

# The Impact of Electronic Data Processing on Organization and Management Theory

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## A METHODOLOGICAL NOTE

This study is an attempt to evaluate the need, progress, and logical future of computer utilization in modern organization. That is, an analysis of the existing effect and probable influence of computer use on public organizations. There are several types of automation processes affecting organization: i. e. production methods, communication systems, transportation systems, and office operations. Each of these must be analyzed separately. But in this paper my concern is limited to the affect of EDP on organization and management, particularly its impact on organization structure, decision-making, and personnel.

## INTRODUCTION

During the past decade social scientists interested in human behavior as expressed in formal organization have concentrated their research on the determinants of organizational effectiveness. Their primary objective has been the determination of the relationship between individual and organizational goals. Empirical efforts have been focused on the relationship between individual motivations and satisfactions and organizational measures of effectiveness, and the way these relationships are affected by supervisor - subordinate relations, work group relations, job content, and organizational policies and practice.

Studying change facilitates the identification of essential elements and their relationships; attempts to effect change tests our working knowledge of individual and organization behavior. The introduction of automation in the factory and electronic data processing in the office has presented social scientists with unique laboratories for investigating the dynamics of organization and the process of change.

As part of a changing mode of life, automation has become a by-word of progress. A by-word with a variety of intonations, lacking an accepted definition or common understanding. Included in this dynamic aura of promise and confusion is the electronic computer.

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Unlike other developments or phases of automation, the electronic computer is not an end product, rather it is a tool for producing end products or performing services. It is a tool that is proving to have application to an ever-widening universe of established processes, and to the development of new activities.

It has become common to predict that the concepts and methods of management are undergoing a revolution because of the electronic computer. The new method and concepts evolving are described in such terms as cybernetics, information theory, and electronic data processing. The combination of the high-speed computer and mathematical models used for such administrative processes as decision-making has produced forecasts of profound change in the practices of management in private industry and in public agencies. For example, Herbert Simon predicts major changes in the role of management, that the utility of computers will include the performance of tasks now being done by managers :

During the next twenty - five years, the job of the managers will undergo some major changes, as machines take over more and more of the activities that now seem too complex and "high level" ever to yield to automation. The chances are strong that, even before the decade is over machines will be able to perform any function in the organization ...and this includes the "thinking" and "deciding" tasks that are the basis of the manager's job.<sup>1</sup>

In contrast, machine - thinking and deciding is referred to by some as the "science fiction" of management. Nevertheless, creative thinkers and technicians continue to see opportunities for application in specific settings and to develop automated procedures for making better decisions than managers can make on the basis of experience alone.<sup>2</sup>

The ever - increasing complexity of society and its effect on performance is nowhere more apparent than in the management of the public service. The old methods and customary practices no longer suffice for efficient administration in a would - be modern environment. New ideas, methods, and techniques are needed. And in order to achieve

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<sup>1</sup> Herbert A. Simon, "Management by Machines : How much and How Soon ?," *The Management Review*, 49 : 12, November 1960.

<sup>2</sup> Melvin Ansher, "The Manager and the Black Box," *Harvard Business Review*, 38 : 87, November-December, 1960.

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maximum results from these new techniques and tools, the social and political system must facilitate their utilization.<sup>3</sup>

### Definitions of Terms

The words "organization" and "management" are of course familiar to students of public administration. In the context of this report, however, these two words will be redefined along with two terms relating the discussion of EDP and its impact on management problems and automation.

To define organization as an entity is to assume that a positive line of demarkation exists between it and administration and management. Dwight Waldo explains these terms in the light of an analogy :

Organization is the anatomy, management the physiology, of administration. Organization is structure ; management is functioning. Each is dependent upon and inconceivable without the other in any existing administrative system, just as an anatomy and physiology are intertwined and mutually dependent in any living organism. We are close to the truth, in fact, when we assert that organization and management are merely convenient categories of analysis, two different ways of viewing the same phenomena. One is static and seeks for pattern ; and other dynamic and follows movement.<sup>4</sup>

While there is no universally accepted definition of Electronic Data Processing, the following definition by Valliant Higginson is clear and useful :

Electronic Data Processing (EDP) is the collection of data ; the subsequent sorting, analyzing and storage of the data by means of a computer ; and the summarizing and transmitting of the resultant information."

