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Leadership in R&D : a theoretical and methodological inquiry

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ABSTRACT

This investigation addresses a number of difficulties surrounding the phenomena of leadership. First, the complexity of leadership as a construct appears to have resulted in an unintegrated body of leadership research characterized by a lack of validation; the literature review conducted here affirmed the need for integrative theory building. Second, the complexity of leadership as a construct makes leadership hard to define, measure, and analyze. A series of exploratory analyses were conducted to further understand the methodological problems associated with leadership research. These included exploratory and confirmatory factor analysis and validity assessment using the multitrait - multimethod matrix.

Data were collected by the United Nations Educational Scientific and Cultural Organization (UNESCO) for an international comparative study on Research and Development (R&D) units. Round 2 (1979-1981) data selected for this study were sampled from five countries (Argentina, Egypt, India, Republic of Korea, Poland, and U.S.S.R.). Unit members were defined as either Leaders, Scientists, or Technicians. The survey instrument measured a variety of internal and external climate and leader performance issues using 205 individual items. Technical procedures used in this study resulted in the inclusion of (n=692) R&D units with one Leader, one Scientist, and one Technician per unit (n=2076).

Principal components and maximum likelihood (ML) factor analyses and common sense methods were used to reduce the number of variables and group 41 remaining variables into five subscales: climate (CLM), external environment (EXT), resources provided by leader (LDRES), rating of leader performance (RAT), leader consideration and structure (LDR). Factor scores were produced for subjects on each of the five subscales and intercorrelated to produce the multitrait-multimethod (MTMM) matrix.

Matrix correlations were lower and weaker than anticipated, pointing to the absence of discriminant and convergent validity; however, a few specific instances of validity were noted and discussed. Coefficients and item mean differences were used to explain leadership on a number of levels. Micro-conclusions highlighted the correlation of leader consideration with measures of climate and external environment. Support was generated for role of the R&D leader as technical advisor and mentor, but the notion of R&D climate as conflict ridden was not supported Macro-conclusions pointed to the complexity of and interrelationships among variables, and the lack of complete agreement with leadership theory. Had the MTMM not been employed, the weakness of validity of many of the variables would not have been uncovered. Theoretical and methodological difficulties associated with leadership research were illustrated and discussed.

INTRODUCTION

Leadership is among the oldest, most frequently researched, and popular phenomena in the social sciences. At the same time it remains of the most complex, and in many ways, least understood. How can a construct which has been so thoroughly researched remain so ill-explained? The answer probably lies in some of the difficulties inherent to the construct of leadership.

One difficulty with leadership is its' sophistication as a construct; it has many definitions depending upon the orientation of the investigating scientist, and has been correlated with literally hundreds of variables. Barrow (1977) characterizes leadership literature as crowded with small scale studies focusing on a very limited number of variables, and labels leadership research as "unintegrated, piecemeal, and heterogeneous" (p. 232).

Another difficulty with leadership is that its' complexity makes it correspondingly hard to measure and analyze properly. Increasingly advanced methods of data analysis are being applied to leadership data, but most often, little is done by the way of validation before testing. As a result, many studies claim statistically significant findings, but their lack of validation make their contributions difficult to evaluate.

The purpose of the present investigation is to explore a few of the theoretical and methodological problems associated with leadership. First, a relevant review of the literature will be conducted with an anticipatory eye toward a lack of integration. If located, the need for integration will be noted and discussed, but developed further in future studies.

Second, exploratory data analysis will be conducted using the multitrait-multimethod (MTMM) matrix, a methodological tool not often employed in leadership research. The multitrait-multimethod matrix is employed as a method by which rudimentary questions about the validity of leadership (as operationalized here) can be evaluated. Data selected for this study concern leadership in the context of international research and development (R&D) units. R&D leadership may present a challenge to traditional leadership theory. In addition, the data set presents opportunities to examine a wide array of variables, which otherwise could not have been collected for a study such as this, which is limited in scope and magnitude.

EXPLORATION OF LEADERSHIP THEORY

Historical Perspective: Leadership research prior to the mid-20th century focused almost exclusively on theory, with most attempting to explain either qualities of the leader or elements of the situation. Researchers shared a common focus on leadership as a product of a single set of forces which did not interact with one another. The earliest known observations of leadership came in the mid-1880s. As a result of the continued development of the sciences, philosophy, and history, multi-disciplinary observations were used to explain the phenomena of leadership. The first theories of leadership proposed that the unique personal attributes of leaders could change the course of history. These Great-Man Theories of leadership (so named because males were thought to represent the embodiment of leadership) represented a leader as having superior powers and qualities which mesmerized his followers.

Petrullo and Bass (1961) summarize the history of leadership research and signify industrialization as the impetus for the first organized leadership studies, which began in the early 1900's. At that time, field observation was the method of choice and leadership remained a phenomena of superior personal attributes which operated independently from the environment; theories of this type are now known as Trait Theories. In later years, as the scientific community undertook more empirical

research, leadership came to be understood as a function of specific forces which were external to the individual, and so Environmental Theories were born. As experimental manipulation became more widely used, leadership research became more diverse. Research topics broadened in focus to include the larger environment (climate), and the individual as embedded in the group (leader emergence). Leader emergence theories attempted to explain how groups allow an individual to lead, as well as the qualities a leader would need to be able to lead; these theories considered both trait and environmental influences, albeit separately from one another.

Contemporary Research: The 1950's and 1960's saw the advent of empiricism in leadership research, and the beginnings of modern leadership theory. Leadership investigations proliferated as evidenced by large scale investigations, such as the Ohio State Studies. According to Bass (1978), the most striking difference between early and contemporary researchers was that early researchers failed to acknowledge interaction between individual and situational variables. In Bass' estimation, early researchers' strength was in theory development; contemporary researchers generally focus on issues that are less ambitious than those researched by forerunners in the field. "The failure of current scientists to investigate certain areas of the leadership problem can be attributed in part to their empirical as opposed to their theoretical orientation" (p. 6). This idea, that leadership theory and research has advanced further empirically than it

has advanced theoretically and methodologically, is clearly evident in contemporary literature.

The literature review presented here covers a broad range of theoretical perspectives. It is by no means offered as all-encompassing, but is intended to give the reader a brief overview of contemporary leadership theory. No attempt will be made to integrate the theory, merely to illustrate its' current condition. Rough categories have been applied (both for readability and commonality of purpose), but these vary somewhat from other literature reviews, as is often the case. In the present study, leadership research is categorized into trait and behavior, situational, contingency, reciprocal causation, attribution, cognitive, expectancy, and humanistic theories.

Leader trait and behavior theories focus upon traits of an individual which are associated with specific leadership behaviors. For example, it is possible to differentiate leaders who use punitive versus rewarding behavior based upon their personality characteristics (Hinton and Barrow, 1976). Leaders who were warm and directive were more likely to motivate subordinates to complete tasks (Tjosvold,1984). Perceptions of leader masculinity/femininity and dominance were found to be significant factors in leadership (Lord, DeVader, and Alliger, 1976). In addition, leaders' locus of control (Goodstadt and Hjelle, 1973) and encouraging and friendly disposition (Eden and

Leviatan, 1975) have also been investigated, although the results were equivocal.

Related studies focused on the effect of leader behaviors on a variety of subordinate responses. For instance, a leader's presentation of a problem influenced the problem solving techniques of subordinates, although not as expected (Maier and Sashkin, 1971). Subordinate performance was also shown to be influenced by both the type of influence a leader exerted (Student, 1968) the leader's use of motivational strategies (Oldham, 1976) and reward/punishment behavior (Podsakoff, 1982). In addition, leader behavior was shown to influence effort expenditure, job satisfaction (Klimoski and Hayes, 1980), and grievances and turnover (Fleishman and Harris, 1962) of subordinates.

Situational causation research shifted the thinking about the nature of leadership as determined by individual factors, to situation factors as primary determinant of leader behavior. Organizational structure and social milieu are thought to influence the individuals embedded in it. Task type (Hill and Hughes, 1974) and hierarchical level (Jago and Vroom, 1977) have been found to have significant effects on leader behavior. Other variables, such as departmental context and formal organizational structure have received mixed support (Ford, 1981). Green and Nebeker (1977) found that leader behavior toward their subordinates changed as a result of whether work circumstances

were favorable or unfavorable. Hersey and Blanchard's (1982) *Situational Leadership Theory* asserts that as the level of follower maturity increases, effective leader behavior will involve less task orientation and less relationship orientation. Subsequent investigations though, suggested that this model may hold true for only certain types of employees (Vecchio, 1987). Overall, the notion that leaders within different organizational environments must necessarily display different behaviors has received empirical support, although the relationships found to exist within the environment are complex and not easily interpreted.

Contingency theories call into question purely situational influence. Leader effectiveness is presumed to be contingent upon the alignment between the situation and the behavior the leader exhibits; the better the "fit" between the situation and the behavior, the more effective the leader. Fiedler's (1964,1967) *Contingency Model* of leadership effectiveness propose that the relationship between leader attributes and subordinates' performance is contingent upon the favorableness of the situation. He described leader consideration (warmth, interest) and structure (coordination, assistance) as being causally related to subordinate performance and ratings of leader effectiveness. Another contingency based approach, the *Vroom-Yetton Normative Model* (Vroom and Yetton, 1973) attempts to describe decision making methods for managers which will have foreseeable outcomes for subordinates. Different levels of subordinate

participation in decision making were suggested based upon the leaders' conflict management skills (Crouch and Yetton, 1987; Field, 1982). Some objections to its relative complexity have been raised, although these have been shown to be essential explanatory elements of the model (Jago and Vroom, 1980). One criticism of contingency based theories is their lack of emphasis on macro variables such as technology, environment, and structure which have been found to be related to leader behavior.

Reciprocal causation, the notion that leaders and subordinates influence one another's behavior, has been developed by researchers in a variety of formats. Greene (1975) made strong inferences that leaders' consideration behavior influenced subordinate satisfaction, and that subordinate performance caused changes in leaders' consideration and structure behaviors. A number of other subordinate behaviors have also been found to influence leader behavior (Farris and Lim, 1969). Sims and Manz (1984) reported reciprocal determinism, in which each party in a dyadic relationship acts as a causal influence on the other.

The *Vertical-Dyad Linkage (VDL) Model* (Dansereau, Graen, and Haga, 1975), the most notable of the reciprocal theories, has received considerable support both in terms of its construct (Herold, 1977) and external validity (Liden and Graen, 1980). It was later

noted that the quality of the interaction could be influenced by subordinate demographic characteristics (Duchon, Green, and Taber, 1986), highlighting its insensitivity to situational influences. The VDL model was extended to the *Leader Member Exchange model* (Graen, Novak, and Sommercamp, 1982) which, although suffering from serious methodological difficulties, emphasized the process of development and negotiation of roles in the interaction between the leader and subordinate (Diensch and Liden, 1982).

Evidence has also been generated for the *Adaptive-Reactive Model* of leadership (Osborn and Hunt, 1975) in which leaders adapt their behavior to externally determined or organizationally driven factors (eg., department size) and react to the needs and wants of their subordinates. The greater the adaptive component the less the reactive component.

Hollander's *Social Exchange Theory* also focuses on the superior-subordinate dyad. As originally conceived, (Hollander and Julian, 1969) a leader would confer a social gift upon the subordinate who in turn felt obligated to reciprocate, typically in terms of reaching the leader's expectations for good performance. Early on, there was little acknowledgement by Hollander that the subordinate could influence leader behavior. Later, however,.Hollander (1978) discussed the exchange process as embedded within

the social situation. While Social Exchange Theory offers some conceptual appeal, it has not been widely supported in leadership literature; Hollander's contribution to leadership research remains concentrated in the area of leader emergence.

Leadership as an attribution. Attribution theory is based upon the perceptions of observers who make social constructions in order to account for occurrences in the workplace. Further, the observer feels compelled to understand the occurrence in order to ultimately be able to control it. Pfeffer (1977) argues that the leader is a primary target of this social construction by serving as a personification of the causation of occurrences. It makes no difference whether or not in fact the leader influences social occurrences, what is important is that subordinates believe s/he does. Meindel and Ehrlich (1987) label this bias of seeing the leader as the causally dominant factor of an occurrence the "romance" of leadership.

Attribution theory has also been applied to the leader, rather than the observer, (Graen and Mitchell, 1979) by considering the leader an "information processor" who uses causal attributions to make sense of subordinates and the environment before attempting to change or control them in some way. Managerial attributions differed depending upon whether subordinates were successful or failures (Gioia and Sims, 1986), but the reverse was also true; good group performance resulted in better leader

ratings (Mitchell, Larson, and Green, 1977). The fundamental shortcoming of attribution theory is that it cannot explain how individuals formed attributions, only that they do so.

Cognitive theories emerged in an attempt to explain the nature of attributions. For instance, *Implicit leadership theory* argues that subordinates use cognitive categories to distinguish leaders from non-leaders, but has only received indirect support (Rush, Thomas and Lord, 1977). Larson, Lingle, and Scerbo (1984) reported that raters responses are based on cognitive processes such as a selective memory and a probabalistic response bias. Phillips (1984) also supported this view by noting that in the absence of specific information raters will rely on more generic information and may have trouble separating the two; despite that, he reported that ratings possess substantial accuracy. *Leadership Categorization Theory* better explained cognitive categories proposed by Implicit Leadership theory by testing the content and structure of the cognitive categories (Lord, Foti, and Phillips, 1982) and was generally supported (Lord, Foti, and DeVader, 1984). Ultimately, it was categorization and not attribution which was reported as the primary process in determining leader perceptions (Cronshaw and Lord, 1987).

Expectancy theories also considered leaders perceptions by subordinates. These theories

argue that an individual's behavior can be predicted by 1) the individual's perceived expectation that the behavior is related to outcomes and 2) the worth of the outcomes to the individual. There is evidence that leader behavior (as a dependent variable) is partially under the control of the leader's own expectations about those outcomes (Nebeker and Mitchell, 1974). There is also evidence that a leader has the ability to influence the subordinate's perceptions of the rewards available to him/her, and the subordinate's perception of the paths (behaviors) through which rewards can be attained (House, 1971). It also appears that intervening variables such as subordinate motivation and locus of control moderate that relationship (Evans, 1974).

A variation on this theme is *Social Learning Theory* in which subordinates recognize reinforcement contingencies initiated from non-leader sources. If the subordinate uses these for self-reinforcement this self-influence can be regarded as a substitute for leadership (Manz and Sims, 1980). In the absence of immediate contingencies Weiss (1977) argues that subordinates seek models so they are able to learn social characteristics which may earn delayed or vicarious reinforcement. Frequently the "model" is the subordinate's supervisor.

Two additional theories, classified here as Humanistic Theories, are also relevant. McGregor (1960) asserts that there are Theory X and Theory Y leaders in

organizations. Theory X leaders tend to view subordinates as resistant to organizational needs and make attempts to direct subordinates to fit those needs. Theory Y leaders, on the other hand, view subordinates as motivated and responsible and apply minimal direction to obtain organizational needs while allowing maximum fulfillment of subordinate needs. Argyris (1957) sees a basic conflict between the individual and the organization. Organizations tend to control their members in order to reach its objectives, whereas individuals are motivated to seek fulfillment of their own goals. In Argyris' model, a leader's role is that of enabling subordinates to make a contribution to the organization as an outgrowth of their own needs for growth and self expression.

To summarize, leadership research presented here was categorized for readability. Inspection clearly indicates the literature lacks a common theme and deserves the labels "piecemeal, unintegrated, and heterogenous". Despite vast literature and empirical studies, and attempts of late to introduce many variables into the leadership equation, the field still lacks an integrated, testable theory of leadership. One of the many reasons for this appears to be the sophistication of leadership as a construct in combination with the inherent difficulties of defining, measuring, and analyzing it properly.

EXPLORATION OF LEADERSHIP IN R&D

Thus far, this investigation has explored some of the theoretical difficulties associated with the construct of leadership. Namely, that the construct of leadership is sophisticated and that leadership research has advanced further empirically than it has methodologically. The literature review conducted here affirms the need for a more integrative approach to leadership theory. Having completed that first purpose of the study, it is now appropriate to shift our attention to the second purpose of the study which deals with methodological exploration.

The second purpose of the study, will account for the all subsequent analyses and discussion in the study. Several common sense analyses will be conducted in an attempt to shed some light on leadership within the context of R&D. As a precursor to those analyses, a brief review of literature surrounding leadership in R&D will be presented, as well as a justification for the use of Multitrait-Multimethod (MTMM) matrix.

Following that introduction, the data set will be examined in search of clues to a possible latent structure. Once identified, an exploratory analysis will be conducted to arrange related groups of variables (factors) which best explain leadership. Those

factors will then be subjected to the four Campbell-Fiske criteria to establish that sufficient convergent and discriminant validity exist to encourage further investigation of the recipe of leadership defined here. If the burden for convergent and discriminant validity are met, limited statistical analysis of the matrix will proceed. If evidence for validity is not obtained, statistical analysis will not proceed; instead, coefficients in the matrix will be examined as an indication of where difficulties with leadership rest and where further effort might be applied in future studies.

