ON THE EFFECT OF SUPERVISORS ON GROUP PERFORMANCE: A HUMAN RELATIONS THESIS CONFIRMED FOR ACADEMIC RESEARCH UNITS

Research Memorandum No. 115

October 1976

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Summary

The literature on leadership in organizations is dominated by the human relations thesis that good leadership should lead to high morale and high morale should lead to increased productivity of group members. While the moral and cooperative nature of organizations presupposed by this thesis must be rejected for industrial settings, university organizations may warrant a description in those terms because of their special structural characteristics. In the present paper it is shown that the above relationship between supervisory quality, group climate and performance does indeed hold for academic institutions; additionally, planning and integrating functions of the supervisor emerge as important intervening variables. As compared to natural sciences, the relationship is significantly stronger in technological science groups, pointing to the fact that more integrated production technologies may be more dependent on leadership functions and group morale than technologies associated with a higher degree of uncertainty and variability as present in natural sciences. Finally, the attempt is made to estimate the amount of response bias due to using perceptive rating scales with the help of the Lisrel technique. While this results in a reduction of variance explained in performance, in general the variables used remain of substantial explanatory value.

1. Introduction

In a recent paper (Knorr et al., 1976b) we have shown that supervisory status within a research laboratory is associated with higher productivity in terms of the quantity of articles and books published; in fact, position seems to be the major explanatory variable accounting for productivity differences in academic research settings. If the paper succeeded in showing the differential advantages in terms of productivity associated with supervisory status for the supervisors, the present paper addresses the somewhat complementary question as to how - and in which respects - supervisory scientists matter for those who are supervised by them. Switching the attention from the gain supervisors experience from their status to the gain scientists supervised experience from their supervisor implies that we no longer focus on individual but on group data, and that we have to introduce quality ratings of supervisory behavior in order to differentiate leadership effects. Leadership differences will be analyzed in terms of the impact they have on work organization, working climate and group productivity, and discussed in the light of the controversial evidence available as to the meaning of the results obtained.

2. Previous research

The literature on leadership in organizations is large and dominated by what came to be called the "human relations" approach. While purely sociological theories of organizations have tended to ignore the question of leadership[1)], human relations theory, which is mostly psychological in orientation, takes as its general focus of research efforts and theoretical considerations the thesis that good leadership should lead to high morale and high morale should lead to increased effort resulting in higher productivity of the members of an organization. Most of the studies presented so far constitute variations or elaborations of the two-factor theory of leadership-style differentiating between "initiating structure" and "consideration", a result of the Ohio State studies (Stogdill and Coons 1957; Fleishman 1953a,b; Fleishman, Harris and Burtt 1955), or of the differentiation between Likert's principle of "supportive leadership" and "instrumental" or "task oriented" leadership styles (Likert 1961; Bowers and Seashore 1966; Katz, Maccoby and Morse 1950). Newer studies have been characterized by introducing progressively more complexities: Herzberg (1966) suggested that factors contributing to satisfaction and those contributing to dissatisfaction are independent, and House and Wigdor (1967) found considerable evidence that job satisfaction and climate depend on the alternatives perceived and accessible to the individual as well as on the individual's sex, age, education, culture, professional status etc.

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1) Meyer (1976:517) derives this tendency from the nature of the organizational theories available: while the Weberian theory overlooks leadership on the grounds that organizations which are rational (bureaucratic) are efficient and stable because of their structure which overpowers the single official's action potential, contemporary organizational theory overlooks leadership because rational organizations have to be responsive to environmental uncertainties which can only partly be handled by (and attributed to) a single leader.

Etzioni (1965), partly substantiated by Rossel (1970), related the level of commitment an organization requires of its constituent groups to the kind of leadership that will be effective, proposing the higher the required labor commitment the more the formal leadership roles tend to be expressive.[1)] Fiedler's "contingency" theory of leadership (1967) demonstrated that the climate of a group has a considerable influence upon the effectiveness of leadership styles; his theory gave rise to a series of attempts to specify those moderating variables upon which the effect of leadership behavior is contingent (e.g. House 1971; Hollander and Julian 1969; Lawrence and Lorsch; Wofford 1971).

If the history of research in this area is one of introducing progressively more complexities in terms of the contingencies and conditions which have to be taken into account, it is also one of "progressive disenchantment" (Perrow) with the possibility of any simple and easy understanding of the relationship between supervisory behavior, climate and productivity.[2)] Consequently, the human relations approach has

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1) Etzioni's propositions are based upon his earlier (1961: 89-126) differentiation between an organization's primary goals and differences in the basis of compliance. Examples for organizations requiring little commitment or compliance are prisons or mental hospitals; moderate commitment according to Etzioni will be necessary in production and service organizations, high commitment in religious socializing organizations. Taking into account different kinds and origins of compliance in addition to organizational goals remedies some of the critical objections raised against goal-approach organizational theories (compare Silverman 1970; Perrow 1972).

2) Some might even want to go so far as to reject the concept of leadership altogether deriving the popular emphasis on leadership from the feeling of indirect control the belief in a leader's ability generates and from the scapegoat function served by the possibility to locate guilt and responsibility in a specific role (compare Lieberson and O'Connor 1972).

increasingly come under critique in the past decade, with two objections standing out particularly: the first says that "the literature is large but the findings are few" (Meyer 1976:516) in this area, referring to inconsistent empirical evidence or to the fact that emerging relationships tended to be very low (cf. Vroom 1964; Korman 1966; Hulin and Blood 1968; Campbell and Dunette 1968); and the second objection centers around the underestimation of the conflict of interest between organizational goals and individual objectives linked to the assumption that organizations are moral[1] and cooperative in nature (cf. Silverman 1970:76; Perrow 1972:145). The critique implies that the relevance of leadership for climate and productivity should be determined theoretically, considering structural and environmental characteristics of a specific organizational setting and the significance they confer to leadership roles. As noted by Hollander (1971:1), the effect of leader characteristics and style as emphasized by industrial psychology must be gauged in the light of two sources of influence: the attributes and perceptions of those led, which should bring into play cognitive psychology, and the structure and setting within which the leader and followers interact as focussed upon by purely sociological approaches to organization.

2.1 The leadership role in academic research units

While there is some empirical evidence and a series of theoretical discussions referring to the special problems occurring with managing the scientist in organizations (e.g. Pelz 1956, 1957; Pelz and Andrews 1966; Kornhauser 1962; Marcson 1960; Burns and Stalker 1961; Scott 1966; Merton 1968), most of this literature addresses the situation of scientists in non-academic and particularly industrial settings. Organizational theory has not until recently attempted to systematically consider different types of organizations (e.g. Blau and Scott 1962; Etzioni 1961;

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1) "moral" as used by Barnard refers to the assuption that the common purpose of organizations is the purpose of all. Organizations are legitimized here by their very definition (cf. Perrow 1972:93).

Parsons 1960; Perrow 1968); nevertheless it is clear that universities differ markedly both in terms of structure and goals from industrial or government institutions.[1)] When attempting to summarize these differences three points emerge as being of major significance:

1. In contrast to industry, the legal organizational entity of the university must be considered an organizational umbrella hosting a variety of institutes or departments which in themselves constitute more or less independent small-scale"organizations"; as a rule in most Western European countries most of the potential structural power and authority of universities (in terms of budget, goal-setting, resource allocation and control) are conferred to the units formed by a single university professor and the assistant and service staff associated with his chair.

