

**An empirical examination of the relationship between organizational
characteristics and research performance**

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ABSTRACT

This research is an empirical examination of the relationship between organizational characteristics and scientific research effectiveness. A sample of research active scientists (N=295) from 25 biological and chemical science university research departments took part in this study. Data was collected using the Organizational Culture Survey (Glaser, Zamanou, & Hacker, 1987) which measures 6 organizational characteristics of the research environment. Organizational characteristics are analysed across a measure of departmental research performance. Results support the hypothesis that specific characteristics of the organizational environment are related to research performance. The implications of these findings for existing literature and the future management and organization of scientific research departments are discussed.

Keywords: Research performance effectiveness organization management scientist

INTRODUCTION

Scientific research can be viewed as making a fundamental contribution to the medical, technological, environmental, and social advancement of the human race. That the scientific enterprise is important is reflected in the extent to which governments allocate human and financial resources to it. With increases in the demand for accountability in scientific research, an increasingly competitive environment, pressure to publish, and the implementation of onerous administrative funding procedures the environment in which scientific research takes place is of considerable interest. Yet despite the obvious influence and importance of science to national economies and society, relatively little effort has been expended on understanding the conditions best suited to its continuing success within the context of the organization.

In the current study, scientific research refers primarily to research conducted in organizations classified by Wilts (2000) as knowledge seekers. That is, research concerned with the production and creation of new knowledge. Specifically the research organizations under examination are university based research departments that are relatively autonomous in their decision-making processes, and allow scientists working within them reasonable latitude in the selection and approach to their fields of research.

LITERATURE REVIEW

A review of the literature on studies conducted on the organizational environment of research, identifies several attempts to model the organization of scientific research as well as a number of identifiable organizational variables believed to influence the performance of scientific research.

One of the earliest attempts to model and explain the administration of modern science was conducted by Glueck and Thorp (1971). During the course of compiling an annotated bibliography of research on the organization and administration of scientific research they developed a general model of the management of research. Glueck and Thorp (1971) identified the 'Management Research Process' as a

collection of organizational characteristics that include such factors as preparation and planning, organization/coordination, control/conflict, organization climate, reward structure, and evaluation.

Unesco (1979) conducted one of the largest studies on the organizational environment of science. The first round of this 'International Comparative Study on the Organization and Performance of Research Units' (ICSOPRU) examined the performance-effectiveness of scientific research units in six European countries (Austria, Belgium, Finland, Hungary, Poland, and Sweden). In all 1,222 research units were examined. The Structural Equation Models (SEM) of research and development effectiveness constructed from the Unesco (1979) data provide useful descriptions of the interactions that take place within the research unit. The relative strength of relationships between the variables (such as supervision, group climate, and R&D effectiveness) examined in the Unesco (1979) varied from statistically weak to moderate.

Thamhain and Wilemon's (1987) development of a systems model of research team performance illustrates how resources and objectives are transferred into results and team characteristics through the influence of various drivers and barriers. Drivers include factors such as stimulating work, freedom, communication, good interpersonal relations, and proper planning. While barriers include factors such as unclear objectives, conflict, lack of commitment, poor communication, and differing interests (Thamhain & Wilemon, 1987).

An alternative approach to understanding the influence of the immediate environment on scientific research comes from the field of creativity research. Amabile suggests that 'the ultimate driving force behind all of scientific progress' is human creativity (Amabile, 1994). As one of the foremost writers and researchers in the area of creativity, Amabile proposes a componential model of scientific creativity. By focusing on the effect of social factors on scientists' motivation and on the effect of motivation on creativity; this model recognises the influential nature of the organizational environment. Experimental support for Amabile's work, is generally based on student samples in contrived research settings (Conti, Coon, & Amabile, 1996). This methodological limitation poses

concerns over the usefulness and validity of the componential model of creativity in explaining scientific performance in the 'real world' of the research organizations, but does succeed in, once again, highlighting the important link between the research environment and research outcomes.

The theoretical model of scientific discovery presented by Hurley (1997) highlights the importance of the suitable combination or 'fit' of organizational variables with individual variables. This theoretical model suggests that the suitability of the scientist's ability and personality, coupled with the suitability of the organizations resources and dynamics, determines the likelihood of a discovery taking place. Hurley's (1997) model has a strong theoretical base, but is lacking in any empirical support. By his own admission the model is 'essentially a speculation on the nature of reality' (Hurley, 1997. p148). Yet despite this weakness the model offers an interesting theoretical perspective on the discovery process, and provides suggestions for future research in this area.

