Study of Work Climate in R&D Organizations: A System Dynamics Approach

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Abstract

Research regarding the examination and evaluation of work climate in understanding organizational functioning has enabled us to formulate strategies that not only improve the behavioural aspects in institutional functioning but also result in more effective organizational performance. While sufficient studies exist on the examination of work climate for industrial, service and allied sectors, relatively few researchers have considered government-funded Research and Development (R&D) institutions as their unit of study. Further, most of the studies reported have been conducted for scientists working in R&D units in developed countries.

System Dynamics methodology as applicable to studying organizational behaviour have found limited acknowledgement in literature. Moreover, most of these studies are based upon theoretical understanding of the subject with little empirical support. The present study is an offshoot of a series of studies which were undertaken in the National Institute of Science Technology and Development Studies on different aspects of R&D Management with primary emphasis on organizational behaviour. An attempt is made here to model the work climate of an R&D laboratory using the System Dynamics methodology with support from the studies carried out earlier as mentioned above. The motivational conditions prevailing in an R&D laboratory was studied in order to understand the factors and forces which are necessary to provide a climate which will motivate the scientists. Likewise, factors and forces that contribute significantly to the overall satisfaction with the work group were also studied. The question whether operating within an environment as is prevailing within the R&D laboratory had a stimulating or a debilitating effect on the work enthusiasm of the scientists were addressed to them. The aspect of R&D effectiveness of the research groups was also probed into and the factors and forces contributing to the same identified. A detailed flow diagram was then developed relating to above factors to the project flow dynamics. Trial runs of the model using the DYMOSIM package have been carried out and project-related data collection are currently in progress to evaluate the constants and multiplier factors and for validation of the model structure.

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I. INTRODUCTION

While managing Research and Development (R&D) organizations, formulation of strategies which improve the behavioural aspects and institutional functioning and result in more effective organizational performance has been a key thrust area. Study of work climate is a critical component of this thrust area.

Sufficient evidence exists in the literature to indicate that examination of work climate in a R&D set-up is as important as in any other type of organizations (Gaddis, 1959; Goodman, 1967; Steward, 1965; Avots, 1969; Cleland, 1967). Barndt et al. (1977) for example, while writing about the role of R&D managers, suggested that one of the major tasks before them is the establishment of a work climate that allows adequate interaction, cooperation, compromise and bargaining necessary for satisfactory job completion among people. Some studies have taken the view that better work climate in an organization will minimize the conflicting situations that arise as a result of say lack of team participation in decision-making, lack of team spirit, job insecurity, etc. (Murphy, Baker and Fisher, 1974). Wilemon's study (1971) also revealed that greater the diversity of expertise among the team members, greater would be the potential for conflict to develop which in turn can affect the overall climate in an organization. Sherman (1986) probed into the relationship between factors in the work environment and turnover propensities among engineering personnel and found that approximately 30 per cent of variable (R) in turnover propensities is explained by factors in the immediate work environment. Factors such as autonomy and goal congruence (with one's superior) were found to have a great influence. Another interesting study by Tuttle et al. (1987) focussed on assessing the job satisfaction of research scientists.

Examining how work climate has been defined by researchers in literature. we find that some theorists have argued in favour of splitting "Organization Climate" into individual focused and organization-focused separately (James and Jones, 1974). They defined climate in terms of organizational attributes, "psychological climate" and individual attributes. Hellreigel and Slocum (1974), by contrast, treated climate as a more unitary phenomenon, defining it as "....a set of attributes which can be perceived about a particular organization and/or its subsystems and that may be induced from the way that organization and/or its subsystems deal with their members of environment" However, one thing common to both the definitions is that climate must be divided into two parts : firstly, related to the members or groups and secondly, related to overall organizational system. Schneider and Snyder (1975) defined climate as "a global (multidimensional) impression of what the organization is ". However, as it is defined, "climate" refers to a systematic phenomenon that pervades an organization and its parts. In addition, climate is a perceived phenomenon, knowledge of which is usually gained by administering and scoring a questionnaire.

