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PROLEGOMENA TO A THEORY OF ORGANIZATION

Oskar Morgenstern

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-1-PROLEGOMENA TO A THEORY OF ORGANIZATION

Oskar Morgenstern

Summary: This is the first two parts of the proposed manuscript. The ultimate form of a theory of organization will undoubtedly be highly mathematical, but the ground work must be laid in careful description, which, since it precedes the theory, is qualitative and approximate in nature.

A framework is discussed within which to make these initial descriptive analyses of organizations. The framework deals solely with the centrally directed organizations. This is analyzed in terms of inner and outer activities, the delegation and arrangement of competences (a neutral word introduced to avoid such terms as "organs"), and the systems of signaling. Game-theoretic ideas are drawn upon considerably. There is also some discussion within the proposed framework of the concepts of learning, input-output, costs and size of organizations.

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-1-PROLEGOMENA TO A THEORY OF ORGANIZATION

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PART I — INTRODUCTIONOrganization and the Economic Problem

Lately a great deal of interest has been aroused in problems of military logistics. This is the science or science-to-be that announces the principles, and helps to develop the methods, for determining the needs in personnel and materiel in order to provide for a campaign, a whole war, or merely for the equipment of a single ship or company. For each of these purposes men and materiel have to be assembled in precise quantities and places; sequences of operations have to be carried out in certain order, and there exist various ways in which the aims can be accomplished. Among the different possibilities there may be an optimum procedure. There are also costs involved. Furthermore, the requirements, once they have been established, have to be spelled out ultimately in greatest detail down to the last bolts and nuts and spare parts that must fit all the utensils used and are subject to spoilage and wear. Arrangements must be made for continuous support of the operations, if necessary.

These tasks are very similar to, if not identical with, those occurring in business where usually continuous production

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and sales are to be performed. The dissimilarity lies at least in the vastly greater scope of military operations. This may indeed produce a qualitative difference and require new methods for description and analysis. Besides, there exists no theory whatever describing the infinitely simpler problems of business logistics.

Whether it be a strictly economic or a military logistics phenomenon, there is for both the common need to organize men and to assemble material in order to carry out operations with them in some determined order. There are also objective, technical factors involved which impose restraints upon these operations. Among these may be some unalterable rules of a purely social nature; they shall be counted among the technical factors when they are not standards of behavior (as understood in the Theory of Games) that arise from the acts of men within a given framework. The practical infinity of variations of organizational set-ups which is encountered in the social world requires that particular stress be placed upon the descriptive approach to the problem, before formulating a theory of organization. Economics, logistics, sociology would all be greatly helped if the simplest principles of organization were well understood and could be consciously applied to concrete tasks. The preparatory descriptive work would be facilitated if a firm conceptual basis could be used. Because of the close interaction and alternation of description and the formation of a proper conceptual background, these two can progress only gradually and in halting steps.

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There exists, of course, a field of common-sense observation (quite apart from a vast literature and the accounts in history) which serves as an adequate preliminary basis for first abstractions. These are exceedingly difficult to make, as must be clear to anyone who has ever tried merely to state what goes on in a city as New York, in a university or a large corporation, not to mention the national capital. Long detailed accounts are possible in each case, as complex as the situations they describe (and often done best by novelists), or sociological descriptions can be rendered. These are often given in terms of complicated, mostly classificatory terminologies that have not contributed decisively to the evolvement of a theory.

In looking for a theory of a field for which none exists, or which is to replace an inadequate one, it is necessary to form some ideas about the properties of the theory-to-be. The main feature is that a theory of organization must be quantitative since any organization (as here understood of Part II) allows for variations in its set-up and also in its results. These may be, for the most, conceived of as input-output relations, although they are more than that. In the former case, the similarity to some aspects of economic organizations is apparent. The success or failure of an organization, its superiority or inferiority to others of the same type, the identical purpose, or conflict with those who attempt something similar, calls for description of its various states by means of numbers. Yet these numerical expressions need not be of a simple nature, readily accessible intuitively. Complicated arrangements for the ordering of the

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different states of one and the same organization are theoretically possible. Recalling the difficulties of assigning numbers for economic set-ups and their different successes and failures (cf. the discussions about the measurement of utility), it seems highly improbable that a quantitative theory of organization where the difficulties are vastly greater is in easy reach.

However, even if the precise nature of a quantitative theory cannot be imagined, its qualitative approximation should nevertheless aim at an operational significance of whatever insights can be gained, and at the expression of success and failure of an organization, though exact measurements are entirely out of our reach.

Work in the field of the theory of organization will for a long time have to be essentially phenomenological. This should be clearly understood because it will influence greatly the nature of the empirical work that has to be done on such a large scale in this field. But even the phenomenological theory will ultimately have to be mathematical; but it is not to be foreseen before the theory actually is established, what its mathematical character will be like. An idea of this can be formed by looking at the mathematical structure of the theory of games, which deals with many aspects of organizations and their properties. The interaction of individual organizations will, as a rule, correspond to games of strategy. But there is a need to investigate phenomena within individual, centrally controlled organizations that are, as yet, not dealt with explicitly by the

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theory of games. In other respects that theory has gone further; e.g., in showing how and when persons—or equivalent individual organizations—may act in cooperation with each other and to indicate when and why the bonds tying them together may sometimes be stronger or weaker. It also shows the extraordinary delicacy and complication of the set-ups in which society may arrange its affairs. Examples will clarify this point later (cf. Part V).

The study of "organization" in economics—apart from the theory of games—has developed in three directions: (a) the discussion of economic "systems" or "orders," meaning the economic organization of society through "free enterprise," "socialism," "corporationism," etc; (b) the investigation of the operation of individual firms or conglomerations of firms imbedded in systems of the type (a); and (c) central authorities and "institutions," such as Central Banks, Treasuries, etc.

Discussions of organizations of the type (a) have in the absence of guidance by rigorous theory tended to be historical, mixed with philosophical interpretation and evaluation. Because of the great difficulty in getting hold of the basic facts in this field and the lack of methods useful in the descriptions, the type and amount of information has not greatly changed. Analyses according to (b) attempt to show: (1) what happens to an organization (e.g., a firm) as a whole in various situations of particular markets under different behavior vis-a-vis other economic forces and units, and (2) what the input-output relations are for such an organization if variations in inputs or

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outputs are made, and the efficiency of the set-up is measured thereby.<sup>1</sup> But neither gives any indications for determining the inner workings of an economic organization as a firm; e.g., in the sense of showing the distribution of authority, the memory of the institution, the recruiting of the leaders, etc. These obviously all influence the outcome to some extent. Economics thus far has therefore only discussed some of the alleged summary properties of these organizations and of the factors determining their success, and there is a decided interest in studying the wider range of questions. Since economics, imperfect as it is, constitutes the most advanced of the social sciences, the contribution it can make toward formulating the characteristics of a future theory of organization should not be overlooked even though it may deal only with a very limited aspect of organization.

Consider, for example, the minimizing of costs as strictly equivalent to the maximizing of profit, or in a more restricted field, of input and output in physical units. In such a statement at least one hidden assumption is made about organization. It is that a rigorously given organization is to be considered only when it might be the case that the same input is handled in a variety of organizational forms or set-ups (operations) without affecting the real (physical) costs or inputs. Such variations would be due to or equivalent to, different organizational arrangements. The sequence of work with the same tools the rhythm of work, the distribution of the flows of raw

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<sup>1</sup> Assuming, for the time being, that (2) is independent of (1), which is the case only under severely limiting conditions not generally made explicit.

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materials, etc., may all come under this heading. Work gangs can be put together in many ways, each producing a different result without any change in input. It is interesting to note that Adam Smith's illustration of the advantages of the division of labor falls into this category. There pins are produced in two different manners: first, each worker produces an entire pin; then each performs only some function which formerly had to be performed by every one of them. Result is that the output rises significantly without increasing input of labor or costs. For example, the same output can be achieved with less cost (i.e., in less time) or a larger output with merely more input of raw material.<sup>1</sup>

The illustration from Adam Smith can be viewed as a particular case of the more general problem of the (optimum) assignment of personnel. There the question is asked what the best arrangement is that can be designed in an organization for persons who have different skills and tasks, and require different pay. A purely marginal-cost approach is inadequate and does not provide the answers.

A theory of the firm that does not allow for these occurrences is too restricted and misses one of the fundamental features of the problem it is supposed to explain. It is clear that there is less determinateness than generally assumed in the solution of the problem as given by the usual formulae.

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<sup>1</sup> If rearrangements of this type are considered—and how could they be neglected?—the notion of a "fixed factor," of "overhead" costs, etc., may have to be revised, even for completely static conditions.

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That "organization"—not further specifically defined—might be a "factor of production" (i.e., have something to do with output, net return, etc.) was recognized by some economists and stated, e.g. (in his usual, rather vague form) by A. Marshall. But there is no evidence that this "factor" has been explicitly incorporated into current economic static theory. If that had been attempted, it is safe to say some profound changes would have occurred.<sup>1</sup>

At present it may seem appropriate for an economist to collect some thoughts and observations about organizations, fully realizing that even a widening of the economist's interest on the nature of organization is far from leading to a theory in this field. But there are some essentially economic phenomena which are primarily of an organizational character and apparently have not been described. They shed some light on basic problems and are intimately connected with logistics. The empirical basis is of a very ordinary kind.

In all centrally controlled organizations—economic and otherwise with which we shall deal primarily—psychological factors play a large role. There are the well-known phenomena of loyalty, the "esprit de corps," corruption, the fact that some leaders of organizations seem to be able to obtain a greater effect than others that are set up similarly. In some

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<sup>1</sup> I.e., under the present basic set-up of economics; however, it is a question whether there is an advantage in making it more realistic in that sense and direction, when basic ideas such as the notion that in economics one is dealing with maximum problems are at fault. The theory of games is far better suited to describe the organizational possibilities; indications will be given in what follows.



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organizations the morale is high, in others low, or there are such fluctuations even within one and the same. If pressed how to describe this "morale," it is difficult to give anything but vague and circular answers, although there is no denying that such conditions exist and have to be taken into account in the operations, however poorly they may be described.

These fields would be fascinating to explore, and any progress would have important practical consequences. But I believe that many phenomena now considered to be psychological can be reduced to structural properties of the organizations and are then best discussed in these simpler terms. Others, where this reduction does not succeed, will have to be left out of account at the present stage.

There are, furthermore, processes within a single social organization that have some psychological appearance but are at the same time of a broader nature. There is, for example, the rivalry among members, their striving for influence, even domination, the chicanery with which superiors often treat their subordinates, the ganging up of some against executives who are disliked; there is the bargaining among members so that one favor granted will, in due course, be repaid by another favor, etc. These are not only real, but exceedingly important phenomena, and it would be desirable to understand them well. It is clear that they are not revealed by organization charts, nor even deeper descriptions of the structures of organizations. It may, indeed, in contrast to many psychological aspects, be

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impossible to express them in a formalistic manner. The interesting thing is that they occur even within single organizations; i.e., such that have some clearly defined central authority. It is, of course, not surprising that bargaining appears when an organization is a composite of several single organizations. In the latter case we are confronted with coalitions such as analyzed in the theory of games. That such phenomena arise even within single organizations, thus giving them the appearance of composite ones (cf. Part II, Sect. 72) and obscuring the distinction itself, is exceedingly interesting but should not guide the first approach which ought to be limited to the study of the structural aspects first. It is clear, however, that some formalistic setups—as expressed in part by organization charts—favor rivalries among the various groups or offices, while another setup may give rise to different psychological attitudes. Too little is known about this at present to allow us to determine whether descriptions in terms of one of these categories should replace descriptions in other terms, etc.

In discussing a field for which a theory is desired, it is necessary, as already mentioned, to form some preliminary ideas about the properties of the as-yet-not-existent theory. This is not easy to do, but certain rules, abstracted from the experience elsewhere, can be observed. The main observation is that a desirable theory would undoubtedly have to be quantitative in character and necessarily highly mathematical, and comprise the great variety of forms in which the object appears in reality. Before such a goal is even remotely approached, it is necessary

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to establish a language, reasonably accurate yet rich enough to provide the possibility of empirical description that must precede the formulation of any theory. The mathematical character of the future theory may be undiscernible at present—before very much more information about the structure and the behavior of organizations is available. It may very well happen, as stated in the Theory of Games and Economic Behavior<sup>1</sup> (which after all is a theory of the interaction of social structures) that fundamentally new mathematical discoveries comparable to the creation of calculus may have to be made in this field. Until such an event occurs, combinational procedures will probably play a major role as in the Theory of Games.

The axiomatic method which has been of such importance over the last fifty years may appear to many a suitable tool for establishment of the first theoretical steps in the field of organization. Indeed, some efforts have already been made in this direction.<sup>2</sup> However, the axiomatic procedure will probably not be very profitable at this juncture. Axiomatization of an empirical field is only possible after a great deal of descriptive work has been done in a form that is rigorous enough to provide the ground work for the exact treatment. This has been the experience in other applied sciences which have started with often vague descriptions before reaching the more exalted position of

<sup>1</sup> John von Neumann and Oskar Morgenstern, Theory of Games and Economic Behavior, Princeton, Princeton University Press, 1944, Chapter I.

<sup>2</sup> J. Kruskall and A. Newell, A Model for Organization Theory, The Rand Corporation Research Memorandum RM-543, dated 8-24-50. Also RM-619, Formulating Precise Concepts in Organization Theory, dated 6-1-51.

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axiomatization. In fact, the description of the operations of organizations may in turn have to be preceded by classifications of types of organizations because there are so many of them that must be kept apart. It is likely that the sequence will be of this kind, although surprises are always possible. The main point is for the reader to contemplate the incredible complexity of organizational forms, no matter where they are encountered, whether in the social or biological field.

Experiments with the establishment and operation of social organizations are possible—and in a rough, uncontrolled form are going on all the time. But it will not be easy to design the experimental conditions and to choose the most promising ones. Therefore, the directly available observational evidence should be used in the interim period until the experimental state has been developed. Among that evidence is a great deal of historical material which should be collected and arranged with the aid of whatever notions about the theory of organization we are able to form at present. The history of organizations is, of course, the first task. The suggestion may seem ludicrous, since virtually all history is one of organizations! But a far more narrow point of view is, of course, intended. For example, it would be important to discover the relation between the communication systems and the size of organizations (Cf. II/10). The Persian empire was geographically much larger than previous empires. This growth was probably achieved by the establishment of an entirely new and vast system of roads and relay stations which enabled the central authority to keep in close enough touch with the Satraps,

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and thereby could assure that the orders emanating from the capital would be executed, etc. This system of communications, information, and control was a novum; an understanding of its evolution and limitations, depending on technological knowledge and progress, is as valuable as ever. We would learn lessons directly applicable to the conditions under which contemporary organizations operate. There are numerous other aspects of organizations, both structural and operational, that could be dealt with in the same historical manner.

Finally, there is still another largely untapped field: In the administrative experience of bureaucracy of many nations and in the evolution of its machinery, an enormous wealth of information is at our disposal. The development of new administrative practices in the Byzantine empire, their transmission to Spain and later to Austria, as well as the great reforms in the Middle Ages in Burgundy, all offer most interesting comparative examples. Bureaucracy has by necessity produced Administrative Law which in many countries has been codified. These codices contain numerous rules, regulations, etc., which are, at present, put in legal terms but could be transformed into adequate non-normative descriptions. It appears to me very probable that here is a source-material that, if reviewed in a modern manner, may yield a surprising amount of information invaluable for anyone interested in an abstract approach to organization. This is true, especially if these experiences and formalizations can be compared with the organizational principles that are becoming available in the biological and, more specifically, the neurological field.

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From there it is a direct step to the domain of electronic computing machines and the even newer one of the general theory of automata.

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-15-PART IIPRELIMINARY DESCRIPTION OF A SOCIAL ORGANIZATION  
WITH CENTRAL DIRECTION1. Introduction

An organization produces an order out of elements that in respect to this order are in a lower form of structural relationship to each other. The organization maintains this order over a period of time. This is true of the biological as well as of the social field. It would, therefore, advance the understanding of social organization if parallels or analogies could be drawn. This will not be possible unless some concepts are available that allow a reasonably accurate, though still qualitative, description of social organization. A quantitative description would obviously be superior but must be preceded by formation of basic qualitative notions. We shall, nevertheless, show an occasional particularly striking similarity between the two fields.

The simplest social organization is a single individual by himself. He may be equipped with physical means to carry on his affairs, but he neither takes orders, delegates authority, passes on information, etc., within his own organization. This individual has problems of organization to solve: He must determine the optimum arrangement of his physical means and find the optimum strategy to use in his contacts with other organizations, if such contacts exist. The other organizations may be as simple as his own or of arbitrarily high complexity. If no contacts

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exist, he is only faced by nature and his is then a special case of the Robinson Crusoe economy.<sup>1</sup> He may have any number of automatic devices, no matter how complicated. He may be incompletely informed about his own state.

When at least two individuals, with or without additional physical means, are involved, then there are two principal types of organization possible: either completely antagonistic (corresponding to a zero-sum two-person game) or cooperative (corresponding to a nonzero-sum 2-person game which is equivalent to a zero-sum three-person game). The first type shows that even conflict is to a high extent organized; the existence of organization is obvious for cooperation, and in those cases where the zero-sum restriction disappears. However, it will be seen that this dichotomy is far from simple.

We concern ourselves primarily with cooperative social organizations with two or more persons, the organization equipped with physical means which are required to carry out its purposes. We assume that a central authority is established by whatever means which directs the organization; i.e., lays out the various organs, decides about the purpose or aim of the institution, and initiates whatever operations are believed to be necessary to achieve the aim. This central authority may be vested in a general assembly, the owner of a firm, a board of trustees, etc. It may, therefore, be democratic, oligarchic, etc.; this would be immaterial to the formalistic side of organizations as here investigated.

