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COMPUTERIZED MANAGEMENT INFORMATION SYSTEMS AND ORGANIZATIONAL STRUCTURES*

by

Zenon S. Zannetos and Murat R. Sertel

The impact of the new information technology on organizations has been the subject of much speculation ever since the usefulness of computers as managerial tools became evident. The surge of interest in the area is reflected in the literature which has now grown into a full spectrum of arguments. Some conclude that computers will lead us toward organizational centralization [(Leavitt & Whisler, 1958), (Lawrence & Lorsch, 1967), (Galbraith, 1968), (Delehanty, 1967), (Whisler & Schultz, 1962), (Whisler, 1967), and (Burck, 1965)]¹, while others contend that, although a definite direction is implied, the tendency will be toward decentralization (Forrester, 1965), (DeCarlo, 1967)². In between these two extremes the spectrum is filled by arguments, as best articulated by Dearden (1967)³, who advances that the new

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¹Among these, Lawrence & Lorch, Galbraith and Burck look at the issue mainly from the viewpoint of the amount of information to be processed and the ease and speed of communication. Others like Delehanty, Whisler & Schultz and Whisler looked at the experience of companies which introduced computers and were convinced that the fate of organizations, due to the impact of computers, was increased centralization. As quoted by Myers (1967, p.7), "Every time I look into a company that has installed computers, I see a change:", says Whisler, "and it's always in the direction of centralization."

²Forrester and DeCarlo, among others, arrive at this conclusion because of what they see to be the future course of events from the standpoint of social pressures, human values and incentives to individuals for innovation.

³In a paper which appeared in a recent volume by Myers (1967) on this subject, after looking at the impact of computers on profit centers, Dearden concludes that there will be "...no significant change in the degree of delegation of authority by top management..." (1967, p. 182).

information technology will be neutral in its impact on organizational structures, and by others who indicate that the effects will vary with the situation (Diebold, 1964).

We feel that the literature mentioned above in the area of organizational structures shows a certain lack of theory, but, even further, that there is the definite absence of an underlying framework of definitions, working assumptions, explicit axioms and rules of measurement from which to rigorously theorize. We realize, of course, that it is by no means easy to develop such an all-inclusive theoretical framework, and that to criticize those who wrote on the subject is in many ways not gallant. In fact, we wish to compliment all those who ventured in this difficult area and especially those who performed field work. Our comments, therefore, must be taken in this light, and as an effort to improve the methodology so that finer discrimination can be made on the consequences of information technology.

Specifically, the purpose of this presentation is to reanalyze the impact of computerized information technology on the design of organizational structures. To this end, we will proceed by:

- (I) Developing a classificatory framework and proposing an accompanying set of rules of measurement to be used in classifying organizations by relative structure;
- (II) Specifying some of the most critical factors favoring centralization and decentralization; and applying the above in:
- (III) Reviewing some of the recent attempts to measure change in organizational structure; and
- (IV) Inferring the impact of the new information technology upon organizational structures across the dimensions and through the factors analyzed in Section II.

I. Preamble

One of the greatest difficulties that we are facing today in the study of the evolution of organizational structures is inherent in our inability to define what we mean by centralization and decentralization. For purposes of communication we do quite well because everyone understands--at least in his own way--what these terms mean. In fact it may be that these terms are useful in conversation precisely because of their vagueness. Everyone can read into them whatever he wishes.

For measurement purposes definitions must be very precise because they must be amenable to empirical validation. For example, in order to establish the impact of the new information technology on organizational structures one must be able to perform before-after comparisons. Of those who have proposed definitions, most define centralization in terms of the relative organizational "level" at which decisions are made.⁴ If the types of decisions made within organizations were immutable, then by concentrating on the definition of "high" versus "low" one might have been able to obtain a meaningful measure of centralization and decentralization. The trouble is that the operational nature of decisions made at the various levels in the organization may change with major changes in the technologies that impinge upon these decisions.⁵ If, therefore, our definitions of centralization and decentralization cannot discriminate with respect to the type of decisions made at the various levels in the organization, a mere attempt to classify organizational structures by the "level" at which decisions are made can easily lead to circularities.