2. In contrast to industry, there is less structural conflict of interests between organizational goals and individual objectives: presumably, the goals of the academic organization are satisfied best if the individual scientist is given the autonomy to realize the aspirations which have been imparted to him by academic socialization.[2)] In accordance with this, academic organizations have far more "slack" than industrial organizations, i.e. an excess of time and ideas which remain at the exclusive disposal of the individual scientific members belonging to them.

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1) They may also differ in terms of what has come to be called technology (cf. Woodward 1965,1970), that is in terms of the kinds of tasks that are performed which presumably affect the structure and to some extent organizational goals.

2) The term "structural" is crucial here: It refers to the definition of roles and to compliance, i.e. to the fact that participant involvement in universities should as a rule be neither alienated nor calculative (as in industry where members calculate whether the wages are worth it), to use Etzioni's distinction (1961). Running a university institute in order to make a reputation should be in accordance with the no-conflict-of-interest thesis. Running it in order to make private money (e.g. not used as investments in equipment etc.) clearly will be not in accordance. Teaching goals, if they become predominant as in the case of many German universities at present, may become the origin of structural conflict. Consequently, the thesis should hold on the aggregate and as far as formal structure of university organizations is concerned; it may not hold in single cases.

3. Finally, the "office" (to borrow from Weber) of the supervisors or heads of the above mentioned units is equipped with far more formal and factual power and adorned with far more symbolic insignia of power than any supervisory office at a comparable level in non-academic institutions. As already implied by what we have said under point 1, the role of the university professor is hence much more similar in structural terms to the role of the top management than to the role of a laboratory or department head in an industrial firm.

In sum total, academic units can be characterized as "rump" organizations constituted by a combination of highest level supervisory status with traditional low level subordinate positions where the research goals of the organizational umbrella (the university) are fulfilled if members follow their professional values and interests. Seen this way academic organizations more or less exactly meet the premise of the cooperative and moral nature of organizations postulated by the human relations approach for industrial firms (and correctly rejected there by the critique which has come up): academic organizations are <u>cooperative</u> since there is no necessary structural conflict of interest between the organization and its members and they are <u>moral</u> in Barnard's sense because they rely upon intrinsic motivation[1)] and because they fulfill nonprofit service goals to the society.

The general thesis underlying the present analysis of academic units can consequently be summarized by saying that gauged in the light of the structure and goals of academic organizations and in the light of the power and authority granted to the leadership role the basic assumption of the human relations approach as to a positive relationship between supervisory ratings, group climate and group productivity should be

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1) The validity of the distinction between extrinsic and intrinsic interests has been questioned recently by Bourdieu (1976) who points to the fact that investments are always organized by reference to (conscious or unconscious) anticipation of average changes of profit (which may be symbolic as in the case of recognition and prestige strived for by scientists). Although this is true, the <u>analytic</u> distinction between degrees of intrinsic motivation may still be warranted but should perhaps be couched in terms of the concept of alienation from work.

verified. The analysis proceeds by first identifying the variables linked to supervisory quality as experienced by subordinates and by establishing the relationship between the latter concept and a measure of group climate. Secondly, the associations between group climate and productiveness, innovativeness and usefulness as components of group performance are examined and the multivariate relationship between predictor variables found most significant in the present data and the performance measure is analyzed. Since it is not clear whether perceived organizational climate and perceived leadership quality are attributes of the individuals or of the organizations in question (cf. Guion 1973; Johnston 1976), and since there is evidence that the relationship between supervisory behavior, climate and productiveness might as well be reversed (as will be shown p. 26), there is no effort to definitely specify causal dependencies between the concepts used up to the last paragraph. Here the attempt is made to estimate the bias or halo effect due to using perceptive rating scales and to social perception specific for different hierarchical levels. In doing so, we venture to specify a hypothetical structural equation model for the main effects isolated in connection with using the model for estimating bias effects.

3. Data

The data presented in this paper are drawn from an international comparative study on the organization and performance of research units done in six European countries (Austria, Belgium, Finland, Hungary, Poland, Sweden). In each country, a sample of 150-250 research units stratified according to type of organization and scientific field has been taken; the final data set comprises 1222 research units and 4057 scientists mainly working in the natural and technological sciences[1)] in academic settings, in cooperative institutes and in industrial enterprises.[2)] In order for a scientist to be included in the population of which the sample was taken, he must have been attached to a "research unit".[3)] Hence individual scientists not belonging to a group of researchers were excluded from the universe. Data were collected in

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1) For selection of scientific fields the UNESCO "Proposed International Standard Nomenclature for Fields of Science and Technology" has been used. The international data set includes the following disciplines by number of research units: Physics (77); Chemistry (240); Life Sciences (215); Earth and Space Sciences (69); Agricultural Sciences (125); Medical Sciences (57); Technological Sciences (345); Social Sciences (75) and Others such as Mathematics, Astronomy etc. (19).

2) The category "academic settings" comprises, beyond universities, institutes attached to universities and academies of science. The category "cooperative institutes" comprises those research units which belong to institutions wholly or partly serving a branch of industry and/or to government institutions. In the international data set, the academic sector is overrepresented; it comprises 2656 respondents as compared to 744 in cooperative institutes and 657 in industrial enterprises.

3) A "research unit" has been defined for the purpose of this international study as a group of scientists which meets the requirement of having specific scientific-technical responsibilities, a distinct life-span, at least one leader and altogether three core members spending at least 8 hours/week in the unit. Furthermore, the group must have had an expected life time of at least one year and the individual scientist, in order to be considered as a core member and as eligible for answering the questionnaire, must have been in the unit for at least six months.

1974 by means of five different questionnaires (based on a pre-test of 150 research units in three countries) from unit heads (personal interview), individual scientists of the unit (self-administered questionnaires)[1], the technical and service staff of the unit (self-administered questionnaires) and external evaluators of the work of the unit (personal and self-administered). The response rate varied between 70 and 85 per cent (depending on countries and fields of study), with no indication of a serious response bias by rank of respondent, field or type of organization. The international combined data set is, however, not representative for either type of organization or scientific field in each of the participating countries because of the different sampling frames that have been used on a national basis.

For the purpose of the present analysis, measures derived exclusively from answers of staff scientists of the units have been used, with the exception of the index of group performance (see p.13). Furthermore, scores of individual unit members were combined into average group scores and employed on the aggregate level, since the concepts and questionnaire items relevant here characterize organizational entities (the research unit or group) rather than individual scientists. Finally, all analyses were conducted separately for academic natural and technological sciences; results for industrial (technological science) groups are available as a check and will be referred to in footnotes where appropriate. The decision to look at natural and technological sciences separately is based upon considerations of the potentially different technologies in both fields and upon a typological analysis of quantitative and qualitative performance measures in different disciplines and types of institutions in the present data (Cole 1975) which showed that performance differs markedly in the above settings whereas no significant gain is made by looking at single disciplines separately (e.g. on academic chemistry).

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1) If a unit comprised more than three core members, in general a random sample of three scientists of the unit was taken for filling in the questionnaires.

