Behavioral Approach to the Conceptualization of Technology※

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INTRODUCTION

Technology has been frequently suggested as a major influence on organizational phenomena. During the past twenty years the expansion of research literature concerning interrelations among technology, organizational structure, and organizational behavior has been considerable. Since the early 1960's it has been popular to label this type of inquiry as research in sociotechnical systems. While by no means inclusive of all the studies that have been done, the Yale technology project, the Tavistock studies, and the work of Joan Woodward and her followers, represent a fair sampling of the research on sociotechnical systems.

The concept of a sociotechnical system is a comparatively new notion, for traditionally organization theory has ignored technology as an element in its conceptual framework (Woodward, 1970). A sociotechnical system is one in which the rational impersonal processes of technology interact with human factors and affect areas such as (1) work-related behavior and attitudes (blue collar or white collar) (2) small-group organization, and (3) formal organization structure.

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It is evident that the greater proportion of research in the behavioral sciences could be classified into one or more of these three categories. Certainly most of the studies done that have been concerned with the topic of human relations seem to fit the requisites for study of sociotechnical systems. As Guest points out…… "the social scientist often makes the error of concentrating on human motivation and group behavior without fully accounting for the technical environment which circumscribes, even determines, the roles which the actors play. Motivation, group structure, interaction process, authority…… none of these abstractions of behavior takes place in a technological vaccum (1962)."

The purpose of this paper is to review the works of the major empirical researchers that deal with the question of technological impacts upon organizational behavior and structures, and to focus upon the main points made with respect to the conceptualization of technology and its measurement in connection with behavioral and structural variables, and the implications of modern technology for organizational behavior in terms of work related behavior and attitudes,

SCHEMES OF CONCEPTUALIZATION OF TECHNOLOGY

This topic will be dealt with in two sub-sections. The first deals with ciassification schemes for describing the technological content of a situation, while the second deals with problems of measuring technological variables.

Concepts of technology—— Classification

Conceptualization of an organization's technology is still at a stage where the word technology may have varying meanings. However, what perhaps is most important in the technology-organizational behavior literature of the past decade, aside from empirical explication, is that it has begun to develop conceptuallzations of technological variables or dimensions. Prominent in this connection have been the works of Woodward (1958, 1965, 1970); Thompson (1967) Blauner (1964), Perrow (1967), Harvey (1968), Bright (1958), and Hickson (1969).

To Woodward, the technology of the organization is the collection of plant, machines, tools and recipes available at a given time for the execution of the production task and the rationale underlying their utilization (1970, p. 4). She classifies organizational tehnology in terms of "technical complexity", which she defines as "the extent to which the production process is controllable and its results predictable." In her classification scheme, she regards unit or small batch production as the lowest level of technology, large batch and mass production as the middle range, and continuous process system as the highest level of technology.

Blauner uses a similar scheme, but one more oriented to the behavior of employees and demands made on them. He defines technology as the complex of physical objects and technical operations regularly employed in turning out the goods and services produced by an industry (p. 6). In his classification, craft work is the lowest form of modern technology, machine tending the next, asembly-line production is the third level, and continuous-process technology is the most advanced. It is cear to him that overall movement is in the direction of lowest to highest and reverse development along the scale is rare. (Woodward also reached the same conclusion.) Perrow, however, argues that technological change, in terms of industry, is neither undimensional nor irreversible. Some firms, for very good reasons, do move from complex to simpler technologies…… and do so to survive. Decomputerization may be an example of this kind of reverse technological change (1967b).

Schon (1967) describes three categories of technology based on sequential stages of the research cycle or rationalization in the production process itself (pp. 50—51). The first, craft work, is a state where technology is nonrational, and without general principles. The second stage commences where scientific analysis begins to replace craft. Technology in this second stage however is not dominent, and is in fact service to production or sales. His third stage involves technology becoming autonomous. Scientific innovation is undertaken without direct regard for variations in sales or production demand. This state would include the new "R&D" firms as well as continuous process or numerical-control production which Schon identifies as the prototype. It should be noted that for Schon, the form of production as used in Woodward's and Blauner's schemes is inconsequential to his stages. For example either a small-batch-production firm or a continuous process plant could be classified as being in his their stage.