Assuming an interpretable matrix is achieved we would expect to 1) measure leadership with high levels of internal consistency, 2) observe more agreement on leadership ratings by different raters on the same leadership traits and less agreement on leadership ratings by the same raters on different traits, 3) achieve higher correlations on traits across raters than for any other correlation in the matrix having neither a trait or method in common, and 4) observe consistent ratings across raters (pattern). Interpretable coefficients within the MTMM matrix, in conjunction with mean item differences, will be used to address issues of leadership in R&D.

Necessity of a Unique Methodology

Despite voluminous research in the field (Bass, 1978 cited more than 5,000 citations over twenty years ago), very few have focused on organizing the process of science in

which they engage. Recent studies have used increasingly sophisticated statistical methods to investigate leadership, but these are merely sophisticated tests of an underlying construct which is neither well validated nor well understood. As a result, we are left without a leadership framework around which facts can be organized.

The vast number of variables and interrelationships leadership presents defy many research methods. Karmel (1978) argues that leadership data challenges traditional research methods in terms of 1) definitional confusion due to confounding effects of environmental variables, and 2) unacknowledged assumptions about causality which influence operational definition of variables. She further suggests that any investigation of leadership must begin to develop an acceptable construct before any operational definitions are assigned.

MacKenzie and House (1978) agree; to develop paradigms in the social sciences researchers must engage in "strong inference", a process which develops cumulative knowledge through theory building. Researchers should start with a crude framework, put it through transformations which extend, improve, and refine it over time. Only then should empirical investigation be undertaken. This study subscribes to that line of reasoning.

The methodological tool which most closely parallels that reasoning is the Multitrait-Multimethod (MTMM) matrix. The MTMM matrix will be used to assess the convergent and discriminant validity of ratings as a first step in evaluating the construct of leadership. The MTMM will help to reduce a vast number of possible variables into a justifiable few, and will allow comparisons of many variables simultaneously against one another.

Multi-Trait Multi-Method Matrix (MTMM)

The MTMM as originally conceived by Campbell and Fiske (1959) is a method used to assess convergent and discriminant validity of ratings by measuring more than one trait (T1, T2,...Tn) each of which is associated with more than one method (M1, M2,...Mn) and obtaining their zero-order correlations. Tests designed to measure a specific construct should correlate highly (convergent) while tests designed to measure different constructs should not be correlated with tests considered to be unrelated to them (discriminant validity). However, Campbell and Fiske point out that tests designed to measure a specific construct may correlated highly not because they measure the same construct but because they are measured by the same method; this they term "methods variance". Similarly, tests which measure different constructs may be displaying high correlations not because they are in fact measuring highly related constructs but because they are measured by the same method. By including multiple

methods of measuring same and different constructs in the same design it is possible to better evaluate of convergent and discriminant validity. Evaluation is based upon inspection of four Campbell-Fiske criteria, to paraphrase:

1. Convergent validity coefficients should be statistically significant and sufficiently different from zero to warrant further investigation. (Convergent validity).

2. Convergent validity coefficients should be higher than the other values in its column and row in the heterotrait-heteromethod triangles. Inability to satisfy this criterion indicates that traits may be correlated or that a method effect exists. In addition, should correlations between traits in the heterotrait-monomethod triangle approach the value of the reliabilities of the traits there is a strong likelihood that a halo or method effect is in operation. (Discriminant validity).

3. The convergent validities should be higher than values in the heterotrait-monomethod block. That is, correlations among traits supposedly measured by the same trait should be higher than different traits measured by the same method. Failure to satisfy this criterion indicates that agreement on a

particular trait is not independent of agreement on other traits assessed by the same method.(Divergent validity).

4. Correlations among traits should be of the same pattern in every heterotrait triangle of every heteromethod and monomethod block. If the same pattern of correlations is found, it provides a general indication of validity of the methods. If it fails to be found, heterogeneous sources of error are likely.

Despite the MTMM's obvious utility, a number of criticisms have been raised. For example, some have argued that the Campbell-Fiske criteria are based on their assumption that traits are uncorrelated with methods and methods are only minimally correlated with each other and that the plausibility of these assumptions is questionable at best (Kalleberg and Kluegel, 1975). The MTMM has also been criticized on the basis of Campbell and Fiske's conceptualization of measurement error which some deem to be inconsistent with classical measurement theory (Marsh and Hocevar, 1988). More commonplace criticisms are those which target the users decision about what constitutes satisfactory results, and consider the MTMM to be an essentially qualitative analysis. Nonetheless, the MTMM matrix has clearly made a major contribution to the social sciences and measurement theory. Marsh and Hocevar (1983) note that "while more sophisticated techniques are now available, it is important to note that these

should be viewed as minor refinements rather than major revisions of the original Campbell-Fiske framework" (p. 234).

Criticisms of the MTMM matrix prompted researchers to investigate other methods of analyzing the matrix including exploratory and multimethod factor analysis (Lomax and Angina, 1979) and analysis of variance. Although exploratory techniques were found to be preferable to multimethod factor analysis, the lack of statistical tests of significance for such analyses often makes them unduly suspect. ANOVA techniques were also suggested, however they suffer from many of the same limitations as Campbell-Fiske criteria in spite of their convenient statistical tests. More recently, sophisticated techniques for the analysis of MTMM data have been proposed, most notably confirmatory factor analysis (CFA). Expanded discussions of this technique can be found in Marsh and Butler (1984), and Marsh, Barnes, and Hocevar (1985).

Research and Development (R&D) as a Social Milieu

In exploring leadership as a construct, a unique social milieu is required in which we can magnify the phenomena of leadership and subject it to examination. Research and Development (R&D) units present just such an opportunity. Research and Development is perhaps the primary contributor of innovation in corporations and government agencies today.

Although it is the organization and not always R&D that act as the driver of the innovation, it is often R&D units that are called upon to bring technology to bear, and execute the innovation. Using Pelz and Andrews (1966) definitions, R&D disciplines can be roughly categorized in the following ways: Basic Research (general study; development of new knowledge), Applied Research (problem solution; creation, but not development, of new components), Development (refine a new product or process; exploratory study and testing of new components or processes), Technical (cost/performance improvements to exiting products, processes, or systems; penetrating new markets with existing products). These are useful in understanding what different types of R&D units do, although it is noteworthy that Salasin and Bregman (1983) found disciplinary area and type of research have less influence on program management than does the agency or organization sponsoring the program. Thus, the indication that organizational structures and climate influence R&D activities.

According to Posner (1986) R&D project teams are fraught with conflict, the root of which is the social and technical makeup of R&D project units. "The team is usually composed of people with different professional affiliations and with different orientations toward work. Informal authority relations are often ambiguous and formal authority is typically split between a project leader and a functional superior.

In addition, the task (technology) itself tends to be substantively complex, open ended, and stress inducing" (207).

In terms of the operation of units and project teams, suggestions have been made to use fairly sophisticated analyses such as Critical Path Analysis (CPA) and other similar networks to manage project teams and their outcomes (Parker and Sabberwal, 1971). These analyses consider routine elements such as statistical plans, prototype completion, assessment dates, activity duration, and production methods. However, Roberts (1974) using a simple model demonstrates how even the lowest complexity network models are incorrectly based on a single-loop model which fails to consider the human element in project actions and decisions. "The attitudes and motivations of the technical performers and their managers, their knowledge of schedules and current estimates in the project, the believed penalty-reward structure of the organization all affect the real progress that is achieved" (p.1).

McDonough and Kinnunen (1984) and Pearson and Davies (1981) report the many planning and monitoring techniques described in the literature, are seldom used because R&D leaders do not see them as being appropriate to the research and development area; this, in spite of the fact that the techniques have been shown to enhance leader-subordinate relationships and productivity.

Rubenstein and Ginn (1985) provide an interesting description of the internal and external interfaces of R&D personnel project managers must attend to. *"Internal interfaces"* (those within the functional area) include research and engineering. Here, lines of authority, territory, and other management issues are quite clear. Also discussed is the responsibility to manage *Imbedded technology*, the individual skills and organizational capability which are often invisible, and frequently are not acknowledged. Leaders must also attend to *"External interfaces*", or interfaces across functional areas, (such as technology transfer from R&D through marketing) which are generally more ambiguous in terms of lines of authority and responsibility than internal interfaces. For instance, the *R&D/Production Interface* represents the exchange of information and know-how, frequently with Production being the "receivers" of technology from R&D. *Inter-Organizational Interfaces* refer to interactions with top leadership, sales/marketing, manufacturing and operations, as well as the procedures, and resources which contribute to the interface. Goal incompatibility frequently induces conflict into these interactions. The effectiveness of an interface is referred to in terms of *Productivity of the Interface* which represents the speed and cost of the interaction, the quality/usability/ reliability of the innovation, and impact on managers and technical people.

R&D as a social milieu may provide some interesting insights into leadership which other milieu (eg., office or school environment) would not. Further, R&D managers as described here, present a challenge to traditional leadership theory as "not applicable"! Leadership in R&D and innovation management is also a contemporary subject, since Total Quality Management (TQM), process engineering and re-engineering, statistical process control (SPC), continuous improvement, and cycle time reduction, are on the agendas of many American corporations today. Many types of departments in organizations are now adopting the management and measurement systems formerly reserved only for R&D and manufacturing, and will need similar leadership capabilities for effective implementation. The nature of leadership tendencies in R&D have clear transfer value to a multitude of other managers and departments in American business.

Special issues for Project Managers as Leaders in R&D:

Empirical evidence supports the notions that 1) R&D groups see themselves as being different than other departments and are reticent to adopt project management techniques, 2) leadership is one of several issues critical to effective project management (Zachary and Krone, 1984) and 3) not all R&D functions are alike, nor should they be managed in the same way (Allen, Lee, and Tushman, 1980).

There are no shortage of studies which have identified characteristics of effective R&D leaders, a number of which are relevant here. For instance, Pelz and Andrews (1966) found that scientific productivity was highest when leaders used a combination of both autonomy and moderate levels of coordination. Barnowe (1971) reports that R&D leaders serve primarily in a helping role by providing assistance to subordinate scientists. Supervisory practices such as technical skills, sensitivity, and use of consultation were shown to positively effect group performance and innovation (Andrews and Farris, 1967). Keller and Holland (1982) summarize R&D professional performance as complex, multi-faceted, and not easily defined or measured; exactly the difficulties this study proposes to explore.

The leadership challenge for R&D managers is apparently to manage the technical and scientific aspects of projects (on time, within budget, commercial viability versus technical wizardry); effectively manage both lateral and hierarchical interactions (marketing/sales/operations versus senior management); mange conflict which is both internally and externally initiated; and manage the motivation, participation, communication, and development of others in the unit.

METHOD

Data Selection and Procurement: An acceptable data set for this study was required to meet a number of criteria. First, it had to include an array of variables which measured leadership and climate. Second, a large number of subjects would be desirable in order to conduct analyses and interpret results with confidence. Third, the data would need to allow for multiple raters rating the same items, or the possibility of creating different methods for the matrix. Finally, for the sake of time savings and efficiency, the data would need to be in a prepared form. The process of data procurement began in Fall, 1988.

At a meeting of the Center for Innovation Management Studies (CIMS), Lehigh University, Winter - 1989, I was fortunate to be seated among Dr. George Farris and colleagues from Rutgers University, who inquired about my research interests. Upon learning of my intended M.A. thesis in leadership, Dr. Farris recommended I speak with Dr. Alden Bean, Professor of Management - Lehigh University, about data collected through CIMS. I did so, and Professor Bean arranged for me to meet with Mr. Roger Whiteley, CIMS-Director. Mr. Whiteley forwarded a copy of the data and codebook to me several weeks after our meeting. The data were reviewed in light of

the criteria previously mentioned. The data was collected by CIMS on R&D managers who had attended CIMS leadership workshops. The survey instrument (104 questions) measured only leader (n=171) self-ratings in Lehigh Valley, Pennsylvania companies (n=15); no subordinate ratings of the leaders were collected. Several articles and a typology had already been generated by Bean and Farris from the data. The data presented excellent prospects for CIMS research, but was not aligned with the goals of the present study. I contacted Dr. Farris to seek his advice about other possible sources of data; however, he was aware of no other data which was readily available.

Dr. Donald Campbell, Advisor to this Thesis, and I located a leadership data set in through a commercial agency. Unfortunately, the agency estimated a delivery date of between eight months and one year due to backlog orders and mainframe problems. The data set, which represented thousands of international R&D units surveyed by the United Nations Educational and Scientific Organization (UNESCO), was already somewhat familiar to me. Dr. Frank Andrews, renown in R&D with Dr. Donald Pelz for Scientists in Organizations had written on this first round of data collection years before. I contacted Dr. Andrews who informed me of three additional rounds of data which were a part of UNESCO's larger study, but had been collected more recently, and which had not yet been widely used. His staff was securing the data for his uses at that time and he suggested they might be suitable for my purposes. He provided me

the name of an associate of his at UNESCO, Madame Nicole Visart, Director of Educational Services, Paris, France.

A several month long process of information exchange commenced among Madame Visart, her assistants, consultants at the Lehigh University Computing Center, and myself. Copies of codebooks and complete documentation for all four rounds of data collection, file specifications, previous research of the data, names of others analyzing the data, and a copy of the raw data on magnetic tapes (interpretable by a Cyber system) arrived in Fall, 1989. Inspection of the data showed that it met the criteria as a considerably larger, more complete, more sophisticated data set than the CIMS data previously considered. At the time the data was procured, only two other requests for the data had been received by UNESCO; these were from Dr. Frank Andrews and Dr. Robert Keller.

Data Set Description: The data set was gathered by the United Nations Educational Scientific and Cultural Organization (UNESCO) for an international comparative study on the management, productivity, and effectiveness of research teams. The objectives of their study were to 1) determine the extent of practical applications of R&D activities as determined by their home government and the international community

as a whole, and 2) to develop new paradigms for R&D management which would transcend national and cultural barriers.

National Study Teams were responsible for collecting the data, then depositing it with UNESCO. The UNESCO Secretariat and an International Research team were responsible for ensuring that the methodological framework and international comparability were met to every extent possible. The study, which ran from 1971 through 1986, ultimately passed thorough four rounds of data collection encompassing twenty three countries and nearly 14,000 research units. The original data set was deposited, and remains available, through the Belgian Archives for the Social Sciences (BASS) and UNESCO.

Subjects: Subjects of the study were members of R & D units sampled in Round 2 (1979-1981) of UNESCO's larger study described above. In Round 2 four forms of a questionnaire were administered to unit members in five countries. A total of 1,460 research units were sampled from Argentina (n= 334), Egypt (n=229), India (n=239), the Republic of Korea (n=200), Poland (n=225) and the U.S.S.R. (n=233). Within units, leaders (n= 1,460), scientists (n=4,224), and technicians (n=1,688) were surveyed, but not all were employed here. Selection of cases for the present investigation are described in the "Technical Procedures" segment of this section.

Sampling: Research conducted at the multi-national level, particularly research of this magnitude, is by its very nature complex. Coordination of multiple national research teams is difficult considering national teams may often have goals which compete or conflict with those of the parent research team. Within nations, cultural standards, national agenda, and political currents determine the type of research which is desirable, the type of research that is funded, and the amount of information shared or made available to research teams. Cross national variation in cultural values toward research make a standard approach toward research across countries impossible. Therefore, it is unreasonable to expect that national research groups employ exactly the same sampling and research procedures across countries.

Sampling performed in Round 2 was bi-phasic: 1) national research teams defined a sub-population, and 2) research units were sampled from within that sub-population. After these two phases were completed, respondents were sampled from each unit. National research teams independently determined the sub-population from which they would sample units. For example, several national teams sampled units from major national research organizations whereas other teams sampled units from those which best represented the country's primary research objectives. Once the sub-population was determined units (N=1,460) were selected from within the sub-population. None

of the national teams utilized random sampling. Methods of stratification varied from country to country. In short, sampling procedures used by national research teams were consistent within each country; however, procedures varied across national teams from different countries. Appendix A presents a crosstabulation of nations and institutions sampled.

Once sub-populations and units were sampled, individuals were sampled from within each unit. Again national teams independently devised methods of sampling respondents. For example, one national team interviewed all members of every unit (except in cases of very large units) whereas other national teams selected the leader of each unit and up to 3 scientists and 3 technicians. For the most part the sampling of respondents in each unit was carried out consistently across units within each country by each national research team. For detailed information concerning Round 2 sampling for each country readers are referred to UNESCO/NS/ROU/512 (1984).

Instruments: Four forms of a questionnaire were administered (CM, RU, EV.SCI, EV.ADM) to each unit. The core member (CM) questionnaire gathered information about the unit's productivity, leadership, and environment. A core member was defined as an individual who worked inside the R & D unit and is defined here as the unit head (leader), scientist, or technician. Data gathered with the CM questionnaire are the

focus of the present analysis, therefore the instrument will be described more fully below following a brief discussion of other three instruments employed by UNESCO.

The research unit (RU) questionnaire provides general information about the research unit and was filled out only by the head of each unit. The scientific evaluation (EV.SCI) questionnaire was directed at individuals (n=1,450) external to the unit who were in a position that rendered them capable of evaluating the unit's scientific effectiveness. The administrative evaluation (EV.ADM) questionnaire was directed at individuals (n=1,109) external to the unit who were in a position which rendered them capable of evaluating the unit's administrative effectiveness.

