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WORK ENVIRONMENT AND PROPENSITY TO INNOVATE

—AN EMPIRICAL STUDY OF JAPANESE ELECTRONICS FIRMS—

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I Abstract

This paper addresses the issue of the interrelationship between work environment, defined as the interaction between the formal structure of an organization and the members' organizational commitment, and the propensity of the firm to innovate, defined in terms of patents taken out in a determined period of years. The main results of the study seem to indicate that Japanese research institutions present distinctive features in terms of formal organizational structure and in terms of organizational commitment of their members. While in the West great emphasis is laid on the degree of discretion to be given to the researcher in the conduct of his research duties and on the shared nature of decision making processes in R&D departments, in Japan much more emphasis seems to have been laid on those organizational factors which motivate the individual to cooperate with fellow researchers and to attain higher levels of performance in his research assignments.

II Aim and Significance of Research

i. Since J.C. Abegglen published *The Japanese Factory* in 1958 the interest in the West for the socio-organizational dynamics which make Japanese corporations so distinctive (and one is tempted to add, so successful) has been growing and, to date, shows no sign of abating. Many studies, in the meanwhile, have been conducted whose aim has been to comprehend, from the various perspectives of the social sciences, why Japan has come to excell in industrial manufacturing, and, possibly, to identify those organizational factors that have been so critical in giving Japan industrial prominence. It is not surprising to observe how most of the outstanding foreign literature in the field of comparative management dealing with Japan almost invariably analyses the Japanese corporation in terms of a production unit or a production system, with little attention being given to other organizational units, such as Sales Departments, R&D Departments, Finance, Marketing, Corporate Strategy, and so on.

The nature of such selective approach to the study of Japanese corporations may have been justified by the fact that industrial manufacturing was Japan's main forte in the 60's and 70's. It can be predicted, with a good margin of certainty, that Japan's next

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main forte will shift from production activities to research activities, particularly in those sectors where research is a *conditio sine qua non* not only for economic viability, but also for organizational survival, such as electronics.

It is the aim of this paper to analyse the organization of Japanese Research & Development Departments of private corporations active in the electronics field. As in the past in manufacturing, we will be hopefully able, although in a much more modest way, to observe how R&D socio-organizational factors are important forces in determining innovative output.

ii. A second aim of this paper is to conduct some empirical testing on C. Perrow's[1] theoretical framework in a Japanese organizational context. Discussing the relationship between technology and structure, Perrow argues that "organizations wittingly or unwittingly attempt to maximize the congruence between their technology and their structure"[2] According to Perrow in a R&D firm, and consequently in a R&D department, where search for the solution of technological problems is not analysable and where standard procedures for identifying and dealing with problematic technological issues are mostly not available, we would find an organizational structure which is characterized by high discretion in the researchers as to how to conduct their "search and solve" activities, by high degrees of power in the appropriation and administration of means which might prove effective in the search and solve process, by high levels of coordination and feedback activity between organizational units involved in the search and solve process, and finally by high levels of interdependence between all agents active within the R&D unit. Perrow defines such type of organization as "organic"[3] as opposed to the bureaucratic type of organization which is characterized by low degrees fo discretion of its members in carrying out their tasks, by high degrees of power in the resource appropriation process, by planned coordination between organizational units, by highly centralized decision making processes, and by highly standardized regulations concerning the execution of work tasks and other organizational duties.

Prior to Perrow, T. Burns and G.M. Stalker in a study on the development of the electronics industry in Scotland[4], had outlined an organizational typology which, according to the authors, was more suitable than a weberian (bureaucratic) type of organization for dealing with a rapidly changing environment, as the one surrounding the electronics industry. The main characteristics of such organization were:

—high degrees of cooperation in the exchange of specialized knowledge among researchers

—the task of each individual was defined in terms of the common task of the organization and was constantly readjusted to the needs of the common task in a process of information and cooperation exchange among workers,

—the main commitment of the individual could not be defined within clearly delimited

1) C. Perrow, *Organizational Analysis: A Sociological View*, London, Tavistock, 1970.
2) C. Perrow, *o.c.*, pp. 80–85.
3) C. Perrow, *o.c.*, p. 81.
4) T. Burns, G.M. Stalker, *The Management of Innovation*, London, Tavistock, 1961.

boundaries (diffuse commitment),
—patterns of communication, authority and control originated networks that comprised whole departments and diverse organizational functions and tended to concentrate where expert knowledge and skills were present,
—power and specialized knowledge were not necessarily related to hierarchical levels,
—the communication between members took often the form of informal advice or suggestion rather than the form of normative prescription or command,
—members were required to be "deeply" committed to the overall task and philosophy of the organization, rather than show simple obedience and loyalty[5].

In fine, what seems to be the main organizational imperative of an organic unit may be explained as follows: in a state of environmental uncertainty a bureaucratic organizational structure in the weberian sense does not seem to be the best suited means to deal with a problematic "search and solve" process. In order to optimize such a search and solve process, the existence of members' commitment to overall organizational goals and cooperation among fellow workers in the work process are regarded as of crucial importance. It is, so to speak, the software of human commitment and cooperation that moves the formal organizational hardware to accomplish its stated task. It is in our view this articulated absorption of synergic human qualities into the hardware of organizational structures that makes on organization organic and not mechanistic. It is this proposition that we set out to test in this paper.

iii. A further aim of this study is to compare in an indirect and tentative way the characteristics of Japanese and American R&D Departments. In the sample used in this study Western respondents were not included. There are, however, enough empirical studies conducted in the U.S.A. whose methodological requirements do not deviate substantially from those used in this research. Methodological similarities as well as similarities in the definition of sample characteristics may render such comparison tentatively possible.