In order to examine scientific productivity in relation to stratification or organizational variables, a variety of approaches to the construction of operational indicators of performance have been used in the literature. Fairly consistent evidence has come up in the literature for a high or moderate correlation between the sheer volume of a scientist's published papers and the quality of his or her work, as measured by ratings of competence by peers or citation counts (Pelz and Andrews, 1966; Cole and Cole, 1971; and Blume and Sinclair, 1973). The conclusion seems to be that where citation counts are not readily available -

as in the case of a study including countries not adequately or not at all represented in the science citation index - publication counts are roughly adequate indicators of the significance of a scientist's work. Wallmark and his associates (Wallmark et al, 1973) investigated the relationship between the size of research teams and the performance of their members. Blume and Sinclair (1973) investigated the relationship between group size and effectiveness using a large sample of British university chemists.

One of the major thrusts in recent organizational behaviour literature has been the contingency approach, not only for leadership, but also for climate. Thus, climate and performance and their relationship to each other are probably affected by certain other variables - technology, process development, or structure of the organization. There are no clear contingency factors related to climate in a universal way. Of interest is Tecklenberg's (1981) argument that to achieve this end, R&D managers must understand, influence, and assess their organizations, and among the aspects to be assessed are perception of time and resource constraints, orientation towards goals of a discipline and goals of the organization, perception about how the organization's reward system works and beliefs about the importance of the individual's work to the organization. Fiedler showed that the climate of a group had a substantial impact upon the effectiveness of leadership styles, and Lawler and Porter (1967) - after examining over 30 studies of performance - reached the conclusion that satisfaction and climate might result from high performance rather than being a cause of it.

Strength of motivation is a factor influencing the performance of research teams. Some teams seem dedicated to the work they are doing. For them, the research or development in which they are engaged presents high challenge. They are heavily involved in what they are doing and committed to making the maximum possible progress on the task before them. Pelz and Andrews (1966) in their study of American scientists had incorporated in their questionnaires a set of five items that they used to measure dedication. The items asked scientists to indicate their feelings of involvement and identification with their work, and to say how challenging, important, and interesting they found it. Using data from more than 1300 scientists, they found that these items showed significant positive relationships to both ratings of performance and actual outputs of scientific products for scientists of widely different types and widely different types of laboratories. They have also shown that the performance of the scientists increase when decision making and goal setting are shared by members of various echelons in the research organization. Newson (1990) highlighted that to increase employees' productivity, managers must know what factors motivate them. He advocated the use of the Expectancy theory which can improve motivation if nine aspects are met: capacity, confidence, challenge, criteria, credibility, consistency, compensation, cost, and communication. These aspects should be properly exercised for better results from the members of an organization. A number of other studies on motivation have revealed that employees look for many other incentives in the job, other than material rewards. Narain (1973), Sinha, (1973) and Ganguly, (1974) argued that they are unable to test their skills and make use of their experiences. Further, they perceive that their jobs do not allow them sufficient freedom to take decisions. Menon & Shamanna (1990) have indicated that the inter-personal relationships that prevail within an organization are influenced by the nature of the work flow in that organization. Other studies on socio-technical system have indicated that the technical system can affect inter-personal factors such as cooperation, communication and influence in a work situation. Inter-personal relationships can affect productivity and this can modify the satisfaction an employee derives from his job.

II. PREVIOUS R&D MANAGEMENT STUDIES

The present study is an offshoot of a series of studies which were undertaken in the National Institute of Science, Technology and Development Studies, New Delhi on different aspects of R&D Management with primary emphasis on organizational Behaviour.

(i) The first study was undertaken by Dhawan and Roy (1989, 1991, 1993) as a part of a research programme of the institute "Scientific Culture and Laboratory Functioning: Case of an R&D Organization". The R&D Organization under consideration was the Council of Scientific and Industrial Research (CSIR), New Delhi which has in its fold about forty research laboratories working on different disciplines of science and technology. The study examined the functioning of the R&D laboratories of CSIR in the context of cultural values and norms of the scientists. The study focussed upon Indian Scientists and their work climate, their Value System and the Sources of their Mental Energy.