3.1 Measures employed

The following measures[1] were used to capture the basic dimensions of supervisory quality, group climate and group performance:

1. An index of "supervisory quality" which included the items degree of satisfaction with the supervisor's technical competence, with his knowledge of the field, with his personality and character, with his leadership qualities, with the amount of work he does, and with his supportiveness for the researcher's work[2]; a final item asked for the degree to which contacts with the supervisor had beneficial effects upon the scientific or technical performance of the respondent.[3]

2. An index of "group climate" experienced, where group climate was measured by seven items referring to the spirit of innovation in the unit, the degree of dedication to work, the degree to which new ideas in technical and non-technical matters are given adequate consideration, the degree to which ideas from junior staff members are accepted, the degree of cooperation and the frequency of staff meetings. With the items mentioned, the index basically comprises the dimensions spirit of innovation and communication, cooperation and dedication.

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1) All measures were additive combinations of items measured on 5-point Likert ratings where item clusters were identified by means of multi-dimensional scalings and correlation analyses. Since we worked with aggregated data, original scores were group mean values the scale of which was reverted as compared to the questionnaire before index construction. The final additive index was divided by the number of items included so as not to exceed the original range of the items.

2) The question was asking for a rating of the immediate supervisor; consequently, in the case of very large units, the head (mostly a university professor) and the supervisor rated may not be identical. As the largest percentage of units does not comprise more than six scientists, the problem can be ignored.

3) The question included one more item which asked for the frequency of contacts with the supervisor but was not included in the index since it did not correlate sufficiently with the other items. See question M on page 15 of questionnaire SB.

3. Group performance. While our data allow for the assessment of the quantity as well as of several dimensions of the rated quality of the scientific output of the research units, the present analysis focusses mainly on "R&D effectiveness" as the most general measure of a group's contribution to research and development.[1] The index is based upon qualitative ratings of the group's productivity (in the sense of adding knowledge or inventions to its field), its innovativeness (in terms of generating new ideas, approaches, methods, inventions or applications in its field) and of the usefulness of the group in helping the organization to which it belongs to carry out its responsibilities with regard to R&D. Average ratings of "external evaluators" competent in the specialty and with sufficient knowledge of the work of the unit but not belonging to the unit, average ratings of group members themselves and the rating of the head of the group - all on the above three dimensions - were weighted equally and combined into an additive measure called R&D effectiveness of the group.[2]

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1) The other rated quality measure developed in the present study captures somewhat different dimensions, i.e. "social" effectiveness, "training" effectiveness, "administrative" effectiveness or "recognition". The latter dimension, albeit potentially suited for the present purpose, refers more to the feedback of the (international) scientific community on the work of the unit, since it is based upon a measure of the degree to which the unit has high international reputation and the degree to which the publications of the unit are in high demand and often cited in the literature.

2) In using quality ratings of competence by peers we follow a frequent procedure which presumably constitutes the most valid assessment of a contribution to science in spite of its being increasingly replaced by the more viable ways of using citation counts as a quality measure (see Meltzer 1949; Dennis 1954; Meltzer 1956; Clark 1957; Pelz and Andrews 1966; Thomasson and Stanley 1966; Jonathan and Stephen Cole 1967,1971; Blume and Sinclair 1973). Since the present study includes countries which are not adequately or not at all represented in the Science Citation Index and since citation counts refer to individual rather than to group productivity, the use of the Citation Index was not feasible.

4. Perception of the supervisor and what it relates to

Before systematically exploring the relationship between supervisory ratings, group climate and performance, the attempt was made to identify those variables which account for most of the variance in supervisor's quality as perceived by those supervised in academic settings. Basically, four dimensions were found to yield significant associations:

(a) Measures associated with the planning and coordinating functions of the supervisor, i.e. the rated quality of the research programme[1), satisfaction with personnel quality[2) and satisfaction with administrative and technical services at the disposal of the group.[3)

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1) All measures are constructed as in previous cases (cf. p.12, footnote 1). The index "quality of the research programme" includes the items quality of the conception of the research programme; interest of the research activities; and the degree of coherence of the research programme.

2) The index of satisfaction with "personnel policy" includes two items: the degree of satisfaction with the manpower recruitment system of the unit and the degree of satisfaction with training and career development facilities available to group members.

3) The measure of satisfaction with "administrative and technical services" includes the items satisfaction with administrative and secretarial assistance received by the unit and satisfaction with technical assistance and services.

(b) Measures linked to the integrative functions of the supervisor, i.e. the rated group climate[1], the attachment to the unit on the part of group members[2], and their degree of information on the research activities and research planning of the unit.[3]

(c) Measures related to the career promoting function the supervisor has for the scientist working with him or her.[4]

(d) A measure of the supervisor's overall status and standing as given by the total amount of influence he was perceived to have on various decisions.[5]

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1) For the measure of perceived group climate see page 12.

2) The measure of "attachment to the unit" on the part of the group members is based upon the items degree of feeling of high job security; degree to which leaving the unit is considered or would be done if there were a suitable opportunity; and degree to which the work the researcher did was interesting.

3) The index "information on research planning and activities" includes the components degree to which the group members are kept informed about all aspects of the research carried out by the unit; degree of information on all aspects of the research planning; and degree of participation (at every stage) in the planning of the research.

4) The measure of "career opportunities" is based upon the items degree to which advancement opportunities seem to be essentially dependent upon the performance of the researcher and degree of satisfaction with advancement opportunities in relation to those of others with comparable qualifications, training and experience.

5) The index "total amount of influence of the head of the unit" is based upon his rated influence on the following items: choice of specific research tasks; choice of methods used; publication and circulation of research results; allocation of work within the unit; coordination and/or cooperation with other units; use of training and career development facilities; hiring personnel for a definite period; termination of employment of personnel; and hiring or buying low-cost equipment.

The following table presents the results of a Multiple Classification Analysis[1] of perceived supervisory quality using the above measures as predictors. The table in this and the following cases lists the Beta[2] and Eta^2 parameters[3] and the Marginal R^2 coefficients[4] as well as multiple correlation coefficients for both academic organizations studied.

Considering Beta coefficients and marginal R^2, measures related to the supervisor's planning function seem to be most important in academic natural science settings, while variables linked to his total influence, group climate (integrative function) and his career promoting function predominate in academic technological sciences. The set of variables used explains most in academic natural science units (about half of the variance in supervisory perception) and still more than 1/3 of the variance in academic technological sciences.

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1) Multiple Classification Analysis is a multivariate technique for examining the raw, adjusted and multiple effects of several predictor variables on a dependent variable based on an additive model. In contrast to traditional regression analysis the technique can handle predictors with no better than nominal measurement and non-linear interrelationships, but cannot handle directly interaction effects. See Andrews et al. 1975 for a full discussion of the technique.

2) Analogous to standardized regression coefficients. See Andrews et al. 1975:47ff for a full discussion.

3) Correlation ratios indicating the proportion of the total sum of squares explainable by the predictor.

4) The unique explanatory power a predictor has over and above what can be explained by some specified set of other predictors. The coefficient used here is identical to the squared part correlation which is equal to the difference between multiple R^2 adjusted with every predictor in minus multiple R^2 adjusted omitting the predictor in another MCA run for which the marginal R^2 is calculated.