Addressing the problem from a quite different direction, Thompson (1967, p. 167) describes three variations of modern technology as "long-linked", "mediating", and "intensive." These classes are based on differences in the standardization of the object of production, and may be applied to service organizations as well as manufacturing concerns. The first class, "long-linked", involves a standard object and a serial interdependence of standard techniques, as seen in an assembly-line operation for example. The second class, "mediating technology" is found in organizations that provide a linking service between customers or clients. Banks and loan associations tie depositors and borrowers together as an example drawn from non-manufacturing organizations This technology employs standard techniques operating extensively on a number of different objects. The primary characteristic of an organization using an "intensive" technology, the third class, is the focusing of a wide variety of skills and specializations upon a single client or object. The feedback technique, numerically controlled continuous process plants, and psychiatric hospitals are examples of the third stage. The definition of the object of production is important in Thompson's categorization. It can either be defined as unique [part of sentence missing in M/S].

Perrow(1967) is another theorist for whom the character of the raw materials is all important in categorizing technology. The most generalized attempt at conceptualizing technology can be found in his contingent two-dimensional model which elaborates a distinction between routine and nonroutine technology. To Perrow, two aspects of technology vary independently: the number of exceptions that must be handled, and the degree to which search is an analyzable or unanalyzable procedure. If there are a large number of exceptions and search is not logical and analytic, the technology is classified as nonroutine. Few exceptions and analyzable search procedures, on the other hand, characterize a routine technology. The frequency of exceptions will be related to the complexity of the material technology, which is defined as "the actions that an individual performs upon an object…… in order to make some change in that object or raw material."

In connection with this classification scheme, it has been noted that even very complicated material technologies may be highly programmed, although the possibility that exceptions will occur in spite of the performance program cannot be totally eliminated. The essential point from an orgatnizaional behavior point of view, however, is not the material technology *per se* but the nature of the problem solving tasks that arise…… handling of exceptions to task programs and…… the importance of the way-exceptions are handled to the viability of the organization (Hunt, 1971).

Another recent typology is that presented by Harvey(1968), in which Woodward's three-state classification is reduced to a more global two state, bipolar range. "Technical specificity" and "technical diffuseness" are his two extremes. To him, diffuseness means that a number of technical processes yield a wide range of products which are likely to vary from one time to enother, while specificity means that the production processes are involved in making the same kind of product more or less all the time. This system differs basically from Woodward's because it takes into account the change within a given production form as well as the form itself.

Probably the most extensive classification scheme for the hardware of technology is the one developed by Bright (1958) and Faunce (1968). Their classifications are strictly based on the mechanical aspects of the production process. They define their states, ranging craft work to fully automated facilities, in terms of the variables of power source, procedures, materials handling procedures. and control methods.

Finally, Hickson *et al* (1969) categorize the organizational technology on the basis of three concepts, which taken together encompass the full range of meanings that have been developed so far by theorists: operations technology, material technology, and knowledge technology. Operations technology is defined as "the equipping and sequencing of activities in the workflow." The term "workflow," taken from Bakke (1959), means producing and distributing the output (Hickson, 1969, p. 380). For this concept he refers to Thompson and Bates (1957), Udy (1959), Burack(1967) and Woodward(1958). The second attribute, "material technology", refers to the same concepts as Perrow's "material technology" and Thompson's "intensive technology" mentioned earlier. The third concept, "knowledge technology" is defined as the characteristics of the knowledge used in the workflow, and is associated with Perrow's ideas of the degree of logical analysis required and the quality of exceptions that must be handled. Hickson, however, uses only the operations technology concept to explore the relationships between technology and organizational structure during his empirical studies.

