found not only that staff disagreement was associated with subsequent patient disturbance but also that patient disturbance led to staff disagreement (Rashkis & Wallace 1959).

Walter Wallace (1964; 1965) obtained a complete sociogram of contacts among students at one college. He also obtained panel attitude data from freshmen at entry, at midsemester, and at the end of the first semester, and attitude data on all other students at midsemester. He constructed measures of the predominant attitude of each freshman's "interpersonal environment," which he related to change in freshman attitudes. Segments of the interpersonal environment, classified by sex and college class, were shown to have differential effects.

Relational panel analysis would be particularly useful in studying role relationships as a system, since it would permit examination of such phenomena as the effects on the whole network of expectations and behavior of a change in one partner's role expectations. But such studies do not appear to exist.

**Panel analysis of organizations.** If standardized data were gathered for a sample of organizations over time, the determinants of organizational change could be analyzed by the same methods that are used in analyzing panels of individuals. The basic data might be from any of the sources we have discussed—qualitative studies, surveys, or institutional records—provided they measure the same characteristics of a large number of organizations at several comparable points in time. A near example of this type of analysis is the finding by Stouffer and his colleagues that companies which before D-day had the highest willingness for combat subsequently had the lowest rates of nonbattle casualties. The relationship was much higher for veteran regiments than for nonveteran regiments (Stouffer et al. 1949, vol. 2, chapter 1).

A comparable approach was taken by Lipset and his colleagues, who analyzed time-series data on party voting in the printers' union, broken down by large versus small locals. They were able to show that a rising opposition normally gains strength first in the large locals, while the small ones support the party in power; when the party supported by the large locals wins, these locals are again the first to go into opposition (Lipset et al. 1956, pp. 373–382). But, once again, such studies are hardly ever undertaken.

For purposes of developing theories of organizational processes at the microlevel, relational panel studies obtaining data on role expectations and behavior would appear to be particularly appropriate. They would provide factual data on which to base development of simulation models and mathematical models, just as panel studies of voting behavior (including data on the *perceived* norms and behaviors of friends and associates and of various social groups) did for the development of simulation models of electoral processes [*see* SIMULATION, *article on* POLITICAL PROCESSES; *see also* Stokes 1968].

For testing theories of organizational change, panel data on organizational characteristics for large samples of organizations would be highly desirable. We now have a good many examples of studies of large samples of organizations, but because they deal with the organizations at only one point in time, they are severely limited in establishing causal relations.

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[*Directly related are the entries* EXPERIMENTAL DESIGN; PANEL STUDIES; *see also* Becker 1968; Powdermaker 1968; Wax 1968. *Other relevant material may be found in* COUNTED DATA; INTERVIEWING IN SOCIAL RESEARCH; MULTIVARIATE ANALYSIS; *see also* Benoit-Guilbot 1968; Simon 1968; Smith 1968; Whyte 1968.]

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