⁴These people, in effect, follow the definition originally proposed by Simon, who said: "An administrative organization is centralized to the extent that decisions are made at relatively high levels in the organization; decentralized to the extent that discretion and authority to make important decisions are delegated by top management to lower levels of executive authority." (1954, p. 1)

⁵This is actually a blessing: otherwise progress would be limited.

Some other problems which compound our difficulties are:

(a) one cannot observe and describe purely centralized or decentralized structures on the basis of definitions so far proposed. What we find in the real world is an impure compromise between these two;

(b) existing methodology does not handle changes in organization structures which affect the relationships between units at the same hierarchical level; and

(c) the definitions and measurements used in empirical research have been unable to discern and classify situations where a unit within an organization is forced to decentralize vis a vis its parent unit (a "without" relationship) and at the same time centralize from "within".

It is for the above reasons, more on which will be presented later,⁶ that we believe one must concentrate on highly discriminating definitions and measures which are based on a sound theoretical framework, if he is to impart a meaningful operational content to the notions of centralization and decentralization.

In order that we may be able to devise measurements, we have to first of all make clear what we mean by the measurement process. In our notion, measurement is a process by means of which criteria for classification by dimensions or characteristics are established. In this sense, for an unambiguous classification, there must exist:

(a) one to one correspondence between the measure and the characteristic being measured. That is to say, the measure must measure what it is supposed to and not give us ambiguous signals about causal relationships for classification, or worse, lead us to designate as identical what are commonly understood to be distinct or even opposite situations.

(b) the unit of measurement must be independent of variations in the

⁶ See our discussion under III Attempts Toward Empirical Measurements

characteristics of the object being measured and vice versa.⁷ This is necessary to avoid circularities or tautologies.

One of us has already discussed the reasons for preferring a classificatory measure which is based on the objectives of the firm (Zannetos, 1965). It was said at that time that, unless we classify relative centralization and decentralization on the basis of the relationships between the objectives of the overall unit and those of the subunit, we will not be able to make meaningful relative statements especially if we try to compare units across firms or even units within one firm. Also stressed at the time were the reasons behind our conviction that the notions of centralization and decentralization cannot be discussed in absolute terms, but only in relative terms. We must somehow refer to some benchmark, saying "relative to what it was before" or "relative to another organization". But again, in these cases, in order to make meaningful statements, which will be amenable to empirical validation, we must somehow associate the objectives of the unit with those of the firm in order to find out how much judgement is left for the unit to exercise. For example, within profit-oriented organizations, a profit-center setup is the epitome of decentralization, because the objectives of the total organization and its parts are almost identical.⁸ Notice that in this description the

⁷ If the system on which measurement is performed is of the Heisenberg type, i.e., if measuring the system affects the system, then this condition cannot be satisfied. If the system is affected in different degrees by different but otherwise equally "good" measurement operations, however, then clearly one should apply a measurement operation which least affects what is being measured. We are indebted to Mr. Prem Prakash for his having pointed out to us that what is known in the theory of dynamical systems - see, e.g., Bhatia & Szego (1967) - as the "group axiom" can fruitfully be interpreted as an expression that the system in question is non-Heisenberg with respect to observation. To express it in plain English, under this axiom it is assumed that the evolution of states is unaffected by our observing that evolution during its course.

⁸ It is recognized that within the framework of a profit-center organization structure some subunit managers may interpret their objectives differently than others, and, as a result, impose upon themselves a structure which is relatively less decentralized than it could be potentially.

judgmental content of decisions, as constrained by objectives is the important ingredient of the unit of measurement, and not the decisions themselves. Therefore, we must somehow define measures which will classify translations of objectives in terms of the information content that is introduced in the process of transformation.⁹ We realize that this is a very difficult task, and we have not as yet been able to solve to our satisfaction all the problems involved, but in our estimation this is one of the most promising ways of measuring relative centralization and decentralization.

Finally, we must note that if technological changes affect the overall objectives of organizations in the same way that they affect the nature of decisions, then we have not achieved anything with the proposed definition. We do believe, however, that this is not the case and that the overall objectives of firms are not as ephemeral as the associated decisions, which are, afterall, information-technology dependent. But, to repeat, the greatest challenge with the proposed definition will come at the time it is applied in actual situations, and we have not as yet submitted this approach to an empirical test.