<sup>1</sup> Special, because the Robinson Crusoe may have in his organization individuals whom he has to treat as such, which imposes new conditions that will become apparent below.



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<sup>1</sup> Special, because the Robinson Crusoe may have in his organization individuals whom he has to treat as such, which imposes new conditions that will become apparent below.

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A "central direction" of the organization is possible only if the human individuals which belong to it, cooperate to some extent; i.e., accept the orders that are given in the name of the organization, carry them out with a certain degree of probability, etc. In this sense there is cooperation even in the most draconic organizations<sup>1</sup>; breaking points exist for every setup even if we cannot indicate them now. The cooperation expresses itself in an identification—however rudimentary—of the individual with the organization. This characterizes the "morale." We shall not deal with these aspects, though they are very important, especially from a psychological standpoint. But it is better to reduce difficulties to the minimum, and this is one that can be avoided now.

## 2. Inner and Outer Activities; Aims of Organizations

In the following we describe certain concepts and phenomena which together give a possible characterization of the main features of an organization, but by no means the only one.

An organization engages in an inner and outer activity.

Either activity consists of the set of all possible arrangements of individual acts that an organization can undertake, given its resources, i.e., its physical equipment (e.g., capital) and its

<sup>1</sup> Probably there never was one more draconic than the Mongolian Army organization. There varying numbers of soldiers would be executed if, in a battle, one of their leaders was lost by enemy action, as a punishment for their failure to prevent his death. The higher the officer lost, the more of his own men would have to die. The fact that this practice weakened the numerical strength of the combat unit was apparently believed to be compensated for by the great fighting spirit it produced. This astounding principle of organization worked so well that the Mongolian armies conquered almost the entire known world and held it down for decades.

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milieu (e.g., rules of the game, legal framework, etc.). Each individual arrangement of acts is called an operation. The separation into two classes of activities is a consequence of the fact that every organization has an inside and an outside. In other words, an organization has clear boundaries which set it apart from its physical and social milieu; it can be defined in space and time. No matter how scattered in both respects the activities of an organization are, there must be a concrete physical substratum.<sup>1</sup>

A consequence of this is, for example, that an individual is either inside or outside of a given organization. It will be seen below that he can, however, in a particular sense and situation, be both inside and outside, unsound as this statement may appear to be at present.

Within the framework set by the (possible) inner and outer activities, particular choices are made by the organization which acts through representatives in a binding manner that will have to be described.

The sequence of moves by the organization as determined by the choice of a strategy constitutes the outer operation. The particular pure or mixed strategy is taken from the domain of all available strategies, i.e., from the outer activity. Availability of a strategy means that the state of the organization **exercises a limiting influence upon the choice of strategies;**

<sup>1</sup> All this agrees, of course, with the classical notion of the persona iuridica. I believe that a great deal can be learned for organizational theory from a study of administrative law, especially where it is built on Roman Law and is correspondingly codified.

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e.g., a small corporation may not be able to engage in as extensive an advertising campaign as a richer organization. Therefore, the technically better strategy is not available.

The inner operation is the sequence of acts (choices) of the parts of the organization (to be called "competences" of Sect. 3) involving the use of materials, resources, and machines taken from all possible operations which make up the inner activity. The domain of all possible acts is restricted by physical data, e.g., technological factors, physiological, physical characteristics of humans and animals, legal provisions, etc., which together are at the disposal of the organization.

Thus we see: An operation consists of acts, which are choices. An activity is the set of all possible operations from which a particular operation is chosen. The choices of the inner and outer operations are not independent of each other.

Just as it is necessary to choose the optimal strategy from the available strategies—i.e., to optimize the outer operation—it is necessary to optimize the inner operation. Their interdependence may assume many varying degrees. The inner operation of a preceding period may further restrict the available strategies; for example, a certain crystallization of the physical equipment of the organization may have taken place which may have to be carried over into the next time phase. But it is best to neglect this complication now; besides, it does not come into play with all organizations. An inner operation is optimal in respect to a given (presumably optimal) strategy or outer operation, if, under consideration of all constraints, no other inner operation will make the choice of the outer operation possible.

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How the optimal inner operation is to be identified and how it is in concreto determined by the optimal outer operation (which in turn may depend on the preceding inner operation, irrespective of whether it was optimal or not) is, of course, a deep problem. It can be approached only when the description of an organization has been accomplished.

A weaker requirement than optimality for inner and outer operations is their feasibility. For inner operations this means that they have to be restricted to the technically, physically, and legally possible arrangements and combinations that the organization may undertake of all its component parts and the acts it may provide for these internally. The restriction of the strategies (for the outer activity) was already mentioned.

A study of organization has, therefore, to consider the two fields of the inner and the outer activities. We shall be concerned mainly with the first, which comprises "organization" in the narrower sense. Social organizations of a higher type in which several individual organizations interact establish their relations to each other, determine payments among themselves, and cooperate or fight (as the case may be), are best described by the theory of games of strategy. We are here concerned with questions of organization that mostly precede that wider field of interaction among individual organizations. But it would be impossible to avoid reference to it, because individual organizations are set up precisely in order to deal with others, or at least with nature. Also, each organization that requires services of individuals (e.g., as employees, stockholders, soldiers, etc.)

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immediately creates situations of interaction of the higher order, even before the organization as a whole comes into that type of contact for which it is formed.

The selection of the optimal inner and optimal outer operations can be made only if the aim of the organization has been formulated. Since the choice of one rather than the other operation will make a difference in the attainment of the aim, the latter should be quantitatively stated. In business this is conventionally accomplished by using monetary terms; in other economic fields by means of formulating a numerical utility. Elsewhere there exist only the vaguest descriptions of what the aims of organizations are (e.g., a university) with no attempt at any sort of quantitative formulation. If a quantity is indicated, it becomes sometimes possible to look upon organization as an arrangement of inputs to be compared with outputs. But we will have to ask ourselves whether this holds true for all organizations irrespective of whether or not their aim be quantitatively stated (cf. Sect. 9 where more is said about aims). An inability to indicate a quantity now does, of course, not preclude the possibility that a measurement be invented. The evaluation of operations is exceedingly restricted where no numbers at all can be attached to the attainment of the aims of an organization. Discussions of such cases often lack precise scientific method. Yet often they are not only not impossible but even precise: If in war one army wins and the other loses, the former has reached its aim decisively—but it is unknown

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with what deviation from an optimum. And perhaps the aim of the army should have been to be so strong that no war would have to be fought! Then the determination of the attainment of the aim is a different matter altogether.

There is, of course, one (trivial) method of characterizing the aim<sup>1</sup> which is useful in the study of biological organization. This is to point out the fact that any biological organization is bent on transforming matter and/or energy. This is obviously true in a most universal sense and applies also to social organizations. All types of transformations can be considered. The formulation of these activities by means of statements about inputs and outputs is only one particular form of expressing this.

Among the entities an organization is made of are human beings. As employees, workers, etc., they are placed in certain positions and are charged with the performance of certain tasks (under the restriction of feasibility). Their arrangement and the interplay with the non-human resources of the organization is entirely a matter for the inner operation. The human individuals are in this sense inside the organization. (Yet this does not make them "organs," or the like, of the organization; for this more is needed. Cf. Sect. 3.) But different from the inert other resources of the organization (equipment, supplies, etc.) the individuals are also outside the organization by being

<sup>1</sup> As a rule, there will be more than one aim. There is a whole set of aims, whose elements are to be numbers. In the discussion above we may think of "the" aim at least as a vector.

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able to make claims against the organization, e.g., for payment of wages, salaries, for particular treatment, etc. The inert resources have no claims; restrictions regarding these are purely technological and possibly legal, inasmuch as they may be owned by other organizations. The individuals are therefore in a dual position. This is true even of an army which cannot treat soldiers in an arbitrary fashion, each soldier having some claim and some status outside the army vis-a-vis the army. This dual role is one feature that distinguishes a social organization from any natural one with which it might otherwise be compared. It creates immediately a higher order of complexity that is peculiar to social life. However fabulous the organization of the human body, and of the brain in particular, this duality alone is a distinguishing feature setting even the small social organization apart from biological organization.

The consequences are immediate: The organization can, on the one hand, order the individual around in his capacity of forming part of an inner operation, but, on the other hand, the organization must even include its relation to the same individual among the characteristics of the strategy it chooses for performing its outer operation. The organization is therefore engaged in at least two simultaneous games: one involving the pursuit of its aim directly, the other in which the human resources are confronted with the organization as a whole.



### 3. The Arrangement of Competences

An organization consists of "competences," i.e., elements that are empowered and able to set acts committing the organization to its outside world and/or to partake in the inner operation. These elements are usually individuals or groups of individuals; but the human factor is not necessarily associated with each competence. In the first case the competence makes a move in the game of strategy in which the organization is involved when pursuing its aim; it commits the organization.

In the second case the competence sets acts which transform or use the inner arrangements of the resources of the organization. The competence is assigned variables (or constants) with a prescribed domain. The competence is given the task to act under specified circumstances, and the duty to act optimally. An act by the competence consists of choosing a value for the variable. This will be done upon receipt of a signal (cf. below). An act is a choice of a value of a variable (or of a vector) made by a competence, and it is specified by stating the value and the variable; an operation is a sequence of such choices or sets of choices and is described (or specified) by giving the sequence of values or sets of values. A variable will be called admissible (with respect to a given competence) when it is within the physical and legal powers of the competence to choose a value from the domain as required by the task.

When no choice is left to the competence, then a constant is assigned to it; upon receipt of an appropriate signal, the act corresponding to, and described by, the constant—if admissible—will be set by the competence. We call these the smallest

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competences of which there may be many in an organization, but no social organization can consist only of constants, i.e., smallest competences. This follows from the fact that an organization as a whole has to make choices and the representation of the organization by constants only would preclude the existence of a problem of selection. Every organization is only probabilistically formulated, although some to a higher, some to a lower extent.

The smallest competences may easily be compared to those automats who can respond to an impulse only in a unique manner. Indeed, many such competences are being replaced by machines. For example, the man behind the post-office window selling three-cent stamps can be substituted by an automat. (This is a not-trivial substitution because the latter is entirely inside the organization, while the employee is also outside.)

Even the smallest competence has a decision to make. For it, the problem consists of deciding whether the signal is the proper one that should cause it go to into action.

The representation of a competence as an element of an organization setting a value of at least one variable corresponds precisely to empirical conditions. Theoretically, it might appear as if the activities of an organization could be completely described so that it would consist only of a set of smallest competences in whatever groupings and arrangements that might be found convenient or satisfy some architectural or other principle. This is, however, impossible (cf. below). Therefore, most competences are given discretion to choose what appears

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to them to be the optimal reaction to the stimulus that causes it to move. This freedom of the competence is well known and extensively treated in legal writings under the name of "freies Ermessen." For law courts it means that the codification has been carried only to the point where a further specification of the duties and the powers of the Court is left undetermined (within the framework of the containing law). In law the tendency has always been to eliminate as much of this indeterminateness (i.e., unpredictability) as possible.

Competences are ranked (i.e., form a hierarchy) which, however, need not be the sole hierarchy of the organization. The highest competence is called the Source. In it is vested the entirety of all variables of the organization. The notion of the Source is an undefined concept needed for describing organizations. The smallest organization—of no further interest—has a Source with only one single constant. Hence there is no choice and no further competence. A competence is created by the assignment and grouping of variables at the disposal of the Source. The competences correspond in some way to the "organs" of the body; it is preferable, however, to use a neutral term in view of the dangers of organic analogies at this stage. Competences are always derived either directly from the Source or indirectly from other competences. This initiates the complicated process of delegation. Parallel with this process is one specifying the tasks and duties of the competences (in military parlance called Missions). The competences are therefore charged to carry them out. The admissible variables assigned to them are to be in a one-to-one correspondence with the imposed duties.

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If this principle is carried out for the entire organization there is a natural way of stating that it is in a particular form of (hypothetical) equilibrium. It is hypothetical as far as the construction goes. In its actual operation, events may occur so that the organization is far removed from "equilibrium."

The variables fall into three classes, inasmuch as some are purely internal, others purely external, and the rest mixed. That is, the first variables partake exclusively in internal, the second exclusively in external, operations. The distinction is easily seen in military organizations where, for example, in the operation of a ship, numerous operations and entire sequences of acts are due to the use of variables which are completely separated from any outer operation. The same holds, of course, for any organization of some size. The distinction becomes important, however, especially in connection with the signaling system (cf. Sect. 4).

It would be desirable to get a clear and complete idea of what a "variable" is in connection with an organization. To some extent it is an undefined concept, or at least a not-well-defined notion. One is, however, comforted in that difficulty by the observation of H. Weyl: "Nobody can say what a variable is"<sup>1</sup>—and this refers to pure Mathematics! A variable is the form in which we state that "the organization" can commit resources, or set acts, or whatever semantically equivalent expressions may be, in order to accomplish some purpose. "Variables" are

<sup>1</sup> Philosophy of Mathematics and Sciences, Princeton (1949).

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available because there is usually a choice between alternative uses of these resources. The total resources have to be distributed or allocated according to some principles connected with the over-all aim of the organization. The more clearly the aim is formulated, the more likely will the allocation be successful to the extent that it facilitates the pursuit of the over-all aim of the organization.

The resources may be the (at first: liquid) capital of a firm, or the time and willingness to help in a volunteer fire-fighting company, or the weapons and other equipment of an army, etc. The form in which the resources are held makes a variety of operations (i.e., arrangements of their uses) possible. One way of deciding their use is to specify in complete detail exhaustively at the beginning of each operation what sequences and combinations of acts are to take place at what moments of time. Such dispositions are imaginable but not usually found in reality. One difficulty is that operations tend to be very complex and cannot be specified in advance, especially not when continuing organizations of sufficient size are considered. Another difficulty lies in the contact of each organization with Nature, which produces randomness and requires reactions that are in principle unpredictable in the detail in which the final action has to occur.<sup>1</sup>

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<sup>1</sup> None of this prevents the use of the notion of a strategy as in the normalized form of the game. Cf. von Neumann and Morgenstern, op. cit., Chapter II.

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The domain of the variable expresses alternatives of action or choice. As a rule, we will identify "power" of an organization with the ability to cover a wider rather than a narrower range of choices. Therefore, if a variable is given a larger domain, its significance in operations is greater than if it were a constant. This characterization of variables and competences—the latter usually comprising several and identified by the names given to this hierarchical arrangement—is significant for the operations and may differ from their hierarchical position. Frequently, however, a higher placed competence will be in possession of variables with large domains. Superior competences can restrict or enlarge the domains of lower variables. In the first case resources may be set free and become available for others; in the second case the shift may go at the expense of others if all resources were allocated at the outset. The shift of resources from one variable to another is not arbitrarily possible, sometimes not at all. When the resources have already been committed but not used up (e.g., the liquid capital is transformed in part into instruments and raw materials), such transfers are eo ipso restricted. All "reorganizations" have to take these factors into account. The higher competence can restrict the lower one either by a formal reassignment or in the course of operations. The latter means that a choice made by it may make it impossible for the lower competence to use the full range of the variables at its disposal. This works also in converse, as far as operations are concerned; i.e., a

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lower competence may, by using its variables (say, inappropriately), impair the full use planned by a higher competence for its own variables. This situation can, of course, arise only if the time sequence of the choices to be made by the competences is not ordered according to their hierarchical sequence. It is clear that this is almost never the case. A lower competence can, however, never formally restrict or enlarge the power of higher competences; it can do so only operationally (cf. below).

- o To what extent a previous inner or outer operation restricts the possible future inner or outer operations will occupy us again.

In delegating variables, the Source can never dispose of all variables lest it lose its own identity. One of the created competences could assume the role of the Source. This means that in every social organization of the type discussed here (i.e., not yet discussing those described by the solutions of n-person games) there will exist a basic competence from which all others emanate and are derived. This Source may, therefore, be a usurper, the people's assembly, an oligarchy of directors, etc. Save for the simplest organizations (with only one constant or even with one variable) there must be a hierarchy through delegation from the Source. The extent of the hierarchies, the number of variables involved, and the manifold forms of direct and intermediate delegation with all the attending influences upon the moves and strategies of the organization are the main field of a (future) theory of organization. •

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to them to be the optimal reaction to the stimulus that causes it to move. This freedom of the competence is well known and extensively treated in legal writings under the name of "freies Ermessen." For law courts it means that the codification has been carried only to the point where a further specification of the duties and the powers of the Court is left undetermined (within the framework of the containing law). In law the tendency has always been to eliminate as much of this indeterminateness (i.e., unpredictability) as possible.

Competences are ranked (i.e., form a hierarchy) which, however, need not be the sole hierarchy of the organization. The highest competence is called the Source. In it is vested the entirety of all variables of the organization. The notion of the Source is an undefined concept needed for describing organizations. The smallest organization—of no further interest—has a Source with only one single constant. Hence there is no choice and no further competence. A competence is created by the assignment and grouping of variables at the disposal of the Source. The competences correspond in some way to the "organs" of the body; it is preferable, however, to use a neutral term in view of the dangers of organic analogies at this stage. Competences are always derived either directly from the Source or indirectly from other competences. This initiates the complicated process of delegation. Parallel with this process is one specifying the tasks and duties of the competences (in military parlance called Missions). The competences are therefore charged to carry them out. The admissible variables assigned to them are to be in a one-to-one correspondence with the imposed duties.



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Delegation arises out of two reasons which sharply distinguish the cases to which they apply. In every case the delegating competence imposes the burden of a choice upon the lower competence. In the first case, the competence delegates, although given the technical facilities it could make the proper choice itself. For example, a higher officer may be able to fire a particular gun as correctly as a private; but he may not be able to fire it better. To fire it at all would conflict with other duties, be wasteful from the point of view of optimum allocation, etc. Hence, it is not done but delegated. In the second case, the competence delegates because it cannot make the proper choice. This may be due to technical circumstances (e.g., requirement of special skill) or because of the position and time of the choice in the entire sequence of all choices, depending therefore on particular states of information. In the second case a true delegation takes place, inasmuch as without it either no decision would be made at all or most certainly not an optimal decision.