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<sup>3</sup> John W. Sullivan, *The Electronic Computer: A Change to Organization in Public Administration* (Unpublished DPA's dissertation, University of Southern California, Los Angeles, 1961), p. 3

<sup>4</sup> Dwight Waldo, *The Study of Public Administration* (New York : Doubleday and Company, Inc. , 1955) p. 6

This definition makes a distinction between "data" and "information"; the former being a mass of unstructured facts, and the latter, structured facts assembled in a meaningful fashion. Not everyone agrees with this definition of data and information, with the result that the terms are often used synonymously, nevertheless a distinction appears in EDP terminology. There is a tendency to refer to all of this equipment as "hardware" in contrast to nonequipment items, such as machine instructions, which are known as "software" and to various combinations of equipment as "configurations."<sup>5</sup>

Likewise automation should refer only to those forms of technological change or mechanization which combine the elements of the computer, transfer devices, and automatic controls.

### THE DEVELOPMENT OF EDP

Few developments of our age have captured the imagination of the public as has EDP. Almost everyone has marvelled at the exploits of the so-called "giant brains" which have been reported in the newspapers and magazines and on television screens. Much of this publicity is inaccurate and misleading, but behind the publicity is a series of accomplishments and promises of future accomplishment which indicate that EDP is one of the most important developments of the 20th century.

When the history of our age is written, it should record three profoundly important technological developments; nuclear energy, which tremendously increases the amount of energy available to do the world's work; automation, which greatly increases man's ability to use tools; and computers, which multiply man's ability to do mental work.<sup>6</sup>

The first electronic computer, the ENIAC (Electronic Numerical Integrator and Calculator) was built at the University of Pennsylvania in 1946 and calculated at the rate of 5,000 additions a second. The ENIAC was not a general purpose machine, but was built to solve particular calculations connected with ballistics problems at the Aberdeen Proving Ground. It is still in operation.<sup>7</sup>

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<sup>5</sup> *Managing with EDP, A Look at the state of the Art*, American Management Association, Inc., AMA Research Study No. 71, 1965, p. 19.

<sup>6</sup> E. Wainright Martin Jr., *Electronic Data Processing, An Introduction* (Illinois: Richard D. Irwin, Inc., 1961), p. 1

<sup>7</sup> R. Hunt Brown, *Office Automation* (New York: Automation Consultants, Inc. 1959), p. II, H. 1

About this same time University of Pennsylvania professors Eckert and Mauchly designed the BINAC (Binary Automatic Computer) for Northrop Aircraft, Inc. In 1950 the Eckert-Mauchly Computer Corporation became a subsidiary of Remington Rand, and in 1951, the first UNIVAC (Universal Automatic Computer) was installed in the U. S. Bureau of the Census. The first IBM 702 (large scale computer) was installed in 1955. All of these early installations are reportedly still in service.<sup>8</sup>

The most recent developments in the computer field are sometimes described as third generation computers. The first generation utilized vacuum tubes. The second generation is usually associated with the advent of the transistor and ferractors which replaced the tube. The third generation, introduced in the year 1961, utilizes an internal thin-film computer memory and is capable to nano-second (billionth of a second) switching speeds.<sup>9</sup>

Potential computer applications in both the scientific and office data processing fields appear to be boundless, especially with the development of smaller solid state computers that are within the cost reach of smaller business. Institutional and individual inertia are the major road blocks to their utilization. It seems likely the art of using and applying the computer to problems, and not the engineering of the machines, is and will continue to be the limiting factor in their use.<sup>10</sup>