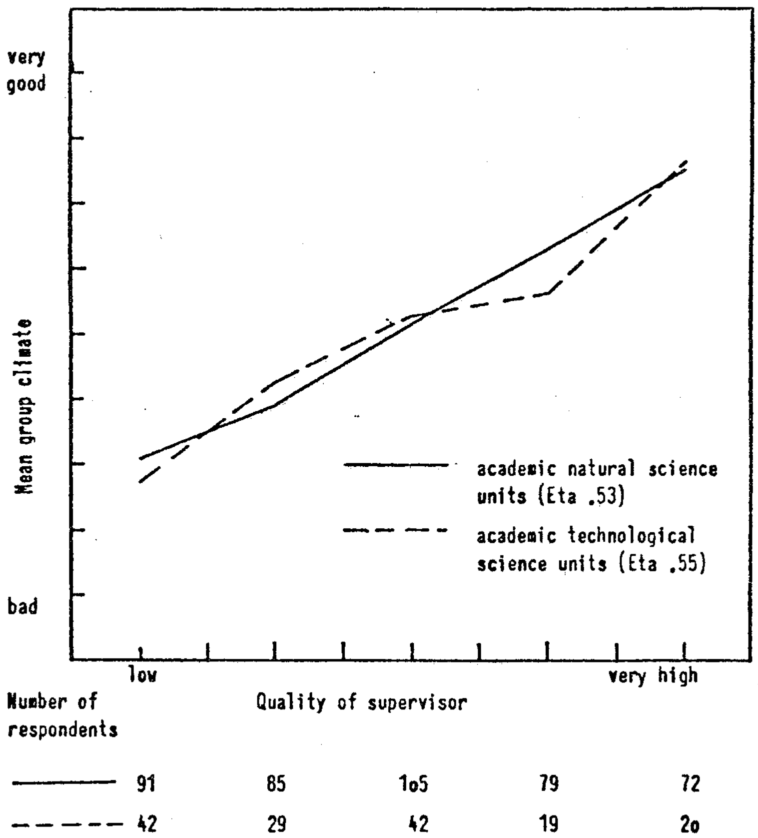
Table 1: Multiple classification analysis of perceived supervisor's quality in academic natural and technological science units.

Predictor variables relating to	Academic natural science units (N=467)			Academic technological science units (N=159)		
	Beta	Eta^2	Marg.R^2	Beta	Eta^2	Marg.R^2
Supervisory planning functions:						
- quality of research programme	.33	.36	.06	.20	.21	.01
- personnel policy	.25	.33	.03	.18	.13	.00
- administrative and technical services	.07	.05	.00	.18	.01	.01
Supervisory integrative functions:						
- group climate	.15	.27	.01	.34	.28	.05
- attachment of scientist to unit	.12	.15	.01	.19	.16	.00
- information on research planning and activities	.08	.11	.00	.15	.12	.00
Supervisory career promoting function:						
- satisfaction with career opportunities	.12	.13	.01	.28	.12	.03
Supervisor's standing:						
- total influence of head of unit	.18	.14	.02	.37	.09	.06
Multiple R^2 unadjusted			.55			.52
Multiple R^2 adjusted			.50			.36

4.1 Perception of supervisor and organizational climate

When examining the bivariate relationship between supervisory quality as perceived by those supervised and group climate in the research units studied, there turned out to be a moderately strong, significant, and almost linear association in academic units.[1] Figure 1 presents those results.

Figure 1: Perceived supervisory quality and mean group climate in academic natural and technological science groups.



1) In industrial units, the relationship is less pronounced, as indicated by an Eta square of .19.

As indicated by Eta^2 coefficients of .29 in natural science groups and of .30 in technological sciences, supervisory quality, if considered alone, accounts for nearly 1/3 of the variance in the climate perceived. In order to evaluate the bivariate relationship obtained the variables found to relate to supervisory quality (and perhaps being explained by it) and a series of structural and functional variables characterizing the organizational units we studied (such as size of the unit, fluctuation, relative equipment lack, average time in research and administration[1]) were examined for their associations with group climate. Furthermore, several multiple classification analyses were conducted for units within each organizational setting with a view to assess the relative contribution of single variables with respect to others when attempting to predict group climate. As a result of both steps of analysis, a set of four variables (including supervisory quality) emerged which appears to account for most of the variance in group climate which can be explained in the present data set: quality of research programme; information on research planning and activities; personnel policy; supervisory quality. It is worthwile to note that none of the structural and functional variables examined showed a substantially significant[2] relationship with group climate; this is especially noteworthy in the case of size, both of the unit and of the organization in question, since there are well known theoretical considerations (and some empirical evidence) which argue that size should be negatively correlated to the climate and atmosphere in an organization

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1) For a full description of measures constructed and inspected for bivariate relationships (Pearsons's r) see the respective "Documentation of Indices and Bivariate Relationships" (1976).

2) In general, correlations below .20, explaining less than 4% of the the variance in the respective measure, were ignored as being substantially non-significant even if the chi-square test (depending on data size) showed a significance level which in general is thought to be acceptable.

(e.g. Pugh et al. 1968; Payne and Mansfield 1972; Worthy 1950)[1]. Equivalently, variables characterizing persons rather than the organization, such as average age of group members or average time in the group were not significantly related to climate perceptions. As an example, Johnston (1976) found such differences in climate perceptions between "longer-time" and "short-time" members in an in-depth study of a social science consulting firm.

It could be argued that relationships between group climate and attributes of individuals in the group did not show in the present data since they were wiped out when aggregating individual scores.[2]

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1) In general, the argument runs that larger size leads to increased bureaucratization, which in turn enhances a climate where interpersonal aggression, emotional control and leaders' psychological distance as well as the number of rules and concern with following rules are higher. It should be noted, however, that the sign of the relationship depends on the aspects of "climate" measured. While the correlation between size and the above mentioned dimensions should come out negative, large size has been assumed to be positively related to scientific and intellectual diversity, readiness to innovate and concern for the involvement of employees in the above mentioned studies. Since the index of group climate used in the present study is somewhat biased towards measuring innovative orientation (as thought appropriate for a measure developed for research organizations), we might as well have expected a positive correlation between group climate and size in the present data. The last mentioned possibility has been checked by using a subindex including only those items of our general climate index which refer to innovation-orientation; again, no substantially significant correlations were obtained.

2) The issue as to the desirability of measuring organizational climate on the level of "perceptual summation of all individuals in an organization" as asked for by Hellriegel and Slocum (1974) or on the level of individual members of the organization is controversial. Since several recent studies found"multiple climates" within a single organization, this can be made a pledge for using individual data (cf. Johnston 1976). Most of the studies, however, refer to variations in climate perceptions among different hierarchical levels within the organizations. In the present data, level is controlled by use of separate measures and variables for supervisors (unit heads) and staff scientists.

However, as documented in an analysis of the links between supervisory behavior, climate and performance, using causal model techniques on non-aggregated data, none of the above personal or structural variables become significant at the individual level (Knorr et al.1976a). In fact, it is the same set of variables which account for most of the variance of perceived group climate in both aggregate and individual level versions of the present data.