We shall now discuss one typical set-up of competences and discuss the question of the sequence of acts or choices and the connection with the signaling system (which will be separately examined in Sect. 4).

Consider first the Source S and assume it has available the variables  $x, y, z$ , which it can dispose of in any manner it may choose. That is, we assume that there are no technical reasons why some variables should be associated together, restricting the freedom the Source has in allocating them to competences it wishes to create. From this, one concludes immediately that in

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whatever manner the Source may make its delegations of the three variables, it must retain at least the power to make and remake these delegations. If this were not the case, the Source would have lost its identity and a totally different organization would result.

The variables  $x, y, z$  can be put into one competence  $C_1$  whose task it is to carry out the choices as they become necessary. Or else the Source may create two, three competences  $C_1, C_2, C_3$ , distributing the variables accordingly. If only  $C_1$  is created, either the Source or, if possible,  $C_1$  may make further delegations  $C_1', C_1''$ , where  $C_1''$  is a delegation from  $C_2'$ .

Example with three variables:

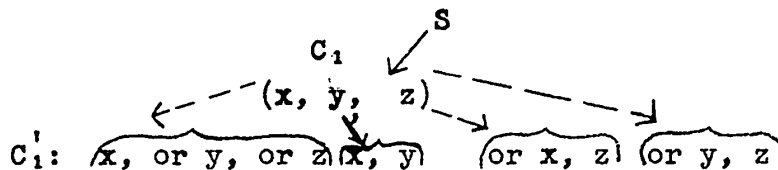


Figure 1

At least one variable must be retained by  $C_1$ ; therefore,  $C_1'$  can at most have two variables. There are six possible delegations. A further delegation to  $C_1''$  (subordinate to  $C_1'$ ) is impossible when  $C_1'$  has only one variable. When it has two variables, six alternative delegations (i.e.,  $x$  or  $y$ ;  $x$  or  $z$ ;  $y$  or  $z$ ) are possible and  $C_1''$  can consist only of a single variable at which point the possibilities of further delegations are exhausted as far as this line of delegations is concerned.

This purely schematic illustration shows the following: Even if only three variables are available, a considerable wealth

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of organizational possibilities exists. As far as the possible accomplishments of the organization are expressed by the variables—and the choices made—there is no difference between these forms and delegations. But from the point of view of hierarchies, of competences, the communication among the competences, the signaling system, etc., great differences exist. Now, as already stated, there will seldom prevail complete freedom as to the creation of competences, since technical, psychological, legal factors may rule out certain combinations or may make some preferable over others.

It is immediately seen that in spite of the separation of  $C_1$  and  $C_1'$  and the possible coexistence of a  $C_2$  (with other variables,  $u$ ,  $v$ , ...) directly set by  $S$  together with  $C_1'$ , any order of sequence or simultaneity of the possible acts described by the variables can be specified or may be allowed to happen upon receipt of the proper signals. If a specific sequence of acts is required another organizational device in addition to the chosen equivalent delegation set-up is needed. This is a particular signaling system. As already shown, every organization requires a signaling system without which no actions would occur. But there exists a certain amount of freedom for the construction of the signaling system which thus needs to be considered in conjunction with the system when both are specified together.

Second, we consider the source  $S$  and the variables  $u$ ,  $v$ ,  $w$ , it can dispose of, now extending the first case so that one variable, say  $u$ , has other variables  $r$ ,  $s$ ,  $t$ , as its domain,

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with  $r$ ,  $s$ ,  $t$ , each having their proper domains in turn, none of them being a constant. This produces a substantial difference in the effects of delegation and has a bearing upon the influence of the signaling system. Example with three variables:

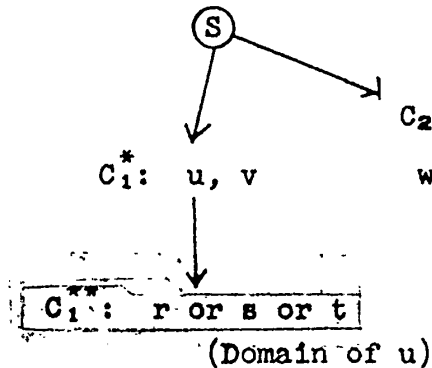


Figure 2

$S$  creates  $C_1^*$  which chooses between  $u$ ,  $v$ , and  $C_2^*$  with  $w$ . If  $v$  and/or  $w$  are chosen, they are taken from their domains and this constitutes the final action. If a signal requires that  $u$  be chosen, one of the variables  $r$ ,  $s$ ,  $t$ , is selected, each of which is alternatively assigned to  $C_1^{**}$  which then selects an appropriate value from the proper domain of the variable chosen by the superior competence  $C_1^*$ .

Now it is clear that  $u$ ,  $v$ ,  $w$ , can be set simultaneously or in any order depending upon the arrival of signals or the systematic set-up of the signaling system (obviously, two different possibilities). But  $r$  or  $s$  or  $t$  cannot be simultaneous with  $v$  or  $w$  unless the chance distribution of signals produces such response, or a specific restriction is placed upon  $C_2^*$  such that it cannot choose a value for  $w$  until after the choice has been

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made for r or g or t.  $C_2^*$  therefore depends then upon the receipt of a signal (direct or indirect) from  $C_1^{**}$ . This particular signaling system has therefore depressed  $C_2^*$  from its apparently equivalent hierarchical rank with  $C_1^*$  (both directly created by S) to one operationally below that of  $C_1^*$ .

This shows that the description of a delegation system is incomplete unless the simultaneous signaling system applied to it is also explicitly described. A hierarchy of competences alone will therefore not indicate completely what sequences of actions have to be expected (besides consideration of the random distribution of signals, i.e., of events). In the sense that it is a restriction of the freedom of action if one competence has to wait upon the prior action of another, the scheme of delegation is to be amended by making such cases explicit in order to express the full state of affairs. This is at least true if the operations of the organization are subject to investigation and their interdependence, e.g., over time, is to be studied with regard to the amount of information within the organization at each moment of time.

An illustration showing at least a temporary annihilation of authority of higher competences by lower competences during operations is shown in the following: Security regulations may require that each person has to identify himself to the complete satisfaction of the guard at the gate, even officers far above the rank of the guard. The guard's competence in this particular instance, place, and circumstance exceeds that of anyone else. After this superior has passed, he may dismiss, replace, or

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otherwise reassign the guard. The pilot of a plane is in absolute command during the flight, and so it is in many other situations. This is partly a temporary superseding of higher competences, but it is one that is foreseen when the structure of hierarchies was created and the possibility is built into it. It would be important to discover whether this phenomenon arises necessarily in types of social organizations. At any rate, it shows that the notions of subordination, higher authority, etc., have to be treated with great care and are probably not well defined unless the domain over which they extend and the specific situations to which they apply are characterized in considerable detail.

So we see: Equivalences between apparently hierarchically quite different organizations can be established by means of appropriate signaling systems. Thus the intermediate delegation (Fig. 2) from  $S$  to  $C_1^{**}$  via  $C_1^*$  can be made equivalent to a direct delegation from  $S$ .  $C_1^*$  is in the position of a general officer in the army who decides which of the various forces at his disposal—artillery, tanks, planes—to use and then, after the choice, lets the commander of the chosen weapon do the allocation of the quantity, deployment, location of attack, etc.

The question arises next whether the Source has complete freedom in arranging the competences, forming arbitrary groups of variables, etc. The answer is in the negative, but the correct and exhaustive formulation will be difficult. Clearly, the variables are related to physical circumstances such as

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the working hours of a man and the properties of machines placed at his disposal. These, in turn, are dependent upon the aims of the organization and on the strategies it uses, has previously used, or proposes to use, in its relation to other organizations. For example, a fire-fighting company has to have engines and men to run them; but it may use these in different proportions, place authority in a variety of ways, etc. Thus, there is neither complete freedom in arranging the variables in competences nor is there complete rigidity. The latter is lacking even in such organizations as line production, set up as conveyor systems; the question of flexibility<sup>1</sup> will be taken up at greater length in Part III. The freedom is greatest when there is complete homogeneity among the resources. But even then there are restrictions—e.g., due to the signaling needs, to the degree of the complication within competences, etc.—and once an organization has actually emerged from the initial state, the form it assumes co-determines together with its experiences the form of its continuation. Besides, these technical interactions of men and machines, and among men, which limit the freedom of the Source in setting up competences, there is a time-sequential factor. Choices have to be made often in a particular sequence. Now even if there are no other objections against grouping some variables together into one competence, this may still be impossible if

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<sup>1</sup> The distinction between flexibility of an organization regarding the choice among various hierarchical set-ups and flexibility in the choices of how to pursue its aim, given one of these, is necessary and not always maintained where the notion of flexibility is encountered. More about this in Part III.

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the time structure of the choices were such as to make their execution impossible without producing conflicts in the persons charged with the tasks of acting—however qualified these persons might be to deal with these variables separately or in different groupings.<sup>1</sup>

The arrangement of competences thus far described makes one basic assumption that will not often be fulfilled. That is, the description of the possible operations of the organization as outlined by the variables and their domain is precise and exhaustive in terms of the situations in which choices have to be made. It is justified to make this assumption for a first outline of the set-up of an organization. But its description has to be extended. It will be recalled that the extensive description of a game of strategy can be given in a form that does not introduce probabilistic elements, but that nevertheless makes incomplete information of the player, even about himself, possible.<sup>2</sup>

The characterization of all possible situations with which the competence has to deal has to be given ex ante; i.e., prior to their occurrence. The impossibility of accomplishing this introduces a probabilistic element into the very structure and design of almost any organization. In some it will be smaller, in others larger. In some cases it can be gradually reduced through the process of learning (cf. II-7). This probabilistic factor has to be distinguished from that arising from the choice

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<sup>1</sup> This is closely related to the idea of the "Maximum Command Span" discussed in Section 11.

<sup>2</sup> von Neumann and Morgenstern, op. cit., Chapter II.



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of statistical strategies to which the organization may have to take recourse. If no uncertainty at all prevailed, it would not be necessary to assign to a competence anything but constants; i.e., upon the receipt and identification of a signal a unique reaction would occur. However, even in this respect there are at least two sources of error; i.e., there is a rudimentary probabilistic element even in the smallest competence (cf. above). For example, an automat might respond to the wrong coin or pass out the wrong commodity, or none, even if the correct button were pressed or coin inserted. This behavior, however, falls into the category of errors (cf. Sect. 5) and the role of probability is different in that respect from the one referred to above.

The famous and perennial phenomenon of the conflict of competences arises—if not due to faulty design of the organization, e.g., by (sometimes even willfully) assigning the same duties and/or variables, or overlapping domains, to different competences—from the impossibility of a complete ex ante description of all possible situations to be faced by each competence. These conflicts ought to be minimized, if such a minimum exists and can actually be found. This is probably the case in the first instance, but much more doubtful in the second. While the phenomenon is of primary practical significance, it may suffice here to point out its existence and its origin in the impossibility of a complete description. The conflicts among competences have a wider significance in that they offer the

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possibility of strategic moves by the Source, within the organization against parts of the organization. But this is a topic with which we are not dealing in these notes;<sup>1</sup> if such operations occur, the organization has to be viewed as a composite one (cf. Sect. 12).

We can summarize: The Source is in the possession and undisputed control of all the resources of the organization. These are allocated by the creation of variables that are combined in competences which are empowered to select values from the domain of these variables upon the receipt and recognition of a signal. The signals are tied to the variables, but they are received by the competences. The selection of a particular value of a variable is a choice and constitutes part of an operation of the organization. Competences having only one variable with a single value as domain, i.e., having only a constant, are called the smallest competences.

We have, in these discussions, abstracted from the human and psychological aspects. There are some, however, that must be mentioned even at this level. The principal consideration is that a competence is in charge of an individual or a group of individuals. Now a great deal follows from this fact about the manner in which variables can be distributed among competences (depending also upon the nature of the variables, i.e., their domain). For example, too much concentration may interfere with

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<sup>1</sup> Illustrations are found in the administration of President Roosevelt in which agencies were created that were given almost the same duties as others but different authorities; this was done in order to get rid of uncomfortable rivals, adherents who had lost their usefulness, etc.

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the physical ability to make the choices or to make them in proper time. On the other hand, concentration of variables will give a competence all the signals and information tied to the variables in a combined form. This will make some communication channels unnecessary and the accumulation of information may actually improve the ability to choose. All this is also related to the technology of the particular organization.

If there exists a large organization where there is, say, a president who is formally in charge of operations and responsible, but where the number of variables assigned to him is too large for physical attention, this then implies that at least de facto delegation must have taken place; otherwise a physical impossibility would have been stipulated.

#### 4. Signaling, Information, and Memory

Every organization relies on at least one signaling system; but there can be many. One problem would be to find the "optimum" system, defined, for example, as the one involving the least cost or producing the greatest speed, the highest accuracy, etc. A signal serves to excite a competence. An event is recognized by competence as a signal. This may be a buzz, the ringing of a bell, a noise made by an enemy, or the reading of a dial, even by a machine. The recognition means that an interpretation of the event is made, e.g., by comparing it with an instruction or key, a previously established signal, an expectation as to what the event might be like, by adding it to other signals already

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received and treated, etc. We make no distinction between signals and messages as is usually done in communication theory. This distinction, necessary there, is not required at present. At a later stage it will become important when the acts of an organization are related to the amount of information, the rate of flow of messages and the efficiency of signaling systems, the codes used, etc.

There are internal and external signals. The first are transmitted from source to competences and back, and among competences. Such signals are transmitted, sometimes by means of a separate inner signaling organization (cf. below...), sometimes without, depending partly on the quantitative extent of the organization. A signal may be an act of choice by one competence the results of which are noticed as an event by another. Thus, the open fulfillment of a duty may be all that is required in order to pass on information and a separate signal in addition may be unnecessary. The event caused by the choice made by the competence may happen inside or outside the organization depending on whether the competence is involved in inner and outer operations. External signals are events coming to the organization from the outside, even if not intended to be a signal or a communication (e.g., the noise made by the enemy); this is then an involuntary signal; only external signals may fall into this class. It is intentional, for example, if it is a customer entering a store. Most of these external signals are random events (from the point of view of the organization) with various probability distributions; they are not random if the other

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organization uses a pure strategy composed of several moves. The internal signals may follow entirely different patterns but cannot be free from randomness. An internal signal may cause an act in the inner or outer operation and an external signal can do likewise.

Any signaling device, especially when it is large and is transmitting a high volume of messages, produces noise, i.e., messages. This is empirically very important for those numerous organizations in which the signaling system is rudimentary and improvised, and where the question of noise is not particularly studied. Every organization has to have some, however rudimentary, technique for filtering messages. This will, as a rule, be achieved by comparing a message with a previous one that had proved itself to have been correct, or comparing it with an instruction specifying the duty of the competence, which would always require the mentioning and description of a signal. The identification of the signal will cause the competence to make one of these decisions: (a) to transmit the signal or a new one, alone or with other messages, to another competence; or (b) to set a material act, i.e., to pick a value for one of its variables. If (a) alone is the case, then the organization has a separate information organization included in its own organization as described by the existence and distribution of Source, variables, and competences.

We return to this case below. We now consider only (b).

When the competence acts materially, i.e., decides on, case (b), it is acting either internally (in the internal operation

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of the organization) or externally (making a move, in the game, on behalf of the organization). If the competence does not act upon the identification of a signal requiring action (though this may be an erroneous identification!), then an error has been made by the competence. If the competence cannot act, a "mistake" has been made by the organization from the point of view of the competence by confronting it with an "impossible" task. The latter case arises when the competence has not been given the necessary admissible variables or domains in order to produce the response to the signal. E.g., the store may be out of stock and the stock level is controlled by another authority; or the military force is underarmed, etc. However, it will be seen that this need not be a mistake of design of the organization. On the contrary, the organization may have been planned by foreseeing the occasional occurrence of such circumstances. In other words, the design may include a probabilistic element, and the question would then be whether the proper probability estimate has been made.

A memory is an indispensable part of any organization that has any continuing existence. Even an organization created ad hoc has more than one single act to set; i.e., either the inner operations require more than one act or the outer operations involve more than one move in the game of strategy. Then some device is needed to retain information in order to carry out the next steps. Such a device is a memory organization. First, it is necessary that the Source know that it has created competences, what they are, what variables of higher and lower order have

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been allocated where, what duties were specified, etc. This burden upon the memory is in itself far from trivial, especially in a large organization. There, however, the memory need not have every single item that is stored in it in a ready state. It often suffices that it has the path to the stored piece of information identified and open. Second, an organization must know, in some form, its state of operations.<sup>1</sup> Few organizations will know their state precisely (still using an anthropomorphic language here); they will often be only statistically informed and this may be entirely adequate. Precise knowledge is often required, e.g., in chess; but it is not necessary to remember the steps that led to the position in order to finish the play in an optimal manner. It is sometimes even impossible, as in Bridge. (It will appear later (cf. ....) that this is a different information from that which must exist for individual competences about the functions of other competences in order that an organization can operate.)

The memory is used in fixing the operations of the organization. It is not necessary that all items the memory has to preserve be stored in any particular place identified as the "memory." The memory of the organization may (in part at least) express itself in the very form the organization assumes. We shall call such a case the protocol memory. This means that restrictions are placed upon the variables that are at the disposal of the competences, or that new variables are introduced whenever some information accrues to the memory. Phenomena of

<sup>1</sup> Cf. further elaboration below about the "organization homunculus."