III Work Environment: Definitions and Theoretical Outline

The concept of work environment (variously referred to as work climate, organizational character, a.s.o.) has gone through so many epistemological vicissitudes in the sciences of organizations that some scholars have suggested that the concept be altogether abandoned. There is no unanimity among scientists as to what work environment really means. Each scholar, usually, proposes his own definition in the hope of clearing the concept of its fuzziness, only to burden it more with variance of meaning. Norman Maier[6], to quote only a few scholars who have devoted their attention to this issue, defines organizational climate as the resultant of these factors: a.—leadership styles, b.—hiring and promotion practices which involve the selection of individuals who satisfy the norms of the established leaders c.—processes of association by which

5) H. Pollard, *Management Thought*, London, Heineman, 1978, pp. 6–16.
6) N. Maier, *Psychology in Industrial Organizations*, Boston, Houghton-Mifflin, 1973, pp. 594–5.

people tend to prefer associates who are similar in personality and attitudes d.—the process of working together and socializing with one another favours a determinate climate, in terms, for instance, of friendliness, seriousness, graciousness, orderliness, etc. Rensis Likert[7] categorizes organizational systems as the outcome of definite management styles in relationship to the exercize of leadership, the generation of motivation, the establishment of information patterns, the process of decision making, the setting of goals, and the administration of control factors. There are, according to Likert, four main organizational systems determined by the form of management style: the exploitive, the benevolent, the consultative and the participative. Likert operationalized his organizational factors in such a way as to be measurable through the means of a standard questionnaire. Forehand and Gilmer[8] define the concept as "a set of characteristics that: a.—describe an organization, b.—distinguish the organization from other organizations c.—are relatively enduring over time and influence the behaviour of people in it". Georgopolos[9] introduces the concept as "a normative structure of attitudes and behavioural standards which provide basis for interpreting the situation and act as a source of pressure for directing activity". Tosi and Carroll[10], quoting Schneider, argue that "the organization climate refers to how an organization practices and procedures are perceived by organizational members, and the relationship of such perceptions to ways of thinking about the organization and subsequent behaviour... Higher perceived amounts of structure, or formalism, have a tendency to arouse power needs and to reduce achievement and affiliation needs for individuals...In stable organizational units we would expect higher concerns about power than in the dynamic units...on the other hand, in dynamic units, where there is informality in structure, high standars of performance, encouragement of innovation and toleration of conflicts, the need for achievement is aroused". Litwin and Stringer[11] state that organizational climate "is a set of measurable properties..., perceived directly or indirectly by the people who live and work in this environment, and assumed to influence their motivation and behaviour". Pritchard and Karasick[12] synthetically: "organizational climate is a relatively enduring quality of an organization's internal environment distinguishing it from other organizations, and which, a.—results from the behaviour and policies of members of the organization, especially top management, b.—is perceived by the members of the organization, c.—serves as the basis for interpreting the situation, and

7) R. Likert, *The Human Organization: Its Management and Value*, N.Y., McGraw-Hill, 1967.

8) G.A. Forehand, B.V. Gilmer, "Environmental Variation in Studies of Organizational Behavior", in *Psychologial Bulletin*, vol. 62, 1964 [quoted from A. Abbey, *Technological Innovation: The R&D Work Environment*, Ann Arbor, Michigan, UMI, 1982, p. 5]

9) B.S. Georgopolos, "Normative Structure Variables and Organizational Behavior" *Human Relations*, v. 18, p. 156–169 [from A. Abbey. *o.c.*, p. 5]

10) H. Tosi, S. Carroll, *Management Contingencies: Structure and Process*, N.Y., Wiley, 1976, p. 465.

11) G. Litwin, R. Stringer, *Motivation and Organizational Cilmate*, Boston, Harvard, 1968 [from A. Abbey, *o.c.*, p. 6]

12) R. Pritchard, B. Karasick, "The Effects of Organizational Climate on Managerial Job Performance and Job Statisfaction", *Organizational Behavior and Human Performance*, vol. 9, 1973 [from A. Abbey, *o.c.*, p. 6]

d.—acts as a source of pressure for directing activity".

P. Selznick[13], commenting on how organizations become institutions (or, as it were, endowed with character), observes that: a.—"the technical, rational impersonal task oriented formal system is conditioned by the responsive interaction of persons and groups, b.—in the course of time, this responsive interaction is patterned. A social structure is created. This patterning is historical, in that it reflects the specific experiences of the particular organization; and it is functional, in that it aids the organization to adapt itself to its internal and external social environment. And finally, it is dynamic, in that it generates new and active forces, especially internal interest groups made up of men committed to particular jobs or policies. In addition, c.—organizations become institutions as they are infused with value, that is, prized not as tools alone, but as sources of direct personal gratification and vehicles of group integrity. This infusion produces a distinct identity for the organization..."

D. Katz, R. Kahn[14] state: "organizational climate reflects the history of internal and external struggles, the kind of people the organization attracts, its work processes and physical layout, the modes of communication, the exercize of authority within the system. Just as a society has a cultural heritage, so social organizations possess distinctive patterns of collective feelings and beliefs passed along to new group members"

From the various definitions of organizational environment (climate, character), we can conclude that we are dealing with a synthetic concept in which the following notions and meanings are subsumed in their dynamic interaction:

i. notions and meanings related to the formal structure of the organization as 1. a system of production with its own task requirements, division of labour, job specifications and standards. 2. as a maintenance system, whose function is the maintenance in the organization of a steady state. Such system finds expression in its attempt at formalizing activities into standard, legitimized procedures, and especially in the institutionalization of the reward system. 3. as an adaptive system, whose function is to scan the environment, track new possibilities, and target new niches. As an adaptive system, the organization may be under constant pressure for change in order to match the changes occurring in the inner and outer environment. 4. as an integrative system, whose function is that of conflict management, control, coordination, direction of the functional substructures, and decision making. The integrative system is typically managerial, in that it is specifically the task of management to integrate all organizational functions to the stated goal (production). The managerial function cuts across all other organizational functions and consequently deals with and controls the production, maintenance, and adaptation system on a regular basis[15].

ii. notions and meanings related to the informal aspect of the organization, i.e., those processes of association (or disassociation) that are originated in the work place, influence to a considerable extent the smooth (rough) functioning of the organization's

13) P. Selznick, *Leadership in Administration*, Berkeley, University of California, 1984, pp. 38–40.