The editors of *Business Week* classified computer applications for data processing into three areas: clerical work, decision-making, and policy determination. Up to this point in time, the emphasis has been on the first area, since management has traditionally analyzed its communications in terms of countable clerks and pieces of paper handled. The decision-making area actually starts where clerical work leaves off, and it is at this level where the computer can start "tumbling the department walls down." Their use in policy determination is more uncertain. The one thing the computer is doing so far in this area is forcing management to reappraise what data they really need and determine how the computer can furnish these data.<sup>11</sup>

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<sup>8</sup> *Ibid.*, p. II, H. 2

<sup>9</sup> William A. Carr (ed), *Office Automation News Bulletin*, (New York: Automation Consultants, Inc., December 31, 1960), p. 2

<sup>10</sup> John A. Postley, *Computers and People* (New York: McGraw-Hill Book Company, Inc., 1960), p. 19.

<sup>11</sup> *Business Week Reports to Readers on: Computers; Social Reports on Major Business Problems* (reprinted from *Business Week*) New York: McGraw-Hill Publishing Co., n.d. (unnumbered pages.)

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Viewing the spectrum of data processing is more like peering into a kaleidoscope than into a microscope. The size of a company, the number of computers it has, and the length of time it has used computers have little or no bearing on the company's success with EDP. The relevant factors are the support and interest of the company's management, and its selection of activities to be computerized.

As pointed out by the Stanford Research Institute, computer applications serve four basic purposes. They can:

1. Reduce operating costs, either directly or indirectly.
2. Lower working capital requirements, thereby releasing funds for investments that yield a higher return.
3. Improve the ability of a company to serve its customers.
4. Enhance the effectiveness of activities that produce long-range improvements for a company.<sup>12</sup>

Applications which bring about long-range improvements generally involve long-range planning and top-level decision-making, by means of analysis of variables and simulation techniques, and better control procedures.

The first large-scale fully automatic business data processing system was delivered to the U. S. Government in 1951 (Bureau of the Census). Since that time, the use of these systems in the U. S. Federal Government has steadily expanded.<sup>13</sup>

For the most part, this has been due to advances in technology, the population increase, and an ever-expanding demand for government services. The great volume of data in some government operations evidences the tremendous problems involved in recordkeeping, accounting, budgeting, and reporting operations. Thus the Social Security Administration is currently maintaining wage records for over 120 million accounts, which requires the processing of 240 million wage records annually. The increased demand for information and services has to be countered by increased efficiency in organizations and data processing, if the process is to be kept within reasonable bounds of cost and speed of action.<sup>14</sup>

In summary, the general impact of EDP on organization and management is felt in five general areas:

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<sup>12</sup> Higginson, *op. cit.*, p. 45

<sup>13</sup> U. S. General Accounting Office, *A Special Report to the Congress of the United States A Survey of Progress and Trend of Development and Use of Automatic Data Processing in Business and Management Control System of the Federal Government as of December 1957*, p. 2

<sup>14</sup> *Ibid.*, p. 6

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1. A decrease in the number of persons required to do a job where output demand governs. This impact is feared by workers and labor unions because they are afraid that automation will lead to unemployment.

2. An increase in output per person. This impact needs no explanation, because EDP is certainly a very good example.

3. A change in the functions of person or persons involved. To avoid unemployment, persons displaced because of the impact of automation may have to change their functions or be retrained for a new assignment.

4. A change in the form of the organization resulting from the altered person-machine utilization patterns. The impact of EDP will reduce the number of line or operational personnel, but the number of staff functions will be increased substantially.

5. A change in the work methods within all or parts of the organization. It is foreseeable that in the future the systems analyst, systems engineer, and computer programmer will play a much more important role in the work methods of the organization.

These are the general impacts of EDP on organization and management. But some authorities even go further by pointing out that EDP not only has a serious impact on organization, but on the entire society as well. The problem of unemployment is a very good example.