In addition to attempts to model the nature of the organization of scientific research, researchers in this field have also identified specific characteristics of the research environment that relate to research performance or proxies of research performance such as the motivation to perform research.

Baumgartel's (1956) research on the attitudes and motivations of scientists identifies leadership style as a characteristic that is related to scientists job satisfaction and their motivation to engage in research. Argyris (1968) identifies nine basic variables that influence the effectiveness of the research organization. These include organizational structure, technology, administrative controls, human controls, leadership styles, interpersonal relations and communication, group effectiveness, intergroup relations, and norms of the living system.

Individual organizational factors such as leadership/supervision, cooperation and participation (Keller, Julian, & Kedia, 1996), have been demonstrated to account for variation in publication quantity, and quality in some samples. Influencing styles of project managers have also been related to a variety of indicators of project success (Thamhain & Gemmill, 1974), while the social context in which science

takes place and the characteristics and states of communication processes has been shown to relate to eminence and research productivity (Pruthi & Nagpaul, 1994; Simonton, 1992).

In a review of the literature on the characteristics of the productive research environment Bland and Ruffin (1992) identify twelve common and recurring characteristics. These include the existence of clear goals that serve a coordinating function, a research emphasis, a distinctive organizational culture, a positive group climate, assertive participative governance, a decentralized organizational structure, the size age and diversity of the group, the reward structure of the organization, frequent and open communication, a well developed recruitment and selection process, adequate resources, and finally effective leadership.

Factors identified by Hurley (1997) include many of those identified by Bland and Ruffin (1992) with the addition of others such as team autonomy, group morale, group membership, and supervision of the research team. Utilizing an ethnographic approach, Mouly and Sankaran (1998) identified several factors which characterize the dysfunctional research environment. Factors such as excessive bureaucracy, lenient selection and recruitment, lack of team identity, lack of autonomy, poor interpersonal relations, and authoritarian and apathetic supervision.

Utilizing a data set from a further round of the Unesco (1979) study, Chawla and Singh (1998) identified several organizational characteristics related to research productivity. These organizational characteristics were chosen for their ability to describe the effectiveness of research organizations in terms of management practices and resources, and were used to identify five distinct types of research organizations with varying levels of effectiveness. The list of characteristics itself includes leadership, work environment, policies, planning, communication, and resources.

Table 1 presents a summary of key research that has examined a variety of organizational characteristics which are believed to influence the performance-effectiveness of scientific research. This summary highlights the degree of conceptual similarity among many of the factors identified

across the various studies summarized here. It also highlights the complexity of approaches and various methodological perspectives that have been taken when examining aspects of the scientific work environment.

What is common in this research is the proposed relationship between a variety of organizational characteristics and research performance. The literature suggests that a positive linear relationship may exist between factors such as research team morale, or supervision, for example, and research performance. However due to the theoretical and methodological variations that exist across studies, the exact nature and strength of this relationship is unclear. The current study aims to better clarify the link between organizational characteristics, such as those presented in table 1 and research performance. In view of the evidence presented in the literature the current research examines to what degree a positive linear relationship exists between a selection of ‘organizational characteristics’ and a measure of research performance. This led to the formulation of the following hypothesis.

Hypothesis 1: Research departments which exhibit more favourable organizational characteristics will exhibit correspondingly higher levels of research performance.

The specific nature of the ‘organizational characteristics’ referred to in the hypothesis are further clarified in the methodology.

Table 1
Summary of characteristics of the research environment identified as influencing scientific research effectiveness

ARGYRIS (1968)	BAUMGARTEL (1956)	GLUECK & THORP (1971)	THAMHAIN & WILEMON (1987)	BLAND & RUFFIN (1992)	HURLEY (1997)	MOULY & SANKARAN (1998)	CHAWLA & SINGH (1998)
Organizational structure	Leadership	Preparation and planning,	Leadership	Clear goals	Good selection processes	Lenience in recruitment processes, professional mediocrity	Leadership
Technology	Freedom in decision making	Organization/ Coordination	Job content	Research emphasis	High morale	Poor self-image	Work environment
Administrative controls		Control/ conflict	Personal goals	Distinctive organizational culture	Positive group membership and supervision	Lack of team identity and role clarity	Policies
Human controls		Organization climate	Work environment	Adequate recruitment and selection process	Autonomy of work teams	Lack of institutional autonomy in project selection	Communication
Leadership styles		Evaluation		Assertive participative governance	Supportive organizational culture	Excessive bureaucracy, apathetic attitudes	Resources
Interpersonal relations and communication				Decentralised organizational structure	Effective communication	Strained interpersonal relationships	Planning
Group effectiveness				Size age and diversity of the group	Effective leadership styles	Apathetic supervision, authoritarian-ism within the institutes hierarchy	
Inter-group relations				Appropriate reward structure			
Norms of the living system				Frequent and open communication			
				Positive group climate			
				Adequate resources			
				Effective leadership			