14) D. Katz, R. Kahn, *The Social Psychology of Organizations*, Second Ed., N.Y., Wiley, 1978 p. 51.

15) T. Parsons, N. Smelser, *Economy and Society*, N.Y., The Free Press, 1956.

formal structures, but are not controlled by them. Examplifying: in an organization operating in a cultural environment where contractual relationships obtain, the associative process of cooperation among workers necessary to carry out a defined task, is not, generally, regulated at the formal level of the organization, but it is a social process of informal negotiation among the workers assigned to some specific task. Although the informal organization arises from expressive rather than instrumental needs, the functional imperatives which lie at the basis of the formation of such organization do not differ significantly from those which rule the formal organization, specifically: 1. imperatives stemming from production needs. In the informal organization the social process of cooperation would be the informal equivalent which supplements and completes the process of the division of labour at the formal level. In an organization where tasks and work roles are minutely defined or where work processes are critically interdependent, the informal aspect of cooperation becomes an important, dynamic ingredient in facilitating the smooth functioning and organic integration of all work functions and roles. 2. The adaptation need at the informal level of the organization would be represented by the need at the socio-psychological level to excell and achieve, and would supplement the formal organization's adaptation need of environmental scanning, tracking, and targeting. To the extent that individuals are motivated at the informal level by a desire to excell and achieve in their work assignments, we expect that such desire may correlate highly with degrees of organizational adaptation, expressed, for instance, in what later will be defined as organizational flexibility. 3. At the informal level the needs for integration are manifested by the social needs of belongingness and recognition, which, in a sense inform the formal integrative function of conflict management and resolution, control, coordination and direction of functional substructures. 4. And finally, at the informal organizational level maintenance imperatives are manifested by the needs to crystallize social relationships into identifiable classes or groups on the basis of either ascription (birth, race, religion, etc) or achievement (skill, education, competence) or both. The maintenance needs at the informal level correlate with the maintenance needs of the formal structure to define activities into standard legitimized procedures, and to institutionalize the reward system[16].

On the basis of what has just been stated above, we hypothesize a relationship between formal and informal structures. We hypothesize, for example, that there is a positive relationship between a production mode based on autonomy among researchers, which is considered as typical of R&D Departments, and cooperation among the same researchers. Accordingly, we hypothesize a positive relationship between organizational flexibility and desire to achieve and excell among researchers; a positive relationship between rule standardization and status polarization among researchers; finally, a positive relationship between formal integration needs (centralization) and informal integration needs (supportiveness) among researchers. The variables just mentioned in the hypotheses formulation will be introduced later in more detail.

16) For a more comprehensive exposition of what has been stated here, see T. Parsons, N. Smelser, *o.c.*

IV Innovation, Innovative Processes, Propensity to Innovate

i. Innovation

As in the definition of work environment, scholars are in disagreement as to what constitutes innovation. Mansfield[17], for example, states that innovation is "the first use ever" of a new idea, product or process. Sheppard[18] defines innovation as the capacity an organizational unit has to "learn to do something that was not known before". Zaltman, Dunkan, Holbeck[19] argue that innovation is the propensity to adopt any idea, practice, or material artifact perceived to be new by the organization. According to Black[20], innovation is the actual introduction of something new into the organizational context. Beck and Whisler[21] prefer to define innovation as "an organizational social process". Carroll[22], in a similar mood, defines innovation as "social process of organizational adoption". Barnett[23] defines it as the "invention of something new". R.C. Parker[24] sees innovation as the integrated managerial effort (Research, Production, Marketing) to make a new product competitive on the market. and finally Kay[25] seems to define innovation as a "marketable product".

ii. Summarizing and commenting on the definitions presented above, the following seems to be in order:

A. 1. Innovation represents something new that organizations have to think of, plan, or simply discover in a casual way (serendipity). 2. The introduction of innovative elements, be they either products or processes, requires organizational change or adjustment, that is, the adoption of new organizational structures that make innovation viable. 3. Innovation is something that has economic value, be it a process of production, marketing, research, or, simply, a new competitive product which crystallizes in itself such processes of "managerial effort".

B. Innovation and invention seem to be two different concepts reflecting two different realities, although some scholars find it still difficult to separate the two (e.g.: Barnett).

C. At the origin of much of the conceptual disparity presented above, there seems to be confusion between innovation as a concept defining a fact, and innovation as a process describing how a given fact occurs. Although we do not want to engage in

17) E. Mansfield, "Size of Firm, Market Structure, and Innovation", *Journal of Political Economy*, v. 71, 1963 [from A. Abbey, *o.c.*, p. 9]
18) H. Sheppard, "Innovation Resisting and Innovation Producing Organizations", *The Journal of Business*, v. 40, 1967 [from A. Abbey, *o.c.*, p. 9]
19) G. Zaltman, R. Duncan, J. Holbeck, *Innovations and Organizations*, N.Y., Wiley, 1973.
20) G. Black, "Innovation in Business Organizations", *The Journal of Business*, vol. 40, 1967 [from A. Abbey, *o.c.*, p. 9]
21) S. Beck, T. Whisler, "The Innovative Organization", *The Journal of Business*, vol. 40, 1967 [from A. Abbey, *o.c.*, p. 9)]
22) J. Carroll, "A Note on Departmental Autonomy and Innovation in Medical School", *The Journal of Business*, vol. 40, 1967 [from A. Abbey, *o.c.*, p. 9]
23) H. Barnett, *Innovation*, N.Y., McGraw-Hill, 1953 [from A. Abbey, *o.c.*, p. 1]
24) R.C. Parker, *The Management of Innovation*, N.Y., Wiley, 1982.
25) N. Kay, *The Innovating Firm*, London, Macmillan, 1979, pp. 10–13.