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this nature can be observed within each organization. The protocol undergoes a gradual change that expresses a learning process (cf 7). Protocol is, for example, the drill imposed upon soldiers; it expresses a past experience with the handling of a particular weapon. It is often found that the best way of communicating and utilizing this experience is in the formalization of the operations. The fact that this is then a part of the memory is not always clear to those concerned, but the purpose is achieved. Another form in which memory is expressed is routine. This is an "automatic" selection of the correct value of the variable, because the frequency with which the same situation is encountered can be relied upon. There exists, apparently, a strong parallel in human behavior where, for example, the experienced pianist need not decide each finger movement consciously and separately. The remembrance of a piece seems to lie in the hand itself which almost instinctively strikes the proper tones.<sup>1</sup>

There are other forms of storing information. These depend mostly, it appears, on the size of the organization. When it is large, special memory organizations have to be created which function very much like the memories of computing machines. Memory organizations are entirely internal; i.e., have no external activities (they never operate on behalf of the whole organization, committing it to the outside).

<sup>1</sup> This is, of course, exceedingly doubtful and possibly even void of meaning. Nevertheless, there is some value to the analogy.



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The staff of an organization (apart from the working and executive functions) is usually a competence charged with storage of information, and as such is part of the memory. Its functions, however, transcend this assignment—it also serves to collect and interpret information which is not derived from a learning process or other past experience of the organization. It has the assignment of gathering intelligence also from the outside of the organization. It is usually assigned to the Source or the highest competences. But these functions frequently overlap empirically, although there is no structural necessity.

Besides the indispensability of a memory for any continuing organization, it is required for learning. The functioning and value of a memory depends upon its accessibility; dead storage of data does not make them information. The data become information only when they are accessible to the proper competence that can utilize them. Social organizations appear to differ considerably among each other in regard to the extent and accessibility of their memory. In the human body the memory is apparently available to all organs on an equal basis. If some appear to have more easy access than others it is, if true at all, perhaps due to frequent challenge and stimulus. In social organizations (always centrally directed!) there is usually, perhaps even necessarily, this feature: The memory is more difficult to get hold of constitutionally for some competences than for others. This is partly intended this way, partly a

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consequence of the particular signaling and information system. When planned, it involves intended secrecy; or access to the memory is reserved as a privilege to higher parts of the hierarchy. This tendency occurs often together with the opposite one of distributing (parts of) general information to all competences indiscriminately.

The memory of an operating organization need not and should not hold its contents indefinitely. If the learning process has been accomplished and some experience is used—that had been stored in the memory—then the memory will have to be relieved of these contents to make room for new storage of those experiences that will accure after the reorganization. The latter go on all the time in business, government, and the military forces. They are in part an expression of the process of learning.<sup>1</sup> The information released from active storage most often is wasted; only in rare cases will it become subject matter for historical purposes.

Next we observe that a distinction has to be made between the system of signaling (or network) on the one hand, and the use made of it (or the actual flow of messages through the system) on the other hand.

Although every competence must be linked to the network directly or indirectly, it need not be able to send messages at all times, or indeed even to receive them from the Source or other

<sup>1</sup> In part they are caused by the need to combat the ever-present tendencies toward disorganization, i.e., the entropy of anything organized.

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competences (e.g., ship alone at sea in war). Discontinuity of actual dispatch and receipt of messages, and of the ability to send or receive them, is compatible with the operation of an organization. Indeed, it is possible that acts about which information must be sent need not be the subject of a separate message or signal. This is, for example, the case when a chain effect between events exists such that x leads to y leads to z and z is the signal that all previous acts have been actually carried out, at least within some probability. This may be the only message the Source or some high competence requires; it then receives automatic cumulative information. This is, of course, a different kind of comprehensive information than that resulting from a process of digestion of messages carried out by interpretative suborganizations (e.g., staff). The accuracy of the former may be much higher than that of the latter, because the latter are subject to error of interpretation in addition to the noise that afflicts each single message separately.

The frequency of messages—in whatever direction—may become so large that the signaling system is unable to handle them within time intervals that are short enough so as not to impair the meaning and value of the message. In that case we speak of congestion. Although this is a term with immediate intuitive meaning, there is no satisfactory mathematical theory available that would help in determining the point when such systems become "congested."<sup>1</sup> Yet congestion is undoubtedly a reason why some

<sup>1</sup> Obviously the problem arises for telephone exchanges, railroad yards, etc. But no theory exists for the latter, and it is difficult to envisage. There are statistical criteria for congestion of telephone exchanges that are useful for their design and operation.

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systems—and the organizations they serve—will break down at least temporarily and perhaps only partly. If the density of signals within the organization changes, very simple changes in the structural—topological—nature of the system can often take care of the variation in flows. For a theory of organization, it would obviously be of prime importance to understand such crucial phenomena, because it can be surmised that frequently very minor organizational changes may be sufficient to change profoundly a given picture beset with difficulties. Adjustments may, however, not always be continuous but require discrete alterations in the organization set-up, either of the basic organization or of the signaling system. These critical points would seem to be of particular interest for the discovery of the events associated with the size of organizations and for the understanding of the phenomenon of growth and expansion.

So far this discussion was in terms of special information intended for a particular, individualized competence or a group of competences. These were the messages considered for their excitation. In some organizations there is, as already mentioned, also a flow of general information which is sometimes even produced by an organized effort. In these cases all competences, or at least special groups, are informed of events without any clear idea that these messages will excite a particular competence, or cause a particular act, or any groups. It is merely anticipated that receipt of these messages may in some way contribute to the functioning of the organization as a whole,

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especially in improving the performance of the recipients, if only a group of competences are affected. Ways in which this is carried out are numerous: There are the general alarms, alerts, etc., that are sounded; there is the publication of company news items, internal statistics, etc. On a wider scale—no longer only within a single organization which is the case here under consideration—there is the role of newspapers, of scientific publications, meetings, and so on. It is interesting to note that the distinction between special and general information is also made in the human body: The nervous system provides the former while the blood stream, reaching every part of the body, provides the latter. For example, it carries warnings of danger, etc., by means of changes in its chemistry, pressure, temperature.

One further point: It appears that when there are more delegations of competences (for the same total number of variables in the organization), there also is need for a larger signaling system. This is only partly true: The signal is related primarily to the variable and not to the competence. A redistribution of competences requires a rearrangement of the signaling system, unless the competence relies exclusively on outside signals not controlled by the organization at all. At this occasion it must be decided what the hierarchy and the sequence of acts of the newly determined competences shall be. We know (cf. Sec. 3) that the signaling system has a decisive influence upon these. When many variables are in the hand of one and the same

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competence there may even be such crowding of messages that a sub-internal system for handling them may have to be created. This would at least involve the setting of priorities for messages, etc., as it indeed often happens. From the economic point of view, it is interesting to note that different schemes involve different costs, yet they may be functionally equivalent. Economic theory has not dealt with these matters.

We return now to the distinction made in Sect. 2 concerning inner, outer, and mixed variables. The possible connections of the variables to signals is summed up for convenience in the following table:<sup>1</sup>

		<u>Variables:</u>		
		<u>Inner</u>	<u>Outer</u>	<u>Mixed</u>
<u>Signals:</u>	(Internal:	<u>A</u>	-	-
	(External:	B	-	-

An internal suborganization exists if there is a complete delegation system within the entire hierarchy of delegations of competences such that only inner variables are contained therein and connected with each other, although A and B types may be intermixed as far as signals are concerned. An internal suborganization comprising only type A is a possibility, but is exceedingly restrained. Any suborganization, being part of the whole organization, is necessarily open-ended since closed sub-systems are an obvious impossibility.

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<sup>1</sup> If the frequencies with which the various combinations occur were given, an important measure describing the structure of the particular organization would be available.

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From these possibilities it follows that the structure of an apparently even "simple" organization will, as a rule, be exceedingly complicated. In particular, the organization is not sufficiently described—as already stated—if only the delegation of the variables is indicated. For an understanding of the practical workings of an organization, it is indispensable to know to what kind of signals the various variables are bound and what the arrangements within the main organization are. The same main organization, as described by some hierarchy, can be of a very different nature from another one, which has the same hierarchy. The network of delegations of variables makes a number of different signaling systems compatible. Lattices, trees, networks, etc., appear to be the proper forms to describe the connectedness of variables, of competences (in which several variables of different types can be held together) and of signaling systems. The ordinary box-like description of organizational structures, based on the idea of "reporting to" is at least inadequate. The chains of "reporting" are essentially those of formulation of duties, responsibilities, etc. They do not always reveal the power vested in the organs. Much less does this description, or even a more detailed one in terms of the variables of action, give information about the chronological sequence of acts for any inner or outer operation (this is taken up below).

Although this last point is of considerable importance, it suffices here to mention this much: We have distinguished between

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the activity and the operation (cf. Sect. 2), the former being the totality of all possible (inner and outer) operations, the latter consisting of a variety of acts or sets of acts. Now it is necessary to realize that one and the same operation can be carried out, under certain circumstances and within limitations, in a variety of forms, such that the chronological sequence of the choice of values for variables is not rigidly prescribed. E.g., a salesman can first sell commodity x and then commodity y or vice versa. This is, as we saw, partly a consequence of the relation between type of signal and type of variable, but also due to the statistical-probabilistic factor in organizational set-ups.<sup>1</sup>

In view of the highly classificatory approach that we must follow—being concerned exclusively with phenomenology—further distinctions relating to signals and choices (for variables) are in order. At the end of Sect. 10 we shall discuss the important problem of the relation between hierarchy and sequences of acts in operations.

A signal is an "event" and vice versa. A signal is (after filtering information for a specific variable or group of variables. It determines that a choice has to be made for the variable(s) to which it is related; if it does not necessarily specify further, it may carry an implicit order. If the signal carries an explicit order, it annihilates the variable by making

<sup>1</sup> The phenomenon occurs also in economics, e.g., in the theory of consumer behavior where it matters greatly whether durable goods are at all involved, etc. It would lead too far to enter upon this here. Cf. footnote, page 114.



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it a constant. Or at least it restricts the variable's domain. Signals that are not even implicit orders are only information, the value of which consists for the competence of the possibility of making another (i.e., better) choice than without that signal at the time when an order-carrying signal arrives. If a competence has all the information that could conceivably influence the choice of a value for the variable, we say that complete information exists. There may even be more information available which is then redundant. Great masses of redundant information may obscure the relevant information which can then be obtained only by processes of digestion, compression, etc. (cf. above) and, in many cases, by inference or other logical operations. (These latter situations are left out of account here.) Their analysis would involve the discussion of information theory in relation to the process of inference.

An "event" becomes known through a signal; in fact, the two are inseparable. For our purposes this classification has to be made: (1) events of the organization which are either the outcome of choices (a) in internal or (b) in external operations; (2) other events, which are either (a') physical, i.e., produced by Nature, or (b') other organizations' choices. Events of Nature are determinable if their probability distributions are known. Even where they are completely random in the sense that their probabilities cannot be estimated, Nature is never malevolent, i.e., bent on impeding the organization in the pursuit of its aim. The latter may apply random, i.e., mixed, strategies,

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but that is a different thing from the possible randomness of (a'). Here we have a motive arising from antagonism. If the environment is not one of pure Nature but also contains acts of other organizations in a mixture with events of Nature, the statement that there will be no malevolence in the milieu is most likely no longer true.

A change in information is thus necessarily equivalent to a change in state of some organization including Nature; for example, it is a change in the state of one's own organization that (generates and) receives the information. When the signal does not arise from Nature, it is also a change in the state of some other social organization, since otherwise there would not have been a signal.

Thus, as far as contacts between organizations are concerned, there is never a one-sided receipt of information since it must have been emitted elsewhere through a change in the state of the other organization. There are also changes of the state of information of an organization about itself; this will be discussed separately below.

Next we discuss the operational dependency of choices; this requires a further classification of variables for discussing the operations of the organization. A competence, in order to make (a) an admissible and (b) an optimal choice for a variable, must have information; i.e., must receive or have received, at various previous moments of time, a number of signals which involve, in various combinations, the following:

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( $\alpha$ ) Technological knowledge: This is fully incorporated into the domain of the variable—the knowledge is deterministic.

( $\alpha'$ ) physical, legal data

( $\alpha''$ ) Random physical events: "Nature":  
the knowledge is probabilistic.

( $\beta$ ) Choices by own organization:

( $\beta'$ ) own inner choices (probabilistically known)

( $\beta''$ ) own outer

( $\gamma$ ) Outer moves of other organizations: Often only the fact of such a move may be known, not its outcome (not even probabilistically); for example, in Kriegspiel.

Choices (i.e., variables) fall into these two further classes—apart from the above distinction about inner, outer, and mixed variables:

(a) A choice is separated if it can be made (optimally) without a specific tie-in with another choice. Such a choice has no (specific) predecessor operationally. E.g., a customer entering a store causes a separated choice to be made by the salesman. Every variable and/or competence except the Source has, of course, a hierarchical predecessor or superior; but here we are talking about sequences of choices in operations.

(b) A choice is successive if its execution requires at least one specific predecessor; i.e., the establishment of a value for another variable. This occurs most obviously in line

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production (cf. Part III). We then have connected choices; the variables concerned may alternatively be inner, outer, or mixed variables.

(c) A chain of choices is given when in connected choices each specific predecessor is of the same class. It is easily seen that there can be only two types of chains of inner variables, depending either on  $(\beta')$  or  $(\beta'')$ . There can be no chains of outer choices. The length of the chains is given by the number of the specific predecessors of the last member.

The question arises whether in any, even the most primitive, organization there must be at least one chain. Or whether it is enough to have at least some successive choices. It is doubtful that any organization at all can be constructed (if it consists of at least the Source and one competence) where all choices are separated.

It was shown earlier that an organizational structure is inadequately described when only the hierarchical set-up is specified. It is necessary to include the corresponding, actually given signaling system. Now it becomes clear that even a complete description—in that sense—does not inform about the sequence of choices in operations. The principal fact is that the various competences do not necessarily act in a sequence corresponding to the hierarchy. Often the lowest competence acts first; e.g., the janitor opens the building before the president can go to his office. But the highest competence selects the entire inner and outer operations. That the sequence of acts

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cannot be according to some hierarchy follows already from the fact that each organization is confronted with random physical events. The observation of the sequence of acts of an organization is therefore not enough to establish its formal structure even if one should succeed in separating, in the observation from the outside, the inner and outer activities.

The account of the functions of information is incomplete unless reference is made to the state of information of the organization about itself. It is clear that the Source must be informed about the entire hierarchical structure, but it is not clear what distribution of one competence's information about other competences is required. However, this much can be said: A competence must know about the competence to which it reports and about those on which it depends operationally in the sense of the above remarks. If every competence had full information about every other it might help but not necessarily; it would clearly be wasteful, if not physically impossible, for most organizations. For that reason we spoke of automatic cumulative information in operations. In operations it is unnecessary and, indeed, wasteful, for higher competences to know everything about the lower. It is also useless for lower competences to know all about those that are very much higher, etc. In no case are the operations significantly affected by such knowledge; but the same is true for the general information mentioned earlier. There also, no direct connection between the amount of information and the choices can be established, although it is reasonable to assume that the information will improve the operations. It is

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noteworthy in that connection that there exists a formidable barrier for military men, businessmen, or practically anybody within an organization to describe what they are doing. Similarly, the human being cannot say what is going on in his own body, although he has plenty of experience in living and knows that he is functioning. It requires at least one science in each case!

The distribution of the knowledge of the organization about itself can be described by suitable mappings. These are not simple; they are everywhere of the one-to-many variety and shall be described more in extenso at another occasion. We find again that in a significant way an analogy exists with the mapping of the human body into the brain. An illustration is offered by the so-called motor-sensory homunculus, as described, for example, by W. Penfield.<sup>1</sup> This mapping shows the relative importance given by the brain to various parts of the body by representing some more strongly and detailed than others. Similarly it is in organizations. There, however, the situation may be even more complicated because the various competences—and not only the Source—have to have their own mappings of the whole organizations. The Source, in turn, will have to be informed about their state of information.

There are, furthermore, several such mappings; the two principal ones are: (1) the hierarchy mapping and (2) the operational mapping. Ad (1): The competences will, as a rule, not have the same and complete information about the different hierarchies

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<sup>1</sup> W. Penfield, The Cerebral Cortex of Man (1950).

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that may prevail in the whole organization. This does not interfere with their operations. Ad (2): The operations of the entire organization can be carried out as intended (i.e., even optimally) when each competence has only information about those factors influencing its own choices and those of the surrounding competences but not about others.

In this connection—also awaiting elaboration—I mention the further fact that the usual description of organizations by means of charts, etc., is at least incomplete. The lacking components are the quantifiers that must be inserted as well as the clear expression of coordination and subordination which is usually blurred. The application of relations logic will be necessary in these cases.<sup>1</sup>

We saw at the end of 3 that every organization has a probabilistic element incorporated already in its basic structure of delegation of variables. From this, as well as from the further fact that there is noise in the signaling system, it follows that each inner operation has a (not-intended) probabilistic nature. This view is strengthened by the observation above that chains and other dependencies exist among the variables and that the outcome of choices of predecessors may be known only statistically, if the outcome is known even to that extent. In many cases a competence may be informed only that another one has chosen a value for a variable, without being told which. Or, even weaker, the competence may merely be able to assume, with a

<sup>1</sup> There is a high similarity here with parentage and its logical description.

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certain probability, that a choice of a variable and of a value has been made, inferring from general information and basing the conclusion upon its knowledge about the organization as such and upon its previous behavior. Examples for such occurrences are easily found in the military field, e.g., from naval operations conducted under radio silence and scattered over wide ocean areas.

#### 5. Mistakes, Errors, and Recovery

In connection with the noise in an information system some remarks were made about errors and mistakes. This is, however, a vast and complicated field about which little is known and not all of this knowledge falls into an acceptable pattern. The best that can be accomplished is to describe some of the principal phenomena in the hope that further clarification can be obtained by extension of such descriptions.