The first conclusion based this examination of the foregoing classification schemes is that there are fundamental differences in the approaches of these researchers. However, each provides evidence that his particular typology facilitates examination of the organizational structure and workers' behaviors and attitudes in a way that helps reveal the effects of technology on these matters. Nevertheless, one desireable attribute of any system of ciassification of technology would be the degree to which it can be used generally specifically, the degree to which the system includes advances not only in manufacturing technology but also technology in service and other organizations. Computors, for instance, have had a major technological impact on a whole variety of non-manufacturing organizations.

A related point which should be made is that few of the schemes of classification discussed above provide white collar technology oriented evidence most of them were developed on the basis of blue-collar industry.

The schemes presented by Perrow and Thompson(or which Hickson also relies heavily) tend to place considerable emphasis on techniques based on the complexity of the raw material and the knowledge technology, atteributes which would seem to raises the chances for applying these concepts to the classification of white collar organizations. In contrast, the schemes of Blauner, Bright, Faunce, Harvey, Schon, and Woodward are based either on the technical hardware and product standardization for its materials handling, or on the level of mechanical means of production.

The most useful and generally applicable system of classifying technology, it seems, might be one that combines the simultaneous assessment of raw materials,machine and task attributes which are suggested one at a time by the theorists. Along this line, Taylor (1971) is attempting to build a toaxonomy of "direct production technology", defined as the principles and techniques used to bring about changes toward desired ends in the raw materials processed by a job or work group. The job or task, to him, is a central concept referring to that protion of the employee's work role which deals with activities directly relevant to the creation of the product. It does not refer to the organizational relevant, but nontask related, interactions of people.

It seems to be clear that Taylor's frame of reference is that of the task oriented behaviors of people in nonmanagerial or nonsupervisoy jobs, be these jobs at the lowest, or production-worker level of the organization, or jobs involving higher level, professional, or technology specialized staff personnel. Taylor combined elements into his model that relate to the service industry as manufacturing. These include (a) the nature of the raw materials, or production system input, (b) the nature of the "hardware" throughout the production system, and (c) the nature of the information exchange and evaluation concerned with the production output. The effects on the job of increased sophistication in all three dimensions are treated in his experiment. This scheme is very close to Hickson's taxonomy.

Measurement of Technology Variables

To test the assumption that different techologies impose different constraints on individual members of organizations and on the choice of organizational structure, techniques are needed to describe and measure both technical and structural characteristics of industrial organizations. The measuring techniques which have been suggested in the literature are different from one writer to another, each of whom defines the variables to be measured in different ways. Hunt (1970) points out that it is necessary to acknowledge that complexity is an elusive concept that takes many forms.

Woodward's scale of (1) unit and large batch, (2) mass and large batch, and (3) continuos flow process is criticized for its crudeness. This was a scale of technical complexity based on the controllability and predictability of the process. The categery definitions, however, are not stated primarily in terms of degrees of control and predicted complexity but rather in terms of the unit of through-put; the operational method tobe used in their application is not specified (Hickson, 1969). It is not really accurate to call the technological variable being measured 'complexity', since the complexity seems to correspond to smoothness of production(Starbuck, 1965). Harvey (1968) points out that the Woodward models of production are arranged on an ascending scale of technical complexity but suggests that possibly this sequence could be viewed as a move toward technical simplicity rather than complexity.

Brewer (1965) identified the parameters on which Woodward's measurement was based. He saw them as bands on a scale of increasing rates of production, and he found that even where the production hardware was similar firms varied considerably in their rate of production, based on Woodward's scale. His argument backs up Hickson's criticism.