The CM questionnaire used in this study consists of 205 items reflecting numerous topic areas in R & D. Items contained in Part I were rated by leaders, scientists, and technicians. Topic areas included climate of the unit, quality of leadership, and resources available in the unit. Items contained in Part II were rated only by leaders and scientists. One topic area covered in this part of the questionnaire concerned the internal evaluation of the unit in terms of meeting work schedules, remaining within budgeting constraints, and following up project outcomes. A second topic area in Part II concerned ratings of the larger environment in which the unit was located. Items addressed issues of the unit's external reputation and working contacts, both on a

national and international level. A copy of the CM questionnaire is provided in Appendix B.

Item scales varied depending on the topic area. All items included in this study were rated on a 1 'TENDENCY TO X' to 5 'TENDENCY TO Y' rating scale. For the present study, an item was selected if it could be rated independently by at least two of the three types of members (leader, scientist, technician). It is important to note that Scientists and Technicians rated the same unit Leader; unit Leaders rated their immediate supervisors (outside the unit). Since unit Leaders did not rate themselves, comparison of self-ratings and ratings by others will not be possible with this data set.

Technical Procedures: UNESCO recorded data at the respondent level and organized it by a unit identification number (UNITID). Each subject possessed a UNITID but were not linked together by it in the data set received. In SPSS-X terminology this translates into one respondent per card. Data organized in this fashion allows a researcher to make statements about how core members rated leadership and the environment overall. However, no statements about how core members rated their own leader or their own unit environment could be made because rater responses could not have been linked to the unit in which they resided. Since this study confronts

issues as they occur within a domain it was necessary to reorganize the data so as to compare ratings within each unit.

Data was reorganized using the commercially available Statistical Package for the Social Sciences: Release X (SPSS-X) to represent one unit per card rather than one respondent per card. This does not mean that the data were aggregated to the unit level, only that they were matched according to UNITID. (Aggregation involves organizing the data to the unit level and then averaging the responses of those at the same level in the unit. However, in this study, averaging item scores for unit members is undesirable. Given that there is one leader per unit and several scientists and technicians per unit, mean scores obtained for each group would be differentially reliable. This has serious implications for the MTMM matrix concerning the contribution of scores to correlation coefficients.) In addition to matching by UNITID, a number of other procedures were carried out to insure that leaders, scientists, and technicians scores contributed to correlation coefficients equally.

Because averaging members scores was undesirable, it was necessary to select one scientist and one technician from each unit. Each scientist and technician who was recorded as the first in his/her unit were chosen to represent the other scientists and technicians in the unit. Since there was no evidence that scientists and technicians were

recorded based upon a defining variable (e.g., importance to the unit, seniority, etc.) this method of selection was considered to be random, or at least comparable across UNITID. In SPSS-X the FIRST function was used to "flag" each scientist and technician using a binary code (1= first in group, 0= all others in group). All those with a code of one were selected.

In a further attempt to insure equality among the groups, an additional restriction was placed upon units. In order to be included in my analyses, the unit must be complete. That is, there must be one leader, one scientist, and one technician present in each group for it to be included in this study. In SPSS-X terminology, each member was "flagged" using the IN function and assigned a binary code (1=present, 0=missing). A unit was selected if it contained one leader, one scientist, and one technician which resulted in the inclusion of (n=692) units; at three employees per unit (leader, scientist, technician) this resulted in a total of (n=2076) subjects.

ANALYSES

Preliminary Factor Analyses: Variable Reduction and Item Delineation. The purpose of these preliminary analyses is to identify the set latent variables which most adequately summarize the pattern of correlations among the observed variables. In

order to reduce the number of variables and determine, prior to any other analyses, if any underlying factor structure existed in the data, an exploratory principal components factor analysis was conducted for all 205 variables for Leaders, Scientists, and Technicians combined (n=2076). Based upon factor loadings, and previous theoretical and empirical evidence, forty-one items were selected for inclusion into subsequent analyses. At the conceptual level, variables appear to represent several areas of the domain. For example, items such as V241 (Innovative spirit) and V249 (Feelings of isolation) could conceivably represent unit social climate. Items such as V284 (Supervisor's professional ability) and V290 (Supervisors support of staff work) could represent leader effectiveness. Items such V170 (National reputation) and V165 (International reputation) may be indicative of aspects of the larger external environment in which the unit operates. In a further effort to explore and refine the data, a maximum likelihood (ML) factor analysis was conducted using SPSS-X.[1]

/1. This included an orthogonal rotation if the SPSS-X program at that time defaulted to that method of rotation. No specification is noted on the printout. The thesis advisor and committee members agree the resulting factors appear to be unrotated. The long delay between the data analysis (Spring, 1990) and writing of this thesis (Fall, 1994), coupled with the inability of the Computing Center to locate the data, make it impossible to determined whether or not orthogonal rotation was employed. Henceforth in this document, factors will described as unrotated. This method of analysis results in factors in which the first factor removes the bulk of the variance in

Though it could be argued that ML is not the optimum method for extracting factors it is mathematically more simple and straightforward than classical factor analysis and avoids extracting too many factors because it involves a test of significance comparing obtained residuals with those expected by chance, given the number of subjects and number of variables.

Results: Factors derived from the initial ML exploratory analysis appear in Table 1. Data labels which represent all subjects is denoted by V#. It is apparent from the table that the analysis resulted in four factors. As expected, the method of factor analysis selected resulted in factors which present the data as primarily uni-dimensional in

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Insert Table 1 about here.

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nature. More than two thirds (33/41) of the items load on the Factor 1, with the majority of loadings ranging in the .20 -.50 range. Highest factor loadings on Factor 1 were in the .60 -.75 range and included V285 (Supervisor's professional ability), V286

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the data, the second factor less variation, the third, less than the second, and so on until no systematic variance beyond chance variation remains. The possibility that factors were not rotated does not undermine the overall value of the factors, but makes them more difficult to interpret; the failure to interpret properly, which could result in "misgrouping" the variables, would prove to be a more serious problem.

(Supervisor's leadership qualities), V287 (Supervisor's personality characteristics), V288 (Supervisor's knowledge of related fields), V289 (Amount of work supervisor does) and V290 (Supervisor's support of staff work). Other variables loaded in the .50 -.60 range including V241 (Innovative spirit), V242 (Dedication to work), V243 (New ideas considered), V246 (Cooperation among scientists), V345 (Coherence) and V390 (Meets quality requirements). Factor 2 shows 4/41 items which, considered together, are not readily interpretable. Factor 3, with 6/41 variable loadings appears to represent support capabilities such as V277 (Quality of office equipment), and V270 (Current budget adequate). Factor 4 provided only one item which had its' highest loading on this factor, V395 (Publications in high demand). This could represent some type of external influence upon the work group.

Maximum likelihood factor analysis proved to be an unsatisfactory method of grouping the 41 items into several separate subgroups or "traits" for subsequent analysis. Nonetheless, it is quite adequate for examining whether or not the factor structure found when all three types of raters are pooled is similar to that found when the responses of the three rating groups is analyzed separately. (Because these analyses will involve only one third of the number of cases, maximum likelihood will tend to extract fewer factors.) Even though the three groups of raters produce distinctively different mean ratings on some variables, as shown in Table 2, this does not at all

preclude each of them from showing the same factor structure. (See also Table 7 and Discussion section.)

Insert Table 2 about here.

Three separate maximum likelihood factor analyses were run, one each for Leaders, Scientists, and Technicians employing all forty-one of the variables as in the preliminary maximum likelihood analysis. The same extraction and rotation procedures were applied to each data set. Factor loadings for Leader, Scientist, and Technician factor analyses run separately appear in Table 3.

Insert Table 3 about here.

In terms of item factor loadings for Leaders, Scientists, Technicians, careful inspection of loading matrices reveals marked similarities among the three groups, sufficiently obvious so that additional analysis in unnecessary. Leaders and Scientists again generated four factors, while Technicians generated only two factors. Similar variables load in a similar manner for the three samples. For Leaders and Scientists, V241-V249 continue to load well on Factor 1. For Scientists, V271-V282 load on f1, f2, f3 with similar differentiation as they did in the pooled factor analysis. In the Technician and

Leader analyses V271-V282 load on Factor 1 and all alternates break out onto Factor 2. In all cases, V283-V290 load strongly on Factor 1; also in all cases, V351-V401 load moderately on Factor 1 with alternates breaking out in pairs on Factors 2, 3, and 4.

While these analyses confirm that it is acceptable to assume the same factor structure in each of the three groups of raters, these unrotated maximum likelihood factor analyses are unusable for automatically grouping the 41 items into meaningful subscales. For this purpose, the results of the original varimax analysis, consideration of leadership theory, and common sense examination of item wording, were all used to supplement the factor loadings on the maximum likelihood analysis to create five subscales, having between 6 and 11 items, no item being used in more than one subscale (to avoid correlated error). In achieving these groupings, the items being pooled were required to be similar in their loadings on all of the maximum likelihood factors, not just in the factor having the highest loadings for each.[2]

/2. Common sense decisions were made to develop the groupings. For instance, an examination of alternate factor loadings shows a number of rough groupings emerging within the factor structure (these appear in the shaded regions in the tables). The majority of alternates load fairly convincingly (.20 -.30) on their factors. For instance V279-V282 and V399-V400 load on Factor 2; V284-V290 load negatively on Factor 2; V241-V243 load on Factor 3; V274-V275, V277-V278 load negatively on Factor 3; and

The subscale for **climate (CLM)** such as the six variables (V241, 242, 246, 249, 250, and 276) appear to convey, captures the current feelings of the group inside the unit. A second subscale dealing with environment is also thought to exist dealing with **external environment (EXT)** in which the unit operates, represented by eight other variables (V384, 385, 383, 387, 389, 393, 394, and 395). A third subscale, **resources provided by the leader (LDRES)**, is represented by eleven variables (V270, 271, 273, 274, 277, 279, 275, 278, 280, 281, and 282) representing resources the leader provides which enable the subordinate to perform. Fourth, **rating of leader performance (RAT)** is defined by seven variables (V284, 285, 286, 287, 288, 289, and 290), representing subordinates perceptions of how well the leader performs in his/her role. Finally, **leader consideration and structure (LDR)**, as represented by the remaining nine variables (V243, 244, 245, 283, 351, 390, 399, 400, and 401) may represent the subordinates perception of how well the leader listens and considers ideas and coordinates the activities of the team.

V244-V246 load negatively on Factor 4. Certainly these loadings are not as strong as first order loadings; however, when considered in combination with first order loadings they are large enough to provide evidence for common sense groupings of the variables, illustrative of relationships as described in the literature (eg., climate, leader effectiveness, environmental, perceptual, etc.) and some confidence that factor structure does exist.

Confirmation of Internal Consistency of Subscales

In order to ascertain whether the five proposed factors (CLM. EXT, RAT, LDR, LDRES) were internally consistent, the maximum likelihood (ML) method was employed with instructions to extract one factor only. Each subscale was analyzed separately for each group of raters. Fourteen separate factor analyses were performed (CLM, LDR, LDRES, RAT, EXT (5) X LEADER, SCIENTIST, TECHNICIAN (3) = 15); since Technicians did not rate EXT variables, one analysis was not possible.

Results: The factor score matrix for the analyses appears in Table 4. In general, variables correlate well with their factors with values ranging from .24 to .87. As expected, variables correlated differently with factors across organizational level. For instance, some items correlate only moderately with leader but higher with scientists and technicians, and vice versa. Overall, Percent Variance Explained ranges from a somewhat bleak 21.8% to a strong 65.4%. Only one eigenvalue is less than 1.00 (TECH/LDR .89), probably as a result of so few variables. The remainder range from 1.73 to 4.57, providing some encouragement about the strength of the factors. Although explained variance for some factors was not as high as hoped, it is apparent

that in general the hypothesized subscales do have merit and are acceptable for additional use.

Insert Table 4 about here.

In order to transfer the meaning of both the raw data and created factors into the matrix in a meaningful way, factor scores were created. Although a number of methods exist to create factor scores, the simplest method was used here. Raw scores were multiplied by factor loadings and summed to create a single score for each factor. These were then intercorrelated and arranged into the multitrait-multimethod matrix by method (Leader, Scientist, Technician) and trait (CLM, EXT, RAT, LDRES, LDR) so that the validity of factors could be investigated and the relationships among them evaluated.

Multi-Trait Multi-Method Matrix Analysis: Validity Assessment

The MTMM matrix provides for review of the methodological and substantive issues under study. If methods are relatively uncorrelated, and traits measure what they were designed to measure the following outcomes are expected:

1. Evidence for *reliability* of ratings, specifically that the monotrait-monomethod values should be among the strongest in the matrix.

2. Evidence for *discriminant validity*, specifically that 1) ratings of the same trait by different raters should be higher than different traits rated by the same raters, 2) validity diagonal values should be higher than their corresponding row/column values in the same heterotrait-heteromethod triangle, 3) the same pattern of relationships should exist in all heterotrait-heteromethod and heterotrait-monomethod triangles, 4) elevation of reliability ratings over their corresponding heterotrait-monomethod values, and 5) heterotrait-heteromethod values for LDR and RAT associated with the LEADER method should be the lowest because Leaders rated a supervisor outside of the unit.

3. Evidence for *convergent validity*, specifically validity values should be significant and large enough to encourage examination.

In addition to MTMM relationships, a number of other findings specific to R&D are expected to emerge; these will be evaluated by inspecting item means. Based upon leadership research and theory reproted here, disagreement among rating groups is expected even when rating the same person; leader behavior is thought to represent

"technical advisor" for subordinates; leader performance will be rated relatively low overall; subordinates ratings of the leader will be related to climate.

Results:

Multitrait-Multimethod Matrix. The multitrait-multimethod matrix appears in Table 5. Monotrait-monomethod values (reliabilities) range from .55 to .95 indicating considerable agreement of raters on trait measurements. Aside from reliabilities, the highest correlations in the matrix appear in the heterotrait-monomethod triangles, in which different constructs are rated under the same method. These values represent moderate methods factors; traits are correlated with one another under the same method. On the whole, monomethod values do not approximate reliabilities with the exception of the CLM-LDR correlations for each method (.55, .64, .61) which depreciate discriminant validity for LDR to some extent.

Insert Table 5 about here.

In the heterotrait-heteromethod blocks, validity diagonal values range from .07 to .29. Corresponding heterotrait-heteromethod values are also low, ranging from .04 to .24, and in only a few cases exceed the values in their corresponding monomethod blocks. The RAT validity coefficients exceed their corresponding heterotrait-heteromethod

values in only one out of three cases. In the LEADER-SCIENTIST block the RAT validity coefficient (.08) is exceeded by two values LDRES (.14) and CLM (.12) values. In the LEADER-TECHNICIAN block the RAT validity coefficient (.07) is exceed in both cases by LDR (.10, .10), CLM (.12, .08) and in one case by LDRES (.09). Additionally, in none of the three heterotrait-heteromethod blocks does LDR validity coefficient exceed all of its row and column coefficients. In the SCIENTIST-LEADER block LDR validity (.16) is matched by CLM (.16) In the TECHNICIAN-LEADER block LDR validity is bested by CLM (.17, .21). A similar pattern is noted in the TECHNICIAN-SCIENTIST block in which LDR validity (.17) is exceeded by CLM (.24, .21).

Heterotrait-heteromethod values show an absence of both convergent and discriminant validity; however, readers are reminded that LEADER ratings of RAT and LDR represent ratings of the Leader's supervisor who worked outside the unit. Naturally, correlations between LEADER and subordinate (SCIENTIST, TECHNICIAN) ratings of RAT and LDR are low since they were nether rating the same person nor would they have contact with the Leader's supervisor outside the work group. Among 44 comparisons of validity coefficients with their corresponding heterotrait-heteromethod values, twelve comparisons showed values higher than the validity coefficients; of those, nine were associated with the LEADER method. The net effect of Leader rating

someone outside the unit is duly noted. For the purposes of aiding interpretation, the matrix in Table 6 has been prepared so that 1) RAT and LDR values associated with LEADER method are segregated by a solid line, and 2) row/column values which exceed their validity coefficients are circled.

Insert Table 6 about here.

At first glance, validity appears non-existent, but further investigation of the coefficients shows that the described invalidity is in fact expected and that there may be some specific validity at hand. For example, TECHNICIAN-SCIENTIST RAT (.23) is bested by none of its corresponding row/column coefficients. Patterns within heterotrait-heteromethod blocks are roughly similar. providing a small amount of additional evidence for discriminant validity.

It is important to note here that methods may not be entirely independent of one another, after all, individuals who work together in work units are prone to relate to one another. Using Campbell and Fiske's criteria, it may still be possible to assess relative validity by comparing coefficients of what are thought to be two entirely independent traits. Here, LDRES and EXT are thought to be independent of one another. Their correlation can be interpreted as method covariance; the .08 coefficient

represents minimal methods covariance indicating that methods do in fact appear to be largely independent of one another. If the overlap of the methods variance were higher, as it might be for SCIENTISTS and TECHNICIANS we would expect all the value in the heteromethod block to be somewhat higher. Although the LDRES-EXT comparison cannot be made in the SCIENTIST-TECHNICIAN block, on average, the values in this block are slightly higher as expected.

The presence of methods variance can be determined in a similar fashion. Given comparable reliabilities across methods, parallel values in the heteromethod and monomethod blocks can be compared. The contribution of method variance by the LEADER method is indicated by the difference between parallel scores.