First a definitional difficulty: A mistake would appear to be anything that involves the misuse of a correctly designed organization. If such a thing is at all possible, it means that there cannot be enough self-checks built into an organization preventing such occurrences.<sup>1</sup> Or can a correctly designed organization pick a non-optimal strategy? This would be possible only if limited information is assumed. But a correctly designed organization would have to provide for proper filters for noise. So the problem reduces to the obvious impossibility of eliminating the probabilistic aspects of nature in the information system.

<sup>1</sup> E.g., is an organization correctly designed in which an incompetent person gets into a top position when the procedures for appointment and promotion are observed?



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Do all cases of misuse reduce to this? It would not be true if a correctly designed corporation put an incompetent person into the position of its president. Can checks be invented which would prevent such an occurrence? Since we do not know what the "fundamental organizational" principles are, we know nothing about their violation. All one can do in this situation, therefore, is to describe typical cases in which there is common-sense agreement that mistakes have been made and that errors have occurred. The distinction between the two—if it can be maintained at all—will not always be sharp.

The problem of discovering the mistakes of, and errors within, an organization is of extraordinary practical significance. Otherwise it would not be possible to tell how the optimum position can be reached (assuming its characteristics to be known!) It is not enough to know that an organization is not at its optimum; it is necessary to be able to indicate where it is and how one can get to the optimum or at least move towards it. A pure trial-and-error procedure is an empirical impossibility when many variables are involved.<sup>1</sup> Numerical estimation of the distance from the optimum is also required because otherwise the significance of an error or mistake is impossible to determine. To visualize what is demanded, it suffices to think of a university: What is its optimum organization? Its aim? How can the aim be formulated quantitatively? What mistakes does the administration make? How far do they keep the university removed from its optimum position? What corrective measures should be introduced? The

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<sup>1</sup> This is significant for the so-called "theory of the firm" where all of these things have been neglected.

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patent impossibility of obtaining anything but the vaguest answers to these questions—which are typical for most administrative set-ups—is an illustration of the grave consequences of the total lack of theory in this field.

It is not better in business. For example, the chairman of a large department store—a very able man—gave this answer to the question: In what percentage of cases would a customer who entered the store and asked for a commodity carried by the store be told "temporarily out of stock"? "Approximately in 2 - 3 per cent of the cases." A statistical investigation had put this figure at 15 - 17 per cent! This enormous divergence of information about a vital aspect of the operation of the business shows what poor conceptions often prevail about the "optimum." Clearly, the percentage cannot be zero. But is 15 per cent bad or quite acceptable? Without any deeper knowledge about mistakes, almost any answer is as good as any other. A department store sells many thousands of different items, none of which is decisive for the outcome of its operations. If the stock is not available, only a small mistake is made. It may not even be a mistake at all because it would cost far too much to be better stocked. The control system may become exponentially more expensive for each reduction of the percentage. Similarly, there is not much of a disappointment to the customer, because a street block away there will be another store having the commodity in stock. Or there may be a close substitute of which even the department store may carry an ample supply. From the point of view of the economy as

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a whole, an entirely negligible event has occurred at any rate, whatever the final outcome for the customer. This is clearly a situation where many small mistakes can be tolerated (if they are such; cf. the reference to the costs of not being in error). In the terminology used above there is not a mistake here, but an error. The reason is that "being out of stock" is attributable to the design of the organization. The incorporation of a technical advance leading to a more rigid control system, or to a system of faster signaling, etc., make it possible to reduce the percentage, but then there is the technological progress which we are now not considering. It is also possible to treat the occurrence statistically in the sense that probability distributions, rather than individual events, are considered and that the correct distribution was chosen, so that no design-mistake was made.

A very different case is offered by, say, a naval supply depot that has to provide ammunition, etc., to warships. If ammunition for 16-inch guns is demanded by a battleship and the depot does not have them in stock, there is no substitute ammunition. The same applies to many other items, such as highly specialized radar gear, electronic tubes, oils, etc. Furthermore, there is no other naval base around the corner which might be better stocked. The loss for the navy may mean the loss of a battle or a campaign and might be valued at an infinite amount. It is clear that this contributes to a different inventory policy, to an "overstocking" in a commercial sense. In fact, there is no comparison possible, because—as far as these items are

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concerned—the naval base is a different kind of organization since it approaches more the type of a digital computer which operates on an either-or basis and tolerates no mistakes whatever. We do not say that the base as a whole should be so arranged. It may be faulty to operate the entire base like a digital computer. Large sectors of the naval base are constructed comparable to department stores where wide substitutions are possible; e.g., when the battleship wishes to get spinach for its provisions, she might also take broccoli or peas if the base is not supplied with the desired vegetables. All this becomes of significance for drawing up a program of logistics where the possibilities of substitution do not appear to be utilized enough (cf. Part IV).

The significance of a mistake in organizations depends also on the possibility of recovery. As a rule it will be easier to adjust to many small errors rather than to a large mistake. Especially when the small errors are quickly recognized and signaled as such is counteraction effective. The noise factor enters here, too, since false signals of mistakes and signals of mistakes when none were made may lead to false counteraction. The human body provides checks in its neural system which make certain that the body will not be caused to act easily upon the basis of false signals. Yet when action is called for it comes as quickly and decisively as if it were an on-off system. The eye is a prime illustration.<sup>1</sup> Small errors in social organizations can be recognized and reported quickly. This can be done

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<sup>1</sup> Cf. the work of Selig Hecht, about the eye, where it is shown that 6 - 7 rods have to be excited before a light sensation is reported to the brain. Smaller numbers are not reported because it happens frequently that single rods will in error go on and the brain discounts these errors by not reacting.

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by people who are not, or little, responsible for their occurrence; e.g., the salesmen in the department store are not responsible for inadequacy of the inventory. Therefore, feelings and pride are not much involved and the remedial counteraction does not create many difficulties. Anything pertaining strictly to statistical error falls into this class and is, therefore, of the more harmless type. Large mistakes, embodied mostly in the structural features of the organization, are difficult to discover and still more difficult to remedy. If they are brought to light they affect many people and probably highly placed ones. High administrators are notoriously unable to accept criticism; in that they are quite different from scientists who are constantly exposed to such challenge. Large mistakes occur probably mostly with organizations where no real effort has been made to state the aim, even qualitatively, clearly—let alone numerically. The mistakes are difficult to determine, cannot be stated uncontroversially, and may therefore go unnoticed for a long time. Common sense is not a reliable guide for finding and remedying them. Many things in large organizations appear outright foolish to an outsider, but the disturbance of these practices may have grave consequences because the practices may not be faulty. The "obvious" clumsiness of many government offices and their procedure invites quick criticism, frequently from businessmen who, whatever they do, deal with vastly smaller quantities and cannot judge from their experience what the best procedure would be. It appears as if it were simple to find out what other procedures are at least equivalent, if not patently superior. In

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most cases opinions of this kind are of little value because of the lack of a theory covering such complicated phenomena (quite apart from the prevalence of purely political prejudices).

The small errors described above do, however, have a larger aspect that must be well understood. The fact that a department store cannot and need not be 100 per cent stocked for all cases makes it necessary to evaluate the statistical situation and to determine and various probability distributions involved. The appraisal of this statistical situation can be correct or it can be fundamentally wrong: Here is the field for the large mistake—vis-a-vis—a statistically determined set-up. The small individual errors are acceptable if they occur within the framework of a correct appraisal of their probability, and the estimation of their influence upon the operation of the entire organization. I believe that the distinction between "errors" and "mistakes" is real and of importance, even though at present not yet followed up into all ramifications.

Recovery, closely related to the notions of error and mistake, is a profoundly important notion which plays a great role in the whole range from biology to military strategy. For a centrally directed social organization there are two basic conditions when the phenomenon may arise: (1) Recovery from the effects of own error and (2) recovery from outside shock and pressure.

(1) is incorporated into the set-up of the organization, and recovery is possible if the distribution of errors is properly

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estimated; i.e., an estimate has been made of the feasibility of avoiding error and the impossibility of achieving the aim of the organization more closely (to the extent that this is dependent on the organization's own acts). For example, one loses by being out of stock but can absorb such losses to a certain extent. If instead of errors, mistakes are involved, the situation is more complex. It is again a quantitative problem: If a wrong probability distribution, in the above case, is chosen, recovery may very well be possible; if a mistake of the nature of placing an incompetent man in charge occurs, recovery may never be possible.

(2) Here is a problem about which nothing appears to be known, except in the most general sense, for individual social organizations. This is undoubtedly also a quantitative problem—it would require measuring the limiting extent or amount of damage done from which recovery can still be expected. But cf. Sect. 9 about the restricted value of the notion of costs! Even the qualitative description is quite obscure and will have to await many studies, the nature of which cannot be easily specified. It is likely that highly specialized organizations, just as such biological organisms, are most vulnerable. Specialization can refer either to the detailed structure or to the lack of flexibility in operations, which we know not to be necessarily the same. A good illustration for the second kind of specialization is a certain tree-living bear which can eat only leaves of one of two kinds of Eucalyptus trees. This animal would be highly

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vulnerable to changes in its environment. The swine and the rat, on the other hand, have a most diversified food intake. So has the human being, thanks to his technological knowledge. He is also little specialized—as was often pointed out—being bettered in virtually every field, by some animal. But in the combination of all of his abilities he is more adaptable than any other living being. Similar conditions may be found in individual social organizations, some of which perish after they have become petrified, i.e., unable to adapt themselves to changing environment. Others survive even mutilations: Transfer of variables and even creation of a new Source are not infrequent but perhaps more often encountered not in centrally directed, but in the more complex composite organizations (cf. Sect. II/10) with which we are not dealing now.

Machines differ usually from living organisms in their inability to recover from shock. This is true of a motor, for example, that cannot adapt itself to many detrimental changes of its environment. However, the difference must not be carried too far since it is possible to build a high degree of adaptability into a machine. A gyroscope, controlling the altitude and direction of flight, will bring an object back to the required position if it has been dislocated—but not "too much"—by adverse air currents. But an automobile motor, once beginning to run down, has no recuperative powers whatsoever. It is simpler to have a mechanic make repairs than to build such devices into the machine itself, even if devices can be imagined.



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The phenomenon of recovery is so obviously beyond the scope of these notes that it has been sufficient to point out that an understanding of this field would be immensely significant. But it appears to be inaccessible to anything but common-place remarks. (About the relation to learning, cf. Sect. 8).

#### 6. Controls within the Organization

Any organization embodies controlling devices, however rudimentary and hidden they may be. Passive control consists of the comparison, for each competence, of duty and the choice actually made for the variables upon receipt of signals. The comparison proceeds as a rule at least on two levels: (a) the control sees whether the signal has been received, identified, and responded to (within a time limit) by the competence that is in charge of the variable. It compares whether the right variables have been used considering the state of information at that time; (b) the control may also compare the value of the variable actually selected with the hypothetical response that "should have" been made. The correct response could be contained in a catalogue listing all possible situations. It could, indeed, be looked up by a machine, which might perform the whole control function and might only be a machine within a machine, a servo-mechanism. The control organ, functioning at a later time than when the action took place, will often be in possession of more information than the competence at the time of action. In that respect control is conceptually always separated from action. It offers no guarantee that it would have done better than the

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controlled competence at the lower level of information. Therefore, the control organ is not a superior substitute for the controlled.

When the aim of the organization is not numerically expressed, i.e., when there exists only a vaguely described payoff, the process of control of type (b) becomes vague, if not entirely impossible. It is then when "judgment," "experience," and "wisdom" enter; all are euphemisms for the fact that one does not have scientific knowledge how to cope with these situations.

Active control consists of the interference with a choice due to be made by a competence by specifying a new domain for the variable or even making it a constant. It is based on the ability of the Source to reassume and redelegate any delegated variable. Such an occurrence may be based upon the results from passive control of past acts and/or upon operational information that would not become available in time to the competence under the existing signaling system. Therefore, active control may involve the reassignment of signals, while leaving the hierarchy unaffected. This will, in particular, be of importance in organizations where separate signaling systems, i.e., a suborganization, exists. Active control is part of the general executive, or officer, as distinguished from the special who is connected with separate variables—hence, the institution of a general officer who can override any competences under him, while a (special) officer can exercise authority only within the delegation set-up where the authority is transitive. For a general officer

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the authority is also lateral (this is further discussed in Sect. 10).

The control may be set up as a separate system of competences. The previous observations about hierarchy, delegation, signaling, etc., apply again. It is an organization within an organization. The control system, however, does not need a memory separate from that of the basic organization, nor any separate signaling system. These latter two are then found to be universal in that they are not necessarily related to separate, distinguishable sub-organizations within the main organization. This ought to be of considerable interest when judging the appropriateness of organizational structures. We shall, however, not discuss this point any further.

The control is primarily concerned with the internal functioning of the organization and has there its easier task. It also checks on the outer operations which are more difficult to check because the records are, as a rule, one-sided; i.e., inner operations consist frequently of transactions involving competences in succession, or have other clear internal interdependencies, so that the behavior of a given competence can be checked not only on the basis of its own records, but even by that of another competence. For outside contacts this is generally impossible. The internal records are available for such purposes, but, even if complete, tell only part of the story. Furthermore, a control of the outer operations would require a very complete knowledge of the strategic situation of the organization

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as a whole and this evaluation is hardly a routine operation. It requires far more and is a function to be fulfilled by the Source. Routing control of the moves made by competences is possible when these can be compared with expected, routine moves which are repetitious in recurrent situations. All control functions aim at holding the organization together and improving it. Since a control is indispensable in any organization, even where "efficiency" is not an overt aim, this indicates that in each existing organization there is also always a tendency towards disintegration. This is similar to the process of entropy in thermodynamics. Organization in itself, wherever it occurs, whether in social or natural life, is something exceptional and extraordinary. The natural state is one of lower order, if not of disorder. Consequently, an organization will not tend to stay in its state of order but rather tend to fall to pieces. It is therefore necessary for each perpetuating organization to provide for tendencies to oppose such trends. The essentially internal control of an organization is to accomplish precisely this. What the causes for this trend towards deterioration of social organizations are can only be surmised in broadest terms. A future theory of organization would have to make the explanation of this basic phenomenon one of its primary objectives. The entropy of organizations differs widely but it can overtake even the apparently best-established ones. Some sudden and surprising collapses of formerly mighty armies tell important stories. Some systems of organizations appear to come under particular stress of this kind.

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7. Degrees of Organization

In several preceding passages an implicit use was made of concept such as "over-organization," "higher" and "lower" forms of organization, etc. It would be desirable to make these terms precise. However, it seems impossible to achieve this at the present state of our knowledge, although intuitively these notions seem quite accessible. However, they involve some idea of an "optimum" or "equilibrium" which would be hard to formulate except in a completely tautological manner. It is quite likely that the notion of the equilibrium of an organization has to be changed and broadened as in the theory of games which deals with composite social organizations. There the characterization of an equilibrium by a single number or set of numbers had to be replaced by new concepts.

Intuitively, one would speak of "over-organization" when "unnecessary" formal steps are provided, when the domain of variables is restricted, etc., while "it is clear" that the choices could be left to lower competences without their referring back to higher ones, when "too many" competences are created (i.e., too few variables concentrated in one), or when internal controls are provided while the selective power of competences should not be interfered with, etc. When there is a tendency towards more constants in an organization, it would appear to coincide with a "higher" form. But on the other hand, an organization will be better able to cope with its problems when it preserves more rather than less freedom to choose. This requires that its resources be held in a form that does not commit it to only one

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single course of action. But such a view contemplates alternative actions spread over a lengthy part of time—a further complication. For a sharply defined aim, to be achieved in the immediate future, the proper organization is the one that fits precisely the needs of the situation; e.g., a fully automatic conveyor system is of this kind (for the inner operation only—but let us assume it to be optimal for the outer, as it should be). This complete specification can be useless if a substantial change occurs in the purpose (e.g., in this case even when considerably fewer units of the same things are to be produced—a very different set-up might then be optimal).

A low state of organization is one in which the resources are relatively amorphous for the purpose, i.e., the strategy. It is thus impossible to have an acceptable measure of the degree of organization or disorganization (for a strictly static case!) without consideration of optimality of operation for a concrete situation involving only the immediate future. A low form may allow the transformation of the resources into a more specific set-up; disorganization, on the other hand, may well consist of the rupture of important functions of an otherwise highly diversified set-up equivalent to its inability to transform further homogeneous resources into the required specifications for moves in the play of the game.

It is noteworthy that in this language the "power" of an organization—which is the freedom to choose from a wide range of possible strategies and corresponding inner operations—requires

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this interpretation: (a) For a fixed situation, it manifests itself in having made the optimal choice, from the homogeneous form in which the resources were originally given by committing them to a particular form; (b) for a situation which is still flexible, it manifests itself in availability of a greater amount of resources that can still be committed, where at least part of these resources are in a homogeneous (i.e., not specified) form and application. Thus, for example, an organization can be powerful, but at a low state of organization, etc.

To interpret: (a) means that the organization, in anticipation of a concrete situation, has used its resources in an optimum form. Comparison with other organizations—possibly hypothetical—that commit different amounts of resources gives a measure as to how wide the range of strategies is for them. In such a scale, the place of relative "power" of the organization in question could be found. Such a scale would be exceedingly difficult to construct because of the formidable task of computing the optimum strategy. (b) means that the resources are still held in an uncommitted form, as, for example, the capital of a firm being available in cash before any purchases of machines and raw material have been made. In this condition it is possible to compare strength or power in a simple manner (assuming that a particular situation is to be faced). In the economic illustration, the liquid form of the capital resources is a sound notion, because we know approximately from the prevailing prices and our technical knowledge how this can be transformed into specific

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goods and services.<sup>1</sup> But for non-economic organizations it is not a priori clear whether resources not yet brought into specific form have quite the same tangible existence, let alone can be given numerical expression as in the case of cash which can be compared with prices. Thus the civilians available for an army—even if they have been trained before—are something different from the soldiers they are when fitted out and arranged in combat form. This observation applies, of course, particularly to the organic field where the materials from which a living body is made give no indication of the strength and power of the organism into which they will be built unless the organizing principle is also formulated and applied. In the economic case such a principle is given in the technological knowledge being combined with the purpose of obtaining a maximum (of profit) by choosing a strategy in a fairly well-known milieu within which action can take place. However, the question how a lesser degree of organization is transformed into a higher one, far transcends the possibilities of this discussion.