This brings us back to the variables listed above which show that group climate - in the relatively small and independent organizational units we are confronted with in academic settings - is best being understood by looking at supervisory perception and the rated quality of planning (as measured by the indices quality of research prgramme and personnel policy) and integrative functions (as measured by information on research planning and activities) presumably performed by the supervisor. Using these predictors results in slight variations of importance of single variables (as indicated by the beta coefficients) depending on scientific field and disciplines represented by the units. Interesting to note, the direct effect of the supervisor over and above what is accounted for by the planning and integrative functions seems to be stronger in academic technological science groups.

Table 2: Multiple classification analysis of group climate in academic natural and technological science units.

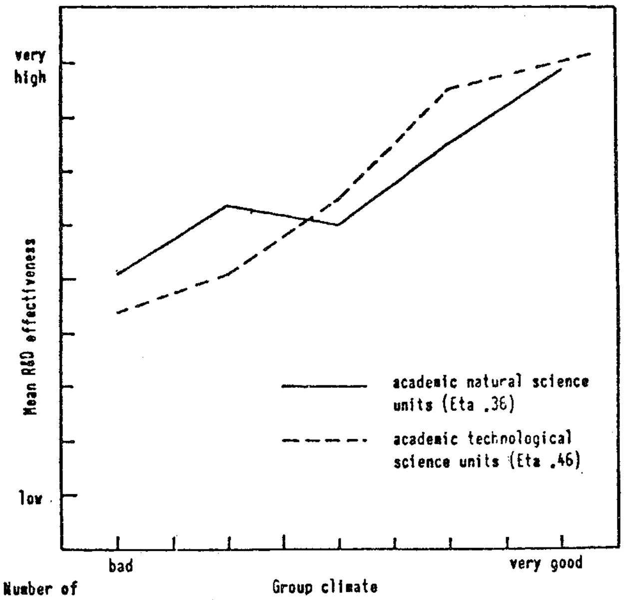
Predictor variable	Academic natural science groups (N=437)			Academic technological science groups (N=155)		
	Beta	Eta^2	Marg.R^2	Beta	Eta^2	Marg.R^2
Information on research planning and activities	.31	.27	.07	.22	.24	.02
Quality of research programme	.26	.35	.04	.29	.33	.05
Personnel policy	.21	.28	.02	.23	.19	.03
Quality of supervisor	.19	.29	.02	.28	.30	.04
Multiple R^2 unadjusted			.51			.51
Multiple R^2 adjusted			.49			.45

As indicated by multiple R^2's, approximately half of the variance in group climate is accounted for by using the above predictor concepts in academic organizations.[1] In academic natural science researchers' information on (and integration into) the research programme and research activities emerge as most important for the group climate experienced when other variables are controlled for; contrary to this, information and integration turn out least important in academic technological sciences, being replaced by the quality of research programme and an additional direct supervisor effect.

4.2 Supervisory perception, group climate and performance

When exploring the variables used so far for their bivariate and multivariate association with R&D effectiveness as our main performance measure, most pronounced relationships in all organizational settings examined occurred with group climate experienced, rated quality of the research programme, and perceived supervisor's quality. The following figure gives an example of the strength of the association between climate and the performance measure.

Figure 2: Group climate and mean R&D effectiveness in academic natural and technological science groups.



Number of units					
———	82	91	84	72	102
- - - - -	36	33	30	28	28

1) In industrial units the predictors used seem to have less explanatory power, but still explain more than 1/3 of the variance.

As indicated by the Eta-coefficients, group climate explains between 10-20% of the variance in the performance measure. When introducing the full set of "core" variables employed above this percentage rises moderately, confirming the pre-eminent importance of the three variables mentioned above:

Table 3: Multiple classification analysis of R&D effectiveness in academic natural and technological sciences.

Predictor variable	Academic natural science units (N=473)			Academic technological science units (N=164)		
	Beta	Eta^2	Marg.R^2	Beta	Eta^2	Marg.R^2
Group climate experienced	.28	.12	.04	.30	.19	.03
Quality of supervisor	.19	.10	.01	.22	.14	.01
Quality of research program	.17	.09	.01	.50	.25	.01
Personnel policy	.15	.05	.01	.15	.11	.00
Information on research planning and activities	.11	.02	.00	.21	.23	.00
Multiple R^2 unadjusted			.19			.41
Multiple R^2 adjusted			.15			.30

The most interesting result of the above table must perhaps be seen in the fact that (a) there is at least a moderate association between rated productivity, innovativeness and usefulness[1)] on the one hand and supervisory behavior and group climate experienced on the other hand in accordance with assumptions of the human relations approach (but contrary to the axiomatic theory of organizations as proposed by Hage in 1965 for instance); and (b) that the size of this association varies considerably between both organizational settings, with most pronounced relationships occurring in academic technological science

1) as combined in the measure of R&D effectiveness

units. The latter results can perhaps best be understood in the light of Woodward's finding (1965) that more integrated production technologies tend to have better interpersonal relationships. Presumably, the degree of variability and the degree of uncertainty (Perrow 1968) is lower in technological than in natural sciences; consequently, "technologies" in technological science institutes should be more integrated and productivity more dependent upon interpersonal relations and group climate than is to be expected in natural science organizations.[1)]

5. A model including measurement error

The moderate association found between rated supervisory quality, planning and integration and group climate on one hand and R&D productiveness, innovativeness and usefulness on the other hand should be evaluated in the light of the fact that the performance measure used combines equally weighted ratings from three different sources (the supervisor, the staff scientists and external evaluators), while all predictor variables are measured on the level of staff scientist ratings only. If exclusively subordinates' performance ratings are used in a multivariate analysis based upon the above predictor variables, the amount of variance explained in R&D effectiveness rises to 27% in academic natural sciences, 42% in academic technological sciences and 24% in industrial units. While such a procedure could be rejected on the ground that the increase in variance explained may be due to an increase in measurement halo effects because of the use of the same kind of subjective rating scales for the same kind of subjects on all variables, it could also be argued that perceptive

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1) Degrees of"variability" and "uncertainty" point to the distinction between basic and applied research which may underlie the distinction between natural and technological sciences. If the technological sciences more or less coincide with applied sciences, routinization of tasks and hence needs of integration and cooperation will be higher than in natural sciences.

ratings always depend on the position of respondents turned to and their relationship to what is being rated, for other grounds than measurement error induced by the instrument used.[1)] If this is true, we cannot argue in favor of a measure combining the ratings of different groups at different levels without giving a theoretical justification for the assumption that group or level-specific perception differences do wipe each other out when scores are aggregated. Since no theory of the social perception of reality specific enough for the present purpose is currently available, no decision can be taken as to the desirability of one or the other measurement approach.