⁹ The information which is introduced at a particular level in the organization, and which expresses the judgmental content of decisions at that level, appears as an objective datum to subordinate units.

II. Theoretical Determinants of Centralization and Decentralization

In order to be able to analyze the impact of the new information technology on the organization structure of the firm we must first delineate the theoretical factors and their dimensions which favor centralization and decentralization. A recent paper (Zannetos, 1965) by one of the present authors suggested that organizational structures will gravitate toward relative centralization if:

1) The objectives of the organizational entity are unified and indecomposable. By this we mean that the objectives cannot be easily divided (broken down) and be assigned to subentities which can operate as independent units. Therefore, if some type of a divisionalization is necessary for purposes of problem solving and making the tasks manageable, then a lot of top-level planning co-ordination must be done at a central location. If the objectives are not subdivided, then we have a structure that is highly centralized from within.¹⁰

2) In the process of accomplishing the objectives, it is necessary to co-ordinate operations so as to exploit complementarities that exist between the operations of the various subunits. These complementarities may be either technological or pecuniary and one mostly finds them in trying to achieve economies of size. The issues here are similar to those presented under (1) above but affect operational planning and operations rather than substantive objectives and top-level planning. If we find that operations are highly coordinated and programmed, then it appears that the organization follows the centralized master-planner approach.

¹⁰ In analyzing issues of centralization and decentralization, it is necessary to look at how the units are organized internally (from within), and also how they are related to their parent (from without). This is so, because a unit may be, let us say, relatively decentralized from without but highly centralized from within or vice versa. Later on (Section III-F) we will give an example where this issue arose.

The theoretical issues which favor relative decentralization are:

(1) The necessity for specialization. If units must be left alone to learn from experience, then they have to be allowed to exercise the necessary value judgement during the period of their isolation for experimentation and learning. This usually occurs in situations where (i) the operating environment is ever changing and necessitates flexibility, or (ii) the environment is not changing but its characteristics are unknown. In the latter case, once enough is known about the environment, the organization may function more efficiently if it reverts toward relative centralization, unless, of course, the knowledge that is gained serves as means to higher level experimentation and specialization.

(2) The number of channels necessary for communication, the amount of information flow, and the associated cost of operating the information system.

It has been pointed out in the literature by Simon (1954) and Zannetos (1965) that decentralized structures require fewer channels of communication, because they do not need as much information flow as do relatively centralized organizations. Obviously, the lower the degree of interdependence the lower the manifested need for exchange of information. And to the extent that the necessary channels of communication as well as the flows tend to increase in an explosive manner with the increase in size of organizations, other things being equal, the larger the firm the greater the tendency toward relative decentralization to avoid cluttering and confusion as well as cost.

(3) The need to reduce the instability within the organization. If the interdependencies between subunits are not checked, then the interactions, and the adjusting response to these, will create erratic behavior patterns within the organization. Furthermore, the continual need for response by a subunit to outside pressures will prevent it from specializing. To avoid these undesirable consequences of interdependence, buffers or "shock absorbers"

are introduced into the system to make subunits insensitive to uncertainties and variabilities that are created elsewhere. These techniques for containing interference and creating a semblance of stability result in a relatively decentralized organization structure.

As a measure of the potential instability generated within organizations by the interdependencies between units, Zannetos (1965) suggested the use of statistical covariances between divisional performances. He further pointed out that negative covariances normally favor relatively centralized solutions while positive covariances suggest buffering and relative decentralization. Subsequently (Zannetos 1965/6) these techniques were applied within two organizations. The results revealed that measures based on statistical covariances are useful as indicators of the necessity of organizational changes, and also pointed out the extremely deleterious effects of instabilities within organizations.

(4) Time sensitivity of decisions and operations, and the task characteristics.

We often find that, for certain types of operations, a delay in making decisions and in taking the proper action may bring about catastrophic consequences. So subunits are often allowed to operate in a more decentralized fashion, even in cases where the decision without a time pressure could be more efficient if made centrally. Of course, if the expert knowledge is located at the subunit level, then relative decentralization is more efficient.