#### 8. Learning

The understanding of the phenomenon of learning will be of primary importance for any ulterior theory of organization. Here only a brief sketch can be provided, in view of the formidable difficulties in principle and especially at the present stage. Learning has been extensively studied in psychology, biology,

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<sup>1</sup> If the firm attempts to do this it enters upon a game, so that the statement in the text is not absolutely correct. But it is not necessary to go further into these complications.



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physiology, etc., but it is fair to say that even there, where so much ingenuity has been applied, the understanding is still highly incomplete. The problem has appeared also in the discussions about the construction of machines, such as computing machines or those that play games with human opponents, where it would be important to understand whether these machines could be so designed that they learn from the opponents' mistakes. Learning involves complicated feedbacks as well as the assistance of, and access to, a memory.

It is a priori clear that learning occurs also in social organizations, whether individual or composite. Some are known to adapt themselves to changing conditions, to emerge from adverse influences, and to survive under the greatest odds even over centuries. The universities are a classical illustration: There the same basic things have been going on while the outer world changed—transmission of knowledge, training of new scholars, and new contributions to knowledge. The learning may have consisted of the ability to adapt to variations in the milieu in order to do essentially the same thing over time. In other cases, learning may appear to consist of doing something differ-  
ent (i.e., have changing aims) in an essentially stable milieu. Sometimes both efforts are intermixed. It remains to be seen in what sense one is justified in speaking of "learning" in all these cases.

It is perhaps—if this may be said in parenthesis—not very surprising that of all organizations, universities ought to be able to survive well since they—we are told—a collection of

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the finest brains of each age! Even if universities have not developed a theory of organization and survival that they can apply consciously, they should easily find the proper adaptation processes. So one should really not be too much surprised that they have survived over hundreds of years, but rather wonder why they have not done far better for themselves.<sup>1</sup>

In those fields where learning has been studied it is inevitably found to be a matter of feedbacks. Certain activities are carried on by the subjects, and the results are observed by them and their superiors in the light of the situation as they see it. The feedback—if successful, i.e., accepted—operates such that the new operation constitutes an improvement over the older in the same, or nearly same, circumstances. Each operation produces new information which, by means of the memory, is compared with information already in possession of the subject. It appears that wherever learning has been studied, the aim or function has always been quite clear to the subject and the investigation. If neither were the case, the observation of the learning process and of its success would undoubtedly be far more difficult, if possible at all.

The subject evaluating the experience and arranging for the feedback to become effective in a learning sense (i.e., as we shall see, by a change in the structure or in the code of the organization) may err and instead of a positive, we get a negative effect. We recall that the aims of social organizations, even when centrally directed, are often obscure or only formulated

<sup>1</sup> It is doubtful that universities in general are a good illustration because the true institutions are not centrally directed but fall into the category of composite, cooperative organizations. This does, however, not apply to those American universities which—archaically—are still run (organizationally) like business corporations.

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in the vaguest generalities. This leaves, therefore, considerable leeway for the possibility of "negative" learning.<sup>1</sup>

Assuming the aim to be clearly understood, we now discuss briefly a distinction that may serve to give a first outline:

(a) Learning for the outer operation: Learning arises only if there is incomplete information and/or a deficiency (e.g., physical) in attaining the aim, and if the physical possibility is actually given to adapt the organization. Under these circumstances an operation produces information that is used in determining the next operation when faced with the same or nearly same situation in which action is required. Now in our discussions so far we have, unless specifically stated otherwise, always assumed complete information, as this term is understood in the Theory of Games, where naturally the problem of learning, i.e., discovering the opponent's intentions and style, also arises.<sup>2</sup> The assumption of complete information precludes any learning by an organization for which a clearly defined aim is described. It will always be at an optimum, although successively over time there may be very different outer operations (i.e., strategies) because of two facts: (1) The common physical conditions will change, bringing about as the most notable consequence a change in the other players' strategies. (2) The strategies available

<sup>1</sup> "Negative" learning is a different phenomenon from the "entropy" of organizations, i.e., their tendency to go over to lower forms of organizational set-up or efficiency.

<sup>2</sup> Cf. loc. cit. There it is shown that the problem really does not exist for the theory because of the equivalence of the description of a game in its extensive and its normalized form.

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in the second period will depend on the changes in the resources of the organization due to the success or failure of the strategy used in the first period. For both these reasons there is a repeated "adaptation," but in this case it does not represent a learning process in the above sense, because there were no deficiencies and there is not the need to meet requirements posed by the same situation. If the same conditions existed and a non-optimal strategy had been used, followed in such manner by others that finally the optimal one is reached, then one could speak of learning in the correct sense. But if optimal strategies succeed each other, no learning takes place.

This observation extends not only to strategies but to the moves of which they are composed. In other words, no rearrangement of moves is possible without thereby altering the strategy; this follows from the equivalence mentioned in footnote 1, page 81. Since each optimal strategy guarantees only the maximum protection in non strictly determined games, which are the rule, it may by remote chance be that in successive situations different optimal statistical strategies yield successively increasing payoffs. This might easily give the impression of a successful "learning" when in fact it has nothing to do with it.

An entirely different situation arises when incomplete information exists which is, of course, the empirically more realistic case. Then learning will occur even if the situations encountered by the organization should be strictly identical with each other, provided the first strategy was only an approximation to the optimal one. It may, for example, be too difficult

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to compute the optimal strategy. Thus, the first one used gives a vast amount of information that can be profitable for finding, or approaching, the optimal one. The information would become available to the organization by comparison of the outer operation by means of the memory with the theoretical characteristics of the optimum strategy and lead to the incorporation of the lesson into the next outer operation.<sup>1</sup> This involves feedbacks which may even have to be provided for specifically. This is learning by mistake. In order to function, the mistake must be recognized as such, which shows the importance of that notion as discussed earlier. The feedbacks will not be automatic by-products of an organizational set-up; they have to be specifically provided for. It is here where interesting and important empirical studies will have to be made. The practical arrangements vary from the anonymous "suggestion boxes" to the calling in of management experts. These techniques will all become gradually superseded by the development of operations analysis which, so far, is applied mostly to the military field in which it has arisen. Industry and business are lagging behind the military; for that there are deep psychological and social reasons.<sup>2</sup> However,

<sup>1</sup> We neglect to mention, however, that a similar process must be going on in the other organizations against which the strategy is to be used, so that there is no such stability. But we shall not complicate matters any more at this juncture.

<sup>2</sup> The lag is interesting, because management control was developed by business. But operations analysis goes far deeper and by virtue of its wider scope endangers some of the prerogatives of business executives. There is only a small and scattered literature on Operations Analysis. Cf. P. M. Morse and J. Kimball, Operations Research (1950) and a recent pamphlet by the National Research Council.

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operations analysis applies more frequently to the inner operations, while we are at present still discussing the outer. Even before the rise of this new applied science, the observation and planned study of one's own operations are frequent, especially in the military organizations. There historical offices exist charged with writing the histories of campaigns, wars, etc. These histories do not serve in the first order some vainglorious desires, but serve to understand the past so that lessons can be learned. This is a systematically arranged feedback which works via the military academies, laboratories, and proving grounds. It is most interesting to note that in that respect too business is lacking in interest and execution. It may be due to the lack of resources (human and monetary), to the short life of the average firm, but it must also be related to a lack of understanding of the issue involved. It suffices to compare the type of standard company-made business "histories" (mostly more expensive forms of advertisements of no analytical value) with the often highly scientific and critical character of military history as written by the military themselves. Business is also suffering from the desire to preserve secrecy. An example is offered by the Bank of England about whose operations 50 or even 100 years ago the full truth cannot be established because the records are not completely released, although they exist, and all concerned are dead.

So we see: Learning in regard to the outer operations consists of approximating the optimum strategy for a given situation

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and to achieve the same for successively varying situations. This is accompanied by the endeavor to discover the intentions of those organizations with which cooperative or antagonistic contact is made; the process by which this learning is accomplished must involve the inner operation which is to be optimized in respect to an outer operation.

(b) Learning for the inner operation: When the inner operation is optimal with regard to the outer—irrespective of whether the outer operation is optimal or not—no learning process will be found. If, as a consequence of the variations in (optimal) strategies, there are equally optimal variations in the inner operations, no learning or adaptation is involved. This follows from the remarks under (a). So the interesting case is again that of incomplete information, this time concerning inner operations. We recall that the structure of the organization embodies probabilistic elements and that the organization cannot be informed other than probabilistically about its inner operation and its whole status. Learning does not necessarily take place but these are conditions under which it can occur. Whether it actually does happen will depend first on the existence of the necessary feedbacks and second on their utilization.<sup>1</sup> Neither is to be expected a priori.

Since we are discussing only the formal side of the question,

(b) shall not be considered in detail. Learning for inner

<sup>1</sup> We may, of course, assume that the organization has the desire to learn. This would be implied by the customary assumption that a maximum of achievement is to be attained. About some empirical obstacles to learning, cf. the last paragraphs of this section.

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operations will consist of those changes in arrangement and utilization of the resources of the organization that are characterized by time and motion studies, eliminating unnecessary steps, determining sequences of acts, speeds of conveyors, routing of papers, etc. In all this there is a wide field where "experience" is important, which is only another word for the feedbacks at work. It would require a very detailed knowledge of particular cases before any generalizations are possible about the origin and direction of the feedbacks that are built into an organization whose inner operations are not at optimum. It is clearly impossible to push further without making concrete assumptions about the form, complexity, and material content and purpose of the organization.<sup>1</sup>

Because of the combination of the two facts that learning is, to a high extent, absorbed through reorganization and that each organization has its own individual historical experiences causing learning processes, a peculiar problem arises: How is the identity of the organization preserved? Is not, after a long chain of such transformations, the organization as actually observed something widely different from the original one? The name may survive or even not; at any event this would not be considered as material by anyone. The question of identity over time will arise only for long periods or when the learning is

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<sup>1</sup> This is precisely what operations analysis tries to accomplish. There is no general theory there, as yet. There are only rules of procedure, so far, and the attempt to go about the task in a scientific spirit as well as equipped with the most modern tools that statistics and scientific analysis can provide. It is probable that there will not be any science in this field without a (simultaneous) far superior knowledge about organizations than we have now.



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exceedingly rapid, involving many major changes; this can be considered as dynamical and, therefore, beyond the scope of these notes. However, it is interesting to observe that the same occurrence is true for the human body: Cells are being replaced almost continuously, functions disappear, and new ones are assumed, etc., so that the question of the identity of the individual is a problem that arises sooner or later even in one's own consciousness. Some of the changes not only are due to the natural causes of growth and age, but reflect our experiences and many conscious efforts to absorb these.

Leaving the formal questions aside, we observe that the actual learning processes within an organization cause many forces to appear that make learning easy or difficult, as the case may be. The new experience to be incorporated into the structure of the organization, or into its protocol, or into the operations themselves, will frequently encounter great opposition. There are, for example, always competences—i.e., represented by individuals!—that will feel their position threatened through the creation of new variables, competences, abolition of others, etc., forms in which learning would materialize. There are persons who are on principle opposed to new things and methods, the old procedure has become routine, experience does not become known widely enough, etc. These are all significant forces, and their study will reveal much of sociological value. The results should then be incorporated into the study of the formal aspects of the process of learning. Some organizations, being highly adaptable,

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succeed in learning rapidly and often; "adaptability" is, then, only another term for learning.

#### 9. Input-Output and Costs of Operations

In economic organizations such as firms and households the evaluation of the result of an operation is usually in terms of costs and profits, obtained through some comparisons of inputs and outputs. Current economic theory uses this pattern, too. The comparisons would have to be made on two levels: First, various operations are to be considered which take place within the same given organization as described by the hierarchical delegation of variables and the information system; second, for different organization patterns.<sup>1</sup> If the economic organization is not a firm, but a cooperative association such as a cartel, labor union, etc., the cost-profit principle is immediately seen to be in grave jeopardy. We shall return to this below. But first this observation: The current notions of costs, profits, inputs and outputs assume that they can be sharply, unambiguously defined and measured objectively with sufficient accuracy. This is, however, not the case, except in a conventional sense—"profits" are often fixed entirely without regard to "costs";<sup>2</sup> the latter depend, among other things, on the rate of depreciation of fixed capital assets which can be varied arbitrarily within wide limits,

<sup>1</sup> This separation is achieved to some extent (i.e., subject to the restrictions discussed at the end of Sect. 1) in the theory of the so-called planning costs and represented by the envelope curve of variable costs.

<sup>2</sup> Cf. O. Morgenstern, On the Accuracy of Economic Observations (1950), pp. 27-32.

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etc. The gross receipts of a firm depend not only upon the physical-financial facts involved, but upon the policy or strategy used in its dealings with its competitors, customers, and suppliers. To the extent to which this is the case, any cost-profit characterization of the operations of a given organization, even in the economic field, is at least incomplete, if possible at all.

So we see: The economic quantities upon which the notions of costs and profits are based are not sharply definable. Thus, the determination of "costs of individual operations" and of entire organizations is likely to turn out to be of a highly complicated nature, if it is possible at any level, except in the above-mentioned conventional manner which need not—and in fact does not—satisfy scientific requirements.

Assuming now, however, that cost-profit comparisons as made in business are a reasonable procedure, this has to be observed: Every social, centrally directed organization has by necessity an economic aspect. Every one of them consumes or uses scarce goods, however rudimentary the quantities, and involves some expenditure. This is true of a church, a hospital, a university, etc., which in this sense incur "costs." None of these organizations has a primary business purpose. Therefore, this input-output relationship is, if not meaningless, at least subordinate. So, for example, the success or failure of a university is not expressed by a financial surplus or deficit as a consequence of a year's operation. It would be absurd to use either as a criterion.

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Thus, if an input-output characterization is nevertheless desired, it has to be in terms of the aims of these organizations, and has to use whatever is being processed from a less-organized state to that of the accomplishment the organization strives to achieve.<sup>1</sup> No general treatment is possible, because there are as many different kinds of inputs and outputs as there are types of organizations, the latter distinguished by their aims.

Descriptions of this kind are not easily made or even envisaged, because of the frequent difficulty of formulating the aims of organizations, let alone their numerical expression (or lesser orderings). Thus, it becomes almost impossible to describe organizations in terms of proper inputs and outputs. For example, is the input of a church sinners and the output saints? Or, at the universities, is the input ignorants and the output scholars? What is the input in the army? What the output? Certainly soldiers or weapons are not being manufactured there, but something far more complicated is to be accomplished. What is the output of a prison? Is the input criminals, the output punishment? Or reform? Etc., etc. A long list could be made.

The fact that all these organizations have economic and financial aspects and in many circumstances must behave as if they were economic institutions (e.g., trying to buy as cheaply as possible) imposes a cost aspect upon their description and obliterates the appraisal of their—outer!—operations in those

<sup>1</sup> A university, for example, might make absurd expenditures—in terms of its aim—and stabilize its budget at the same time!

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terms that are proper for them. But even if appropriate input-output quantities could be found for each type of organization, it does not follow that this is a useful, an exhaustive, or a correct method<sup>1</sup> by which to measure their success or failure. Indeed, it is doubtful that the method is even correct for business organizations where it appears to be quite natural; more about this below.

Consider this case first: As already mentioned, one of the two concepts, costs, is quite arbitrary because of the great freedom as to what should be assigned to costs." The details of these difficulties need not be discussed here, although they are of real significance. Instead, assume that this were a well-defined concept allowing a reasonably precise measurement. Then "input" and "costs" would be identical and the efficiency of the organization (we leave it open whether for both, the inner and outer operations) could be determined by comparing the input with the output. If the latter is also a precisely measured quantity and both can be reduced to a common denominator, the difference gives an expression of the efficiency of the business.

Such a view does not give consideration to a number of phenomena that determine the picture. There is first the fact that what can become "input" must already be related to the organizational principle and purpose. No physical thing is an input by virtue of its physical properties, but because of its relation to the order into which it is to be fitted. This is as a rule

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<sup>1</sup> About the formulation in terms of information inputs and outputs, already discussed above, cf. further below Sect. 9.

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easily seen to be the case in business where nothing would be considered an "input" that according to our technological knowledge is not needed. But we do restrict even those "inputs" because the free goods, which may technologically be just as important, are not counted as inputs with the property of cost items. This is one expression of the selection that takes place. It is important to see the significance of this behavior, because it must by necessity recur in organizations that have no business purpose, although there it will be much more obscured.

Second, the same input, thus selected, can be "organized" in different ways. The technological principles alone do not uniquely determine for what variations in the organization the input is used. The input relates to a broader type or class of organizations—in this case business enterprises—rather than to an individual one.

Third, and this is the important point, the output—i.e., the payoff of an outer operation—is determined not primarily by the input, but by the strategy used, on the basis of the physical possibilities that the input provides. But even the selection of the input and its specific arrangement in the inner operation is governed by the strategies that are alternatively at the over-all disposition of the whole organization. And it is the payoff in relation to the cost-input that determines the profit or "success" of the (business) organization. Thus, in order to carry the input notion through, it would be necessary to consider also the strategy chosen as part of the input—clearly a very

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artificial procedure that does not recommend itself. Instead, it is better to study how the strategies available to the organization are restrained by the physical inputs that can be made (which, as already mentioned are themselves restrained by the total abstract capital of the organization and possibly also by the freezing of some resources into a particular form because in the preceding period a particular strategy was actually chosen). Then it will be discovered that the same strategy may often be accessible to business organizations with different resources. This means that there is no one-relationship between resources and strategy. From this follows, of course, that the outcome of the outer operation for a given organization is due to the choices made by all organizations, each having a number of strategies to choose from.