The presence of trait variance is minimal. Traits correlated to a very low extent with one another when measured by different methods. Trait ratings failed to meet the requirement that ratings of the same trait by different raters correlate higher than ratings of different traits by the same rater. Even when LEADER RAT and LDR values are not considered, trait ratings for LDRES, CLM, and EXT under different methods exceeds .21. This is generally disappointing news for the newly created factors which function here as traits.

What were the specific findings for the newly defined factors? The **LDR** factor received the lowest reliability coefficients of all the factors with LEADER LDR receiving the lowest reliability (.55) followed closely by TECHNICIAN (.60) then SCIENTIST (.65). Since Leaders rated their supervisors outside the unit the validities in the SCIENTIST (.16) and TECHNICIAN (.16) blocks cannot be accurately interpreted. The validity for SCIENTIST-TECHNICIAN (.17) comes in only slightly higher than the leaders; further, it is bested by the LDR-CLM coefficients in two cases (.21, .24).

The **LDRES** factor received differential validity coefficients across methods, for LEADERS (.59), SCIENTISTS (.72), TECHNICIANS (.61). The best argument can be made for the validity of LDRES under the LEADER-SCIENTIST method with a validity coefficient of .28, bested by no others. The picture becomes much dimmer however under LEADER-TECHNICIAN and SCIENTIST- TECHNICIAN where validity coefficients are only .17 and .11 respectively.

Reliabilities for the **CLM** factor were relatively consistent over the methods at .75, .74, and .78. The CLM factor exhibited a small amount of specific validity for the Leaders and Scientists (.23) which was the highest row/column value and approached some of the heterotrait-monomethod values. This was also true for Leaders-Technicians (.22)

and Scientists-Technicians (.29) although in the latter case the LDR-CLM values (.24,.21) are encroaching upon it.

Reliability coefficients for the **RAT** factor were the highest among all reliability coefficients across methods (.95, .92, and .89). Validity coefficients for the LEADER method cannot be adequately interpreted. The SCIENTIST-TECHNICIAN RAT validity coefficient (.23) is certainly lower than expected although it is among the highest coefficients in all three heteromethod blocks.

For the **EXT** factor, reliability coefficients were moderate for both LEADER (.64) and SCIENTIST (.67). The EXT variable exhibited some specific validity for SCIENTIST and LEADERS (.23) which bested both row/column counterparts and approached some of the heterotrait-monomethod values.

Item Means and Grand Means: An examination of item means and grand means, which are provided in Table 7, should prove useful in interpreting the above findings. For the **Climate - CLM** factor, grand means show Leaders rate the environment most favorably, followed by Technicians, then Scientists. More specifically, Leaders feel the most innovative spirit, dedication, cooperation and sharing; although they also experience the most intellectual isolation. Scientists rate the environment least

favorably in terms of innovation, dedication, cooperation and sharing; they experience a less isolation than leaders, but more than technicians. Technicians rate innovation, dedication, cooperation and sharing between Leaders' and Scientists' ratings; they experience the least isolation and the most technical arguments with others.

Insert Table 7 about here.

For the **Leadership - (LDR)** factor, Leaders rated their supervisors less well overall; Scientists and Technicians ratings of the Leader were almost identical. Leaders rated their supervisors better on almost every dimension, than their subordinates rate them. An exception is V283 (Frequent contact with supervisor), where Scientists and Technicians have more frequent contact with their Leader than Leaders have with their supervisors; Technicians have the most contact with their Leaders but rated "junior's ideas considered" lower than both Leaders and Scientists. Leaders ratings indicate they feel more informed of research planning by their superiors than do scientists who report to the Leaders.

A different picture emerges on the **Resources from Leader - (LDRES)** factor. Here, Scientists are least satisfied with the resources overall, while Technicians are most satisfied. Leaders and Technicians disagree with Scientists markedly on almost every

variable with the exception of computer processing, on which Technicians are prone to agree to the inadequacy. Leaders most closely agree with Scientist regarding inadequacy of scientific equipment, work space and office equipment, and technical administrative assistance. Overall, Leader resources Leaders and Scientists are prone to agree more with one another than with Technicians.

On the **Rating of Leader - (RAT)** factor Leaders rate their supervisors about as well as their Scientists rate the Leader. Technicians rate the Leader much higher than Scientists. Leaders rate their supervisors lower than their subordinates rate them on every dimension; this is especially marked for "effective contacts with supervisor" and "supervisors knowledge of related fields". Scientists rate Leaders lower than Technicians on every single dimension.

The final factor, **External Influences on Unit - (EXT)** showed Leaders more prone to acknowledge outside pressures than Scientists. No ratings were available for Technicians. Least highly rated by both was international reputation; highest ratings were given by both to the utility of research to the organizations larger R&D goals. Leaders and Scientists disagreed most about the national reputation of the unit.

DISCUSSION

Analyses yielded both expected and surprising results. The data was successfully reduced from 205 to 41 variables through the use of principal components factor analysis. As a follow-up to that, a preliminary maximum likelihood factor analysis revealed that an underlying factor structure did exist in the data. Given the goal of using MTMM analysis, it was necessary to delineate maximally dissimilar methods within the data set. Theoretical and empirical studies suggested that leaders and their subordinates differ; this was affirmed by an inspection of mean item responses, and extended to further delineate subordinates (Technicians and Scientists). Thus, three separate Methods were identified: LEADER, SCIENTIST, TECHNICIAN. In order to affirm that the latent structure observed in the first factor analysis existed across methods, three separate factor analyses were performed. The latent structures were similar overall, although TECHNICIAN variables loaded on only two factors as opposed to four for both LEADERS and SCIENTISTS.

Based on factor loadings and theoretical support five hypothetical factors were defined: climate (CLM), leader resources (LDRES), leader ratings (RAT), external environment (EXT), leader consideration and structure (LDR). These functioned as the Traits in the

matrix. Fourteen separate maximum likelihood confirmatory factor analyses produced fourteen individual factors, as specified. Strength of the factors, and variance explained varied with both organizational level and type of factor; leader rating (RAT) variables produced by far the strongest factors which explained the most variance. The two weakest factors were SCIENTIST and TECHNICIAN leadership (LDR) factors.

Factor scores were obtained by multiplying each raw score on an item by its corresponding factor loading and summing the products; these were then intercorrelated to produce the multitrait-multimethod matrix. Generally, the results were disappointing, but explainable. Reliability coefficients were acceptable. Validity diagonal coefficients were weak and could not always exceed their row/column companions; they did not exceed the monomethod values, method variance exceeded trait variance. Although some discrete instances of validity were noted, and some interesting relationships uncovered, convergent and discriminant validity could not be supported. Two of the four hypotheses regarding leadership in R&D were supported. An examination of item means and grand means sheds some light on relationships evident in the matrix. Implications are discussed below.

Micro-Conclusions: Leadership within R&D

Item means depict the climate of R&D as one of innovation and intellectual isolation,

but with camaraderie and cooperation. R&D as a conflict ridden environment suggested in the literature has gone largely unconfirmed here, although much variance remains to be accounted for under the climate (CLM) factor. Some feelings of conflict were noted. Leaders felt the most intellectual isolation; technicians reported the most technical arguments with others. This suggests that leaders, who have more advanced education, specialization, and authority feel removed from their subordinates and peers; leaders are also structurally removed from the work of the unit whereas technicians are close to the work. This probably accounts from technicians reporting more technical arguments. This line of thought is evidenced in lower validity ratings between TECHNICIANS-LEADERS than SCIENTIST-TECHNICIANS.

Leaders rate the environment most positively overall, but rated levels of cooperation more highly than both Scientists and Technicians. Leaders' feelings of isolation may contribute to their lack of attention to *internal interfaces* and *imbedded technology*, which the literature has accused them of ignoring. Scores on isolation suggest Leaders do not ignore internal processes, rather they may feel removed from them. Scientists rated the climate least favorably overall which is not surprising considering scientists engage in many of the *external interfaces* with non-R&D personnel such as marketing and production, and may feel "misunderstood" or frustrated.

In terms of leader consideration and structure behavior (LDR) raw item means and grand means, Leaders rated their supervisors better than their subordinates rated them. Unfortunately, there was no independent method against which to compare leaders ratings of their supervisors. It may be that there are differences between a manager rating another manger than a subordinate rating a manager. Predictably, Technicians reported the most frequent contact, reinforcing Farris' notion of Leader as technical advisor. Finally, obvious disagreement was noted between Scientist and Technicians on perceptions of leader consideration and structure. Measures of internal consistency and validity were low, pointing to disagreement both within and between the groups. We may be witnessing the results of sampling, in that there were large cultural and organizational differences among scientists and technicians. Scientists report they receive less consideration, less structure, and less contact as evidenced by mean item ratings; thus, their disagreement with Technicians.

Subordinates ratings (RAT) of their supervisors presented some surprising findings. Leaders rated their supervisors lower on every dimension of supervisory performance than their subordinates rated them; this is in sharp contrast to the finding presented above. This may indicate that, at higher levels (unit supervisor), leaders exhibit less effective supervisory behaviors but more consideration and structure skills. This is underscored by the fact that Leaders rate their supervisors' performance best on

personality, least well on effective contacts, and consideration/structure best on "informed of research planning". Subordinates ratings of the leaders exhibit more basic supervisory skills and less consideration and structure skills. Scientists and Technicians rate performance in terms of "high knowledge in related fields" and "professional ability". Thus, Supervisors serve Leaders more as goal setters; Leaders serve Scientists and Technicians more as technical advisors and mentors.

Leaders and Scientist ratings of the external environment (EXT) variables were similar in most regards, but with Leaders rating each dimension higher than Scientists. This indicates Leaders are more aware of the role outside the unit, most notably so for national reputation. This may have to do with the leader's own personal recognition in the field, such as through publications, which they also rated higher. Scientists, who are presumably less well developed professionally, feel less recognition.

The multitrait-multimethod analysis also revealed three notable findings. results. First, for Scientists and Technicians, leader ratings were correlated with leader resources, climate and, external environment ratings. But this was not so for leaders. One explanation may be that Scientists and Technicians see the leader and larger environment as closely intertwined, and see resource as separate, perhaps provided by the organization rather than the leader. Leaders, on the other hand, may do not see

their supervisor's effectiveness as greatly influencing the unit environment. They may or may not be cognizant of their own role of both influencing and being influenced by the unit, but clearly differentiate their supervisor from the equation.

Second, for Leaders, Scientists, and Technicians ratings of leader consideration and structure are related to climate and the external environment. Again, we see Leader behavior ratings covary with environmental factors. Leaders related their supervisors' consideration and structure behavior to environmental factors. Perhaps, for leaders, the supervisor's approach (participation, involvement, coordination) is more important to climate than supervisory performance. For Scientists and Technicians, Leadership consideration and structure behavior was more highly related to climate than to leader performance ratings, and were among the strongest relationships noted.

Third, as to agreement among the three groups, Leaders and Scientists agree more than Leaders and Technicians. This is evident in both validity coefficients and grand mean scores. We can surmise that Scientists, who receive most of the Leaders' delegation, are in closer proximity, organizational level, and education, and therefore are more apt to share the Leader's point of view. Technicians are less likely to share those views for the same reasons. In addition, Leaders and Scientists agree more than Technicians and

Scientists. Moderate reliabilities, and low validates point to differences both within and between groups which we might ascribe to cultural and organizational differences.

Macro Conclusions:

Difficulties with the Construct of Leadership. A number of the findings are to be related to the difficulties of the theories of leadership discussed in the review of the literature with which this thesis began. First, results of exploratory analyses remind us that a quagmire of variables exists for scientists who wish to explore the field of leadership. In an attempt to maximize variance explained by the fewest number of variables, this study reduced 205 ratings to workable set of 41 upon which the major analyses were based. While some factors were reasonably successful in representing their constructs, others were rather unsuccessful. Future studies will need to consider other variables, and variables with more explanatory power.

Second, correlations observed in the matrix underscored the complex interrelationships among the variables. Most notably, the tendency of ratings of leader performance (RAT) to covary with climate (CLM), leader consideration (LDR), and external ratings (EXT) needs to be explored further.

Third, ratings of leader performance (RAT) received the best reliability while leader consideration (LDR) the lowest reliabilities. This may point to our ability to measure leadership better by asking general questions about performance. However, our ability to measure it more specifically (such as consideration and structure) needs to be improved. What we may be tapping by asking indirect questions are attributions. That is, a subordinate may rate her leader well, but when asked about characteristics that might contribute to that rating cannot "put her finger" on them. This phenomena has been previously noted and forms the basis of criticisms of attribution theory, that individuals make attributions without knowing why. Cognitive theorists have suggested that respondents have trouble separating specific from general information, although not at the expense of accuracy of ratings. The inclusion of variables which measure cognitive processes might be a useful addition to our variable set.

Fourth, differences among raters (as evidenced by low validity for SCIENTIST and TECHNICIAN methods) were apparent. Differences in reliabilities and validates for leader performance and leader consideration/structure point to the possibility that leader effectiveness may be a more universal concept than leader consideration/structure. If an integrative theory of leadership is to be developed by researchers these cross-cultural issues demand further investigation, particularly since they have not been actively pursued in the literature. If it is possible to develop

leadership theory which transcends national, cultural, and organizational differences we should see substantial agreement within and across countries. We would also expect responses of raters from different cultures (nations, organizations, etc.) on the same variables to agree more highly than ratings from the same country (nation, organization, etc) on different variables. In MTMM terminology we would expect substantial reliability and validity coefficients and higher heterotrait-heteromethod validity values than heterotrait-monomethod values. If it is not possible to develop such a global theory, we must as the question, "What makes leadership different for one country (organization, cultural group) than for others?"

Fifth, a number of phenomena previously described in leadership theory were witnessed in operation here. *Leader traits* and *personality* variables were included in the leaders performance factor and were found to be important contributors to that factor. *Situational influence*, including unit climate and external environment were found to be relevant. Variables such as innovation and cooperation in the unit, and national and international reputation correlated highly with ratings of leader performance and leader consideration and structure. Although *reciprocal determinism* was not observed directly, we can safely presume it exists to some degree having reviewed differences in leaders interaction with Scientists and Technicians and differences in Scientists and Technicians ratings of leaders. *Attribution theory* was also indirectly observed in our ability to

measure leadership well in general, but not specifically. Overall, much of leadership theory reported earlier in this paper was not supported.

Finally, at the most fundamental level it was obvious that had the MTMM matrix not been employed the weakness of the validity of the many variables would not have been exposed. Interestingly, some of the variables that we thought would pan out did (eg., consideration), others did not (eg., conflict). Above all, the analyses reaffirmed the difficulty and complexity inherent in the phenomena of leadership.

Methodological Difficulties with Leadership. Intercorrelations obtained for the five leadership traits and three methods were lower and weaker than anticipated. A number of explanations account for the observed outcomes. The content of leadership developed here, although based on previous literature, had never been defined or validated in this manner before and is immature in its development. The postulated relationships among the variables included in this exploration have been previously investigated at some length, but not within the context of more than 30 other variables as they were in this study. Traits, although produced by statistical analyses were selected using the most simple and interpretable qualitative and quantitative methods available. Factors were perhaps too simple, and in several cases did not possess substantial explanatory power or sufficient technical refinement. Although the

methods of data collection were intended to make all raters independent of the influence of other raters (eg., their supervisors), more likely than not some level of reciprocal causation is at work among leaders, scientist, and technicians who share a work unit.

Pertinent characteristics of sample include lack of random sampling at both the national and unit level; respondents were later selected by matching (to assure a complete work group) but in combination could have inadvertently introduced a "restricted range" which is hard to overcome in the MTMM matrix. In retrospect, a number of procedural and methodological decisions such as this may have had an adverse impact on the coefficients achieved. For instance, the decision to employ maximum likelihood factor analysis may have produced less interpretable results than if principal components analysis had been used alone.

It could be argued that maximum likelihood factor analysis was not the optimum method to create comparison factors on which to base decisions about the factors to be employed in the study. Alternatively, principal components analysis with orthogonal rotation could have been used. Kim (1970, p. 404) notes that "with a large number of variables, several high-loading variables per factor, with the same well-chosen number of factors, and with similar values for communality, the results of

extraction will be similar regardless of which extraction method is used". Perhaps, but the failure to properly rotate variables may have weakened this investigation.

For whatever reason, the factors themselves did not account for enough variance. The introduction of additional variables, or fewer variables with more explanatory strength, would have been desirable.

Summary of Findings

The present investigation attempted to explore some of the theoretical and methodological difficulties inherent to leadership research. A review of pertinent literature affirmed that current theory is fundamentally disjointed, and in need of integration. Exploratory analyses of leadership within Research and Development departments was performed using the multitrait-multimethod matrix. Three sources of ratings (Leaders, Scientists, Technicians) and five traits (Climate, Leader Effectiveness, Leader Consideration and Structure, Leader Resources, and External Environment) were intercorrelated, the traits having been generated through exploratory and confirmatory factor analysis.

R&D units provided a unique social milieu in which to investigate leadership, in part due to levels of conflict, task orientation, professional, and role differences purported

to proliferate in that environment. While several assumptions about leadership in R&D were confirmed, others were not supported.

Sufficient evidence for convergent and discriminant validity was not obtained in the multitrait-multimethod matrix to support the construct of leadership defined here. However, some aspects of leadership within R&D were explained through several unique correlations that were observed. Multitrait-multimethod matrix coefficients and item mean differences were used to illustrate some of the theoretical and methodological difficulties inherent in the construct of leadership.