(5) Psychological reasons. Social psychological and human relations experts [Argyris (1952), Haire (1963), McGregor (1960)] argue that decentralized structures must be preferred for reasons of human motivation. Therefore they would err toward decentralization often because of philosophical preference. One of the claimed advantages of decentralization--aside from the pure humanistic arguments--is that it provides the opportunity for training managers.

III. Attempts toward Empirical Measurements

We will now review some of the most recent attempts to describe and, in some cases, measure the degree of centralization and decentralization within organizational structures.

A. The Decisions Versus the Objectives as a Basis for Classification

One of the people who have been actively pursuing research in the area of computers and organizations for the last few years is a respected colleague of ours, Professor Myers. In his interesting paper "The Impact of EDP on Management Organization and Managerial Work" (1965) where he exposes the results of his work, he chose to define centralization and decentralization in terms of the "decision," as evidenced by the following statement: "Since decisions about the design of the system of managerial controls are made at higher levels in management, the clear implication is that both in its decision and implementation, the computerized system results in a more centralized organization structure" (Myers, 1965, p. 5).

As we have already pointed out, it is a little difficult to define and measure centralization and decentralization solely in terms of the level at which decisions were made before, as compared to where they are made later, for mainly three reasons: (1) Because decisions are always constrained by objectives which originate at higher levels. Unless, therefore, we analyze these outside constraints to determine their nature, we will not be able to ascertain what type of relationship exists (centralization or decentralization) from without. The decision itself may appear superficially to be the same. (2) Whenever a decision is taken, if it has operating implications, it generates constraints by introducing "objective information" and thus reducing the opportunity for judgment of subordinate entities (i.e., affecting centralization and decentralization from within). (3) Several dimensions of the decision making process, which do not necessarily relate to the issue of

centralization and decentralization, are affected by the information processing technology whether electronic or manual. One may, therefore, observe changes in the nature of decisions made at various levels in the organization, without being able to discern changes in the organizational structures.

To repeat, we prefer to concentrate on studying the impact of computers on objectives rather than decisions. Otherwise, every time anything occurs which affects the nature of decisions, then, automatically, the definition will become inapplicable. The only statement that we can then make is the rather tautological one, that the organization structure has changed because the information and control technology which governs the nature of decisions has changed. But we can say nothing with confidence about centralization and decentralization.

Even in the unlikely case where the information-control technology does not affect the nature of decisions, still the above definition does not help us very much. In order to clarify our arguments, let us look at the accounting control system. It has always been designed centrally, and, in fact, one of the major motivations to install computerized information systems has often been the desire of top and middle management levels to free themselves of this bondage. Now we install the new systems and we are told that we only succeeded in tightening the noose around our necks. In view of all this confusion, one may ask the question, "were not decisions about organization structures always made at higher levels?"

That is to say, where could one find the locus of decisions regarding the establishment of decentralized organization structures? Obviously, at the top! But as one will notice, Myers' definition by its nature classifies such a decision as centralizing, thus giving rise to an unwarranted paradox.¹¹ In our

¹¹ On the basis of Myers' definition, one can prove a "non-existence" theorem of decentralized organizations.

estimation, the questions that confront us here are: 1) What are the reasons for relative decentralization in some cases in the past? If the decentralization was in some cases necessary because of the inability of management to comprehend and encompass, in its decision making, complicated interactions of known nature (that is to say they had difficulty in tracing through the relationships whose impact management knew), then computers will centralize. If the difficulty is in the nature of the relationships, however, especially of those within units, then undoubtedly the organization structure was forced toward decentralization and, in our estimation, it will continue to be so in the future, as we will point out later, because situations such as this necessitate capabilities of design and analysis of experiments at the point of action.

To elaborate a little further, if the reason for decentralization within a company is the inability of the higher levels to cope with the processing of detailed data, then computers will undoubtedly lead to centralization. If, however, the reason for the decentralized structure, again in a relative sense within a firm, is the ignorance of the higher levels, of the functional relationships that are applicable in the specific situations, and, in order to determine these, experimentation must be established at the level of data generation, then, in our estimation, the computer may lead to further decentralization.