### THE IMPACT OF EDP

The EDP revolution has initiated a number of trends which are culminating today in major technological changes in office management. The sharp rise in office white collar employment during recent years has been associated with a substantial increase in paper work. This in turn has led to the development and introduction of electronic devices for handling the ever-growing volume. Thus EDP equipment is now organizing and computing information at prodigious rates. The "white collar" employee, who tends to respond only occasionally to the demands of modern technology, is now confronted with the necessity of relating to a machine environment. In this respect, these employees are less well-prepared than their counterpart "blue collar workers" in the factory.

Besides affecting the work lives of the employees, automation in the office is bringing about changes in the structure of organization. Not only are new hierachial patterns emerging, but certain traditional concepts of the role of top and middle management are

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changing. And EDP has affected decision-making processes and reshaped the functions of many high level executives. <sup>15</sup>

### The Impact of EDP on Organization Structure

Organizational structure has been of systematic interest to sociologists from at least the time of Weber ; but its study in analytical terms has recently engaged social scientists. During the past decade, political scientists, psychologists, and economists have turned their attention in this direction. The necessity for further interdisciplinary work in the institutional aspects of organization has, for example, been stressed by March and Simon among others. <sup>16</sup>

The introduction of Electronic Data Processing systems requires such basic changes in personnel and procedure that change in formal organization structure must be expected. In addition, substantial changes in working relationships between organizational units should be anticipated. The use of EDP, for example, reversed the trend from decentralization toward more centralization. Divisional and departmental lives are affected, operations consolidated, and layers of administration reduced. Similarly, EDP stimulates two types of recentralization. One relates to the intergration of specific functions and affects primarily the internal organization of the company. The other involves the regrouping of entire units of the operation and causes sweeping changes in external structure. <sup>17</sup>

Leavitt and Whisler believe that the organization chart of the future may look something like "a football balanced upon the point of the church bell." The football, of course, is top management and here is where individual autonomy, group decision-making, and so on, should arise more intensely than ever. It can be expected that will be dealt with quite independently of the bell portion of the company, with distinctly different methods of remuneration control and recommendation. <sup>18</sup>

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<sup>15</sup> Ida R. Hoos, "When the Computer Takes Over the Office," *Harvard Business Review*, Vol. 38 No. 4 July-August, 1960. p. 107.

<sup>16</sup> James G. March and Herbert A. Simon, *Organizations* (New York : John Wiley and Sons, Inc. , 1958). p. 83.

<sup>17</sup> Hoos, *op. cit.* , p. 106

<sup>18</sup> Harold J. Leavitt and Thomas Whisler, "Management in 1980's," *Harvard Business Review*, 36:41, November - December, 1958, p. 47

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### The Impact of EDP on Management

The installation of extensive electronic computer and peripheral equipment cannot help but affect management. In the past, each segment of the total data processing system belonged to various departments of an organization. But this is going to change. In making the transition, however, there will be difficulty in breaking down the vested interest and department barriers that have to be broken down.<sup>19</sup>

Many executives fail to realize the impact that this will have on organization. There will be reluctance on the part of departmental managers to accept the proposal that clerical and administrative procedures can be most efficiently performed centrally. The potentials of presently available equipment are great ; the realization of these benefits requires progressive thinking and the avoidance of hampering restrictions arising from traditional concepts and old-fashioned methods.<sup>20</sup>

The affects of EDP on corporate management are certain to be large. Melvin Ashen of the Carnegie Institute of Technology, for example states that the new information technology will revolutionize the decision-making process and thereby bring about radical changes in organization structure and administration. Some of the predicted changes are :

1. An upward shift of the boundary between planning and performance, as a result of which many planning responsibilities will be removed from middle-level managers.
2. A reversal of the recent trend toward decentralized operations with top management taking on a much larger share of the innovating, planning and creating functions.
3. Radical reorganization of middle management structure, downgrading the status of some jobs and upgrading others.
4. The appearance of a sharper, more impenetrable demarcation between the top and the middle of the organizational structure.<sup>21</sup>

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<sup>19</sup>E. Frederick Halstead, "Data Processing and Company Organization," *Journal of Machine Accounting*, 2: 16

<sup>20</sup>Philip Gustafson "What Management is Learning from the Computer", *Nation's Business*, November 1958. Reprinted by State of California, Serramento: State Personnel Board. 1960, p. 1

<sup>21</sup>Dunlop, *op. cit.*, p. 43

With the introduction of computer technology the role of middle management may be substantially attended. Two schools of thought prevail. One holds that the job of middle management will be enriched ; the other that the number of middle management jobs will be greatly reduced.