METHODOLOGY

The first stage of sample selection was the identification of a population of scientists from which to draw a participant sample. In the current study the population of scientists was limited to research active scientists working in UK university departments who had taken part in the UK's Research Assessment Exercise (RAE), and were working in research departments in the fields of biological and/or chemical research. A list of such departments and their RAE scores was collected from data available from the website of the Higher Education and Research Opportunities in the United Kingdom (HERO, 2002b).

INSTRUMENTS

The Organizational Culture Survey (OCS) (Glaser et al., 1987) was chosen to measure characteristics of the organizational environment. The OCS measures six dimensions of organizational functioning including Teamwork, Morale, Information Flow, Involvement, Supervision, and Meetings. Immediate links can be drawn between many of these concepts and the characteristics of the research organization identified in a review of the literature, and summarized in Table 1.

The measurement of research performance across participating research departments was facilitated by an existing and readily accessible measure known as the Research Assessment Exercise (RAE). The RAE is a UK government initiated research performance measure that is designed to enable higher education authorities to distribute public research funds selectively to research departments in tertiary institutions on the basis of their research quality. The assessment, which takes place every four to five years, provides research quality ratings for academic departments across all academic disciplines, and on the basis of these ratings distributes approximately UK£1 billion a year (HERO, 2002a). The quality ratings themselves, which range from a high of 5* through 5, 4, 3a, 3b, and 2, to a low of 1, are based on detailed submissions from the participating departments.

While the RAE is certainly not a perfect or flawless evaluation procedure, it does provide a relatively thorough and detailed evaluation of the quality of research across a large number of research departments in UK universities, based on the information contained within each submission. This

information is similar in nature to that employed in the evaluation of research performance in the Unesco (1979) study in that it includes a variety of dimensions in the analysis of performance. As such the RAE offers the most readily available and comprehensive evaluation of research effectiveness suitable for use in the current study. It also offers the additional benefit of allowing for the stratified sampling of scientists from research departments of varying levels of research effectiveness.

PROCEDURE

Departments were separated by RAE grade from 5* to 1. The lists of departments in each grade of the RAE from 5* through to 5, 4, 3a, 3b, 2 and 1 were then randomized. Contact was then made with the heads of department in each list starting at the top of each list. The heads of departments were contacted via email and phone and the nature of the study was explained to them while access to their staff was requested. This step was repeated down the lists of departments until sufficient sample size was procured. At an early stage in the research it became clear that insufficient numbers of responses in the 1, 2, and 3b categories would be attained to allow for a useful examination of departments within these grades. Consequently they were excluded from further investigation. Reasons for this are elaborated on further in the discussion. In total 727 research scientists were requested to participate in the study, 295 responded, giving a response rate of 30.6%. Participation in the study at both the departmental and individual levels was voluntary, and confidentiality was assured. Of the total of 295 respondents 243 (82.4%) were male, 52 (17.6%) were female.

A paper and pencil copy of the Organizational Culture Survey (Glaser et al., 1987) and a biographical questionnaire was prepared for each participant. A copy of the booklet of questionnaires was mailed to the work addresses of all research active staff in the participating department. Included with the questionnaire booklet was a self-addressed envelope to assist participants in returning the completed questionnaire to the researcher. Data from the completed questionnaires was then inputted into an SPSS file for analysis. The data from a haphazard selection of 30 completed questionnaires were then rechecked to ensure accuracy in data entry.

The analysis of data from the current study was conducted in two stages. The first stage examined the scale reliabilities of the OCS (1987) The second stage examined the primary hypothesis presented previously, examining the relationship between characteristics of the organizational environment and research performance.