Combey and Rackharm accepted Woodword's unit-batch-continuous process scale as their starting point with the addition of a new variable, the firm's product range as it varied over time,according to Eilon's suggestion (Woodward,1970). Harvey (1968) also starts with Woodward's work as a point of departure, using a continuum from technical diffuseness to technical specificity as the basis for his technological measurment scale. He uses the criterion, number of product changes, as a measure of technical-diffuseness/technical-specificity. He also argues that it is not only important to take into account the form of technology, as Woodward has done, but also to consider the amount of change that takes place within a given form. For the experiments he performed, Harvey's technology variables are divided into three categories according to the frequency of product changes as suggested by Eilon (1962) and Brewer: diffuse, intermediate, and specific.

Burns and Stalker (1961) and (1967a) are interested in measuring the variation in products produced as a factor affecting the organizational task. Based on his classifications scheme discussed earlier, Perrow chooses to consider only two aspects of technology which he considers directly relevant to organizational structure: "exceptional cases" or variability of the raw material, and the "search process" that is undertaken by the worker when exceptions occur. For his measurement, he distinguishes two types of search related to the nature of material or problems: unanalyzable problems and analyzable problems. Also, he scales the exceptional cases along the continuum of few exceptions to many exceptions. In all he develops a four-fold table as a basis for comparative analysis. Rackham and Woodward (1970, p. 33) argue that Perrow merely states that the number of exceptional cases varies on a scale from low to high, giving very little indication of the exact techniques he would use to position a firm on this scale. They also allege that his attention seems to be focused on the perception by organization members of the constraints in the work environment, rather than on the constraints themselves. Indeed, he classifies technology in terms that are social. This reduces the usefulness of his framework as an instrument for relating technical variables to structural and behavioral difference, although his approach leads to conceptualization at a high level of abstraction, sufficiently high as to permit application to organizations of quite different kinds, including manufacturing firms, hospitals, shops, etc.

Despite their different approaches there are similarities between the results that would be obtained using Woodward's scale and the scale concepts of Harvey, Perrow and Burns. For instance, in a unit production firm, the system deals almost entirely with exceptions and its problem-solving modes are likely to be very much unroutinized, especially if it is technologically diffuse. In a continuous process system at the other extreme, whether exceptions are frequent or not, they will be critical when they do occur so that such systems, too, are likely to be rather highly structured with respect to problem-solving or trouble-shooting procedures. On the other hand, other operations faced with fewer exceptions and being less vitally affected by ones that do occur are likely to be structured as mechanistic performance systems.

As did he in his attempt to classify technology, Hickson (1969) combines a full account of the development of scales by others……

ranging from Bright's "mechanization profile" to Woodward's "forms of production" and their relationship to organizational structure into his measurement scales of operations technology. The variables of operations technology are (1) automaticity, (2) workflow rigidity, (3) quality evaluation of operations, and (4) continuity of production. Throughput complexity, cycle and rate, number of operations, variety of sequence and uniformity of equipment are excluded from his analysis because of the difficulties or conceptualization and operationalization associated with these factors. To measure automaticity, Amber and Amber's (1962) classification of automation is utilized in terms of the degree to which first energy and then information for the process are provided by machines rather than by man. Measurement of workflow rigidity is based on the work of Thompson and Bates (1957) who define "adaptability of the technology" as "the extent to which the appropriate mechanics, knowledge, skills, and raw materials can be used for other products" and, it may be added, services. The scale for the quality evaluation of operations consists of three items: personal evaluation only, evaluation by blue print, and partial measurement. Production continuity is measured by a 10-item scale based on Woodward's original scale (1958).

On the basis of his broad-gauge definition of technologies, Taylor (1971) assesses the conditioning effects of each of his three technology variables, raw material (input), hardware (throughput), and sophistication of feedback information (output), on work group acceptance of planned social system change in the direction of more participative and responsible and responsible activities. For measurement of the effects of technology as the conditioning variable he develops a four-fold table consisting of two dimensions: efficacy of complex technologies, and disruptive side effects of technological change, with high and low scales for each dimension.