(ii) The present study also draws upon the factors identified and inferences drawn by Nagpaul and his colleagues in the institute (1987) as a part of the International Comparative Study on Organization and Performance of Research Units (ICSOPRU) carried out in several countries and in a variety of international contexts. Though the scope of this study in India went beyond the boundaries of CSIR, only those aspects have been considered in this present effort which were related to CSIR and whose samples were comparable to the previously-mentioned study by Dhawan and Roy.

III SYSTEMS DYNAMICS METHODOLOGY AND ORGANIZATIONAL BEHAVIOUR STUDIES

Systems Dynamics methodology as applicable to studying organizational behaviour have found limited acknowledgement in the literature. Notable among the researchers who have worked in this field include Breiter (1990), and Donnadieu et al (1990) who have focussed on employee motivation. Other researchers have focussed on motivation of project managers (Jessen, 1991), organizational change (Frechette et al, 1991), and group behaviour (Sushil et al, 1991). However, most of these studies have concentrated on industrial and service sectors and Research and Development organizations have not found much favour. Further, most of these studies are based on theoretical understanding of the subject rather than a solid empirical foundation. The present study is an attempt to bridge this gap.

IV THE SYSTEMS DYNAMICS MODEL

The system dynamics model (figure 2) described here is based upon the the results of the empirical studies mentioned above. Figure 1 presents the results of the cluster analysis with motivation as the central factor (three laboratories separately). Our aim in this analysis was to understand the factors and forces which are necessary to provide a climate which will motivate the scientists. The three factors found common in the three laboratories are: human resource primacy, communication flow, and decision-making practices.

Figure 1: Motivation and Related Factors - Results of Cluster Analysis

Motivation

Lab.1	Lab.2	Lab.3
- Human Resource Primacy - Communication Flow - Decision-making Practices	- Human Resource Primacy - Communication Flow - Decision-making Practices - Technological Readiness	- Human Resource Primacy - Communication Flow - Decision-making Practices - Goal Clarity

One may try to generalise that in case the management of R&D institution wishes to activate the efforts put in by its scientific staff then they must develop a suitable system of decision-making which involve scientists at all levels. They must also develop a system of proper communication both upward and downward and parallel across the organization. And finally they must take into consideration the welfare aspects of the scientific community. Better communication systems can help scientists to update knowledge in their area(s) of interest and can improve productivity.