philosophical considerations about the logics of definition, we still think in the analytical usefulness of keeping a clear-cut distinction between what is a concept, function, or process. There is no doubt that innovative activity requires "an organizational social process" which may require receptivity, preparedness, adaptation, etc. However, this is not innovation qua innovation, but rather an essential condition, a socio-organizational prerequisite for innovation to occur. Again, innovation requires a capacity on the part of the organization to engage in "processes of adoption". Such skills may be critical in producing innovative activity, but they are not coterminous with innovation. Innovations are the result of many social, organizational, scientific, technological processes which are important in weaving innovative activity into "innovative fact." By innovative fact we mean, (a) a discrete fact, which can be measured and observed, like a product or a process of production, marketing, research, etc., (b) a fact which is economically meaningful, i.e.: a new, competitive product which successfully meets consumers' demand; or a new process which institutes a more efficient ratio between means used and output obtained.

In fine, what was used as "discrete innovative fact" in this study were both product and process innovations, but only at the patented level. We are aware that such operationalization of innovation is arbitrary and that we, in the process, may be making an additional contribution to the existing confusion in the field. Surely, the patenting of innovative activity, properly speaking, is not innovation. Only a small percentage of patents are incorporated into successfully marketable products or processes. However, patented activity does meet the definitional requirements spelled above, in that (a) it represents a quantifiable fact, (b) endowed with economic meaning. The first (a) proposition needs no explanation. As to the second (b), it is a well known fact that patents do have an economic meaning for a firm, even if they do not eventually become either marketable products or marketable processes. A firm may sell its patents, may use them to forestall market entry, or it may just find out that what is not useful today it may turn out to be useful tomorrow. Briefly stated, patented activity is an intangible asset, with a potential of profit always present. The indisputable fact, however, remains, that much of patented activity is doomed to senescence and, ultimately, to obsolescence. Moreover, it would be risky to equate patented activity with innovative activity, if distinction is not clearly made between patented activity with economic value and patented activity with little or no economic value. Unfortunately, no provision was made in this study to draw such a distinction.

iii. Propensity to innovate

Propensity to innovate in this study means the likelihood of a firm to engage in patenting activity in relation to its organizational environment. On the basis of what was previously discussed, organizational environment may be imagined as a variable which polarizes between mechanistic values at one end, and organic values at the other end of the continuum. We hypothesize that on the basis of an organizational environment C, it is possible to predict degrees of propensity to innovate. In symbols: if $I=f(C)$ represents an innovation function, then $I'=dI/dC$ represents the marginal

propensity to innovate in relation to C, defined as organizational environment.

V The Electronics Industry and Work Environment

i. C. Freeman[26] analysing the relationship between uncertainty and innovative activity, distinguishes three types of uncertainty: technical uncertainty, market uncertainty, and general business uncertainty. General business uncertainty applies to all management decisions and is not specific to R&D projects. Technical uncertainty and market uncertainty on the contrary, are specific to innovation projects, so much so, that to different degrees of combined uncertainty, correspond different types of innovative activity, specifically:

a. In an organization where true uncertainty prevails, fundamental research/and or fundamental invention will impose themselves of necessity.

b.—Very high degrees of uncertainty will be associated with radical product innovation and/or with radical process innovations outside the organization.

c.—High degrees of uncertainty will be associated with major product innovations and/or with radical process innovations within the organization.

d.—Moderate uncertainty will be associated with new generations of established products.

e.—Low uncertainty will be associated with licensed innovation, imitation of product innovation, modifications of products and processes, early adoptions of established processes.

f.—Very little uncertainty will be associated with "new model" manufacturing, product differentiation, late adoption of established process innovation within organization, minor technical improvements.

ii. There is little doubt that the electronics industry operates in a technical and in a market environment characterized by very high or high degrees of uncertainty. It is the main hypothesis of this study that organizations operating in highly uncertain environments have to develop a particular organizational climate, which in turn will contribute to marginal innovative activity.

VI Research Design

A. Sampling

The sample analysed in this study was chosen from among the electronics firms listed on the First Sections of the Tokyo, Osaka, and Nagoya Stock Exchanges as of August 1st, 1983. The unit of the analysis was not the firm itself, but its R&D Department, where ideal conditions to study the interrelationships described above would be available. Out of a population of 180 firms which were, somehow or other, involved in the electronics field, 120 firms were chosen. The reasons for including a large number of cases in the sample are the following:

26) C. Freeman, *The Economics of Industrial Innovation*, London, Frances Printers, Second Ed. pp. 149–150.

a.—We anticipated the fact that some firms would not qualify for the study for lack of R&D facilities. To offset this eventuality, a sample size larger than it would be warranted was chosen.

b.—We anticipated that many firms would not participate in the study because of the secret nature of the work conducted in their R&D Departments, or for any other reason.

Simply stated, we anticipated that where another research project would obtain a response rate of fifty percent to a given questionnaire, this type of research for its risk factors would obtain a response rate between twenty-five and fifty percent, with the number of participating firms between thirty and sixty. In reality, the response rate was even lower than anticipated, falling to twenty-three percent, with twenty-seven firms participating in the study.

B. Instrumentation

Data were collected by means of a structured questionnaire, designed to measure the work environment of R&D Departments. The questionnaire was created on the basis of other questionnaires which had been previously used particularly in the U.S.A.:

—A. Abbey's Work Climate Questionnaire, administered to R&D personnel active in the American electronics industry[27]

—R. Likert Profile of Organizational Characteristics, used to operationalize the concept of supportiveness within R&D facilities[28]

—Campbell and Pritchard's Organizational Climate Questionnaire[29]

These instruments seem to have high reliability as well as validity when used in organizations which operate in the same field of activity. Such instruments, however, have been devised for a cultural environment which is different from the Japanese environment, and even translating them may pose serious problems of comprehension. To overcome such difficulties, the translated questionnaire was sent to different groups of researchers, and corrections as well as observations of various kinds were solicited. The instrument was adjusted and readapted in various ways to guarantee a minimum of reliability and validity.