We must stress here that many previous problems which were of management concern will no longer be so with the introduction of the computer. But the consequence of this need not be centralization. Consider the not unlikely case where programmable tasks are automated and many of the remaining tasks of top management are degraded and made at lower levels. For example, many investment decisions, financial decisions, manufacturing decisions and product line decisions may be made at lower levels with the aid of computers, while before these were made without computers at top levels. Can we call this centralization? Not necessarily, for, in a sense, it is relative decentralization. But the most

important impact of the change depends on the answer to the following question. How will top management in this case fill its time schedule? With extra leisure? Of course not, since it is very likely that management will now become occupied with problems of a different nature, problems that include as endogenous variables many of the planning variables that used to be considered exogenous to the management information system. It will be, in short, a different managerial world. And in order to decide whether a subunit with this new structure is now more centralized or decentralized, we must analyze its objectives vis a vis those of the firm. Looking at the problem in this light, the decentralization content within the total organization, that is to say the average judgmental content of "lower" managerial decisions, will probably increase. And this because, with programming, some middle and low management levels will be eliminated; and the fewer the tiers in the hierarchy, the greater the overall scope of the decisions that will take place in the average tier, hence more decentralized content.

B. The Organization of the Computer Facility and Its Impact on that of the Firm

Many, including Myers (1965, esp. p. 9, 14) claim that electronic data processing introduces centralization because it creates "a central center getting inputs of data from a number of different traditional functions and providing data to them." Of course the accounting system does the same thing, but let us limit ourselves to the computer facility. It is granted that, to achieve economies of specialization, we may need to have central computer installations. But can we really equate the structure of the data storage and processing system with the structure of the information system, and then equate the latter with the structure of the organization itself?¹² If we have central university libraries

¹² On this issue we share the views of Klahr and Leavitt quoted in Myers (1967, p.10) and Dearden (1967, p. 181) who do not see a necessary relationship between centralization of the computer facilities and centralization of organizational structures.

can we necessarily say that we have centralized research or centralized usage based on such libraries? Will we, as teachers or researchers, lose part of our independence if the rules for acquisition of books and storage of data as well as retrieval remain unchanged? For example, with a project such as INTREX at MIT, access to library information may be obtained through telephone by means of a time-shared computer system; but we should be surprised if one could discern any effects of consequence on the organizational structure of MIT because of this innovation.

We must admit that with huge central computer facilities, the potential is there for eager individuals to exploit their strategic position and concentrate a lot of controlling power under the computer facility. In this way, through control of information, they might indirectly affect the decision-making processes and the objectives of the organization, and consequently distort the whole organization structure. This can happen, but there is no fundamental reason why it should. If the people running the computer facility view themselves as operating a service organization, like a power plant, then one need not worry too much about the consequences of potential misuse of power. The potential for centralization is inherent in any huge vital central facility. After all, if the power plant shuts down in winter we can be frozen out, but not many custodians of power plants would exploit this potential power to bring us to our knees.

C. Salaries of Top Management as a Measure

Professor Whisler, in his challenging paper, attempted to devise surrogates for measurement and, as the most promising measure, he used the percentage of salaries that are allocated to the top 2, 4, 10, 25 percent people in the management hierarchy (Whisler, 1967, pp. 28-32).¹³ In effect, he postulated

¹³ He also implicitly used the number of hierarchical tiers as an index for centralization and decentralization, implying that an elimination of tiers implies centralization. Also he claims that span of control is a good measure. Hence he claims that a mere reduction in size permits centralization evidently irrespective of task characteristics.

that if the percentage of total salaries received by the top, let's say, 5 per cent in the managerial hierarchy increases, then this implies centralization, and if it decreases it implies decentralization.