So we see: The notion of an input of an individual firm or business organization is not very precise (even if the other difficulties of measuring costs are neglected) and of doubtful value except in a conventional manner. The notion of an output to be compared in the same unit of measurement with that of an input, in order to determine a profit, is definitely of even more restricted value.<sup>1</sup> In particular the "result" or "payoff" of an outer operation—which is by necessity the one concept definitely involving the aim of the organization—cannot be properly described by relating it to inputs and "costs"; there is, in general, no

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<sup>1</sup> Of course, the output of a motor car factory can be measured in terms of cars produced, and they can be expressed as a monetary sum. But this is a very limited operation, having little to do with the above, where the payoff is to be described.

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one-to-one correspondence. On the other hand, the notion of the cost of a strategy deserves further study. All these remarks apply to business organizations where the payoff can be characterized in terms of money to a very large extent, although businesses are considering other factors such as goodwill, etc., that may often restrict their money craving.

Consider now the second case, that of organizations other than business organizations. Clearly, conditions for input-output comparisons cannot be better either conceptually or in regard to measurement. This is due first to the difficulty or rather inability of assigning numbers to the success and failure of outer operations (in our present state of knowledge) except in a highly arbitrary manner, and second because all centrally directed social organizations are by necessity involved in games of strategy played against other organizations, simple and composite, or against Nature. At any rate, the idea of a strategy prevails, and this reduces the notion of costs to comparative, theoretical insignificance. Costs could be defined also for these other types of activities—i.e., apart from the "costs" of their economic aspects. But this notion will frequently be of limited value. For example, what is the "cost" of operating a hospital whose output is health or healthier patients? No ratio between those brought in and released (including those buried!) nor one between the knowledge of the doctors and the states of the healed gives any measure of costs and success. Neither does such an idea of cost help us to establish a notion of rationality of



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the behavior of the institution. Yet there is a possibility of speaking of inputs and outputs, at least in the sense of the description of changes in states of the organization in connection with information.

This expresses our present inability to describe the inner and outer activities of non-business organizations in the form of input-output relations. But this does not necessarily imply that this type of description can never be accomplished. We question, however, the desirability to insist now upon this idea. The efficiency of the inner operations can perhaps be approached in this manner, but the rationality of the behavior of social organizations hardly at all. In fact, the latter concept falls into the domain of the theory of games of strategy where input-output relations, if they can play any role at all, are relegated to an inferior position.

#### 10. Size of Organizations

Quantitative elements in the type of organizations so far considered concerned the number of variables, their domains, the length of communication channels, the number of signals sent and received, the abstract resources not yet committed, etc. A problem for any kind of organization is to determine the relation between their functioning and their size. This is also closely related to the problem of whether a given organization can be expanded without altering its formal structure, or to determine what changes must take place and whether the transition to new forms is discrete or continuous. Furthermore, we would like to

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know, in close connection with this, whether the quantitative extension of a given type of organization will lead to a break-up and if so to discover the point at which this will happen. The actual transition from one quantitative state of a given organization to another one of the same type and the transition to another type would have to be described by an account of the dynamics of this process—obviously as important as difficult, if it is possible at all. (Some remarks about this are found in Sect. 11.)

Clearly, all this transcends anything that can be done at present since there is not yet even a reasonably complete and consistent language to talk about these matters. We shall, therefore, endeavor only to circumscribe these questions in order to bring them to a point where it is possible to see them as a connected group. It will be observed, however, that everyone of these questions is encountered in the illustrations to be given in Part III from line production and conveyor systems.

We have a sort of intuitive understanding that the "type" and "size" of an organization are somehow correlated, but the exact nature of the correlation has apparently never been established. It is clear that a corporate set-up with boards of directors, vice presidents, etc., would not be used for a small grocery store; neither can a very large corporation be run like the latter. Somewhere in between are critical stages where changes in the type of organizational set-up have to take place so that the tasks of the organization can be accomplished. To

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complicate matters further, this relationship extends to the already mentioned notion of "power," which, in turn, is dependent upon the form in which resources are held and organized.

Size as a controlling factor is recognized, for example, in the United States Army where a "maximum command span" is defined. The number of subordinates is limited to seven. Similarly, a long time ago Fayol tried to determine the maximum number of "assistants" in business and found it to be six—obviously there is already a conflict here. The same number has been set by General Wavell,<sup>1</sup> while Clausewitz was willing to go much farther and put the limit (also for a military set-up and at an earlier time of slower communications!) at nine to ten. But are these numbers significant?<sup>2</sup> What is an "assistant," in business, administration, science, or in military matters? If the subordinates perform only minor and perhaps even identical jobs, their number can easily be higher without affecting the efficiency of supervision and direction. A corporal can have seven men under him, peeling potatoes, perhaps even 27, but certainly not 2,700. Somewhere the possibility of supervision vanishes. If some subordinates hold great responsibilities, have vast authorities, are very brilliant, etc., six or five or four may be too many. Thus, the number of people, or more correctly, of variables, subordinated is not necessarily a good criterion for

<sup>1</sup> ". . . it has been found by experience that six units is the maximum that can conveniently be commanded and administered by one headquarters." Army Organization, Encyclopedia Britannica, 14th ed., vol. 2, p. 410.

<sup>2</sup> There is some discussion of this in the literature; cf., for example, Alvin Brown: Organization, A Formulation of Principle, New York (1945) pp. 116-125, but no definite result is announced there either.

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the amount of "complication" with which an officer can deal directly. Of course, the number cannot increase indefinitely. For example, the amount of time he has to give each one, the state of summarization of the problem presented to him, the variation of the problems from each other, are far more important. However, they are difficult to express and (at present) impossible to evaluate numerically as one would like to do. If the problem the subordinate has to submit for decision is well summarized, in fact numerically expressed, it may be possible to decide it very quickly although it may be enormously important, while a messy, less important, and perhaps badly represented problem may mean great delay. The proverbial empty desk of the executive is an expression of the first condition. It is less a symbol of his own efficiency than a symbol of the ability of the lower employees to summarize a problem presented to him. Furthermore, the communication systems available also have an influence upon the manageable maximum of subordinates, as well as their spatial arrangements. The latter point was already referred to, but more will be said about this below. These relations between superior and subordinates are in terms of individuals, rather than functions; they involve important psychological factors, principally. But our interest is not in that direction.

Size and Form are old problems in biology, morphology, and engineering.<sup>1</sup> They have come up again in Cybernetics and in the study of automata in general. For example, it was shown by Galileo

<sup>1</sup> Cf. particularly D'Arcy W. Thompson, *Growth and Form* (1917), Sec. Edit. 19. .; and Julian Huxley, The Size of Living Beings, in. . . .

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already that you cannot have a man five times his present size because his construction would then be faulty; for example, the thigh bones would be unable to support the weight of the body.<sup>1</sup> For, more generally, the increase of the cell surface in the case of growth proceeds by the square, but the cell's need for food increases by the cube.<sup>2</sup> A fish growing to twice its length increases its weight eight times. But there may be great differences otherwise—a mouse cannot be enlarged more than 3 - 4 times for the same reasons, but vertebrates can differ 1:1 Million in size (mouse and whale). Furthermore, when an increase in the over-all size occurs, it is not only not necessary, but would be positively harmful, to increase all organs linearly. Thus, the elephant's eye is "small" in comparison with his mass, but highly efficient, and an increase in the eye's size would be wasteful or even make the eye inefficient. This leads, of course, to a change in the ratio of the size of organs to each other.

<sup>1</sup> Cf. Galileo Galilei; Dialogues Concerning Two New Sciences. English Translation by H. Crew and A. de Salvio. Chicago, 1946, pp. 4 - 5 and 125 - 127 (of the translation). There all these principles are discussed with utmost clarity and many illustrations. It is, for example, also shown why fishes can grow to dimensions enormously larger than land animals and survive as long as they remain in water. Generally, it is proved that an increase in the size of machines will tend to lower their efficiency. Where is there a similarly clear and convincing principle for social organizations? Galilei is careful to stress that he excludes any change in the property of the materials of which the comparative structures are made.

<sup>2</sup> Cf. Sect. 11 and the remarks on technology and growth. Here the answer might be that there should be a transition to more efficient food to make the growth possible—but that is a technological change at least of the environment.

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For example, the ratio of the weights of the spinal cord to the brain is 1:5 in the cat, but 1:50 in the human—with known consequences. So the change in proportions may be a prerequisite for the assumption of either more functions of the same type or of entirely new functions. An interesting case is offered by the insects: It can be shown that they cannot grow to more than at most three times their present size and still stay insects, because their breathing apparatus would fail them completely. They would have to adopt an entirely different system. There are also other engineering reasons limiting rigorously their size, connected with properties of their rigid bodies, etc. Mere size of the individual of a given species may also be positively correlated with the total intelligence of the individual,<sup>1</sup> in the sense that a larger individual is more intelligent (i.e., has greater learning ability) than a smaller one.

In engineering similar relations are found (for the first time formulated by Galileo); this is not surprising, because some of these in biology are identical with engineering problems. For example, the economic height of skyscrapers is limited by the elevator space. Fifty years ago, the economic limit was given as 16 - 20 stories;<sup>2</sup> now it is far higher, because of the greater

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<sup>1</sup> Cf. work by Professor Rensch. I owe the reference to Rensch's work to Dr. Julian Huxley.

<sup>2</sup> Cf. Scientific American, March 1951, p. 6.

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speed and capacity of elevators. But for each technological condition there is a definite ceiling. Mutatis mutandis the same applies to almost any other technical illustration.

It is not our task to elaborate these illustrations, interesting and important as they may be. Instead, we shall look for correspondent phenomena in social organizations. They will, by necessity, be of a general intuitive character, but nevertheless indicate the direction further research should take.

Variations of size are possible without any need arising for transition from one type of organization to another. There are small and large grocery stores set up exactly alike, the larger one doing more business and simply employing more clerks. There are small and large corporations. Both are characterized by the identical box-scheme of arrangement of competences, differing only in the quantifiers that are needed for each box. We have seen (Sect. 3) that there is not a complete-technological-freedom in arranging variables into competences. But there are further restraints: (a) the properties of the available signaling system (speed and accuracy of messages) and (b) the "capacity" of each competence. We shall not discuss (a) at present.

The reader familiar with the difficulties—not yet overcome—of assigning a scientifically satisfactory meaning to "capacity" in economics will realize that they will not be less here. There the task is to find a numerical expression for the maximum a given firm or plant or unit can do, e.g., in producing steel, transporting passengers, feeding people, etc. When "capacity" has been reached, in any organization, a further output

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is impossible and, if demanded, will lead to a "breakdown"—or, at best, to no increase in output. These limits are not rigidly given because, for short intervals of time, "capacity" may be exceeded (by letting machines run beyond the time when due for overhaul, by forcing longer hours upon men than they can sustain permanently, etc.). Capacity, as here used, refers to operations, as distinguished from the structural capacity limitations mentioned above, regarding distribution of weight in a body, relationship between height of building, number, and speed of elevators, etc. Operational capacity is thus a phenomenon of organization embedded into the physical background upon which it has to rely (this background may be in part of its own making!). If the demands upon the organization increase, it may therefore be necessary to change the organization itself and to choose another form altogether, e.g., to go over from the individual firm to the stock company with very different distribution of variables, arrangements of competences, and corresponding signaling systems.

The analogy between the limiting factors for biological organizations and the structure of organizations is apparent. If properly extended it should yield interesting insights and perhaps quantitative theorems for organization. But this will have to be preceded by a great deal of empirical work in order to be fruitful. The analogy for operational capacity is far more difficult to establish. We are pretty much in the dark why some operations of certain organizations bring about their collapse in the sense of their inability to carry out any, or any significant



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part, of the demanded operations, while other organizations have no particular trouble vis-a-vis the same demands. Probably one of the most important factors is that from some point on confusion begins to appear, i.e., a breakdown of the communication system happens. Confusion is, as a rule, cumulative, i.e., confusion breeds further confusion;<sup>1</sup> it consists of the receipt of too many signals, in the inability to process them within the allotted time space, in misdirection of signals, issuing of contradictory signals, etc.<sup>2</sup> More obvious is, of course, that demands are made which go beyond the physical possibilities of the organization. Yet the real cause is not in that phenomenon, but rather in the fact that the organization allowed itself to get involved into situations where such demands could be made. There is some malfunction of the organization behind any physical inability and that is the condition to be discovered. If the environment can impose conditions leading to a breakdown, then the (optimal) organization may be helpless and is absolved. But frequently a breakdown is the result of lack of learning, adaptation, etc., and expresses then a structural-organizational fault. These two types of breakdown should be kept apart as far as possible, although the distinction is not

<sup>1</sup> It is amusing that besides heat, unpleasant smell, etc., confusion has been listed early as a particularly objectionable attribute of Hell. Cf. George Morgenstern: Sermones (1508).

<sup>2</sup> Whether or not "confusion" exists depends on the knowledge the observer has of the interrelation of the processes observed. An ant heap may be confused or not, depending on how much we know about the ants' activities. But the members of an organization may be assumed to know enough about it to determine whether or not confusion reigns. One also frequently encounters the opposite opinion that everything that is highly complicated must be the product of a great deal of thought.

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always sharp. The reason for this lack of sharpness is that there always exists some freedom in choosing the particular, concrete form of organization. A different choice might place the point of breakdown somewhere else. All this refers to the same size of organization, as measured, for example, in terms of abstract (uncommitted) resources.

One of the main difficulties in defining an operational capacity is that an organization carries out acts of different kinds and can arrange these alternatively, or at best in some combinations. Now even if a "capacity" is found for each organ or competence or proper combinations, this does not give a description of the operational capacity of the entire organization. Capacity of the whole is non-additively connected with the capacity of the parts. If too many acts are performed simultaneously they may interfere with each other, although a different sequence of these acts may be well within the scope of the organization. There is a strict analogy here with living organisms. For example, simultaneous hearing and seeing is limited<sup>1</sup> for each organ to less than its maximum separately. Similarly, a military unit cannot perform all combinations of activities at the rate of the maximum of which each activity, taken separately, is capable. The nature of the interferences which arise can be discovered only for each case separately, although some general principles such as that of non-additivity may exist.

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<sup>1</sup> Neglecting now the aspect of the contents of the messages and their interaction.

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It is conceivable that there exist firm relationships between the volume of inner and outer operations, similar to those between cell surface and cell volume. Nothing is known about it and without detailed empirical studies not much can be ascertained. Here is a large field for investigation. It is closely related to that of the expansion of organizations (cf. Sect. 11).

Another problem, at least to be mentioned, is the connection between size and recovery. Do small or large organizations recover more easily from shock, disruption, and pressure? It would be very important from a practical point of view to understand this situation well. There is a likelihood that for composite organizations one that is made up of many independent ones recovers more quickly than one that is highly centralized. The picture of the American economy comes to mind for the first case; the difficulties some highly concentrated European economies have encountered may be illustrations for the second case. However, for centrally directed organizations there appears to be no material available telling us about the correlation between recovery and size. It is possible that there is no correlation, but that larger organizations are more specialized and that their difficulties in recovery are due to higher specialization (cf. Sec. 5) rather than to size. There is, of course, always the famous dinosaur who allegedly became extinct because it took two seconds for a nerve impulse to travel from the tail to the brain. Similarly, the paperwork in a very large corporation is

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so formidable that recovery from shock—and perhaps even functioning under ordinary circumstances—becomes a real problem. The government, where the same applies, survives because of its monopoly.

Finally, there is the connection between size and tech-  
nology. As already mentioned, the most important feature in that respect is the communication system. Any significant technological progress in that field has brought an increase in size, beginning from the invention of Darius. But there are two different influences: (a) those technological changes that make larger organizations possible and (b) those that require them. The larger state made possible by faster communications is of the first kind. The large steel firm, due to the required size of rolling mills, is of the second kind. There will, of course, be some interaction, inasmuch as organizations of the second kind require some others, with which they deal, also to be large. Some technological change produces, by necessity, variations in the proportions of the various parts of an organization. For example, when a mass production technique becomes available in a firm, the distribution and sales departments will have to increase much faster in order to cope with the enlarged production volume.

For (a) there is no need for the facilities to be actually used—small states followed large ones, although the technology was the same, which would have enabled formation of large states. Likewise, television, telefax, etc., may be technological prerequisites for the creation and maintenance of world governments and the like.

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So far we have tacitly assumed that the "size" of an organization is easily capable of unambiguous measurement. But there are great difficulties here. Some of these shall be pointed out. Taking first organizations of the same type, it is sometimes not too difficult to make over-all comparisons for size. Clearly General Motors is larger than Studebaker, or the University of California is larger than the University of Vermont, etc. For economic entities we appear to have such measures as invested capital, turnover, number of workers, etc., (although the latter is not necessarily a good criterion if an automatic factory is compared with a labor-intensive banana plantation!). Combinations of such numbers are needed to give a suitable measure. Also, it is clear that the American Army is larger than the Portuguese. But when it comes to comparing two armies, one inferior in numbers of soldiers but highly mechanized, the other with large numbers of soldiers and little equipment, a measure such as firepower must be devised to express difference in "size."<sup>1</sup>

A quantitative description of the difference in size of organizations (with the same aim), e.g., firms, must tell us not only about the differences in the operations (for example, more or less turnover), but also about the differences that obtain for individual parts. Thus, every organization will have only one Source, though in the larger organization it will be more powerful. The ratios of workers to executives, of the number of

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<sup>1</sup> Cf. above and the remarks about the "power" of an organization. This is, while related to "size," not the same phenomenon, because it concerns efficiency rather than mere size.