C.1 Variables Defining Work Environment (Independent)

Two sets of variables were chosen to define work environment. One set tries to describe the formal organization of the R&D Departments and consists of the following:[30]

—AUTONOMY: or the degree of discretion that the researcher has to conduct and organize his work. As it was previously stated, autonomy or lack of it, is related to the need of the organization to establish task requirements, division of labour, job specifications and standards in relation to some production schedule.

—CENTRALIZATION IN DECISION MAKING: the degree of the researchers' participation in the process of decision making. Centralization in decision making,

27) A. Abbey, *o.c.*, p. 107–113.

28) R. Likert, *o.c.*

29) J. Campbell, R. Pritchard, *Organizational Climate Questionnaire*, University of Minnesota, 1969.

30) Most of the variables used in this study were used in the study conducted by A. Abbey, *o.c.*, pp. 33–34.

or the lack of it, corresponds to organizational integrative needs, expressed in conflict management, control, coordination, and direction of the functional substructures.

—FORMALIZATION: the degree to which the organization defines activities and work processes into standard, legitimized procedures. Formalization is required by the maintenance needs of the organization.

—FLEXIBILITY: the degree to which the organization adapts to the environment where it operates, trying, for instance, to respond promptly to the needs of the environment, and conversely, to stand ready to make good use of any opportunity offered by the environment. Flexibility is a requirement of the organization's adaptation needs.

—REWARD SYSTEM: the degree to which organizational inducements and contributions balance out. A requirement of the maintenance need of the organization.

The other set of variables is intended to ascertain the nature of the informal organization within R&D Departments. The following variables were chosen:

—COOPERATION: the degree to which specialized knowledge and skill are contributed to the common goal of the organizational unit (innovative activity). Cooperation would be a subsidiary informal contribution requested by the production needs of the organization.

—ACHIEVEMENT MOTIVATION: the need of the researchers to excell in their research tasks. Such need would require a high degree of adaptability on the part of the organization members, and would somehow form the psychological substratum for the adaptation needs of the organization as such.

—SUPPORTIVENESS: the degree to which the needs of belongingness and recognition are aknowledged by higher management. Supportiveness would be a subsidiary informal prerequisite which balances the formal integration need of control, conflict management, decision making, coordination and direction of the organization's subunits.

—STATUS POLARIZATION: the extent to which informal social relationships crystallize into identifiable "classes" or groups within the R&D unit. Status polarization would reflect a maintenance need on the part of the informal organization to keep social relationships in a steady state.

C.2 Innovation Variable (Outcome Variable)

The outcome variable represents the average number of patents taken out by a firm over a period of ten years. This variable will be taken as an index of technological innovation.

D. HYPOTHESES

a. General Hypotheses:

1. Major : Organizational units operating in very highly/highly uncertain technological environments tend to structure themselves in an organic way rather than in a mechanistic way (Burns and Stalker, Perrow),

   Minor : R&D units of electronics firms operate in a very highly/highly uncertain technological environment,

Ergo : R&D units of electronics firms would most probably assume an organic type of structure.

2. A second general hypothesis was formulated as follows: R&D units which conform more to an organic type of organization will experience higher rates of performance than firms which deviate significantly from the organic type. In symbols: Ho: $m1-m2=0$; Ha: $m1-m2>0$, where m1 is the performance of the organic organization, and m2 is the performance of the deviant.

b. Subset Hypotheses:

1. A high degree of discretion of the researchers to schedule their work will be positively related with technological innovation.
   Ho: $rho=0$; Ha: $rho>0$
2. High rates of organizational cooperation will be positively related with technological innovation.
   Ho: $rho=0$; Ha: $rho>0$
3. High rates of organizational supportiveness will be positively related with technological innovation.
   Ho: $rho=0$; Ha: $rho>0$
4. High rates of organizational formalization will be negatively related with technological innovation.
   Ho: $rho=0$; Ha: $rho<0$
5. Perceived high rates of inducements relative to contributions will be positively related with technological innovation.
   Ho: $rho=0$; Ha: $rho>0$
6. High rates of achievement motivation among researchers will be positively related with technological innovation.
   Ho: $rho=0$; Ha: $rho>0$
7. Status Polarization will be negatively related to technological innovation.
   Ho: $rho=0$; Ha: $rho<0$
8. High degrees of flexibility will be positively related with technological innovation.
   Ho: $rho=0$; Ha: $rho>0$
9. High degrees of centralization in decision making will be negatively related with technological innovation.
   Ho: $rho=0$; Ha: $rho<0$

VII Results

A. Description Variables

i. The twenty-seven firms in the sample spent, relative to net sales, 6.8% on R&D activities. Compared to what the firms had spent in R&D activities in 1981 this figure represents an increase of more than two percent points. Taking into consideration that none of the big five[31] were included in the sample, this surge in R&D expenses

31) NEC, Fujitsu, Hitachi, Mitsubishi El., Toshiba

may indicate the need and willingness of the firms to counteract the competitiveness of the bigger firms. The absolute Yen value of the funds invested on R&D activities amounted to about one billion US dollars. This sum represents roughly eleven percent of all funds spent in R&D activities by firms active in the electronics field.

ii. Turnover rate, defined as previous work experience in company different from the one the respondent was working for at the time of inquiry, was of 17.2 percent. We are unable to assess the meaning of such figure in a comparative way. Yoshino[32] states that "although mid-term recruitment in Japan is kept to a minimum, there are some companies which engage in extensive mid-term recruitment and in a quasi institutional way". If this is the case, we expect that firms active in research intensive fields such as electronics may be gradually becoming used to this practice[33]. This, of course, would require a redefinition of the life-time employment practice in R&D Departments.

iii. The ratio between the time spent in R&D and the length of employment in the same firm was of .85, meaning that researchers may have spent an average 1.5 years doing work which may have not been necessarily related to R&D activity sometime during their careers.