We believe that the above measure is inappropriate. It can be easily shown that an increase in the percentage of salaries drawn by the top echelons in management can also occur under a re-organization for decentralization. Taking first the case where total employment has not increased, more delegation of authority within the top group would most likely be accompanied by an increase in the percentage of salaries received there, thus irrevocably invalidating the usefulness of Whisler's measure.¹⁴ Also, in the case where we introduce additional tiers in the hierarchy, which, according to Professor Whisler, is a sign of decentralization, his definition gives us conflicting signals. On the one hand, by increasing the number of tiers, he would have to claim that the organization has decentralized. On the other hand, however, we can show that such a re-arrangement could increase the percentage of salaries drawn by the top percentage of managers, implying, according to his salary measure, that we have centralized. One can very easily construct an example which shows the opposite effects.

D. The Research Setting and Its Relevance

Professor Whisler as well as Professors Myers and Delehanty have conducted most of their research with insurance companies. Since most of the functions of these companies involve procedures and repetitive processes, on the basis of our theoretical formulations, they are, by nature, carried out better within a centralized structure. Their product is standard, that is to say, standard policies which have been subject to very little innovation; there exist unified

¹⁴ Of course, if he views the top versus the rest, then the measure will point out different things depending on where one draws the line between "top" and "low" levels of management. The reason for this is that the measure, even if relevant, does not discriminate between without versus within relationships.

objectives and, for the achievement of these objectives, there exist the utmost complementarities between staff resources. Above all, to re-emphasize, there is a conscious effort to discourage deviation from central policies and procedures, and, to a great extent, innovation. These characteristics are the sinew of centralization. There is no need to adjust to changes in the environment or push the frontiers of knowledge in the situations that these people have studied. Hence, with electronic computers, these companies are now able to do what they should have been doing but could not do in the past. Thus, the computer has not changed the nature of their operations or shown them new methods of doing business, but, as we have said, it has merely enabled them to do better what they originally wanted to do and should have done anyhow. In effect, here we have a case where the reason for prior decentralization was the inability of higher levels to cope with the processing of detailed data and control by remote means, so the advent of computers helped them centralize.

If we look at the way these insurance companies carried out their operations, we will find that they had neither sufficient channels of communication nor any central processing capability realizing economies of size. Therefore, if any instability existed in the system, it was not due to the fact that the technology was unknown, but, rather, because there was not enough capacity to handle the data processing and the channels of information were clogged. Notice, also, that the time sensitivity of decisions made by these companies is very low, and that there are no particular task characteristics that will necessitate specialization of functions at low levels with information inputs necessary for such specialization generated by the immediate environment of the decentralized units.

E. Impact of Information Technology on the Organization of Operations Control Versus Decision Making

Another shortcoming of most studies is that they restrict their focus to the impact of computerized systems on operations control, that is to say, the process by means of which observations on the use of resources are collected and signals generated for possible remedial action. We strongly believe that one must look at the nature of decision making and the factors constraining it before he can safely make statements about centralization and decentralization, because decision making and control are not identical.¹⁵ Often we find that electronic data processing will affect the two processes, control and decision making, in opposite directions. For examples of such confusions between controls and decentralization see Dearden (1967).

F. Centralization and Decentralization from Within vs. Without

Further confusion arises because authors neglect to distinguish between relationships existing between units and those existing within units of an organization. A case in point is a paradox which Whisler (1967) encountered in his findings. He noticed that his salary measure, which we already discussed, when applied to the divisional level of a company which, by policy, was decentralizing, showed further centralization. Of course, as we stressed, the salary measure is ambivalent. In this case, however, it just might have been measuring correctly, since a division could be decentralized from without, yet centralizing from within. In other words, the divisional heads in this case may have assumed more responsibility at the expense of both the levels above and below. We feel that decentralization from without can give the results shown on Table 2 (p. 29) of Whisler's paper without necessarily the changes being accompanied by any centralization from within the division. Also,

¹⁵ The imposing of constraints limiting the judgments of decision makers may be viewed by some as part of the control process. We view it as part of what we call planning process control as distinguished from operating process control, the latter being the process which guarantees efficient allocation of resources given the plan and the decisions which follow from it.

in the above mentioned case, there is a confusion as to the relationships between the number of tiers in a hierarchy and the centralization-decentralization content of any particular hierarchical level.¹⁶