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messages processed to the number of acts performed, or the number of administrative decisions, etc., all give information of the required kind. At least, this is a conceivable way of demanding information, but it is not certain that it is the right kind, in view of our inability to describe satisfactorily the various degrees of complication about which we want to learn. We would get some information which would have to be supplemented at present by common-sense experience. Only when it can be shown conclusively that one organization is more complicated than another—both pursuing the same aim—will we identify this with "size."

Comparisons between the sizes of organizations pursuing different aims (not even too widely different ones) become correspondingly highly involved. Yet such comparisons are constantly made, often involving judgments about their comparative efficiencies as due to the alleged difference in size. There is no method available which would allow us to express with sufficient confidence whether, for example, the organization of General Motors is as large or—equivalently—as complicated as, say, that of the Catholic Church. However, it would be important to be able to make such comparisons.

The following will give some further ideas of the difficulty in making statements about relative sizes of organizations. Consider two business organizations, i.e., two actively operating enterprises. First, we have the individual firm where complete direction and supervision is vested in the single head of the

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business. Second, we have a large corporation, such as General Motors, where sub-units are formed ("divisions") which are created so that they must actually be in sharp competition with one another. Both types of organizations work, although each embodies a somewhat different principle. It is clear that an interchange of the principles is impossible when the size of the operations (as expressed, for example, in turnover) is held constant. It would be physically impossible to have an individual firm doing a business of the volume of General Motors directed and supervised by a single head. Conversely, a small individual firm cannot have competitive departments, there not being enough volume of transactions to provide the set-up and the individual at the head of the firm not being able to split himself into competitive parts. So there appears to be here a case where an increase in the number of transactions (internal and external operations) requires changes in structure, similar to the case of the insects whose breathing apparatus is inadequate for a larger animal.

Both businesses in this comparison are "actively operating," but in a particular restricted sense. Difficulties arise immediately if we look at, say, a hydroelectric power plant and wish to compare it with a baseball team, both also "actively operating." Which is the "larger" organization? The first has an immense capital investment, virtually no employees, and perhaps sells its entire product to one single distributor. The financial figures are impressive, the organization is transparent in

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hierarchy and operation. There are few individual transactions. The baseball team has no physical investment to speak of, may have as many employees as the power plant or even more, and has perhaps also more individual transactions per unit period. From the point of view of organizational complication the latter may have to be viewed as the "larger" organization. So even in the economic field such otherwise useful criteria as capital investment, number of workers, total amount of sales, etc., can easily fail sometimes to express the size of organizations.

We carry this comparison over to non-business organizations; For a political, "actively operating" organization such as the United States, a great expansion of transactions has been possible while maintaining the high centralization in the Presidency (accompanied by technological progress). It is possible that limits exist, as in the case of the single firm, beyond which changes are necessary. Thus, cooperative autonomy, regional or otherwise, appears to be similar to the competition factor in large corporations. This is because an increase in population automatically increases the number of transactions that ultimately must be routed over the President's desk. Wherever this applies, limits appear,<sup>1</sup> as indicated. There are organizations that are formally similar but not in the above sense "actively operating;" e.g., the Catholic Church with the Pope in a comparable position.

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<sup>1</sup> They are apparent in the mechanization of the President's signature, in the appointment of special assistants, etc. This is not delegation in the hierarchical sense, but merely a technological development, such as the use of a typewriter or telephone.



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Here the individual head will stay much less affected by an increase in the number of believers. There is no such direct, necessary relationship between their numbers, their activities, and the transactions the Pope has to carry out (this too depends, of course, on the state of technology). This may be called a "followership organization."

Still different is an organization such as the Red Cross. It is mostly dormant. A small operating core is surrounded by a large, potentially operating layer which can be increased or decreased without affecting much the structure of the operating core. When in the case of disaster the whole apparatus is set into motion, a much greater level of operations is reached in a discontinuous step, but the structure of the whole need not be greatly changed. Such organizations appear top-heavy in their dormant stage. This is a factor which makes comparison with other types quite difficult. Yet there are even corresponding business organizations—theatres are an illustration. There the smaller or greater attendance has little effect on the over-all organization (but a great effect upon the financial outcome!). A museum is in a similar situation, although its economic basis is quite different and may be entirely independent of the attendance.

From all this can be seen that we need a classification scheme of organizations before we can really start comparing sizes and measure their efficiency. The botanical stage of listing and subdividing everything and bringing it into a system has

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obviously not yet been reached. Unfortunately, there seems to be no shortcut so that we could avoid the tedium of going through that level. It will probably take a man of the stature of Galileo to discover the principles that govern the properties of organizations, their complexities, and their ability to fulfill their tasks.

The present knowledge of the limitations of size of living beings and other engineering constructions cannot be applied in any strict sense to the social phenomena before us. That it is possible to make exact statements for the organic and inorganic field (i.e., to compute, for example, that no bird having the weight of an adult man could be constructed, able to fly in the atmosphere of our density) is due to the fact that the laws of mechanics are known and can be applied. Thus, we have precise and specific knowledge, the application of which yields this information. It is not at all clear what laws, rules, and principles are available in the social world to allow us to make similar statements. We do have common-sense reasons for the kind of statements made above about the relative suitability of organizing General Motors or a grocery store. But we do lack completely any precise, detailed knowledge which could be applied constructively. How tricky the situation is can be seen from the fact that the same effect of an organization can be achieved by alternative set-ups, e.g., by replacement of men by machines in many circumstances. But while it produces a simplification of the organization in one direction (eliminating men in their duality role), it also causes new complications elsewhere

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in the organization (perhaps by placing a heavier burden on communications and paperwork, by increasing the speed of operations). I know of no generally acceptable methods of comparing the degree of simplification with the degree of complication from the point of view of social organization as caused by choosing one over the other type of set-up.

To summarize: We now have collected the principal elements of centrally directed organizations. We ask ourselves what information is available for observation of organizations that we wish to describe. We may or may not possess an organizational chart giving the hierarchy. Such a chart is seldom, if ever, complete<sup>1</sup> enough to tell us about the variables that are assigned to the respective competences. If the variables (and their domains) are given, we have implicit information about the abstract and concrete resources of the organization. More likely, the variables are not stated, in which case an inventory of the physical resources is needed. If this is available together with the chart, there is still no unique way of combining these two into a chart with variables, because of the freedom to distribute the variables among the competences. Thus, our description is incomplete. Even if complete—for the hierarchical set-up—we know that the signaling system should be known to us in order that we might predict the operations (also provided that the aim can be unambiguously formulated and is known to us!). Assuming also that

<sup>1</sup> Cf. above about the lack of uniqueness of describing hierarchies by charts. We may neglect this very serious difficulty at present.

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this information is completely available, it is nevertheless impossible to predict the internal and external operations of the organization—but it may be possible (theoretically) to describe the internal and external activities, i.e., the two sets of all possible operations.

This approach is, however, not the typical one to be chosen. As a rule the observation of an organization proceeds from observing the acts constituting the various concrete internal and external operations as they follow each other. There may be a rudimentary knowledge of the hierarchy; but the internal acts are for the most part inaccessible. Some, however, become known, though only as "acts," which are often not uniquely attributable to one or the other class. The sequence in which acts are carried out is frequently immaterial, since the organization is only to some extent tied to a chronological ordering (for example, by virtue of technological necessities or because of the ordering of the moves in the game in which the organization finds itself involved). Therefore, not much can be inferred from the time sequence of the observed acts upon the importance or value that the acts have in the behavior scheme.<sup>1</sup> In order to make this inference, it is necessary to have a certain degree of knowledge about the various hierarchies as expressed by charts with

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<sup>1</sup> The same holds true for economic theory: It is not possible, without considerable additional assumptions, to infer the ranking of the individual's preferences from the order in which acts of choice are made. Cf. O. Morgenstern, Das Zeitmoment in der Wertlehre, Z. F. Nationalökonomie, 1954. This point has been completely neglected in value theory; it is of particular relevance for an immanent criticism of indifference curves and for the constructive design of observation of behavior of the individual.

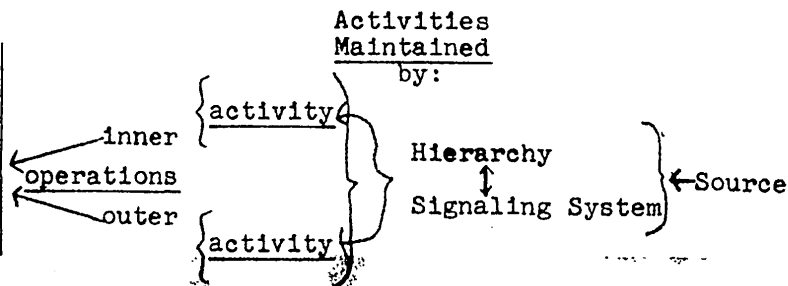
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quantifiers.<sup>1</sup> A hierarchy chart without quantifiers does give us some information about the possible activities of the organization, inasmuch as, for example, a true chart for an army showing a tank force must at least be an army that operates some tanks, while a true chart for an army without a tank force will not show a tank force on the chart. This allows some immediate conclusions about possible operations. But the quantifier would tell how many tanks there are, from which one concludes more about possible operations, the implied existence and magnitude of supporting services, their numbers, etc. Thus, a true chart is not valueless but a much lesser piece of information than frequently assumed. Quantifiers in the chart can be replaced to some extent by a description of inventory in the ordinary sense. Yet neither kind of statements is equivalent to the description of the organization in terms of the variables and their domains<sup>2</sup> themselves. This is far superior information and, together with the signaling system, the ultimate knowledge that can be established.

Schematic Representation would be as follows:

Observable:

Acts of the organization (mixture of some internal and all external) and sometimes parts of the Hierarchy with or without Quantifiers



<sup>1</sup> I.e., an indication of the number of elements to which the competence applies, e.g., the number of employees, regiments, planes, etc., to which reference is made.

<sup>2</sup> These depend, obviously, on the physical inventory and the entire array of resources in their transitional states of abstractness to concreteness.

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### 11. Expansion and Growth

Organizations may experience changes in size. We consider only expansions and, at first, make no distinction from "growth." The question is what constitutes expansion. There must be a (permanent) increase in functions, in activities per unit of time, or an increase of the potential in the case of dormant organizations. In view of the difficulties encountered in the preceding section it is clear that an analysis of the transition of an organization from one size to another is even more complicated and less likely to succeed.

Growth and expansion are primarily properties of biological systems and constitute there some of the deepest mysteries.<sup>1</sup> For social organizations historical descriptions of the growth and development of important types constitute for a very long time to come a proper, if not the only proper method of approach in describing the phenomenon. Much can be accomplished with even rudimentary concepts or pictures as is always the case in new fields. If anywhere, it is for economic phenomena where one has a little more experience and a beginning of theory. Therefore, this section will refer mostly to economic illustrations, where the input-output approach with all its limitations is the most natural way of describing an increase in activity.

An expansion of an organization may be internal or external. According to the observation in Sect. 10 we have to distinguish between the increase in "power" and the increase in organizational

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<sup>1</sup> Cf., in particular, d'Arcy W. Thompson, op. cit., passim.

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"complication." The former can be achieved without the latter; e.g., when larger generators are installed in the hydroelectric plants, this increases the investment, makes a bigger product, etc., but does not change the organizational set-up in any way. On the other hand, our baseball team may take in more sets of players, play correspondingly more often, and yet have no increase in capital investment. Its organizational set-up has increased in complication and in that sense an expansion has occurred—its operational capacity has increased. Thus, we get the first interesting result—an increase in capital investment (e.g., by transition to more costly machines) does not necessarily indicate an expansion of the organization in the sense of its organizational internal set-up. It may increase the possibility of more, or more extended, outer operations, by making additional strategies available. We know that this is possible because the dependency of the outer activity upon the inner activity is not unique.

Excluding expansion as working merely through such larger numbers as more horsepower, more money, etc., without involving a change in the organization set-up proper, we now ask what happens if an economic organization expands qua organization, presumably involving complication.

Organizational expansion of an economic unit requires concomitant changes in structure or operations. Thus, a burden is placed somewhere upon the organization in order to make the expansion possible.

We distinguish these possibilities:

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(1) Source: We used the Source as an undefined concept but attributed to the Source definite limitations. It can create variables and arrange them in competences only up to a limit. Expansion is possible if the limit is replaced by a wider one, allowing for more variables and competences. This would be achieved by an (external) growth of the Source (e.g., more capital raised,<sup>1</sup> more members gained, more technological knowledge acquired,<sup>1</sup> more work performed<sup>1</sup>). The Source may also be strengthened by an outside Source, thereby influencing the strategic situation of the organization.

(2) Inner Operations: As a consequence of a temporary choice or sequence of choices of cheaper strategies,<sup>2</sup> the organization may accumulate resources (by forming inventories, reallocation of resources—even under constant technology, retention of profits, etc.) in order to expand thereby the Source and thus to set a process of expansion of the whole organization into motion (cf. (1)).

(3) Imbedding of the organization with others into a higher-order composite organization. This is cooperation among organizations. Some phenomena arising here are discussed in Sect. 12.

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<sup>1</sup> The converse of these does not necessarily make for greater organizational complication! Cf. above.

<sup>2</sup> By staking out a more modest aim, temporarily. E.g., the firm can, for the time being, be satisfied with a lower level of activity, not involving all of its resources which can thus be diverted in part to the accumulation process. We encounter here the difficulties of having to view strategies as subject to costs, as well as sequences of plays and their interrelation. There is always the possibility of considering such sequences as one play. But here we are concerned with more detail than that.



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Not every form of imbedding leads to an organizational complication of the unit in question; indeed, it can lead to great simplification for the organization in question, for example, by transferring some acts to others.

These expansions are different from another development that may occur, discussed in Sect. 7, "overorganization." There, too, a higher state of complication is assumed but without a simultaneous improvement in attaining the goal or aim of the organization. For expanding organizations either the aim is more nearly approached or the same degree of success is distributed over a wider group of the individuals that maintain the organization. The comparison with "overorganization" unfortunately involves again the notion of an equilibrium which we found lacking in precision at the present time, although accessible to intuition. If we could use a notion of equilibrium freely, we would say that overorganization is a disequilibrium, while the increase in organizational complexity due to an increase in functions of the organization does not destroy the equilibrium. In the absence of a clear definition of a static equilibrium, statements like this, involving dynamic considerations, are not very illuminating, however.

The following distinction is possible: (a) We have expansion of an organization if the same setup (i.e., the same order of complexity) is used more intensively. There occurs an increase in the operations, a wider range is covered, and the given aims of the organization are achieved to a higher degree. (b) We have

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growth of an organization, if concomitant with an increase of operations a transition to a higher degree of organizational complexity occurs and is necessary. The critical point where the transition is required is, at present, not known for most organizations. When growth occurs there is, as a rule, also a widening of the aim (i.e., more values that the organization attempts to achieve come within reach), or the given aim can be approached more closely. All this hinges on the precision with which the aim can be stated; otherwise the distinction between growth and wasteful "overorganization" is practically impossible.

These comparisons refer to organizations of given type, i.e., with comparability of aims. If there is no comparability we lack, at present, means to compare growth phenomena for organizations of different types. In the preceding section we found that even comparisons of size were impossible except in the most obvious sense.

If an anthropomorphic picture is wanted—and they come to mind almost automatically—a man may gain weight or he may grow in size or both. Gaining weight is like an expansion in the above sense. The organism has more work to perform, but is also stronger and can achieve more. If the gain in weight means merely getting fatter, then, as in overorganization, some ideal state has been exceeded and no advantage is gained any more. Only more work is imposed upon the body, with no gain to compensate for it. If a child grows into an adult, new aims appear which even in their changes are consistent with the previous ones

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(in particular the main aim, namely to stay alive, remains unchanged), and the more complex body functions the adult is capable of are correlated with these additional aims. This is closely analogous to what was stated above, restricted to any given type of social organization (centrally directed)..

Organisms have various growth curves—by no means restricted only to the familiar logistic curve. But they all have in common that the individual cannot exceed a certain point, thus limiting him in regard to his accomplishments. If too much is imposed upon the individuals by their environment they may die or otherwise collapse, i.e., seek an equilibrium at a lower level of accomplishment. Social organizations have a different alternative: The individual organization can transform itself into an organization of a different type; i.e., there is the choice of allowing growth to go on for the existing form of organization or to produce a sort of "mutation." If the grocery store grows very much, the choice may have to be made either to let it stop at a maximum level of performance compatible with its present form of organization or to reorganize it into a joint stock company with a very different organizational set-up which in turn has its now distant maxima. This freedom, which is not found in living individual organisms, indicates that at least in some respects social organization is different and possibly more complicated. Whether and under what conditions such "mutations"<sup>1</sup>

<sup>1</sup> The term "mutation" is, of course, again borrowed from organic life. But there it refers to different generations of individuals, while here we are talking about the same individual!

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actually will occur is none of our concern at present.

A further step can be indicated: The mutation need not mean the transformation to a known type of social organization. Invention, a very common achievement in the physical sciences, exists undoubtedly also for the social world. There is plenty of evidence before our eyes and much historical documentation, even if the record is not read with this notion primarily in mind. These inventions are not necessarily associated with the appearance of new technological devices, such as new means of communication, although these provide perhaps the biggest stimulus. Inventions of organizations are possibly more often observed for composite organizations, i.e., consisting of more than one centrally directed social organization, than for their components themselves.<sup>1</sup>

The problems of size not only are of general theoretical interest but have direct practical aspects. A good theory would tell us at what points of growth to expect bottlenecks, when organizations should be broken up into smaller components, transformed into federalized forms, etc.

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<sup>1</sup> It would lead too far to attempt any more elaborate discussion of invention. In particular, it is clear that the phenomenon is a high-order version of learning and is therefore associated with reorganization as discussed in that connection. Cf. Sect. 8.