TABLES

Table 1: Factor loadings for leader, scientist, and technician variables run together.

Variable	f1	f2	f3	f4
V241 Innovative spirit.	.56821	.17509	.30271	−.16244
V242 Dedication to work.	.55605	.18533	.28375	−.23274
V243 R&D ideas considered.	.54188	.16792	.34135	−.25670
V244 Technical ideas considered.	.43371	.13402	.24895	−.26266
V245 Juniors' ideas condiered.	.47618	.11637	.29620	−.35350
V246 Scientists and engineers cooperate.	.55104	.18722	.21543	−.30286
V249 Intellectual isolation.	.27640	.10329	.10170	−.06074
V250 Technical arguments with others.	.26129	.34551	.14232	.04046
V270 Current budget adequate.	.18376	.35963	−.36513	.06036
V271 Scientific equipment.	.33524	.39096	−.40383	.03856
V273 Computer processing services.	.27520	.32405	−.23325	−.04767
V274 Adequacy of work space.	.19501	.26661	−.31436	−.01252
V275 Technical assistance.	.39463	.37094	−.42594	0.0112
V276 Sharing of equipment.	.41771	.36568	−.21793	−.10194
V277 Quality of office equipment.	.27864	.38250	−.41024	−.00793
V278 Admin. and seccretarial assistance.	.34971	.32425	−.39461	−.01723
V279 Library facilities.	.29747	.36216	−.36074	.03862
V280 Training and career developmt.	.46336	.29623	−.19745	−.03509
V281 Information services.	.46435	.33455	−.31560	−.03863
V282 Human resources.	.42712	.18271	−.16679	−.11825
V283 Frequent contact with supervisor.	.55469	−.22721	−.02727	−.01080
V284 Effective contacts with supervisor.	.73419	−.32765	−.07244	.00032
V285 Supervisor's professional ability.	.73812	−.36262	−.10303	.05548
V286 Supervisor' leadership ability.	.75387	−.29784	−.06533	.01592
V287 Supervisor's personality characterstcs.	.65056	−.30899	−.04790	−.00751
V288 Supervisor's knowlg. of related fields.	.74501	−.38086	−.14263	.06386
V289 Amount of work supervisor does.	.73084	−.32691	−.11196	.05096
V290 Superviso's support of staff work.	.74205	−.29418	−.07953	−.03173
V351 Informed of research planning.	.41267	.26995	.25249	−.13361
V383 Outside follow−up pressure.	.12056	.24182	.02893	.17362
V384 Responsibility to disseminate results.	.24819	.18148	.08663	.10297
V385 Contact with external users.	.34953	.24553	.11779	.20987
V387 Useful to R&D goals.	.47547	.22067	.31719	.26957
V389 Useful to S&T goals.	.44316	.14666	.29145	.24140
V390 Meets quality requirements.	.51810	.21553	.25958	.21190
V393 National reputation.	.34573	.23631	.21053	.33027
V394 International reputation.	.32169	.12725	.17998	.30577
V395 Publicat'ns in high demand.	.28245	.15879	.27378	.29686
V399 Follows−up or uses results.	.37713	.30525	.18058	.19048
V400 Meets working schedule.	.41675	.23081	.17541	17502
V401 Stays within budget.	.29959	.26054	.00634	.15223

Table 2: Item means for leaders, scientists, and technicians.

Leaders

Variable	Cases	Mean	Std. Dev.
VL241 Innovative spirit.	680	4.04797	.79678
VL242 Dedication to work.	690	4.11449	.81882
VL243 R&D ideas considered.	688	4.25000	.81442
VL244 Technical ideas considered.	672	3.72619	.97399
VL245 Juniors' ideas considered.	686	4.31487	.81530
VL246 Scientists and engineers cooperate.	682	4.32258	.75335
VL249 Intellectual isolation.	678	3.79056	1.22164
VL250 Technical arguments with others.	678	4.30531	.98891
VL270 Current budget adequate.	678	3.15929	1.35274
VL271 Scientific equipment.	673	3.85884	.99607
VL273 Computer processing services.	678	3.04603	1.14480
VL274 Adequacy of work space.	687	2.69869	1.41659
VL275 Technical assistance.	682	2.70381	1.16191
VL276 Sharing of equipment.	673	3.85884	.99607
VL277 Quality of office equipment.	676	2.65237	1.08111
VL278 Admin. and seccretarial assistance.	686	2.67055	1.17888
VL279 Library facilities.	684	3.48977	1.11131
VL280 Training and career developmt.	667	3.35232	1.12512
VL281 Information services.	677	3.00295	1.12370
VL282 Human resources.	689	3.19739	1.18356
VL283 Frequent contact with supervisor.	608	3.55263	1.22523
VL284 Effective contacts with supervisor.	603	3.26368	1.24098
VL285 Supervisor's professional ability.	590	3.87797	1.01885
VL286 Supervisor's leadership qualities.	598	3.90635	1.07940
VL287 Supervisor's personality characterstcs.	595	3.90635	1.07940
VL288 Supervisor's knowlg. of related fields.	570	3.77895	1.10030
VL289 Amount of work supervisor does.	602	3.72425	1.13541
VL290 Supervisor's support of staff work.	602	3.72425	1.13541
VL351 Informed of research planning.	682	4.75367	.56329
VL383 Outside follow–up pressure.	677	3.40916	1.25874
VL384 Responsibility to disseminate results.	674	3.35905	1.33671
VL385 Contact with external users.	670	3.79254	1.12380
VL387 Useful to R&D goals.	679	4.39617	.73324
VL389 Useful to S&T goals.	643	3.78849	.96170
VL390 Meets quality requirements.	649	4.12173	.75561
VL393 National reputation.	681	3.94567	.94214
VL394 International reputation.	658	2.93161	1.25079
VL395 Publicat'ns in high demand.	643	3.39813	1.06813
VL399 Follows–up or uses results.	677	3.95421	.94214
VL400 Meets working schedule.	680	3.76176	.89783
VL401 Stays within budget.	659	4.03642	.96914

Scientists

Variable	Cases	Mean	Std. Dev.
VS241 Innovative spirit.	685	3.87591	.98939
VS242 Dedication to work.	690	3.92464	1.00368
VS243 R&D ideas considered.	687	3.98253	1.03480
VS244 Technical ideas considered.	659	3.50076	1.08877
VS245 Juniors' ideas considered.	681	3.85756	1.15377
VS246 Scientists and engineers cooperate.	671	3.94784	1.09569
VS249 Intellectual isolation.	680	3.63235	1.22272
VS250 Technical arguments with others.	671	4.29359	1.04968
VS270 Current budget adequate.	636	2.98742	1.30529
VS271 Scientific equipment.	679	2.84389	1.17636
VS273 Computer processing services.	641	2.87302	1.12814
VS274 Adequacy of work space.	686	2.75510	1.46082
VS275 Technical assistance.	677	2.69424	1.19425
VS276 Sharing of equipment.	658	3.60486	1.10499
VS277 Quality of office equipment.	666	2.65916	1.13118
VS278 Admin. and seccretarial assistance.	676	2.65530	1.20274
VS279 Library facilities.	685	3.49635	1.23168
VS280 Training and career developmt.	675	3.07259	1.22078
VS281 Information services.	673	2.97177	1.16403
VS282 Human resources.	664	3.19227	1.22227
VS283 Frequent contact with supervisor.	687	4.22271	1.06462
VS284 Effective contacts with supervisor.	682	3.85484	1.17462
VS285 Supervisor's professional ability.	679	4.12813	1.07069
VS286 Supervisor's leadership qualities.	677	3.71935	1.20514
VS287 Supervisor's personality characterstcs.	674	3.97181	1.06021
VS288 Supervisor's knowlg. of related fields.	677	4.11669	.98153
VS289 Amount of work supervisor does.	672	4.01637	1.09810
VS290 Supervisor's support of staff work.	677	3.93353	1.16928
VS351 Informed of research planning.	686	3.98688	1.07679
VS383 Outside follow-up pressure.	668	3.21108	1.29487
VS384 Responsibility to disseminate results.	659	3.27314	1.35811
VS385 Contact with external users.	660	3.56515	1.18051
VS387 Useful to R&D goals.	676	4.18047	.84330
VS389 Useful to S&T goals.	620	3.51613	1.04252
VS390 Meets quality requirements.	624	3.98878	.84066
VS393 National reputation.	673	3.48737	1.19757
VS394 International reputation.	644	2.58851	1.24383
VS395 Publicat'ns in high demand.	625	3.12160	1.07401
VS399 Follows-up or uses results.	664	3.76506	1.03168
VS400 Meets working schedule.	672	3.75148	.94054
VS401 Stays within budget.	615	3.93984	.94152

Technicians

Variable	Cases	Mean	Std. Dev.
VT241 Innovative spirit.	666	3.89940	1.00091
VT242 Dedication to work.	685	4.09343	.96681
VT243 R&D ideas considered.	660	4.05000	.95421
VT244 Technical ideas considered.	639	3.55869	1.10694
VT245 Juniors' ideas considered.	657	3.65601	1.21329
VT246 Scientists and engineers cooperate.	661	4.06051	1.05135
VT249 Intellectual isolation.	644	3.55590	1.26180
VT250 Technical arguments with others.	654	4.33486	1.03331
VT270 Current budget adequate.	473	3.04440	1.11727
VT271 Scientific equipment.	648	3.12191	1.17507
VT273 Computer processing services.	333	2.91892	.97785
VT274 Adequacy of work space.	678	2.92330	1.42445
VT275 Technical assistance.	653	3.04747	1.21763
VT276 Sharing of equipment.	640	3.72969	1.02667
VT277 Quality of office equipment.	649	3.02773	1.13662
VT278 Admin. and seccretarial assistance.	632	3.13449	1.19772
VT279 Library facilities.	648	3.83025	1.08381
VT280 Training and career developmt.	646	3.28947	1.24902
VT281 Information services.	599	3.41068	1.04539
VT282 Human resources.	598	3.63712	1.04767
VT283 Frequent contact with supervisor.	687	4.31150	.99734
VT284 Effective contacts with supervisor.	676	4.07998	1.05556
VT285 Supervisor's professional ability.	677	4.43427	.89696
VT286 Supervisor's leadership qualities.	671	4.09985	1.08179
VT287 Supervisor's personality characterstcs.	681	4.15712	1.05315
VT288 Supervisor's knowlg. of related fields.	670	4.39701	.88069
VT289 Amount of work supervisor does.	660	4.30455	.95606
VT290 Supervisor's support of staff work.	679	4.12224	1.09681

Table 3: Factor loadings for leader, scientist, and technician variables run separately.

LEADER Variables	f1	f2	f3	f4
VL241 Innovative spirit.	.51355	.21483	−.19069	.11578
VL242 Dedication to work.	.57167	.23314	−.28096	.24547
VL243 R&D ideas considered.	.26361	−.08114	.14057	.00963
VL244 Technical ideas considered.	.35874	.17284	−.17545	.08732
VL245 Juniors' ideas considered.	.31776	.18199	−.16688	.16619
VL246 Scientists and engineers cooperate.	.49238	.20487	−.24296	.15448
VL249 Intellectual isolation.	.26206	.09421	.04982	.04125
VL250 Technical arguments with others.	.29228	.13490	−.18789	.07056
VL270 Current budget adequate.	.32763	−.49727	.21034	−.05526
VL271 Scientific equipment.	.46600	−.41731	.00065	−.18281
VL273 Computer processing services.	.28990	−.20849	−.05280	.01762
VL274 Adequacy of work space.	.26080	−.24772	−.03509	−.14470
VL275 Technical assistance.	.47155	−.43716	−.03266	−.11151
VL276 Sharing of equipment.	.46206	−.149311	.04746	.03496
VL277 Quality of office equipment.	.38938	−.38858	−.03509	−.14470
VL278 Admin. and seccretarial assistance.	.40772	−.35070	.00681	−.10455
VL279 Library facilities.	.44327	−.32526	.15180	−.10620
VL280 Training and career developmt.	.46290	−.20810	.09109	.02854
VL281 Information services.	.53050	−.33361	−.05415	−.10077
VL282 Human resources.	.50241	−.18748	−.31783	.14307
VL283 Frequent contact with supervisors.	.51879	.20651	−.16643	−.03204
VL284 Effective contacts with supervisor.	.62644	.43222	−.09824	−.01009
VL285 Supervisor's professional ability.	.72614	.35381	−.06175	−.00021
VL286 Supervisor's leadership qualities.	.70762	.49445	−.14296	.07545
VL287 Supervisor's personality characterstcs.	.59126	.42606	−.18428	.12637
VL288 Supervisor's knowlg. of related fields.	.72351	.26799	−.23214	−.14488
VL289 Amount of work supervisor does.	.68820	.28957	−.11920	−.02630
VL290 Supervisor's support of staff work.	.70791	.35077	−.09925	−.05378
VL351 Informed of research planning.	.30988	.11827	−.03847	.08893
VL383 Outside follow−up pressure.	.20147	−.02862	.38884	.13340
VL384 Responsibility to disseminate results.	.17551	.08688	.06193	.12838
VL385 Contact with external users.	.25252	.16270	.35148	.17944
VL387 Useful to R&D goals	.51245	.04954	.36255	.10502
~~VL389 Useful to S&T goals.~~	~~.38632~~	~~.21627~~	~~.14929~~	~~.06825~~
VL390 Meets quality requirements.	.47855	.26374	.11594	−.10536
VL393 National reputation.	.41103	.33915	.12557	−.36604
VL394 International reputation.	.36115	.34835	.04389	−.50643
VL395 Publicat'ns in high demand.	.30210	.19965	.09333	.35420
VL399 Follows−up of uses results.	.44921	.29375	.10623	.04202
VL400 Meets working schedule.	.47316	.20625	.37469	.27340
VL401 Stays within budget.	.36546	−.01642	.40602	.13312
Eigenvalue	(5.79)	(2.53)	(1.29)	(1.34)
Percent Variance Explained	16.6	7.2	3.7	3.2

SCIENTIST Variables	f1	f2	f3	f4
VS241 Innovative spirit.	.62052	−.26748	−.23964	−.00667
VS242 Dedication to work.	.63695	−.22189	−.31576	−.05346
VS243 R&D ideas considered.	.59508	−.15720	−.33207	.01663
VS244 Technical ideas considered.	.47098	−.08458	−.28836	−.07648
VS245 Juniors' ideas considered.	.50643	−.14252	−.35812	−.04329
VS246 Scientists and engineers cooperate.	.57764	−.07929	−.32743	−.04239
VS249 Intellectual isolation.	.35635	−.00633	−.15006	−.00143
VS250 Technical arguments with others.	.24879	.12949	.37425	.02006
VS270 Current budget adequate.	.27510	.41935	.19852	.32906
VS271 Scientific equipment.	.42277	.49826	.16923	−.07418
VS273 Computer processing services.	.27947	.22314	.02015	−.01377
VS274 Adequacy of work space.	.21662	.34413	.05918	−.08946
VS275 Technical assistance.	.47286	.49137	.07826	−.09437
VS276 Sharing of equipment.	.48676	.28400	−.07516	−.07101
VS277 Quality of office equipment.	.34338	.50040	.08496	−.06685
VS278 Admin. and seccretarial assistance.	.37070	.46374	.02211	−.00860
VS279 Library facilities.	.34905	.33272	.06180	.08758
VS280 Training and career developmt.	.54602	.27268	−.05707	.12797
VS281 Information services.	.49418	.42026	−.04689	−.06293
VS282 Human resources.	.46218	.21804	−.18174	−.16472
VS283 Frequent contact with supervisor.	.68375	−.31367	−.14543	−.02885
VS284 Effective contacts with supervisor.	.72490	−.32699	−.09879	.05367
VS285 Supervisor's professional ability.	.66541	−.20411	−.07377	.09910
VS286 Supervisor's leadership qualities.	.76884	−.26477	−.05946	.03923
VS287 Supervisor's personality characterstcs.	.72343	−.22302	−.11670	−.00892
VS288 Supervisor's knowlg. of related fields.	.77877	−.29345	−.06004	.03427
VS289 Amount of work supervisor does.	.70336	−.27641	−.11385	.12794
VS290 Supervisor's support of staff work.	.67055	−.21403	−.15879	.10328
VS351 Informed of research planning.	.48791	−.14248	−.15739	.11307
VS383 Outside follow−up pressure.	.18899	−.11501	.18477	.38160
VS384 Responsibility to disseminate results.	.30388	−.10437	.02869	.28514
VS385 Contact with external users.	.43077	−.08972	.15360	.36908
VS387 Useful to org. R&D goals.	.59167	−.30189	.18232	−.00060
VS389 Useful to other S/T goals.	.55181	−.17761	.12987	−.10550
VS390 Meets quality requirements.	.56644	−.21513	.13108	.05007
VS393 National reputation.	.44282	−.22993	.57492	−.17292
VS394 International reputation.	.40721	−.13130	.42127	−.35748
VS395 Publicat'ns in high demand.	.41655	−.23265	.21486	.23563
VS399 Follow−up or use results.	.51466	−.22063	.09115	.22947
VS400 Meets working schedule.	.48746	−.20604	.11701	.26119
VS401 Stays within budget.	.31322	−.04900	.17700	.40046
Eignevalue	(7.44)	(2.54)	(1.61)	(1.13)
Percent Variance Explained	21.2	7.2	4.6	3.2

TECHNICIAN Variables	f1	f2
VT241 Innovative spirit.	.55688	−.44986
VT242 Dedication to work.	.57077	−.49417
VT243 R&D ideas considered.	.50723	−.44175
VT244 Technical ideas considered.	.43659	−.33704
VT245 Juniors' ideas considered.	.46236	−.40986
VT246 Scientists and engineers cooperate.	.52401	−.39783
VT249 Intellectual isolation.	.22839	−.13688
VT250 Technical arguments with others.	.39880	−.24551
VT270 Current budget adequate.	.29529	.35694
VT271 Scientific equipment.	.53656	.49541
VT273 Computer processing services.	.34287	.14118
VT274 Adequacy of work space.	.38333	.35265
VT275 Technical assistance.	.55278	.32388
VT276 Sharing of equipment.	.52256	.13506
VT277 Quality of office equipment.	.45103	.40555
VT278 Admin. and seccretarial assistance.	43442	.28450
VT279 Library facilities.	.44993	.29055
VT280 Training and career developmt.	.57594	−.00826
VT281 Information services.	.59417	.09463
VT282 Human resources.	.48822	.03003
VT283 Frequent contact with supervisor.	.79459	−.41625
VT284 Effective contacts with supervisor.	.76360	−.38551
VT285 Supervisor's professional ability.	.70450	−.45379
VT286 Supervisor's leadership qualities.	.69944	−.26622
VT287 Supervisor's personality characterstcs.	.64590	−.35004
VT288 Supervisor's knowlg. of related fields.	.78991	−.41627
VT289 Amount of work supervisor does.	.72300	.36789
VT290 Supervisor's support of staff work.	.70641	−.38275
Eigenvalue	(4.70)	(2.08)
Percent Variance Explained	23.5	10.4

Table 4: Forced single factor loadings for the five subscales with leaders, scientists, and technicians run separately.