G. Computers and the Role of Management

We have also noticed that there is another conflict and confusion that is often caused by failure of many people to stress the fact that the computer will change the role of management. No doubt, with the aid of sophisticated computer systems we will be dealing with managerial situations that we have not been aware of before, because we could not rise to the required level of abstraction. In effect, the computer can be used as a means to an end, the end being more high level planning and more high power decision making. In this sense, the computer may be viewed as being in general neutral to the issue of centralization and decentralization, affecting the organization structure only through its effects on management and managerial functions. In any case, however, in order to evaluate in which particular direction the electronic data processing and information systems will push us, we first have to analyze each particular situation on the basis of our theoretical framework, specify the various characteristics of the organization, its objectives and operations, and, on the basis of this analysis, estimate the net impact of the new technology. More often than not, we will find that in certain aspects we will be pushed toward centralization and in others toward decentralization. It will, therefore, be up to management to balance these and find the dominant characteristics of its own operations before it can decide whether, in conflicting situations, it should move toward centralization or decentralization.

¹⁶For this see (Whisler, 1967, pp. 27-34)

Another point that we must stress here is that the organizational structure of the firm will be a mongrel of pure centralization and pure decentralization, the exact nature of the mixture varying from "level" to "level" and from function to function. Given that units within the firm operate mostly with multi-dimensional indices of objectives, for certain functions the sub-divisions of subunits may operate in more decentralized fashion than for others. Such flexibility will be required if we do not want to stifle innovation and regimentally mold the organizational structure of the firm.

Note that, normally, the greater the time sensitivity of decisions, the greater the tendency toward decentralization. Nevertheless, some firms may try to avoid this through detailed advance planning at a higher level and by then designing constraints and instructions (that is to say, detailed decision rules for all possible occurrences) aimed at guaranteeing consistency between plans and operations at all levels. This, of course, is relative centralization. With on-line real-time systems, some of this planning may disappear, but, conceivably, some can be performed at lower levels in real-time, especially if the lower levels have access to the central data base. This would lead to relative decentralization.

IV. New Information Technology and Organization Structures: Conclusion

We will now use the discussion of the previous sections to focus our attention more closely on the organizational consequences of the new information technology. In particular, we will take our theoretical determinants of centralization and decentralization one by one and view them in the context of computerized systems.

A. Factors Normally Favoring Centralization

(1) One of the main reasons for centralized planning and co-ordination is the existence of unified and indecomposable objectives. The reason for indecomposability, however, may be purely practical, as when mathematical decomposition techniques could actually be applied if it were not for the virtual infeasibility of carrying out the required computations manually. In such cases, the advent of computers may be a decisive factor toward decentralization, since decomposition techniques become practically applicable and the old objective or objectives can now be broken down into components which can be assumed by relatively decentralized divisions.

If, on the other hand, the objectives are indecomposable for fundamental reasons, so that no amount of computational facility can solve the problem, then, computers or nor computers, the organization will have to continue to be as centralized as before.

Thus, to the extent that the indecomposabilities of objectives are of a practical nature which can be overcome by an increased ability to compute, the new information technology may exert a mild influence toward relative decentralization; otherwise the impact of computers will be none.

(2) Rather dually, but at the more operational level, the other theoretical factor which tends to centralize organization structures is the necessity to co-ordinate operations and so exploit both the complementarities that exist between resources and operations, and the economies of size that can be potentially realized. Here we believe that the introduction of computers can have two opposing consequences.

On the one hand, the faster transmission of information will enable the organization to allow more flexibility for planning at the operating level. If the inability of units to be informed in time and adjust to non-planned actions was the main reason for which initiative was curbed and de-

viations from plan were not allowed, then the new technology of data processing and transmission will lead toward relative decentralization.

On the other hand, we now have a new common resource (see complementarity of resources above) to contend with, namely the computer, the efficient use of which requires co-ordination. If, therefore, the decision processes and operations of the subunits critically depend on this facility, then we will see a tendency toward more co-ordination from "above" and, therefore, more centralization.¹⁷ We must further add, however, that "time-sharing" systems with a semblance of facility divisibility and fast access mitigate this co-ordinative necessity, so that, on this score, the operations may be either not affected at all or we may see an inclination toward relative decentralization.