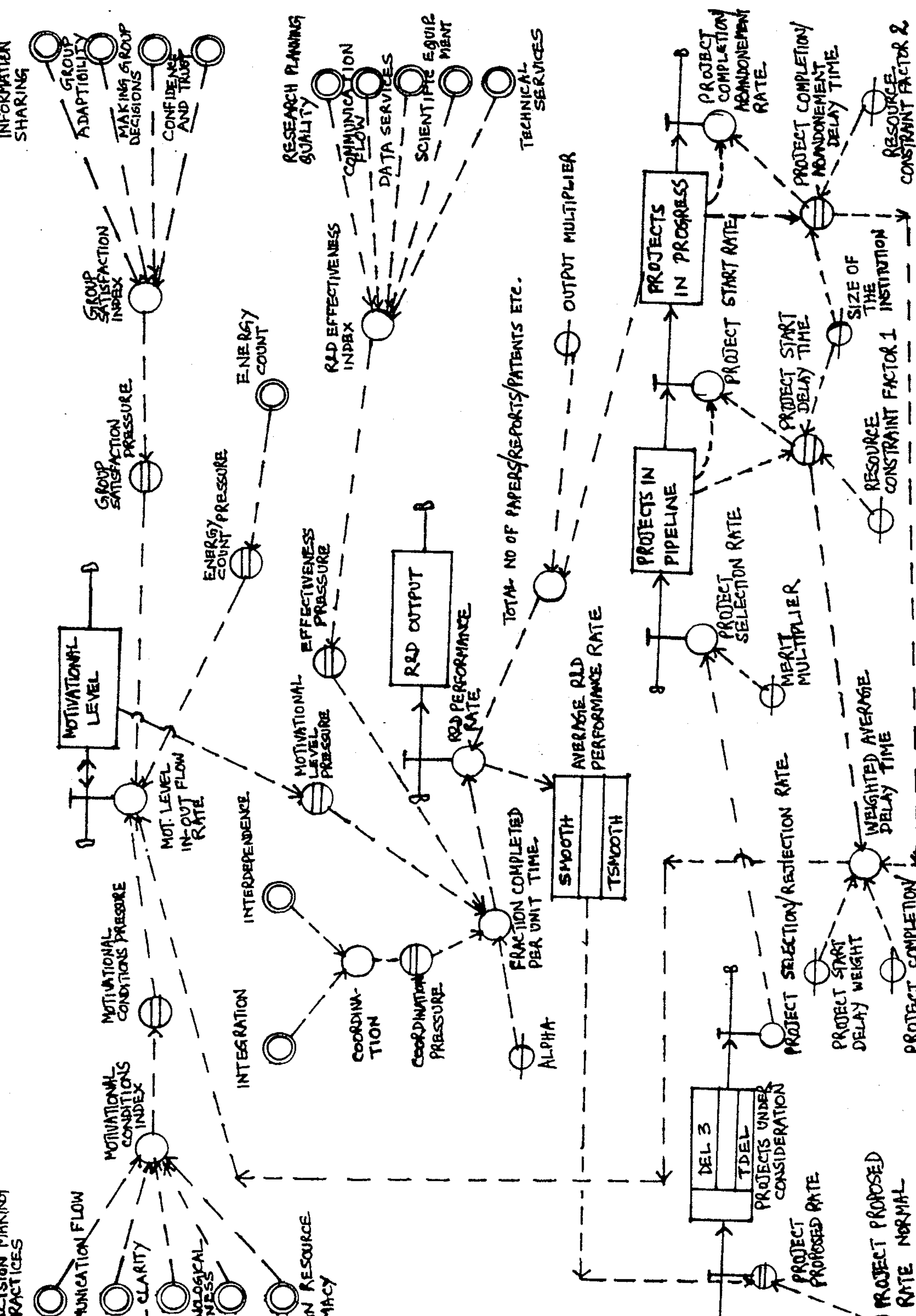
INFORMATION SHARING
GROUP ADAPTIBILITY
MAKING GROUP DECISIONS
CONFIDENCE AND TRUST
GROUP SATISFACTION INDEX
GROUP SATISFACTION PRESSURE
ENERGY COUNT
ENERGY COUNT PRESSURE
MOTIVATIONAL LEVEL
MOT. LEVEL IN-OUT FLOW RATE
MOTIVATIONAL CONDITIONS PRESSURE
MOTIVATIONAL CONDITIONS INDEX
DECISION MAKING PRACTICES
COMMUNICATION FLOW
GOAL CLARITY
TECHNOLOGICAL READINESS
HUMAN RESOURCE PRIMACY
INTERDEPENDENCE
INTEGRATION
COORDINATION
COORDINATION PRESSURE
ALPHA
MOTIVATIONAL LEVEL PRESSURE
EFFECTIVENESS PRESSURE
FRACTION COMPLETED PER UNIT TIME
RESEARCH PLANNING QUALITY
DATA SERVICES
SCIENTIFIC EQUIPMENT
TECHNICAL SERVICES
R&D EFFECTIVENESS INDEX
R&D OUTPUT
R&D PERFORMANCE RATE
SMOOTH
TSMOOTH
AVERAGE R&D PERFORMANCE RATE
TOTAL NO OF PAPERS/REPORTS/PATENTS ETC.
OUTPUT MULTIPLIER
PROJECTS IN PROGRESS
PROJECT COMPLETION/ABANDONEMENT RATE
PROJECT COMPLETION/ABANDONEMENT DELAY TIME
RESOURCE CONSTRAINT FACTOR 2
SIZE OF THE INSTITUTION
PROJECT START RATE
PROJECT START DELAY TIME
RESOURCE CONSTRAINT FACTOR 1
PROJECTS IN PIPELINE
PROJECT SELECTION RATE
MERIT MULTIPLIER
WEIGHTED AVERAGE DELAY TIME
PROJECT SELECTION/REJECTION RATE
PROJECT START DELAY WEIGHT
PROJECT COMPLETION/ABANDONEMENT DELAY WEIGHT
DEL 3
TDEL
PROJECTS UNDER CONSIDERATION
PROJECT PROPOSED RATE
PROJECT PROPOSED RATE NORMAL

FIGURE 2

To understand the factors and forces that contribute significantly to the overall satisfaction with the group, step-wise regression was carried out and results are presented in Table 1(three laboratories separately).