The adherents of the enrichment school contend that computerized activities will reduce middle management's routine tasks and open up opportunities for more creative work, problem identification, and more thorough implementation of these tasks. Melvin Anshen contends that :

The tasks of middle management will resemble more closely, not less closely, the tasks traditionally associated with top management because of heightened concern with problem identification, decision implementation, and now new implementation ; and new opportunities to find solutions, middle managers will be top managers in miniature. They will have more occasions to exhibit their capacities, build on experience, and qualify for advancement.<sup>22</sup>

Likewise, Likert predicts that the tendency toward centralization as a result of the new information technology will be accompanied by hostile attitudes and resentment not only among nonsupervisory employees, but also among lower and middle levels of management. The latter will almost surely react adversely to the substantial in their sense of importance and personal worth which this development will bring about. In the light of his newer theory of organization it is not necessary to centralize decision-making to obtain the full benefit of computers. In fact, companies operating under the newer theory would make more extensive use of computers than do companies whose operations are centralized.<sup>23</sup>

In "Management in the 1980's" Harold Leavitt and Thomas Whisler theorize, however, that the introduction of the "mechanical brain" to organization life means that decisions, particularly at the middle management level, can be transferred from the human being. Among their many prognostications, most of which seem to be turning out well, were two about middle management :

1. Its ranks would be reduced, and business organization structure would be consequently "flattened".

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<sup>22</sup> Anshen, *op. cit.*, pp. 85-82.

<sup>23</sup> Rensis Likert, *New Patterns of Management* (New York: Mc-Graw-Hill Book Co., 1962) p. 120

2. Many middle management functions would be routinized, downgrading many middle managers.<sup>24</sup>

### The Impact of EDP on Decision Making

Since decision-making is an activity which has historically been performed by people, one can expect that people will be defensive about their exclusive prerogative to perform this activity. Decision-making, then, is the job of determining the course of action which is most likely to produce the desired results according to some pre-determined criteria. When the criteria and the rules for determining likeliness are explicitly provided to a device which has the capacity to manipulate this information logically, such as a digital computer, the computer assumes the ability to "make decisions".

As expressed by data processing and system managers, the meaning of "decision making" is both broad and concrete. It includes all types of decisions that are made by executives whether they require strategic or operating information or whether they are needed on a continuing basis, periodically or occasionally, or perhaps only once. The only requirement is that the information be programable.

Herbert A. Simon, for example, takes the viewpoint that executive decision-making is analogous to the behavior of the computer. They are, he says, programmed and non-programmed decisions.

1. Decisions are programmed to the extent that they are repetitive and routine, to the extent that definite procedures are worked out for handling them so that they do not have to be treated de novo each time they occur.
2. Decisions are non-programmed to the extent that they are new, unstructured, and consequential.<sup>25</sup>

Since programmed decisions tend to be routine and repetitive, those who make these kinds of decisions can follow tested rules. Some familiar examples are routine inventory replacement of standard operating supplies, routine treatment of employee absences, etc. The value of computers for programmed decisions lie in their speed, accuracy, and ability to handle masses of data. For the same reasons, computers can be applied to solving unstructured problems, such as comparisons of alternative courses of action; however they are used less

<sup>24</sup>Postley, *op. cit.*, p. 96|

<sup>25</sup> Herbert A. Simon, *The New Science of Management Decision* (New York : Harper, 1960) pp. 5-6.

frequently to provide information for non-programmed decision-making. "The controller of one oil company listed the benefits that have resulted from its use of computers: better decision-making information, increased profits, and better investment decisions. These benefits, he stated, have occurred as a result of better analysis of inter-function variables, and dept analysis of a greater number of alternatives prior to decision-making".<sup>26</sup>

Non-programmed decisions are rather novel and complex and demand special treatment. When, for example, conditions inside the organization deviate from the standard, when they do not follow the organization's plans, or when outside conditions suddenly create an element of risk, only non-programmed decisions can remedy the situation. One classic example of non-programmed decision-making is General Eisenhower's D-Day decision. Examples in business would be decisions to add or drop a product, or to make a fundamental change in financial structure. However in most non-programmed decisions, some components are programmed.