B. Inference Variables

i. Zero-order correlation coefficient matrix: innovative activity predicted by organizational environment.

Table 1.

	1	2	3	4	5	6	7	8	9	10
1-Autonomy	1									
2-Centralization	−.854***	1								
3-Cooperation	.353	−.412*	1							
4-Flexibility	.834***	−.718***	.536***	1						
5-Status polarization	−.224	.320	−.288	−.379	1					
6-Achievement motivation	.353	−.473**	.649***	.600***	−.216	1				
7-Reward system	.618***	−.597***	.412*	.702***	−.079	.449**	1			
8-Supportiveness	.354	−.320	.395*	.576***	−.273	.683***	.597***	1		
9-Formalization	−.902***	.851***	−.345	−.750***	.215	−.354	−.631***	−.315	1	
10-Number of patents	.416*	−.425*	.642***	.437*	−.185	.552***	.246	.256	−.530***	1

* P<.05, ** P<.025; *** P<.01

ia. There seems to be a basic internal consistence between the relationships of the independent variables. Measures of work autonomy, for example, are negatively and highly associated with measures of centralization and formalization as we would have expected. This indicates that the variables in the model may be, in fact, measuring real dimensions of autonomy, centralization, formalization, a.s.o.

32) M. Yoshino, *Japan's Managerial System*, Cambridge, MA., MIT, 1968, p. 233.

33) It is a known fact that the exchange of information (both internal and external) among researchers is very important in the process of idea generation and in the process of research generally. Such exchange may be encouraged by researchers who have worked in other firms in similar fields and have been employed in a new organization. On this, vide T. Allen, *Managing the Flow of Technology*, Cambridge, MA., MIT, 1966, VI chapter.

ib. The hypothesized relationships between the variables representing the formal organization and the variables representing the informal organization are not clearly supported by the present data. In discussing the relationship between the formal and informal organizational systems we had anticipated the following:

—A positive relationship between autonomy and cooperation (production system's needs): such relationship exists, but it is not statistically significant.

—A positive relationship between centralization and supportiveness (integration system's needs): the association is negative, but not significant.

—A positive relationship between formalization and status polarization (maintenance needs) the association exists, but again, it is not statistically relevant.

—A positive relationship between flexibility and achievement (adaptation needs): this relationship is highly and significantly associated as hypothesized.

In conclusion, the theory tentatively advanced in this study about the relationship between formal and informal organizational systems was not either fully supported by the data or fully rejected. Further testing may be necessary to ascertain the nature and extent of such relationships.

ic. Among the environment variables, the best predictors of innovative activity are cooperation, achievement motivation, flexibility and autonomy, positively; formalization and centralization, negatively. Three variables seem not to have any significant association with innovative activity: status polarization, reward system, and supportiveness. Six of the subset hypotheses, were, therefore, not rejected. Of particular interest is the strength of the association between cooperation, achievement motivation and innovative activity. Among structural variables, the strongest relationship (negative) was observed between formalization and innovative activity, followed by flexibility, centralization (negative), and finally autonomy.

At this first level of analysis the general hypothesis that stated that R&D departments have to assume an organic type of organization in order to perform successfully, was not rejected. The strength of the relationships between such variables as cooperation, achievement and the outcome variable, suggests that organizational commitment, an ingredient of organic units, is an important predictor of positive performance.

id. A. Abbey[34] summarized the most significant studies conducted on the relationship between innovative activity and dimensions of work environment in American R&D units. Abbey's summary is presented readapted on page 47.

The findings of the present study do not seem to contradict, generally, the results obtained elsewhere in the West. In particular, there seems to be a rather close similarity between the results obtained in this study and those obtained by Pelz[35]. High degrees of autonomy are related with high degrees of cooperation and achievement motivation, the main, critical factors which make a work environment organic and which,

34) A. Abbey, *o.c.*, p. 18.

35) Pelz's stuy was conducted among eleven R&D institutions. According to Pelz, innovative activity is best correlated with conditions requiring "security" (independence, self-direction, self-confidence, esteem, and protection from disruptive forces), and "challenge" (diversity of activities, unfamiliar problems, involvement and interaction with others, coordination), in A. Abbey, *o.c.*, pp. 15–16.

Table 2.

	Variables of organizational environment								
	Centr	Auton	Size	Coop	Achivm	Support	Rewar	Formal	Statpol
Studies by:									
Andrews (67)		+				+			
Evan-Black (67)	+							−	
Sheppard (67)				+		+			
Litwin (68)					+				
Palumbo (69)	−							−	
Pelz (66)		+		+	+				
Langrish (72)				+					
Aiken-Hage (71)	−		+					−	
Baldridge (75)			+						−
Paolillo (78)		+	−				+	−	
This Study	−	+		+	+			−	

in a way, "compensate" for the autonomy necessary in the research process. Our first tentative conclusion, then, is that Japanese research establishments are not very different from their counterparts in the West. Both Japanese and Western research units seem to share organizational structures which are organic, and which contribute significantly to positive innovative performance.

ii. Analysis of Partial Coefficients

When many variables are used as predictors of variance in the dependent variable, it is advisable to control for spurious relationships between the predictor variables and the dependent variable. To this purpose, an analysis of the partial coefficients of correlation would be appropriate:

Table 3. Standardized Partial Coefficients of Correlation Inovative Activity Predicted by Environment Variables

Autonomy	−.075
Centralization	.242
Cooperation	.505*
Flexibility	−.078
Status polarization	.009
Achievement motivation	.320
Reward system	−.279
Supportiveness	−.086
Formalization	−.542*
*P<.05	

After each variable was allowed to explain all the variance it could explain, while controlling for all the other variables, the following relationships were observed:

iia. Compared to the previous zero-order relationships, the relationship between co-

operation, formalization and innovative activity did not change significantly. Such relationships can be appropriately defined as "robust" relationships.
iib. Considerable changes in the strength and nature of relationships were observed between autonomy, centralization, flexibility, reward system, and innovative activity.
iic. The relationship between achievement motivation and innovative activity was somewhat reduced in strength (from .552 to .320) and was not statistically significant.