Table 1: Factors Contributing to Variation in Group Satisfaction Level of the Respondents: Results of Step-wise Regression

Significant Factors	R-SQ	R-SQ Change
Laboratory-1		
Information Sharing	0.62	
Group Adaptability	0.76	0.14
Making Group Decisions	0.84	0.08
Laboratory-2		
Confidence & Trust	0.49	
Group Adaptability	0.61	0.12
Making Group Decisions	0.70	0.09
Laboratory-3		
Confidence & Trust	0.62	
Coordination	0.79	0.17
Making Group Decisions	0.86	0.07

Scientists of Lab-1 have perceived three key factors - information sharing, group adaptability, and making group decisions as explaining the variance in overall group satisfaction. Therefore, if any action to increase the team spirit or group effectiveness among these scientists are being considered, then the management must develop a system in which the relevant information is shared with the concerned scientist(s), group decisions are made in a participative style, and some sort of training in group adaptability be imparted to them. For Lab-2, the significant factors are: confidence & trust, group adaptability, and making group decisions. A new factor for this laboratory is confidence and trust among the group members. Thus, the scientists desire that for effective performance of the group a higher degree of trust leading to high degree of cooperation among them is a must.

Yet another new factor for Lab-3 is coordination among various functions of the group. This is understandable as the multi-disciplinary nature of R&D requires an adequate amount of coordination among scientists of different fields, different divisions or even different institutions.

The question whether operating in an environment as is prevailing within the R&D laboratory had stimulating effect or a debilitating effect on the work enthusiasm of the scientists was addressed to them. In case of the first (stimulating effect), it was termed as "Energy Generating" (EG) and in case of the second, it was designated as "Energy Draining" (ED). The ratio of the value attached to Energy Generating activities to the value attached to Energy Draining activities is known as the Energy Count which is a measure of the health of the organization. The energy count also provides a pressure for overall motivational level within the organization.

Probing into the aspect of R&D Effectiveness of the research groups, an analysis was carried out to identify the factors and forces contributing to R&D effectiveness. The factors identified were research planning quality, communication flow, data services, scientific equipments and technical services. To assess the role of human and organizational resources vis-a-vis material resources affecting R&D effectiveness, multiple classification analysis was carried out with material resources as the background variables and human and organizational resources as the intervening variables. It is observed that organizational resources are the most important set of predictors, followed by human and material resources. The findings have important implications for research management that the planning and allocation of financial and material resources to research activities must go beyond a simple cost-benefit approach. It must entail the determination of optimum organizational, managerial and social-psychological conditions for successful conduct of R&D.

The combined R&D effectiveness index provides a pressure affecting the fraction of the total number of papers/reports/patents/processes or know-how developed per year which in turn determines R&D performance rate. This fraction is also determined by a pressure from overall coordination - both intra and inter-departmental (into which significant contributions are due to integration and interdependence among the departments/areas), a pressure from overall motivational level within the organization and a multiplier constant alpha. The R&D performance rate is smoothed or averaged which, coupled with project proposed rate leads to project selection/rejection rate after a delay. A multiplier depending upon the merit of the incoming project proposals gives us the project selection rate. Then after a series of first-order delays come project start rate and project completion/abandonement rate. The level variables are projects in pipeline and projects in progress respectively. The total number of projects in progress also determines the total number of papers/reports/patents/know-how under process along with an output multiplier. Both project start delay time and project completion/abandonment delay time are affected by the respective level variables apart from a resource constraint factor multiplier (both financial and material) as well as the size of the organization. A weighted average of these two delay times determines the overall motivational level in-out flow rate. The detailed flow diagram may thus be translated into a set of equations that can be simulated by using computer packages.

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