In the present data, the attempt was made to estimate the amount of response bias for different groups of respondents (i.e. supervisors or unit heads and staff scientists), where response bias can be understood as measurement error induced by the use of the same perceptive rating scales or as a social perception effect presumably identical for respondents of the same hierarchical level. For doing so, we ventured to specify a minimum of causal relationships between the predictor variables so far identified as most important, restricting our attention to one

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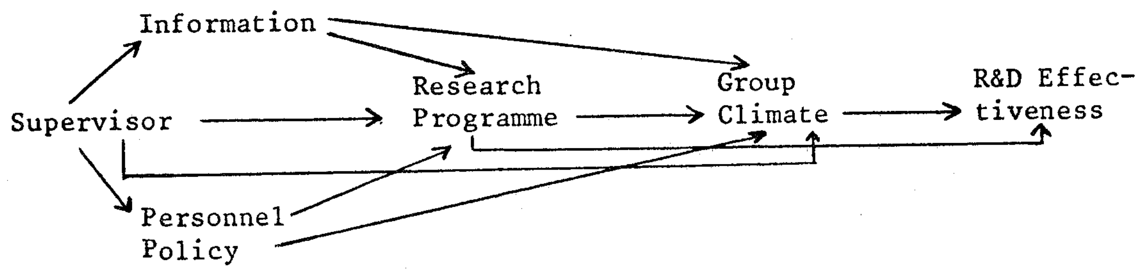
1) As mentioned earlier, there is some evidence that rated climate perceptions depend on position in the organizational hierarchy as recently suggested anew by Payne and Mansfield (1973:525) and explained by Thompson (1967). Johnston (1976:101) expects that climate varies with the level of uncertainty absorbed at different organizational levels, and Pritchard and Karasick (1973) found that climate in regional offices of an organization is a function of overall organizational climate and the demands of local environments. Theoretically most interesting, Bourdieu recently made a point in showing that "judgments on a student's or a researcher's scientific capacities are <u>always contaminated</u> at all stages of academic life by knowledge of the position he occupies in the institutional hierarchies" (1976:20).

indicator of supervisory planning functions (quality of research programme, neglecting personnel policy). With a view to supervisory power and authority in academic settings, causal dependencies such as the following among the above variable set may be presumed[1]:



However, it should also be noted that results such as those by Fiedler (1967) and Lawler and Porter (1967) would put into question the causal flow of events as suggested by the diagram; Fiedler showed that the climate of a group has a substantial impact upon the effectiveness of leadership styles, and Lawler and Porter - upon examining over thirty studies of performance - reached the conclusion that satisfaction and climate might result from high performance rather than being a cause of it.[2] Both studies imply that the main string of effects might as well be reversed in the above diagram.

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1) and have been examined by using path analysis and the Goodman technique (cf. Knorr et al. 1976a; Aichholzer 1976).

2) According to Lawler and Porter this would be the case if the employee was rewarded for high performance.

With a view to this the following Lisrel model[1)] of the relationship between the supervisor, his planning and integrating functions, group climate and R&D effectiveness should primarily be evaluated in the light of the information provided for the amount of response bias in the data. Figure 4 presents the respective model for academic natural science units while Figure 3 illustrates the size of the respective parameters linking the above concepts if no bias estimation were attempted.[2)] The model in Figure 4 differs from the latter in that three additional measures

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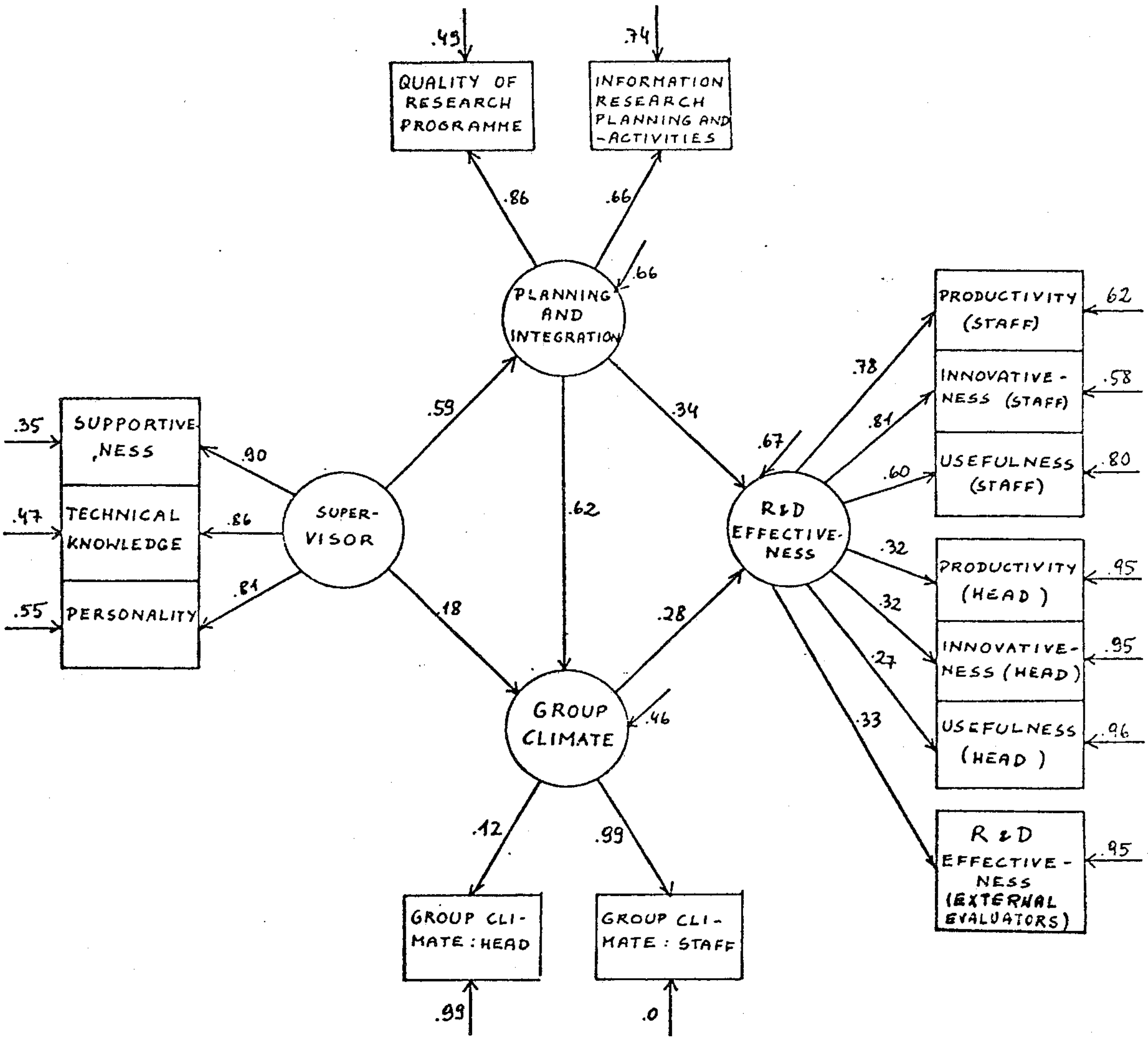
1) Lisrel is a computer programme for estimating general linear structural equation models with the specific advantage of allowing for unmeasured hypothetical constructs or latent variables measured by several observed indicators each. In relation with this, the method allows for a differentiation between errors in equation (disturbances), indicating the amount of variance explained, and errors in the observed variables (measurement errors), yielding estimations for both. (Joreskog and van Thillo 1972; Joreskog 1974.)