The analysis of partial correlations, imposes, obviously, a revision of the conclusions reached through the analysis of zero-order correlations. The only significant relationships are those between cooperation, formalization and innovative activity. However, we would have probably obtained significant relationships for achievement motivation, reward system, and centralization, had been the sample larger. A tentative conclusion that can be formulated at this second stage of analysis would emphasize the following characteristics typical of Japanese R&D organizational units:
—Japanese R&D Departments, have, generally, a work environment where clear, standardized rules and procedures do not direct the behaviour of researchers during their "search and solve" activities. The existence of such rules in a R&D work environment may be not only inappropriate, but it may also discourage the researchers from engaging creatively and aggressively in those "search and solve" processes that are demanded by high technical uncertainty.
—The R&D Departments analysed in this study have consistently shown to be cooperative systems of activity, as well as systems where researchers are eager to challenge new areas of research and tackle new problems. These two positive characteristics, coupled with the lack of standardized rules governing the research process, seem to be, in our opinion, the main driving forces that synergize Japanese R&D establishments. The relationships between centralization, reward system and the outcome variable are also worth a few words of comment. Centralization of decision making is positively related with innovative activity. The nature of such relationship indicates that centralization may serve two purposes in Japanese R&D units: a.—it serves to compensate for low degrees of autonomy among researchers, and b.—to bring in some formal element in a work environment which appears to be quite informal. A R&D unit with an informal work environment where researchers seem not to perceive work autonomy as a salient feature informing their research process, needs some organizational agent which ensures "direction" in the research process and a minimum of rules which coordinate the way research is to be done. In Japanese R&D Departments the agent which ensures both direction and coordination in the research process seems to be the management in charge of the R&D unit, where decision making takes place. Some attention should be paid to the negative association between the reward system and innovative activity. This relationship seems to suggest that, according to their perception, successful researchers are not adequately rewarded monetarily and otherwise (promotion, fringe benefits)

At this stage of analysis the following proposition can be formulated: Japanese R&D Departments (in electronics) are characterized by a lack of standardized rules

and procedures in their work environmnet, by high rates of cooperative activity and achievement, and by a moderate degree of centralization in decision making, the function of which is probably to define research goals and to establish some standards regarding the general process of R&D activity within the unit. Such organizational configuration would, in our opinion, still qualify as a special case of organic work system, in the sense that organizational commitment among researchers (in terms of cooperation and motivation to achieve) are conspicuous and critical for the preformance of the R&D unit. Differently stated, the main factors which seem to direct the "search behaviour" of Japanese researchers do not come from static (read: mechanistic), objective, rational organizational structures, but rather from the socio-psychological dynamics of social exchange involved in cooperative activity and in achievement motivation among R&D personnel. It is our impression that in Japanese R&D units high degrees of organizational commitment dispenses the organization from building formal structures in order to generate such commitment and make it a reliable, programmable fact.

iii. Multivariate Analysis of Variance

The next step in the analysis will be to observe how the set of variables used in the model will explain variance in the outcome variable not one by one, but taken together as a set:

Table 4. Analysis of variance: Innovative Activity Predicted by Environment Variables (All Variables in the Model)

Variables	Standardized Coefficient of Regression	F-VALUE
AUTONOMY	−.138	.096, n.s.
CENTRALIZATION	.347	1.055, n.s.
COOPERATION	.479	5.818*
FLEXIBILITY	−.118	.103, n.s.
STATUS POLARIZATION	.006	.001, n.s.
ACHIEV. MOTIVATION	.383	1.973, n.s.
REWARD SYSTEM	−.295	1.433, n.s.
SUPPORTIVENESS	−.089	.126, n.s.
FORMALIZATION	−.953	7.071*

*P<.05

Coefficient of Determination: R-square=.671
Coefficient of Determination Adjusting for DF: R-square=.500

ANALYSIS OF VARIANCE S.O.V.	SS	DF	MS	F-VALUE
Regression	284348.3	9	31594.26	3.856*
Residual	139282.1	17	8193.07	
Total	423630.4	26		

*P<.05

Analysis of variance does not add much to the information obtained through the analysis of partial correlation. The strongest variables in the model appear to be, again, lack of standardized rules in the work environment and cooperation. The explaining power of the model was of about fifty per cent when all variables were used in the regression equation. Further effort was made to select the best regression equation which would allow us to choose the fewest and most powerful variables in the model. The stepwise regression procedure was used with the following results:

Table 5. STEPWISE REGRESSION: Innovative Activity Predicted By Environment Variables (Selected Variables Only)

	Standardized Coefficient of Regression	F-VALUE
COOPERATION	.596	16.127**
REWARD SYSTEM	−.339	3.566*
FORMALIZATION	−.539	9.547**

Cofficient of Determination, R-square=0.585
Coefficient of Determination Adjusting for DF, R-square=0.531

ANALYSIS OF VARIANCE

S.O.V.	SS	DF	MS	F-VALUE
Regression	247827.4	3	82609.12	10.808***
Residual	175803.1	23	7643.62	
Total	423630.5	26		

*P<.05; **P<.01; ***P<.001

At this stage of analysis the data have practically yielded all the information they contained. Stepwise regression has added a new bit of information which is hardly surprising. The negative relationship between reward system and innovative output has been consistent at all levels of analysis, when other variable effects were controlled. The meaning of such relationship, as hinted earlier, may be explained as follows: the more successful Japanese researchers perceive that they are not rewarded satisfactorily in terms of salary, promotion, and fringe benefits. The data do not allow us to go beyond this simple statement. This problem, however, would be worth further investigation. It is interesting to observe that negative perception of remuneration does not influence considerably cooperative action as well as achievement motivation among researchers. A fact which may puzzle some Westerner.

iv. Discriminant Analysis

The second general hypothesis advanced in this study stated that R&D units which conform more to the organic type of organization will experience higher rates of performance in terms of innovative output than firms which deviate from the organic type. The hypothesis could also be stated in a different way: firms with a higher rate of innovative output will conform more to an organic type of organization than to a mechanistic one.