B. Factors Normally Favoring Decentralization

(1) One of the factors which favor decentralization is the need for specialization. Here we note two cases: (a) the case where the environment is ever changing, and (b) the case where it is unknown but not changing. If the environment is ever changing and pattern recognition capabilities are necessary, the computer may lead to a relative decentralized structure, because it cannot as yet assimilate and transmit patterns upward, provided that it can bring down to the operating level higher echelon constraints. If the last proviso does not hold, the computer will be neutral. In the case, however, where the environment is unknown but not changing, the computer eventually will lead toward relative centralization. And this because, once the knowledge is obtained through decentralization, then centralized procedures will be the

¹⁷ Some organizations, no doubt, will attempt to reduce the interdependence by obtaining their own computer, buffering themselves with excess resources.

best means for disseminating the knowledge gained and instructing the various subentities within the organization as to how they can cope with it.

(2) The cost associated with the number of channels of communication and the likelihood of cluttering were among the reasons for relative decentralization in the past. Given that the new computers have huge capacity and low cost, and in view of the progress in hardware and software design, we believe that in the future we will see a tendency for relative centralization on this score.

(3) Still we have to contend, however, with possible destructive interference among units and instability of the behavior and performance of the overall organization. If the relationship among units and the speeds of adjustment of units are such that the system can give ample warning time for an impending change, and provided that these responses will not interfere critically with the specialization of units, then the computer will push organizations toward relative centralization. Otherwise, if specialization is more important and/or the warning lead time is too short, then the decentralized buffers (shock absorbers) will continue.

In order to be able to predict what impact the computers will have on the instability inherent in some organizations, we will have to fully understand the reasons for such instabilities. As has been pointed out previously (Zannetos, 1965), positive covariances between the performance of divisions (which normally lead organizations toward decentralization) are the result of dynamic changes in the environment at the operating level. We believe therefore that computers will in most such cases lead us toward further relative decentralization.

(4) Two other reasons which presently favor relatively decentralized structures are the time sensitivity of decisions and the task characteristics.

If time sensitivity is the dominant reason, then the computerized information system will enable higher levels to respond in ample time and, therefore, bring about relative centralization. If, on the other hand, the task characteristics are as described under (1) above, then we have consequences similar to what we described when we considered the various dimensions of the applicable environmental conditions.

(5) The psychological reasons concerning motivation and also the need for training managers will no doubt remain and even become stronger with the advent of the new systems. Therefore, we expect to lean more heavily toward decentralized structures for these reasons, especially since the new integrated information systems can bring higher level considerations to low levels, and also allow the introduction into plans and operations of factors which were formerly exogenous to the organization.

As we have seen, then, we cannot make all-inclusive statements regarding the impact of information technology on organizations. We must analyze the impact across the various dimensions of centralization and decentralization, and see whether we observe any dominant patterns. If no dominant patterns are discerned, then we must trade off at the margin between the various opposing tendencies in order to decide which units should be relatively centralized or decentralized and for what functions and for how long.

It may be that the arguments which we have presented here portend the demise of the terms centralization and decentralization. Although they served us well in the past, and may have helped us realize the progress we claim, these terms now appear too simplistic to describe present day complexity. Any attempt to patch up the definitions will not, in our estimation, bring about any worthwhile results, because the terms will become increasingly more and more complicated and at the same time more and more meaningless. We should no

doubt be looking for new definitions and measurements of the phenomena we wish to describe. The notion of statistical covariance and the analysis of covariance matrices for the underlying cause and effect relationships may help in this respect. However, a necessary prerequisite for any attempt toward measurement is the definition of the appropriate input data which will provide useful indicators on the interactions between organizational subentities. And this throws us back to the careful definition and partitioning of objectives.

In closing, we would like to make it clear that we certainly do not consider what is offered here as the definitive answer to the earlier call we had made for an underlying theoretical framework to be used in analyzing problems relating to organizational structures. Although we believe that this paper is an advance over what exists in the literature we mentioned and reviewed, we would like to stress the need for further work in this direction and add that we ourselves are in the midst of ongoing research in the area. Some of the results of our further efforts will be reflected in a forthcoming paper which attempts to measure the cost and value of changes in organizational structures.

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