2) With a view to estimating level-specific response bias the model includes, where possible (i.e. where the respective questions had been asked in the questionnaire), measures based upon unit head scores in addition to the measures based upon staff scientists as used so far. The latent dimension quality of supervisor is measured by three indicators referring to the supervisor's supportiveness, his technical knowledge and his personality; the three indicators cover exactly the same items as listed for the overall supervisor's quality index (see page 12), but leave out the question as to his workload for conceptual reasons. The latent dimension "planning and integration" uses the two indices "quality of research programme" and "information on research planning and activities" employed in previous analyses as observed indicators of the fulfilment of planning and integrating functions. The dimensions "group climate" and "R&D effectiveness" are based upon indicators stemming from different groups: indices of the supervisor's and staff ratings in the case of group climate, both in terms of items identical to the index used so far; and supervisor's and staff ratings on the items productiveness, innovativeness and usefulness in the case of R&D effectiveness in addition to an overall measure of R&D effectiveness based upon external evaluator ratings.

covering different sections of the questionnaire have been introduced in order to allow for a broader basis of estimating bias effects.[1)]

Figure 3: Lisrel model of R&D effectiveness (without response bias) for academic natural science groups.



average residual: .070
highest residual: .446
variance explained: .33

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1) Introducing a bias variable into a model which contains only concepts which are quite strongly related to each other poses a methodological problem in so far as one has to make sure that only the common variance due to personal "bias" is taken into account by the bias variables, while common variance giving substance to the model is left for

The model in Figure 3 is characterized by a relatively high relationship between supervisory quality and the quality of planning and degree of information in the unit, and an equivalently high relationship between the latter and perceived group climate. The model explains 33% of the variance in R&D effectiveness[2]; additionally, supervisory quality, quality of planning and degree of information account for more than half of the variance in group climate. The model still suffers from yielding high residuals.[3]

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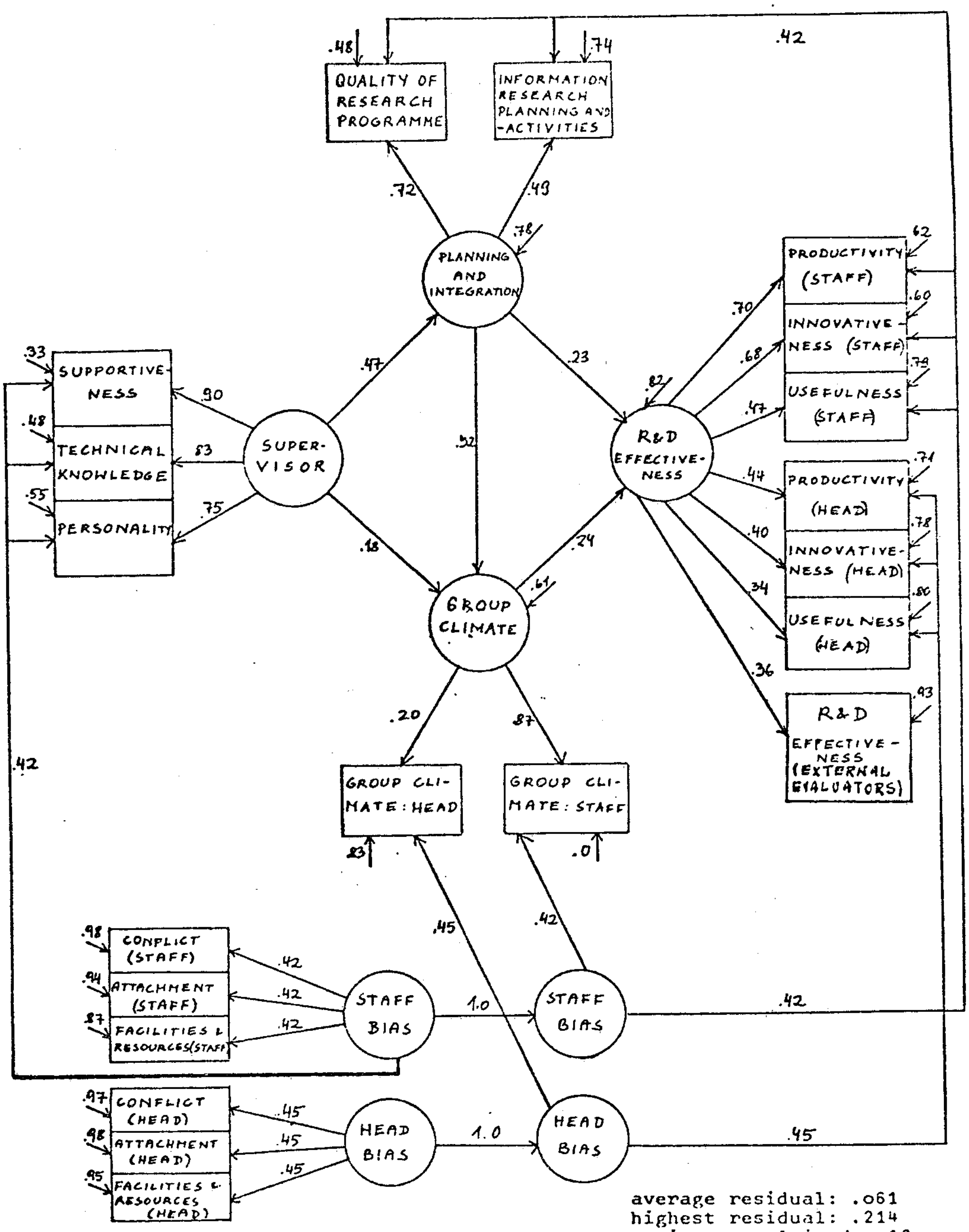
explanation by substantial concepts. The solution adopted here is to provide for a broader basis of variables from which bias factors can be estimated. Hence the inclusion of three additional dimensions from the questionnaire, which - being measured in the same way as the concepts used so far - should be subject to the same response bias. The dimensions used are those of the degree of "attachment of scientists to the unit" (see p. 15, footnote 2), an indicator of the amount of non-technical conflict in the unit, and an index of the overall evaluation of the "facilities and services" at the disposal of the group, composed of items such as the degree to which the unit is well-equipped scientifically, the satisfaction with the administrative and secretarial assistance and with the technical assistance and services, or the adequacy of the current budget of the unit for completion of the group's research and/or scientific tasks. The penalty for this kind of solution is that relatively high residuals (e.g. around .4) between these additional variables, which are only linked to the bias variables (no attention is given to their interrelationship or to their being related to other dimensions in the model), remain.

2) The increase in variance explained as compared to the results of multiple classification analysis (see table 3) is due to the fact that here we estimate errors in equations only (attributing measurement error to the special error terms for observed indicators) while traditional techniques yield one estimator combining both kinds of errors.

3) Residuals originate from measures based upon ratings of unit heads which do not correlate well with staff ratings-measures; a fact in accordance with the assumption of the level-dependence of perception and experience.

Figure 4: Lisrel model of R&D effectiveness (response bias included) for academic natural science groups.



average residual: .061
highest residual: .214
variance explained: .18

As opposed to Figure 3, the model in Figure 4 includes two bias variables, linked to supervisory ratings and staff ratings in the respective observed indicators.[1] Allowing the bias factors to be different for supervisors and staff scientists results in a much better fit of the model: the highest residual relating to indicators of the four main concepts of the model is now .214, the average residual is .061.[2] A further comparison of the parameter estimates of Figures 3 and 4 also shows a moderate reduction of all the direct effects in the model due to the amount of common perceptual bias in the original variables; only the link between supervisor and group climate seems unaffected by bias factors. Finally, the amount of perceptual bias is estimated at .45 for supervisors and .42 for staff scientists, confirming bias estimates of .43 and .41, respectively, in an attempt to estimate the construct validity of the rated performance measures used in the present study (cf. Andrews 1975b). In relation to this there is a 15% reduction in variance explained in R&D effectiveness by the model.