Various measurement schemes have been discussed so far. It is, however, necessary to note that little has been attempted to obtain measurements of sophisticated technology,[1] and every researcher has used a different approach to the assessment of technology. This fact might account for much of the inconsistencies in their research

1) Perrow (1967b, p. 215) argues that mechanization and computerization should not be the index of technological change and sophistication.

findings. There is still a need for a reliable measure of the sophistication of technology, one that is applicable to many different kinds of organizations and to both white-collar and blue-collar industries.

The Implication of Technological Changes on the Organizational Behavior and Structure

One of the important developments in the technology-organization literature of the past few years has been the attempts to conceptualize technology. The published classification schemes vary widely one from another. In an attempt to build a taxonomy which may be used to classify technologies in the service industry as well as manufacturing, and for any kind of work, blue-collar and white-collar, there has been a great deal of discussion of problems of definition. The characteristics of technology are the nature of raw materials, workflow, hard ware, and cognition of problems involved in operation. There is an attempt to conceptualize technology as a single variable distinct from the other variables affecting organizations.

Significant relationships between technology and organizational behavior, attitudes, and structure are recognized. In general, a more sophisticated technology is found to provide a potential for enhanced discretion and responsibility for individual workers and to require higher levels of intragroup autonomy and skill in both blue and white collar organizations. On the other hand, the behavioral effects of sophisticated technology seem to include generating favorable attitudes which may in turn reinforce the new behavior. These effects obviously are conditioned by management decisions to facilitate living with the new technology. This is supported by the Tavistock researchers' conclusion that a more sophisticated technology is a necessary condition in instituting autonomous groups, but that for best results, group structure must be consciously installed (Trist, *et al.*, 1963, p. 293). Work satisfaction increases despite the more rigid and structural work environment imposed by automation partly because of the employees' improvement of their partly as a result of skill, how they are related to the other employees in the organization, and partly as the result of a better functioning work system especially a more predictable work flow. However, worker displacement and unemployment that develop with the introduction of sophisticated technology elicit workers' resistance to technological changes.

The results of these studies reveal that technological effects on organizational behavior are stronger in blue-collar than in white collar organizations. The labor union movement has been affected by technological change as the behavioral and attitudinal effects of technology become a salient characteristic of their members' work situations.

Most empirical studies postulate impact of technology on the organizational structure in such a way that the more sophisticated the technology, the less flexible and more bureaucratic the structure. This bureaucratic structure is characterized by 'performance' or 'mechanical' structure, in contrast with 'problem-solving,' 'non-routine,' 'organic' structure. The bureaucratic sort of structure is alleged to be the most appropriate one, given the stable though sophisticated nature of the technology used. This issue, however, is dealt with in various ways from one author to another. An interesting proposition is suggested that may liberate the theorists from the "technological imperative" in such a way as to break the stalemate between the classical management theorists and the behavioral theorists. That is, the proposal that contextual variables other than technology, such as size and dependence, have a greater impact on structure than technology. Thus, the variables of size and organization deserve more attention in future research. The contingency theory and comparative analysis provide the organization theorists with new perspectives on the relationship of an organizational structure to its environment, implying that different kinds of organization are necessary for coping effectively with different strategies and environments. Increases despite the more rigid and structural work environment imposed by the automation-partly, because of the employees' improvement of skill how they are related to the other employees in the organization, and a better functioning work system, especially a more predictable work flow. However, worker displacement and unemployment that develop with the introduction of sophisticated technology elicit workers resistance to technological

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In this connection, most of the writers note that social change not only results from technological change because it is one of the environmental variables, but also results from a planned social change, and furthermore, that this change could be fostered inirectly by the disruption created as a result of technological changes and the situational constraints on the worker's behavior and attitudes. This certainly impies that a planned social change in industrial organizations could be preceded by technical changes that create pressures in the direction of work group autonomy and self leadership, thereby achieving a planned degree of change in the system with less organizational and workers' resistance.

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