Subscales and Items.	Organizational Level:		
CLM–Climate	**(LDR)**	**(SCI)**	**(TECH)**
V241 Innovative spirit.	.61588	.65319	.80642
V242 Dedication to work.	.78330	.79479	.82868
V246 Scientists and engineers cooperate.	.64533	.73098	.76535
V249 Intellectual non–isolation. (reversed)	.24878	.32875	.39235
V250 Technical arguments with others.	.34372	.55880	.59313
V276 Sharing of equipment.	.42221	.56354	*
Eignevalue/Percent Variance Explained	*(1.85/30.9%)*	*(2.16/36.1%)*	*(2.28/45.6%)*
LDR–Leadership	**(LDR)**	**(SCI)**	**(TECH)**
V243 R&D ideas considered.	.46839	.53766	.61710
V244 Technical ideas considered.	.30520	.46126	.61660
V245 Juniors' ideas considered.	.39052	.47174	.63519
V283 Frequent contact with supervisor.	.32144	.48891	.62635
V351 Informed of research planning.	.33794	.47519	.59222
V390 Meets quality requirements.	.47976	.55472	*
V399 Follows–up or uses results.	.43414	.41583	*
V400 Meets working schedule.	.56615	.59495	*
V401 Stays within budget.	.49067	.39194	*
Eigenvalue/Percent Variance Explained	*(1.74/37.4%)*	*(1.96/21.8%)*	*(.89/22.5%)*
LDRES– Resources from Leader	**(LDR)**	**(SCI)**	**(TECH)**
V270 Current budget adequate.	.42805	.45052	.39133
V271 Scientific equipment.	.52645	.67419	.62869
V273 Computer processing services.	.32421	.33188	.36010
V274 Adequacy of work space.	.45877	.42271	.50562
V277 Quality of office equipment.	.58675	.64277	.60264
V279 Library facilities.	.56129	.49186	.54403
V275 Technical assistance.	.69214	.64484	.65939
V278 Admin. and seccretarial assistance.	.56552	.61108	.61662
V280 Training and career developmt.	.34993	.47303	.49481
V281 Information services.	.64539	.53904	.55407
V282 Human resources.	.43739	.37253	.44386
Eigenvalue/Percent Variance Explained	*(3.65/33.5%)*	*(3.04/27.7%)*	*(3.60/32.8%)*

Category and Variables:	Organizational Level:		
RAT– Rating of Leader	**(LDR)**	**(SCI)**	**(TECH)**
V284 Effective contacts with supervisor.	.77299	.81238	.72996
V285 Supervisor's professional ability.	.81091	.87374	.82603
V286 Supervisor' leadership ability.	.80234	.81855	.80906
V287 Supervisor's personality characterstcs.	.75741	.69146	.74673
V288 Supervisor's knowlg. of related fields.	.79423	.85096	.82139
V289 Amount of work supervisor does.	.75001	.80148	.82292
V290 Supervisor's support of staff work.	.80554	.79809	.78042
Eignevalue/Percent Variance Explained	*(4.31/61.6%)*	*(4.57/65.4%)*	*(4.39/62.8%)*
EXT– External Influences on Unit	**(LDR)**	**(SCI)**	**(TECH)**
V384 Responsibility to disseminate results.	.12062	.11829	*
V385 Contact with external users.	.16243	.21942	*
V383 Outside follow–up pressure.	.43788	.57382	*
V388 Useful to R&D goals.	.54789	.67774	*
V389 Useful to S & T goals.	.45128	.64425	*
V393 National reputation.	.62216	.55690	*
V394 International reputation.	.64989	.45366	*
V395 Publications in high demand.	.46382	.37221	*
Eignevalue/Percent Variance Explained	*(1.54/32.1%)*	*(1.73/28.9%)*	*(N/A)*

Table 5: Multitrait– Multimethod Matrix for Leader, Scientist, and Technician Ratings.

				1 LEADER					2 SCIENTIST					3 TECHNICIAN			
				RAT	LDR	LDRES	CLM	EXT	RAT	LDR	LDRES	CLM	EXT	RAT	LDR	LDRES	CLM
				A1	B1	C1	D1	E1	A2	B2	C2	D2	E2	A3	B3	C3	D3
1	LEADER	RAT	A1	(.95)													
		LDR	B1	.29	(.55)												
		LDRES	C1	.28	.29	(.59)											
		CLM	D1	.23	.55	.26	(.75)										
		EXT	E1	.17	.43	.14	.39	(.64)									
2	SCIENTIST	RAT	A2	.08	.04	.06	.12	.04	(.92)								
		LDR	B2	.07	.16	.06	.15	.09	.55	(.65)							
		LDRES	C2	.14	.12	.28	.11	.08	.26	.26	(.72)						
		CLM	D2	.00	.16	.10	.27	.08	.53	.64	.33	(.74)					
		EXT	E2	.07	.15	.08	.19	.23	.41	.50	.24	.47	(.67)				
3	TECHNICIAN	RAT	A3	.07	.10	.09	.12	*	.23	.19	.06	.21	*	(.89)			
		LDR	B3	.10	.16	.09	.21	*	.12	.17	.05	.21	*	.42	(.60)		
		LDRES	C3	.06	.04	.17	.04	*	.03	.09	.11	.03	*	.19	.23	(.61)	
		CLM	D3	.08	.17	.12	.22	*	.16	.24	.07	.29	*	.50	.61	.26	(.78)

Table 6: Multitrait–Multimethod Matrix showing segregated Leader (RAT and LDR) Scores and row/column values which exceed their corresponding validity diagonal coefficients.

				1 LEADER					2 SCIENTIST					3 TECHNICIAN			
				RAT A1	LDR B1	LDRES C1	CLM D1	EXT E1	RAT A2	LDR B2	LDRES C2	CLM D2	EXT E2	RAT A3	LDR B3	LDRES C3	CLM D3
1	LEADER	RAT	A1	(.95)													
		LDR	B1	.29	(.55)												
		LDRES	C1	.28	.29	(.59)											
		CLM	D1	.23	.55	.26	(.75)										
		EXT	E1	.17	.43	.14	.39	(.64)									
2	SCIENTIST	RAT	A2	.08	.04	.06	.12	.04	(.92)								
		LDR	B2	.07	.16	.06	.15	.09	.55	(.65)							
		LDRES	C2	.14	.12	.28	.11	.08	.26	.26	(.72)						
		CLM	D2	.00	.16	.10	.27	.08	.53	.64	.33	(.74)					
		EXT	E2	.07	.15	.08	.19	.23	.41	.50	.24	.47	(.67)				
3	TECHNICIAN	RAT	A3	.07	.10	.09	.12	*	.23	.19	.06	.21	*	(.89)			
		LDR	B3	.10	.16	.09	.21	*	.12	.17	.05	.21	*	.42	(.60)		
		LDRES	C3	.06	.04	.17	.04	*	.03	.09	.11	.03	*	.19	.23	(.61)	
		CLM	D3	.08	.17	.12	.22	*	.16	.24	.07	.29	*	.50	.61	.26	(.78)

Table 7: Raw item means arranged into subscales showing grand means.

Subscales and Items:	Average Item Scores by Organizational Level:		
CLM–Climate	**(LDR)**	**(SCI)**	**(TECH)**
V241 Innovative spirit.	4.04797	3.87591	3.89940
V242 Dedication to work.	4.11449	3.92464	4.09343
V246 Scientists and engineers cooperate.	4.32258	3.94787	4.06051
V249 Intellectual isolation.	3.79056	3.63235	3.55590
V250 Technical arguments with others.	4.30531	4.29359	4.33486
V276 Sharing of equipment.	3.85884	3.60486	3.72969
Grand Mean	**4.07329**	**3.87987**	**3.94563**
LDR–Leadership	**(LDR)**	**(SCI)**	**(TECH)**
V243 R&D ideas considered.	4.25000	3.98253	4.05000
V244 Technical ideas considered.	3.72619	3.50076	3.55869
V245 Juniors' ideas considered.	4.31487	3.85756	3.65601
V283 Frequent contact with supervisor.	3.55623	4.22710	4.31150
V351 Informed of research planning.	4.75367	3.98688	*
V390 Meets quality requirements.	4.12173	3.98878	*
V399 Follows–up or uses results.	3.95421	3.76506	*
V400 Meets working schedule.	3.76176	3.75149	*
V401 Stays within budget.	4.03624	3.93984	*
Grand Mean	**4.05277**	**3.88889**	**3.89405**
LDRES– Resources from Leader	**(LDR)**	**(SCI)**	**(TECH)**
V270 Current budget adequate.	3.15929	2.98742	3.04400
V271 Scientific equipment.	2.97797	2.84389	3.12191
V273 Computer processing services.	3.04603	2.87302	2.91892
V274 Adequacy of work space.	2.69869	2.75510	2.92330
V277 Quality of office equipment.	2.65237	2.65916	3.02773
V279 Library facilities.	3.48997	3.49635	3.83025
V275 Technical assistance.	2.70381	2.69424	3.04747
V278 Admin. and secretarial assistance.	2.67055	2.65533	3.13449
V280 Training and career development.	3.35232	3.07259	3.28947
V281 Information services.	3.00295	2.97177	3.41068
V282 Human resources.	3.19739	3.19277	3.63712
Grand Mean	**2.99558**	**2.92742**	**3.21685**

Category and Variables:	Organizational Level:		
RAT– Rating of Leader	**(LDR)**	**(SCI)**	**(TECH)**
V284 Effective contacts with supervisor.	3.26368	3.85484	4.07988
V285 Supervisor's professional ability.	3.87797	4.12813	4.43427
V286 Supervisor' leadership ability.	3.66555	3.71935	4.09985
V287 Supervisor's personality characteristics.	3.90635	3.97181	4.15712
V288 Supervisor's knowlg. of related fields.	3.59664	4.11669	4.39701
V289 Amount of work supervisor does.	3.77895	4.01637	4.30455
V290 Supervisor's support of staff work.	3.72425	3.93353	4.12224
Grand Mean	**3.68763**	**3.96296**	**4.22785**
EXT– External Influences on Unit	**(LDR)**	**(SCI)**	**(TECH)**
V384 Responsibility to disseminate results.	3.35905	3.27314	*
V385 Contact with external users.	3.79254	3.56515	*
V383 Outside follow–up pressure.	3.40916	3.21108	*
V387 Useful to R&D goals.	4.39617	4.18047	*
V389 Useful to S & T goals.	3.78849	3.51613	*
V393 National reputation.	3.94567	3.48737	*
V394 International reputation.	2.93161	2.58851	*
V395 Publications in high demand.	3.39813	3.12160	*
Grand Mean	**3.62760**	**3.36793**	**(N/A)**

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APPENDICES

Appendix A: Crosstabulation of research units across country and type of institution.

Country / Type of Institution	Argentina	Egypt	India	Rep. of Korea	Poland	U.S.S.R.	TOTAL	PCT
Universities and associated institutions (1 – 2)	237	104	–	23	132	–	496	
	47.8	21.0	–	4.6	26.6	–	100.0	ROW %
	71	45.4	–	11.5	58.7	–	34	COL %
National research organizations (3)	84	50	227	57	23	173	614	
	13.7	8.1	37.0	9.3	3.7	28.2	100.0	ROW %
	25.1	21.8	95.0	28.5	10.2	74.2	42.0	COL %
Branch co–operative research institutes (4)	11	61	12	51	70	60	265	ROW %
	4.2	23.0	4.5	19.2	26.4	22.7	100.0	COL %
	3.3	26.6	5.0	25.5	31.1	25.7	18.2	
Contract research institutes (5)	–	4	–	50	–	–	54	
	–	7.4	–	92.6	–	–	100.0	ROW %
	–	1.8	–	25	–	–	3.7	COL %
Research laboratories (6)	–	10	–	19	–	–	29	
	–	34.5	–	65.9	–	–	100.0	ROW %
	–	4.4	–	9.5	–	–	2.0	COL %
Other (7)	2	–	–	–	–	–	2.0	
	100	–	–	–	–	–	100.0	ROW %
	0.6	–	–	–	–	–	0.1	COL %
TOTALS	334	229	239	200	225	233	1460	
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	COL %
	22.9	15.7	16.4	13.7	15.4	15.9	100.0	TOTAL

UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANIZATION

APPENDIX B

Unesco/NS/ROU/386/CM
Paris, March 1977
Original: English

INTERNATIONAL COMPARATIVE STUDY ON THE ORGANIZATION AND PERFORMANCE OF RESEARCH UNITS

CORE MEMBERS OF THE RESEARCH UNIT

Form "CM"

EXPLANATORY NOTES

Thank you for your co-operation in the Unesco International Comparative Study on the Organization and Performance of Research Units.

This questionnaire is one of a series of instruments designed to provide relevant data on research units of your country. The administration of the set of questionnaires and the subsequent analysis of their contents constitute the survey research project in which you have been asked to participate. The major premise guiding this work is that a better understanding of the organization of individual research units will facilitate improved management of research units in general and stimulate decisions which may improve their effectiveness.

In answering this questionnaire, it is most important that your responses be as complete and candid as possible. In addition to facts, many questions ask for your opinions and perceptions. Thus, the value of this work relies heavily upon how you complete each question.

Concerning the confidentiality of your reply, both UNESCO and the national authority responsible for the present study declare that all responses will be kept in strict confidence. Furthermore, both organizations declare that in subsequent analyses of the data, and during eventual presentations of the results, no responses from individuals, and no data from individual research units will be identified.

Any feedback of results at the national or international level will come from your national scientific research team. Your interviewer will be glad to tell you about your country's plans for communicating results back to interested participants.

Please note that :

(i) instructions for completing each question are given just before each question is asked;

(ii) concepts for which explanations are provided have been marked with an asterisk.

If you have any questions, ask your interviewer.

WORK ALONE! DO NOT CONSULT ANYONE ELSE IN MAKING YOUR REPLIES.

You may now begin to complete this questionnaire. When you have finished, please return your completed questionnaire to your interviewer.

Once again, thank you for your help.

on behalf of your national research team
co-operating with Unesco

SECTION I

This section of the "CM" Questionnaire is to be completed by ALL Core Members of the Research Unit

For the purposes of this study a research unit is one which meets all of the following criteria :

(a) Has at least one leader who is a core member

(b) Has at least three core members, each of whom has been a research unit member for at least half a year

(c) Has a total expected life-span of at least one year,

and where a "core member" is a person who devotes at least 8 hours per week to the work of the research unit and who has communication (direct or indirect) with the unit leader(s) at least once each month.

Scientist and engineer: This group includes any person who has received scientific or technical training in the fields of exact and natural sciences, engineering, agricultural, medical or social sciences and humanities as specified below :

(i) completed education at the third level leading to an academic degree
(ii) completed third level non-university education (or training) which does not lead to an academic degree but is nationally recognized as qualifying for a professional career. It is necessary for each country to establish criteria for distinguishing between scientists and engineers as defined on this basis, and the technical staff who have received formal training
(iii) training and professional experience which is nationally recognized (e.g. membership in professional societies, professional certificate or licence) as being equivalent to the formal education indicated in (i) and (ii).

Technical staff: This group includes any person who has received specialized vocational or technical training in any branch of science or technology as specified below :

(i) one to two years' training beyond completed education at the second level or three to four years' training beyond the first cycle of secondary education, whether or not leading to a degree or diploma
(ii) on-the-job training and professional experience which is nationally recognized as being equivalent to the level of education indicated in (i).