As would be expected from previous multiple classification analyses, applying the model to academic technological sciences results in much higher explanatory power than obtained in natural science models described so far. According to the following model, 51% of the variance in R&D effectiveness is being accounted for by supervisory quality, planning and information and group climate, while bias effects are only slightly reduced (to .37 for unit heads and .41 for staff scientists) as compared to the previous case.

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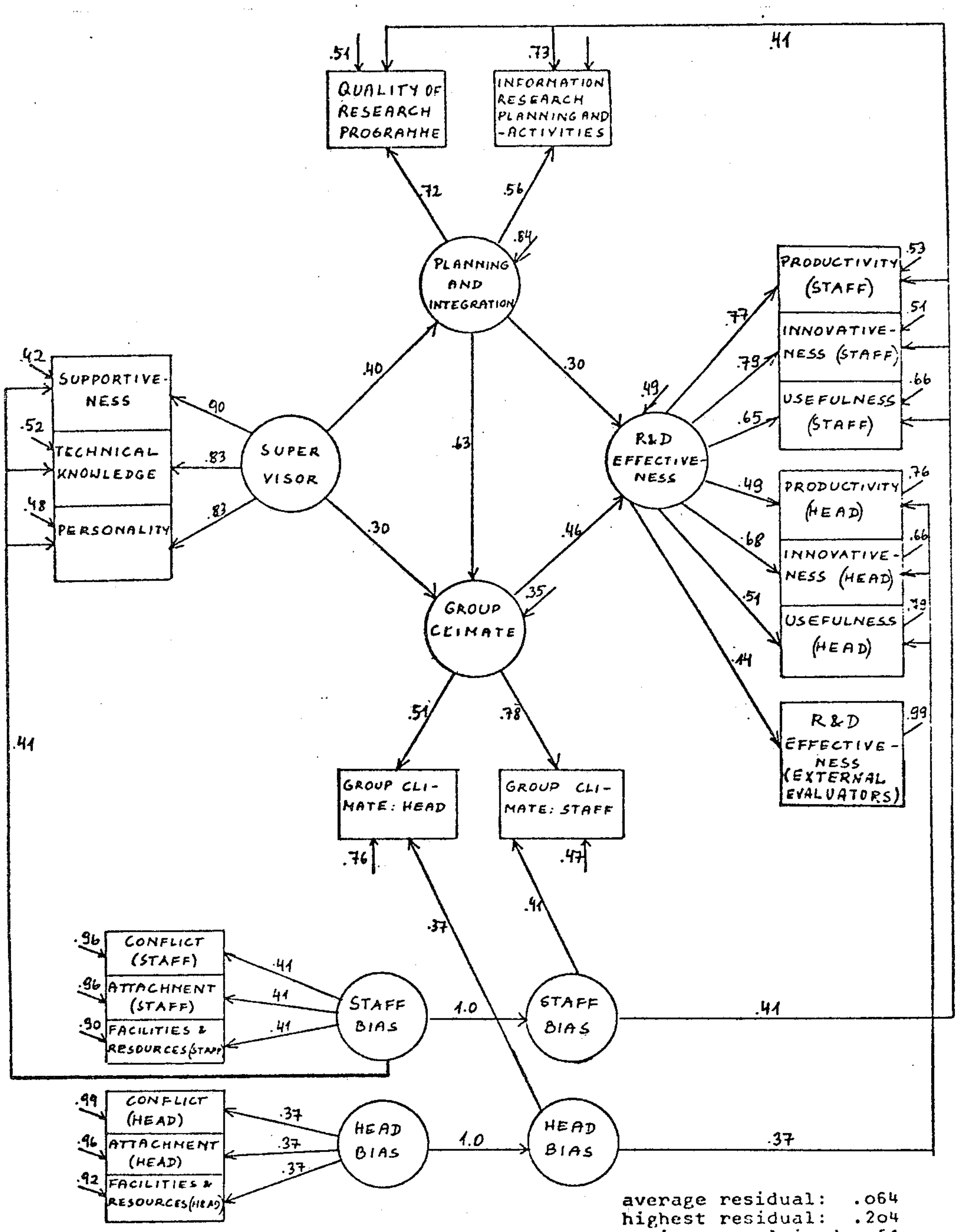
1) For syntactical reasons of the Lisrel programme, latent bias dimensions have to be split into separate components for dependent and independent variable indicators. Both components are connected by a linkage fixed at 1.0; furthermore, loadings of the linkages between latent bias factors and observed measures are constrained to be equal.

2) Excluding residuals originating from variables introduced solely for the purpose of bias estimation (cf. pp 28,29. footnote 1).

Figure 5: Lisrel model of R&D effectiveness (response bias included) for academic technological science groups.



average residual: .064
highest residual: .204
variance explained: .51

Again, the effect of the quality of planning and degree of information show a predominant influence on group climate; yet the direct effect of group climate on performance turns out nearly twice as high as in the case of natural sciences. Both the relatively high amount of variance explained in the performance measure and the significantly higher contribution of group climate presumably substantiate the assumption that technological science work involves more integrated production technologies associated with a lower degree of variability and uncertainty than natural science research. Consequently, high performance of technological science groups will be more directly dependent upon the factors specified in the model (especially group climate) than natural science units.

6. Discussion

The main interest in the present analysis which confirms the positive association between supervisory behavior, group climate and productivity postulated by the human relations approach, derives from the fact that the study was not designed to investigate this particular relationship. In other words, the predominant importance of the above variables for explaining group performance was the result of close investigations of a large variety of organizational variables and their relationship to group performance rather than the inevitable side effect of a continuing research focus on the above relationship. Consequently, it may be less interesting to note that some of the human relations results are replicated here, than to note that the above variables provide the best set of predictors out of a large number of organizational variables which seemingly do not contribute significantly to understanding rated research performance. In connection with this it may be worthwhile to point once more to those organizational variables which apparently did come up in addition to the main concepts in the following order of importance: the quality of the research programme, information on research planning and activities and personnel policy. Assuming the flow of events as specified in the Lisrel models, all three variables mentioned point to the importance of the planning and integrating functions (through information) of the supervisor in research laboratories.

The main drawback of the present analysis will perhaps be seen when the results of this paper are connected with the results of an earlier one referred to in the introduction (Knorr et al. 1976b): there it was shown that supervisory status and a series of intervening concepts linked to it account for most of the variance in productivity as measured by quantity of publications; here it is shown that supervisory quality and a series of intervening factors linked to it account for most of the variance in rated quality of performance. Both studies imply that supervisors (unit heads) are of pre-eminent importance in academic settings as far as productivity in general is concerned. And both studies show no overlap of the respective explanatory variables for both kinds of performance. The question, however, as to how both results and both kinds of performance are to be related, cannot be answered at present.

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