### **The Impact of EDP on Personnel**

The conviction that electronic computers will help reduce the drudgery of many office tasks is not uncommon. "Labor leaders, businessmen and scientists all seem to have agreed that whatever the effects on employment, the advent of electronic computers into the office will result in the upgrading of skills, a redistribution of the work force towards a higher proportion of skilled jobs, and the virtual elimination of routine, uninteresting and monotonous tasks from the office of tomorrow".<sup>27</sup>

The introduction of the new technology in organization results, with respect to lower levels of employment, in more isolation and less chance of face-to-face interaction. Dr. J. Douglas Elliott cites four basic fears and misconceptions concerning electronic data systems which tend to be widely, if unfortunately, held by the public:

1. That the new electronic brains will become masters of men, reducing the worker to a subordinate position.
2. That only a few high-priced, highly educated specialists, technicians, and mathematicians will be necessary to organize and operate the machines.

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<sup>26</sup>Higginson, *op. cit.*, p. 77.

<sup>27</sup> Jack Steiber, "Automation and the White-Collar Worker" *Personnel*, November-December, 1957, pp. 8-17.

3. That the few workers still needed will lose their individuality with jobs reduced to simple repetitive tasks.
4. That wholesale layoffs will result when complete electronic systems are installed".<sup>28</sup>

### CONCLUSION

From the standpoint of management, the fact that electronic data processing can provide more accurate information more quickly seems less significant than its use for problem-solving. In many organizations, however, the impact created by computers and systems analysis on management is considered the most significant aspect of EDP. It is more than a change in awareness, in emphasis, or in the approach taken in planning, organization structure, controlling, decision-making and executing.

It would be foolhardy to assume that all of the problems of organization can be solved by computer utilization; but it is practical to state that efficient computer use is more economical than human effort in the performance of certain services. It is obvious that electronic computers can reduce costs by eliminating duplication of effort; and that they can supply current, accurate data to increase the efficiency and speed of human decision making. Thereby allowing management additional time to accomplish more adequately those tasks that require human effort.

In introducing EDP into organization, there are several factors to be carefully considered: the convenience of programming, the system used to do the job, the size of the operation to be automated, and the ability of the organization to finance and profit from EDP. Thomas J. Kelly and John R. Nolan state that there are three questions to be kept in mind by every consultant before becoming involved in a feasibility study. These questions are:

1. Is EDP equipment really necessary to this client at this time?
2. Is EDP desirable because it will bring almost immediate payoff in making an existing system of operation less expensive or because it will permit greater integration of the entire network of systems by which the company operates? Which goal does management want most?

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<sup>28</sup> Douglas J. Elliott, "Will Electronics Make People Obsolete?" in *The Impact of Computers on Office Management*, Office Management Series No. 136, (New York: American Management Association, 1954), p. 49.

3. Is the company management hoping to justify a computer simply because it wants one, for prestige purposes and with little or no hard, logical justification for one?"<sup>29</sup>

The simple fact that computers can be applied to all types of activities suggests that they can be placed anywhere within an organization. Executives thus are frequently confronted simultaneously with the questions: "How should we organize our EDP?" and/or "What applications should we have?" These two issues are obviously related, and one cannot be resolved without considering the other. Nor should they be resolved without careful attention to the other obvious but critical variables: the nature, objectives and traditions of the business.

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<sup>29</sup> Thomas J. Kelly and John R. Nolan, "The EDP Feasibility Study," *Management Services*, July-August, 1964, pp. 48-54.