Laboratory assistants who meet the requirements (i) or (ii) are also classed as technical staff. Clerical, administrative and other supporting personnel are excluded.

Other personnel: The residual group includes skilled workers, such as machinists, sheet metal workers and other trade workers, operators, etc. as well as unskilled workers; all clerical, administrative and other supporting personnel. Exclude security, janitorial and maintenance personnel engaged in general house-keeping activities.

H. INDIVIDUAL PROFILE

1. Your present position in the research unit*

a. Please indicate your present position in the unit by selecting ONE number below and writing it in the space provided

1 = head of the unit

2 = staff scientist/engineer* of the unit

3 = technical staff* of the unit

. . 1/12

b. During what year did you begin working with this research unit? .1 .9 . . . 13-14

c. Please indicate,

(i) how many scientists and engineers you directly supervise in the unit at the present time (write in "00" if none) . . . 15-16

(ii) how many technical staff members you directly supervise in the unit at the present time (write in "00" if none) . . . 17-18

d. During what year did you become Head of this research unit? (Unit Heads only) .1 .9 . . . 19-20

2. Personal Information

a. Year of birth: .1 .9 . . . 21-22

b. Sex: 1 = male
2 = female . . 23

c. Fields of specialization:

Considering the knowledge and expertise gained during your professional research experience (including the preparation of a Doctor's degree), please indicate in the spaces below the scientific/technological sub-disciplines which best characterize your fields of specialization. You may indicate as many as three specializations by entering the appropriate sub-discipline titles and their accompanying 6-digit code numbers. (Please refer to the attached "International Standard Nomenclature for Fields of Science and Technology" for the complete listing of scientific/technological sub-disciplines.)

Specify whether you acquired your specialization primarily in your present country, or abroad by inserting, in the last column on the right, the appropriate number from the two listed below.

1 = acquired specialization in present country

2 = acquired specialization abroad

Fields of Specialization (sub-disciplines)	Code Numbers for Sub-disciplines	In Country/ Abroad
(i) _____	. . . . . 24 29	. . 30
(ii) _____	. . . . . 31 36	. . 37
(iii) _____	. . . . . 38 43	. . 44

d. Interdisciplinary orientation of your research work

In carrying out your research work, do you borrow some methods, theories or other specific elements developed in other fields, not normally used in your research?

If No, write "0" and move to Item e. below
If Yes, write "1" and continue . 1/45

If Yes, write below the names of these other fields and their TWO DIGIT major category codes, using the attached "International Standard Nomenclature for Fields of Science and Technology".

Name	Code
_____	. . 46-47
_____	. . 48-49
_____	. . 50-51

e. Please indicate the number of years, in full-time equivalent, which you have devoted to education. (Include your first year of primary school through post-graduate studies. Do not count any year where studies were repeated.)

. . 52-53

f. Please indicate the number of years of your R&D experience. (Original research leading to a Ph.D. degree should be included.)

. . 54-55

J. ACTIVITIES AND TASKS PERFORMED

Design and engineering studies: Consist of the preparation of (original) blueprints and other supporting material such as cost/effectiveness calculations, which combine existing products and processes with a view to manufacturing goods or delivering services.

Extension work: Consists of helping to carry the results of original research or experimental development into effective practical application.

Research project: A group of interrelated research and experimental development activities aimed at obtaining original results by creating new theories and methods, improving the understanding of nature, inventing and developing new products or processes, discovering new fields of investigation, etc. The progress achieved on a research project is usually reported upon separately as one whole to higher hierarchical levels or sponsoring authorities of the unit. The work performed may - or may not - be directed towards a specific practical aim.

Scientific observation and/or monitoring work: Cover repetitive scientific work performed through established practices with existing instrumentation and aimed at collecting quantitative or qualitative data on natural phenomena. Monitoring work includes an element of compulsory periodicity.

Scientific surveys: Consist of the systematic probing into the characteristics and dynamics of observable sites or phenomena.

1. Activities Performed:

Please indicate, in percentage terms, how much of the annual work time in your present position is spent performing the following activities. Write the percentage figures in the spaces provided at the right taking care that they total 100%.

Types of Activities	Percentage of your working time
a. Research and Experimental Development inside the unit	1/56 58 %
b. Research and Experimental Development outside the unit	59 61 %
c. Administrative activities	62 64 %
d. Teaching, including the preparation of pedagogic material and the popularization of science	65 67 %
e. ~~Consulting work (including medical), extension work,~~* standardization work	68 70 %
f. Scientific information and/or documentation not directly relevant to your research	71 73 %
g. Routine and control analysis or measurements, scientific observations and/or monitoring work,* scientific surveys*	74 76 %
h. Design and engineering studies,* feasibility studies	77 79 % 2/11
j. ~~Other professional functions (please specify)~~ _____	2/12 14 %
_____	
Total Working Time :	1 0 0 %

2. Please indicate the number of research projects* for which you have served as Project Leader during the last three years. (Write in "00" if the response is None.)

   a. Number of projects INSIDE the research unit . . / 15-16

   b. Number of projects OUTSIDE the research unit . . / 17-18

3. Types of activity in research and experimental development (R&D)

You are given below a list of main types of research and experimental development activities (R&D). In the space provided at the right, please fill-in the number corresponding to your level of PERSONAL INVOLVEMENT in each of the types of R&D activities mentioned.

Note: Please avoid leaving blanks by writing in "NA" if not applicable, or "UN" if unable to reply.

Types of R&D Activities	Levels of Personal Involvement					
	Very High	High	Medium	Low	Very Low or Nil	
a. Perception and identification of an area of interest	5	4	3	2	1	. . / 19
b. Literature review	5	4	3	2	1	. . / 20
c. Problem precision: conceptualization, formulation, analysis	5	4	3	2	1	. . / 21
d. Orientation and perception of methods and techniques, apparatus, etc.	5	4	3	2	1	. . / 22
e. Time-table, administration, organization and economic considerations	5	4	3	2	1	. . / 23
f. Formulation and statement of hypotheses	5	4	3	2	1	. . / 24
g. Research design: planning, strategies and experimental outlay	5	4	3	2	1	. . / 25
h. Collection and production of data, including experimental work	5	4	3	2	1	. . / 26
j. Results: detailed analysis, interpretation and conclusions	5	4	3	2	1	. . / 27
k. Report writing, e.g. for publication, thesis, etc.	5	4	3	2	1	. . / 28

K. WORKING CLIMATE OF THE RESEARCH UNIT

This series of questions concerns your views about the working climate of the research unit. The individual questions touch upon issues like the levels of co-operation and the spirit of dedication among the team members, staff meetings, and distractions from the research work. Please indicate your views on these issues by selecting one number for each pair of extreme statements given below, and write that number in the space provided.

Note: Avoid leaving blanks by writing in "NA" if not applicable, or "UN" if unable to reply.

X		X applies	Tend. to X	Intermediate	Tend. to Y	Y applies	Y	
	1	Innovative spirit						
There is generally a very innovative spirit in the unit		5	4	3	2	1	There is generally no innovative spirit in the unit	29
	2	Dedication to the work						
There is an atmosphere of great dedication to work in the unit		5	4	3	2	1	There is no or very little atmosphere of dedication to work in the unit	30
	3	Consideration towards new ideas in R&D or other technical matters						
Nearly all new ideas for research or other technical matters are given adequate consideration		5	4	3	2	1	Very few new ideas for research or other technical matters are given adequate consideration	31
	4	Consideration towards new ideas in non-technical matters						
New ideas for improvement in non-technical matters are given serious consideration		5	4	3	2	1	New ideas on non-technical matters are ignored	32
	5	Acceptance of ideas not coming from senior staff						
New ideas on all matters from junior staff are as seriously considered as if they originate from the senior staff		5	4	3	2	1	New ideas are only taken seriously if they come from senior staff	33
	6	Co-operation among scientists & engineers in the unit						
There is a very high degree of co-operation among the scientists and engineers of the unit		5	4	3	2	1	There is very little or no co-operation among the scientists and engineers of the unit	34
	7	Scientific/technical staff meetings in the unit						
Scientific/technical staff meetings are convened very frequently		5	4	3	2	1	Scientific/technical staff meetings are very rare in the unit	35

X		X applies	Tend. to X	Intermediate	Tend. to Y	Y applies	Y	
	8	Participation of the technical/service staff in meetings						
The technical/service staff are very often invited to participate in scientific/ technical staff meetings		5	4	3	2	1	The technical/service staff are very rarely or never invited to participate in scientific/technical staff meetings	2/36
	9	Feeling of isolation						
I have the feeling that the research unit is intellectually isolated		5	4	3	2	1	I have the feeling that the research unit is not intellectually isolated	37
I am often involved in unpleasant arguments over technical matters with :		Technical Arguments with :					I am rarely involved in unpleasant arguments over technical matters with :	
	10	Other members of the research unit						
		5	4	3	2	1		38
	11	My immediate supervisor						
		5	4	3	2	1		39
	12	The administrators of the research institution						
		5	4	3	2	1		40
I am often involved in unpleasant arguments over non-technical matters (politics, race, religion, colour, personal matters) with :		Non-technical arguments with :					I am rarely involved in unpleasant arguments over non-technical matters (politics, race, religion, colour, personal matters) with :	
	13	Other members of the research unit						
		5	4	3	2	1		41
	14	My immediate supervisor						
		5	4	3	2	1		42
	15	The administrators of the research institution						
		5	4	3	2	1		43

X		X applies	Tend. to X	Intermediate	Tend. to Y	Y applies	Y
	16	Administrative constraints on the staff					
The constraints imposed on the scientists and engineers of the unit by administrative regulations are excessive		5	4	3	2	1	The constraints imposed on the scientists and engineers of the unit by administrative regulations are minimal 2/44
	17	Distractions					
There are too many distractions (noise, phone calls, unforeseen visits, etc.) interrupting the work in the unit		5	4	3	2	1	There are few if any distractions interrupting the work in the unit 45

L. ABOUT YOUR JOB

This series of questions concerns your feelings about your job, including such issues as the amount of overtime work you do, the time pressure under which you work, and the level of responsibilities you currently exercise. Please indicate your views on these issues by selecting one number for each pair of extreme statements given below, and write that number in the space provided.

Note: Avoid leaving blanks by writing in "NA" if not applicable, or "UN" if unable to reply.

X		X applies	Tend. to X	Intermediate	Tend. to Y	Y applies	Y
	1	Job Security					
I have a feeling of high job security in my work		5	4	3	2	1	I have a feeling of low job security in my work 46
	2	Thinking of leaving the unit					
I rarely if ever consider leaving the unit		5	4	3	2	1	I frequently consider leaving the unit 47
	3	Knowledge of assessment of my performance					
I am very well informed of the assessment of my performance		5	4	3	2	1	I am very poorly informed of the assessment of my performance 48
	4	Voluntary Overtime					
I do a great deal of voluntary overtime		5	4	3	2	1	I do no voluntary overtime 49

X		X applies	Tend. to X	Intermediate	Tend. to Y	Y applies	Y	
	5	Level of Responsibility						
I would like to have more responsibility in the unit		5	4	3	2	1	I would like to have less responsibility in the unit	2/50
	6	Time Pressure						
I work under much more time pressure than I think is optimal for me		5	4	3	2	1	I work under much less time pressure than I think is optimal for me	51
	7	Other employment opportunities						
I anticipate few difficulties in finding a similar or better position should I leave the unit		5	4	3	2	1	I see little chance of finding a similar or better position should I leave the unit	52
		Remuneration in relation to:						
	8	Service given to the unit						
I am satisfied with my remuneration in relation to the service I give to the unit		5	4	3	2	1	I am dissatisfied with my remuneration in relation to the service I give to the unit	53
	9	Cost of living						
I am satisfied with my remuneration in relation to the cost of living		5	4	3	2	1	I am dissatisfied with my remuneration in relation to the cost of living	54
	10	What others receive						
I am satisfied with my remuneration in relation to that of others with comparable qualifications, training and experience in the organization		5	4	3	2	1	I am dissatisfied with my remuneration in relation to that of others with comparable qualifications, training and experience in the organization	55
		Advancement opportunities in relation to:						
	11	My performance at work						
My advancement opportunities seem to be essentially related to my performance		5	4	3	2	1	My advancement opportunities seem to be essentially unrelated to my performance	56
	12	The opportunities of others						
I am satisfied with my advancement opportunities in relation to those of others with comparable qualifications, training and experience		5	4	3	2	1	I am dissatisfied with my advancement opportunities in relation to those of others with comparable qualifications, training and experience	57

M. BUDGET, FACILITIES AND SERVICES AVAILABLE TO THE RESEARCH UNIT

The next set of questions asks for your personal evaluation of the budget, services and facilities available to the research unit. As before, please indicate your views by selecting one number for each pair of extreme statements given below, and writing that number in the space provided.

Note: Avoid leaving blanks by writing in "NA" if not applicable, or "UN" if unable to reply.

X		X applies	Tend. to X	Intermediate	Tend. to Y	Y applies	Y	
	1	Adequacy of the budget						
The current budget of the unit is adequate to allow successful completion of the unit's current research and/or scientific tasks		5	4	3	2	1	The current budget of the unit is not adequate to allow successful completion of the unit's current research and/or scientific tasks	. . 2/58
	2	Scientific Equipment						
The unit is well equipped scientifically		5	4	3	2	1	The unit is poorly equipped scientifically	. . 59
	3	Manpower recruitment system						
I am satisfied with the manpower recruitment system of the unit		5	4	3	2	1	I am dissatisfied with the manpower recruitment system of the unit	. . 60
	4	Computerized Data Processing services						
I am satisfied with the computerized data processing services available to the unit		5	4	3	2	1	I am dissatisfied with the computerized data processing services available to the unit	. . 61
	5	Adequacy of the working space						
The space provided for the work of the unit is adequate		5	4	3	2	1	The space provided for the work of the unit is inadequate	. . 62
	6	Technical Assistance						
The technical assistance and services the unit receives are satisfactory		5	4	3	2	1	The technical assistance and services the unit receives are unsatisfactory	. . 63
	7	Sharing of equipment						
The way in which equipment is shared in the unit is satisfactory		5	4	3	2	1	The way in which equipment is shared in the unit is unsatisfactory	. . 64
	8	Quality of office equipment						
The unit has excellent office equipment		5	4	3	2	1	The unit has poor office equipment	. . 65
	9	Administrative and secretarial assistance						
The administrative and secretarial assistance the unit receives is satisfactory		5	4	3	2	1	The administrative and secretarial assistance the unit receives is unsatisfactory	. . 66

X		X applies	Tend. to X	Intermediate	Tend. to Y	Y applies	Y	
	10	Library facilities						
The library facilities available to the unit are satisfactory		5	4	3	2	1	The library facilities available to the unit are unsatisfactory	. . 2/67
	11	Training and career development facilities						
I am satisfied with the available training and career development facilities		5	4	3	2	1	I am dissatisfied with the available training and career development facilities	. . 68
	12	Information services						
The information services available to the unit are satisfactory		5	4	3	2	1	The information services available to the unit are unsatisfactory	. . 69
	13	Human resources						
I am satisfied with the human resources available to the unit, as compared with its current research project(s) and/or scientific task(s)		5	4	3	2	1	I am dissatisfied with the human resources available to the unit, as compared with its current research project(s) and/or scientific task(s)	. . 70

N. SUPERVISOR

The questions in this section concern the nature of your contacts with your supervisor, as well as your general satisfaction with several aspects of his/her professional and personal characteristics.

By "Supervisor" is meant here :

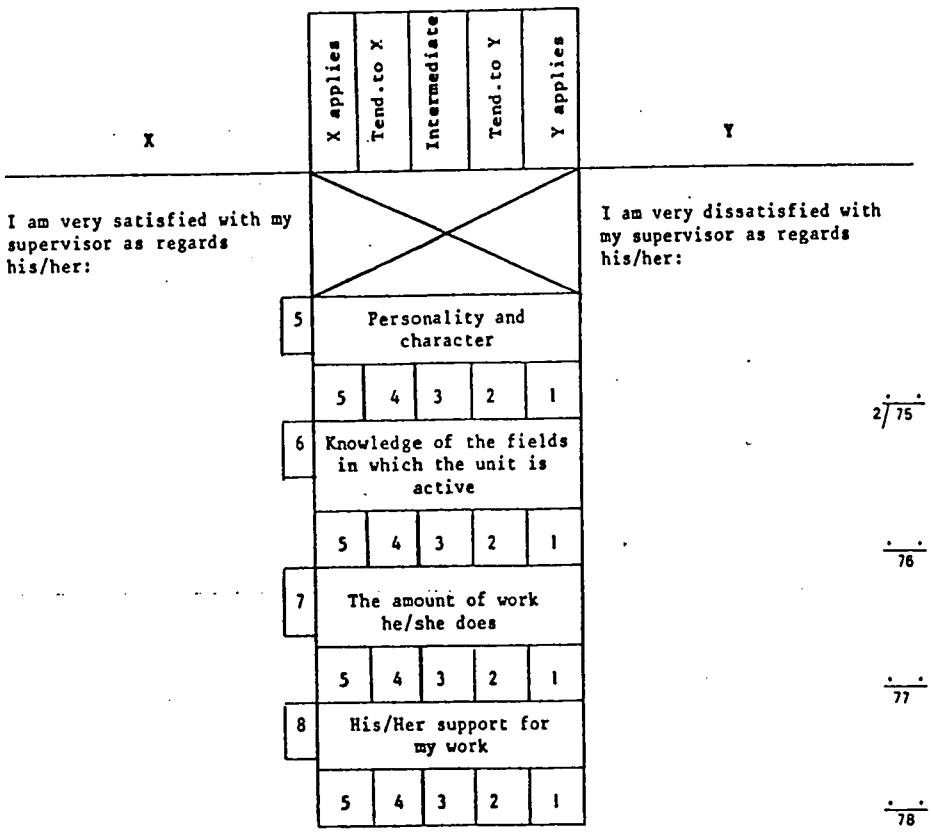
(1) the Head of the Unit in cases where this question is answered by the "Core Members of the Unit"*, irrespective of whether they are scientist/engineer staff* or technical staff* of the Unit;

(2) the Immediate Supervisor of the Head in cases where this question is answered by the Head of the Unit.