In order to test such hypothesis, discriminant analysis was used. The firms in the sample were divided into two groups on the basis of quantity of output, or number of patents taken out in an average period of ten years. To the first group were assigned those firms whose number of patents, for the stated period of time, amounted to one hundred patents or less (15 units); to the second group were assigned firms with more than one hundred patents (12 units). The criterium used to classify the R&D Departments may be rather crude, since number of patents may not in fact be coterminous with R&D performance. One patent, for instance, may be of great qualitative importance for a firm and may be worth hundreds of other patents. We used number of patents as an index of R&D performance because we did not have any better index available. The reader, however, is warned of the risks involved in the type of classification we have just made.

The rationale of discriminant analysis consists in finding a dimension which maximizes group differences along some specified set of variables, in this case variables representing aspects of both formal and informal organization, and variables representing performance. The results of discriminant analysis were as follows:

Table 6. Correlation coefficients of all sets of variables with discriminant factor

Autonomy	.3315
Centralization	−.1313
Cooperation	.2687
Flexibility	.1698
Status polarization	.0056
Achievement motivation	.3213
Reward system	−.2745
Supportiveness	−.1440
Formalization	−.5253
Number of patents	.5445

Coefficient of discrimination: 60.34, F10/F16, $P < .01$

The coefficient of discrimination was statistically highly significant, indicating that there are important differences between the two groups along the newly contructed discriminant dimension. The meaning of such dimension must be gained from the nature and strength of the various associations between the set of stated variables and this new dimension. The newly found dimension correlates highly with number of patents, autonomy, achievement motivation and cooperation positively; and correlates negatively with formalization and the reward system. Stated simpler, the units which perform quantitatively better are those where researchers enjoy more autonomy, are highly motivated, are more cooperative, and operate in an environment mildly decentralized and highly informal. On the basis of these results the second general hypothesis in this study was not rejected.

VIII Discussion of Results and Conclusion

A variety of techniques were used to test the hypotheses formulated in this study:

i. Zero-order correlation found a significant relationship between innovative activity and autonomy (+), contralization (−), cooperation (+), flexibility (+), achievement motivation (+), and formalization (−). From the evidence yielded at this stage of analysis, the first general hypothesis and six of the subset hypotheses were not rejected.

ii. When multivariate analysis was used, it was found that the most powerful associations, when other relationships were controlled, were cooperation among researchers, lack of standardized rules directing research activities, the perception of a reward system that is not too viable and, to a lesser extent, motivation to excell in research activities and a mild degree of centralization in decision making. At this stage, two of the hypotheses were not rejected, while the formulation of another hypothesis regarding the reward system was confuted. Regression analysis, however, made clear that the overall Japanese R&D units are organized around two factors which are also the main ingredients of an organic system: cooperation and lack of standardized rules to direct the work process. In view of this fact, the first general hypothesis was not rejected. Japanese R&D units, although exhibiting some particular characteristics of their own, can still be considered as organic systems of action.

iii. Discriminant analysis was applied to test the second general hypothesis which stated that more successful firms would approximate an organic type of organization more than less successful organizations. The hypothesis was not rejected.

We will limit our discussion to the implications contained in the second and third level of analysis. It was stated earlier that overall Japanese R&D Departments rely more, as working units, on the commitment of their members (cooperation and achievement motivation) to the work activity and to the organization, than on the structural, rational elements which, would, in theory, make the organization "objectively viable". The interesting fact that emerges from this study is not so much the relationships between "soft" organizational variables and outcome variables, but the fact that such relationships exist either in the conspicuous absence (as in the case of autonomy, flexibility) or despite the presence (as in the case of centralization, unfavourable reward system) of associations between hard organizational varibles and innovative activity. If a system is defined as organic on the basis of how its parts are interdependent on one another and cooperate like the parts of a living organism to attain a certain goal, then Japanese R&D establishments are highly organic units. More than organic units, Japanese R&D institutions could be defined as "synergetic" systems of action. By synergetic we mean a type of system whose main and essential characteristic is the cooperative nature of its parts and whose organizational viability is only partly contingent on the planned, rational aspect of its organizational structures. According to C. Barnard[36], organizational structures have one clear function and goal: that of eliciting

36) C. Barnard, *The Function of the Executive*, Cambridge, MA., Harvard, 1938.

and guaranteeing a continuous and reliable flow of cooperative activity from the organization's members and units. This study points to the fact that if an organization is "naturally cooperative" formal structures may be only marginally important in relation to organizational performance. That such formal structures, when organically integrated into the informal structure of the organization, contribute to better organizational performance, is one more conclusion that can be gained from this study. "Natural cooperation" seems to be marginally effective when it expresses itself in an auxiliary structural form of organization.

Statistical associations alone do not necessarily imply causal relationships, but they certainly are one of the conditions which accompany relations of cause and effect. If such causal relationships between formal structure and informal structure were to be tentatively outlined, we would state that it is the informal structure of R&D Departments that "determines" their formal structures, and not the other way round. It is from the informal, highly cooperative, social relations of Japanese R&D groups that formal relationships are generated, not in a reified way, but in an auxiliary and supportive way. This final proposition is only tentative and much testing is necessary before its theoretical worth can be ascertained. Further research in this direction could prove vastly useful not only to explain the work environment of R&D institutions, but also to understand the genesis of social institutions in Japan.