Please indicate your feelings on these issues by selecting, for each of the pairs of extreme statements given below, the number which most accurately describes your opinion, and inserting it in the space provided.

Note: Avoid leaving blanks by writing in "NA" if not applicable, or "UN" if unable to reply.

X		X applies	Tend. to X	Intermediate	Tend. to Y	Y applies	Y	
	1	Frequency of contacts with supervisor						
I have continuous working contacts with my supervisor		5	4	3	2	1	I seldom, if ever, have working contacts with my supervisor	2/71
	2	Effects of contacts with supervisor						
There is a very positive effect on my scientific or technical performance arising from contacts with my supervisor		5	4	3	2	1	There is no positive effect on my scientific or technical performance arising from contacts with my supervisor	/72
		Satisfaction with supervisor						
I am very satisfied with my supervisor as regards his/her:							I am very dissatisfied with my supervisor as regards his/her:	
	3	Professional ability						
		5	4	3	2	1		/73
	4	Leadership qualities						
		5	4	3	2	1		/74


X
X applies
Tend.to X
Intermediate
Tend.to Y
Y applies
Y
I am very satisfied with my supervisor as regards his/her:
I am very dissatisfied with my supervisor as regards his/her:
5 Personality and character
5 4 3 2 1
6 Knowledge of the fields in which the unit is active
5 4 3 2 1
7 The amount of work he/she does
5 4 3 2 1
8 His/Her support for my work
5 4 3 2 1

2/75

76

77

78

SECTION II

Section II of this questionnaire is directed towards the scientists and engineers of the research unit (including the Unit's Head).

Technical staff are asked to skip over this section, turning directly to the last page of the questionnaire (p. 27) where space has been provided for additional comments

P. PATTERNS OF INFLUENCE

Listed below are several types of research and experimental development activities, and types of management decisions, which affect the operations of a research unit. For each of these, please specify the actual amount of influence exercised by each of the four groups of people indicated at the right.

Note: Indicate the actual amount of influence by using the scale of values given below.

5 = high influence (X)

4 = tendency towards (X) above

3 = "intermediate" as regards (X) above and (Y) below

2 = tendency towards (Y) below

1 = little or no influence (Y)

Do not leave any blanks. Write "NA" if not applicable, or "UN" if unable to reply.

3
3/11

Type of activities and decisions	Unit Head(s)	Staff scientists/ engineers of the unit	Leadership outside unit but inside institution	Authorities or customers outside institution
1. Determining general research themes	3/16	17	18	19
2. Preparing proposals for new research projects	20	21	22	23
3. Choice of specific research tasks	24	25	26	27
4. Choice of methods used in the research work	28	29	30	31
5. Allocation of work within the unit	32	33	34	35
6. Publication and circulation of results	36	37	38	39
7. Pursuing the application or furthering the utilization of research results	40	41	42	43
8. Co-ordination and/or co-operation with other research units	44	45	46	47
9. Use of training and career development facilities	48	49	50	51
10. Hiring personnel for a definite period	52	53	54	55
11. Terminating the employment of personnel	56	57	58	59
12. Hiring or buying low-cost equipment (value up to $500 US per piece)	60	61	62	63

Q. PLANNING AND ORGANIZING THE UNIT'S RESEARCH ACTIVITIES

Please characterize the organization and planning of the research work in the unit by selecting one number for each of the pairs of extreme statements given below and writing it in the space provided.

Note: Avoid leaving blanks by writing in "NA" if not applicable, or "UN" if unable to reply.

X		X applies	Tend. to X	Intermediate	Tend. to Y	Y applies	Y	
	1	Interest of the research activities						
The research activities of the unit are very interesting and conceptually exciting		5	4	3	2	1	The research activities of the unit tend to be uninteresting and unimaginative	3/64
	2	Scientific significance						
The scientific significance of a research problem is a major consideration when selecting the unit's research activities		5	4	3	2	1	The scientific significance of a research problem is a minor consideration when selecting the unit's research activities	65
	3	Potential for successful application						
When selecting the unit's research activities, the potential for their successful application is a major consideration		5	4	3	2	1	When selecting the unit's research activities, the potential for their successful application is a minor consideration	66
	4	Information about on-going research						
I am well informed of all aspects of the research carried out by the unit		5	4	3	2	1	I am poorly informed of most aspects of the unit's on-going research	67
	5	Scientific/technological objectives						
The scientific/technological objectives of the research work performed by the unit are closely related		5	4	3	2	1	The scientific/technological objectives of the research work performed by the unit are loosely connected	68
	6	Establishing the budget						
The budget of the unit is established as a whole, without any indication of the share allotted to each of its research workers		5	4	3	2	1	The budget of the unit is established as a collection of the budgetary allotment earmarked for each of its research workers	69
	7	Coherence of the research programme						
The research programme of the unit is highly coherent		5	4	3	2	1	The research programme of the unit is utterly fragmented	70

X		X applies	Tend. to X	Intermediate	Tend. to Y	Y applies	Y	
	8	Adequacy of the research planning						
The research planning in the unit is very well conceived		5	4	3	2	1	The research planning in the unit tends to be poorly conceived	3/71
	9	Contacts with potential users of results						
The research planning in the unit usually foresees contacts with potential users of the anticipated results		5	4	3	2	1	The research planning in the unit seldom, if ever, foresees contacts with potential users of the anticipated results	72
	10	Nature of research work						
The nature of research work in the unit requires extensive co-operation among its members		5	4	3	2	1	The nature of research work does not require extensive co-operation among its members	73
	11	Participation in research planning						
I participate in the research planning at the unit level		5	4	3	2	1	I do not participate in the research planning at the unit level	74
	12	Social utility						
The social utility of a research topic is a major consideration when selecting the unit's research activities		5	4	3	2	1	The social utility of a research topic is a minor consideration when selecting the unit's research activities	75
	13	Information on research planning						
I am well informed of all aspects of the research planning at the unit level		5	4	3	2	1	I am largely uninformed of most aspects of the research planning at the unit level	76

R. WORKING CONTACTS BOTH INSIDE AND OUTSIDE YOUR INSTITUTION

Questions in this section inquire about the nature and frequency of working contacts both inside and outside the institution to which your unit belongs. The first set of questions inquires about the frequency of these contacts whereas the second and third parts seek your views about the quality of these contacts and their influence on your scientific/technical performance. Part four asks about the types of assistance you receive from other members of your unit.

Note: Please write ONE number below in each of the spaces provided. Avoid leaving blanks by writing in "NA" if not applicable, or "UN" if unable to reply.

1. Frequency of contacts

Indicate the frequency of your working contacts by using the scale of values given below :

1 = very rarely, if ever
2 = annually
3 = quarterly
4 = monthly
5 = weekly
6 = daily

Answer Column

a. How frequently do you discuss your work with members of other research units within your institution? . . 3/77

b. How often do you visit (or are you visited by) colleagues from other institutions working in the same field? (Include here foreign colleagues as well.) . . 78

2. Satisfaction about contacts

Indicate your satisfaction about these contacts by selecting ONE number for each of the pairs of extreme statements given below, and writing it in the space provided.

X		X applies	Tend. to X	Intermediate	Tend. to Y	Y applies	Y
	a	Satisfaction about contacts within the institution					
I am very satisfied with the opportunities I have to discuss my work with members of other research units within the institution		5	4	3	2	1	I am very dissatisfied with the opportunities I have to discuss my work with members of other research units within the institution . . 79
	b	Satisfaction about contacts outside the institution					
I am very satisfied with the opportunities I have to visit colleagues in other institutions working in the same field		5	4	3	2	1	I am very dissatisfied with the opportunities I have to visit colleagues in other institutions working in the same field . . 80

3. Effects of contacts

Indicate the effects of these contacts by selecting ONE number for each of the pair of extreme statements given below, and writing it in the space provided.

X	X applies	Tend. to X	Intermediate	Tend. to Y	Y applies	Y	4 4/11
	Effect on scientific or technical performance						
There is a highly beneficial effect on my scientific or technical performance arising from contacts with other units	5	4	3	2	1	There is almost no discernible effect on my scientific or technical performance arising from contacts with other units	. . 12

4. Types of assistance received from other members of the research unit

Questions in this section inquire about types of assistance which you may in general receive from other members of the research unit.

In answering, please consider all members of the unit, professional and non-professional.

Note: Please avoid leaving blanks by writing in the space provided, "00" if none, "NA" if not applicable, "UN" if unable to reply.

a. HOW MANY people in the unit are particularly useful TO YOU for giving technical information? . . . 13 - 14

b. HOW MANY people in the unit are particularly useful TO YOU for providing original ideas? . . . 15 - 16

c. HOW MANY people in the unit are particularly useful TO YOU for providing administrative help (e.g. in getting needed resources and facilities, information about administrative developments, etc.)? . . . 17 - 18

d. What is the TOTAL number of different people you mentioned in your responses to (a), (b) and (c) above? . . . 19 - 20

5. CONTRIBUTION TO THE PRODUCTION OF THE RESEARCH UNIT

Listed below is a series of written products and other materials which commonly result from work performed in a research unit (see definition on page 4). For each of these possible products, please indicate :

In Column A - The NUMBER of individual items produced during the LAST THREE YEARS and resulting from your work in the research unit.

Note: Please avoid leaving blanks by writing in the space provided, "00" if none, "NA" if not applicable, "UN" if unable to reply.

In Column B - The IMPORTANCE of this type of product in light of the objectives of the research unit.

Note: Please indicate importance by using the scale of values indicated below. Avoid leaving blanks by writing "NA" if not applicable, or "UN" if unable to reply.

5 = of great importance to the objectives of the research unit (X)

4 = tendency to (X) above

3 = "intermediate" as regards (X) above and (Y) below

2 = tendency to (Y) below

1 = of very little or no importance to the objectives of the research unit (Y)

Type of product	Column A Number of Items Resulting from my Work	Column B Importance of the Type of Product to the Unit's Objectives
1. Books (including editorship)	4 [21-22]	[23]
2. Original scientific or technical articles published in the open literature:		
a. In the unit's country	[24-25]	[26]
b. Abroad	[27-28]	[29]
3. Reviews and bibliographies published in the open literature	[30-31]	[32]
4. Internal reports on original R&D work within your institution	[33-34]	[35]
5. Routine internal reports	[36-37]	[38]
6. Patents or patent applications	[39-40]	[41]
7. Algorithms, blueprints, flowcharts, drawings, etc.	[42-43]	[44]
8. Experimental prototypes or devices, instruments and apparatus, components of devices, etc.	[45-46]	[47]
9. Experimental materials such as fibres, plastics, glass, metals, alloys, substrates, chemicals, drugs, plants, etc.	[48-49]	[50]
10. Other products (please specify)	[51-52]	[53]

T. DISSEMINATION AND UTILISATION OF THE RESULTS OBTAINED BY THE RESEARCH UNIT

This series of questions inquires about your evaluation of factors that may influence the dissemination and practical utilization of the results obtained by the research unit during THE LAST THREE YEARS. Indicate your feelings about these issues by selecting ONE number from each of the pairs of extreme statements, and writing it in the space provided at the right.

Note: Avoid leaving blanks by writing in "NA" if not applicable, or "UN" if unable to reply.

X		X applies	Tend. to X	Intermediate	Tend. to Y	Y applies	Y	
	1	Outside pressure for practical utilization of results						
There is strong pressure from outside the unit to ensure that its results find follow-up or practical utilization		5	4	3	2	1	There is no pressure from outside the unit to ensure that its results find follow-up or practical utilization	4/54
	2	Dissemination of results						
The unit members are directly responsible for the dissemination of their results to potential users		5	4	3	2	1	The unit members are not directly responsible for the dissemination of their results to potential users	55
	3	Unit's contact with follow-up						
The unit maintains close contact with those ensuring the follow-up or practical utilization of its results		5	4	3	2	1	The unit does not maintain any contact with those ensuring the follow-up or practical utilization of its results	56
	4	Secrecy in dissemination of results						
The dissemination of the results obtained by the unit are often submitted to secrecy rules or practices		5	4	3	2	1	The dissemination of the results obtained by the unit are never submitted to secrecy rules or practices	57

U. INTERNAL EVALUATION OF THE WORK OF THE RESEARCH UNIT

This series of questions inquires about your general evaluation of the research unit's work during the LAST THREE YEARS. The individual questions touch upon such issues as the unit's ability to generate new ideas, to contribute to the achievement of institutional goals, to publish its research results, to meet quality standards, and to maintain a high level of productivity. Indicate your feelings on these issues by selecting ONE number from each of the pairs of extreme statements, and writing it in the space provided at the right. Since this questionnaire is used in a variety of institutional setting, some questions may be irrelevant to certain research units.

Note: Avoid leaving blanks by writing in "NA" if not applicable, or "UN" if unable to reply.

X	X applies	Tend. to X	Intermediate	Tend. to Y	Y applies	Y	
			Effectiveness				
The work of the unit has been extremely useful in helping the institution to which it belongs to carry out its objectives with regard to :						The work of the unit has been largely ineffective in furthering the objectives of the institution to which it belongs with regard to :	
1			Research and experimental development (R&D)				
	5	4	3	2	1		4/58
2			Training of scientists and engineers				
	5	4	3	2	1		59
3			Other scientific/ technical objectives				
	5	4	3	2	1		60
4			Meeting quality requirements				
The unit has been very successful in meeting the quality requirements associated with its work (e.g. design, product performance, validity of results, consumer reception, presentation of findings)	5	4	3	2	1	The unit has been very unsuccessful in meeting the quality requirements associated with its work	61
5			Innovativeness				
The unit has been highly innovative in generating useful new ideas, approaches, methods, inventions or applications in its field of work	5	4	3	2	1	The unit has been very uninnovative in the sense described	62

X		X applies	Tend. to X	Intermediate	Tend to Y	Y applies	Y	
	6	Productiveness						
The unit has been highly productive in the sense of adding to the store of knowledge, methods, or inventions in its field(s) of work		5	4	3	2	1	The productivity of the unit has been very low in the sense described	4/63
	7	National reputation						
The work of the unit is well known in its own country		5	4	3	2	1	The work of the unit is virtually unknown in its own country	64
	8	International reputation						
The unit has a high international reputation		5	4	3	2	1	The unit is virtually unknown abroad	65
	9	Demand for the unit's publications						
The publications of the unit are in high demand and are often cited in the open literature		5	4	3	2	1	The publications of the unit are largely ignored	66
	10	General contribution to science and technology						
The unit has made an outstanding contribution to scientific or technical development in its field		5	4	3	2	1	The unit has made little or no contribution to scientific or technical development in its field	67
	11	Social value of the unit's work						
The social value of the applications or potential utilizations of the unit's research work is highly positive		5	4	3	2	1	The social value of the applications or potential utilizations of the unit's research work is highly negative	68
	12	Solving current problems						
The work of the unit has been extremely useful in helping to solve some current problems facing society		5	4	3	2	1	The work of the unit has been of little use in helping to solve some current problems facing society	69
	13	Follow-up or use of results obtained by the unit						
Most of the results obtained by the unit in its research and experimental development activities are followed-up or made use of		5	4	3	2	1	None of the results obtained by the unit in its research and experimental development activities are followed-up or made use of	70
	14	Meeting the working schedules						
The unit has been very successful with respect to meeting its working schedules		5	4	3	2	1	The unit has been very unsuccessful with respect to to meeting its working schedules	71
	15	Staying within the operating budget						
The unit has been very successful with respect to staying within its operating budget		5	4	3	2	1	The unit has been very unsuccessful with respect to staying within its operating budget	72

BIOGRAPHY

Kimberlee Lyn Williams was born in Phillipsburg, New Jersey, November 9, 1966. Her parents are Albert and Linda Lewis of Loretto, Pennsylvania. She has a younger brother, Keith Lewis. Ms. Williams graduated from Moravian College in 1988 with a Bachelor of Arts degree with Honors in Industrial-Organizational Psychology and a minor in Management.

Currently, she is Director of Training and Development for Ogden Facility Services, an $800 million dollar division of Ogden Services Corporation headquartered in New York, New York. In that capacity, she provides human resources, management development, and quality systems training to managers and executives nationally. Formerly she served as Human Resources Manager-Eastern States Region and Personnel Administrator with Ogden Facility Services.

After completing her M.A. degree, Ms. Williams intends to pursue doctoral study in Organizational Behavior.

Among her personal interests are travel, antique auctions, and Victorian antiques. She resides with her husband Andrew, and their German Shepherd Molly, in Nazareth, Pennsylvania.

END OF TITLE