RESULTS

Prior to the analysis of the primary relationship proposed in the hypothesis, an examination of the scale reliabilities of the OCS was conducted. The instrument is reported to be well constructed with principal-component factor analysis yielding a six-factor solution with eigenvalues in excess of 1.0. In addition no items in the scales have an item loading less than 0.56 (Rubin, Palmgreen, & Sypher, 1994). Glaser et al (1987) reported scale reliabilities ranging from .63 to .91 using Cronbach’s alpha. Independent examinations of the Cronbach alpha for each subscale were conducted on the results from the current study. Table 2 lists the Cronbach alpha reliabilities for each subscale of the OCS for the current sample of research scientists.

Table 2
OCS subscale Cronbach alpha reliabilities for sample of participants in current study (N=295)

SUBSCALE	CRONBACH ALPHA
Teamwork	0.90
Morale	0.91
Information Flow	0.78
Involvement	0.78
Supervision	0.88
Meetings	0.75

For ease of data entry and analysis a slight readjustment of the labeling of RAE scores was made. For example 5* ranked departments were recorded as ‘6’. The RAE rankings of 5 and 4 remained the same while 3a rankings were relabeled ‘3’. As mentioned previously both the small number of departments in categories 3b, 2 and 1 and their small size resulted in their exclusion from analysis. The number of respondents in each departmental category and the number of departments from which they were drawn is presented in Table 3.

Table 3

Number of participating departments and scientists in each RAE category

RAE category	Number of Participating Department in each RAE category	Total number of participating scientists in each category N
3	8	77
4	8	70
5	6	69
6	3	79

The primary hypothesis presented below predicts a linear relationship between characteristics of the research environment and research performance, with performance improving as organizational characteristics become more favourable.

Hypothesis 1: Research departments which exhibit more favourable organizational characteristics will exhibit correspondingly higher levels of research performance.

The testing of this hypothesis requires the examination of the relationship between departmental scores for organizational characteristics and departmental score for research performance.

Departmental scores for each of the six factors of the OCS were compiled by aggregating responses from participating scientists within each department. As the measure of research performance used in the current study (the RAE) is essentially an ordinal ranking a one-tailed Spearman rho was conducted for each of the OCS factors and RAE rankings. Results are presented in Table 4.

Results identify significant positive correlations between all measured characteristics of organizational environment and the performance ratings for each department, and consequently confirm the primary hypothesis that ‘research departments which exhibit more favourable organizational characteristics will exhibit correspondingly higher levels of research performance’

Table 4

Summary of Spearman rho correlations for OCS factors and RAE scores for participating research departments

OCS Revised Factor	Correlation with Research Assessment Exercise (RAE Score)	
Teamwork	Pearson Correlation	115*
	Sig. (1-tailed)	.024
	N	294

Morale	Pearson Correlation	.299**
	Sig. (1-tailed)	.01
	N	294
Information Flow	Pearson Correlation	.211**
	Sig. (1-tailed)	.000
	N	295
Involvement	Pearson Correlation	.239**
	Sig. (1-tailed)	.000
	N	295
Supervision	Pearson Correlation	.236**
	Sig. (1-tailed)	.000
	N	282
Meetings	Pearson Correlation	.143**
	Sig. (1-tailed)	.007
	N	294

* correlation is significant at the 0.05 level (1-tailed)

** correlation is significant at the 0.01 level (1-tailed)

DISCUSSION

As presented in the results of the current study, the primary hypothesis: ‘Research departments which exhibit more favourable organizational characteristics will exhibit correspondingly higher levels of research performance’, was supported. The identification of statistically significant correlations between variables examined in the current study shows that more favourable organizational characteristics exist in tandem with higher levels of research performance. However while the hypothesis was supported, the relative weakness of the correlations reported suggests the existence of other important variables in our understanding of research effectiveness. Some of these alternative variables have been empirically examined. The role and importance of developmental characteristics, educational environment, individual differences, and other social conditions are reported by several researchers (Feist & Gorman, 1998; Hurley, 1997; Ryan, 2003; Simonton, 1991, 1992; Zuckerman, 1977). Results of the current study add to this literature by providing empirical evidence of the relationship between organizational characteristics and performance, and highlighting the need for a greater understanding of the organizational and managerial environment in which scientists work.

Where empirical evidence has been gathered in this area it has tended to be of a qualitative nature, is often irreplicable, and leads to difficulties in confirming relationships. However current findings

provide quantitative empirical evidence of the significant link between the organization and scientific research effectiveness hypothesized and identified by other research in this area (Argyris, 1968; Bland & Ruffin, 1992; Chawla & Singh, 1998; Mouly & Sankaran, 1998). Concepts contained within Thamhain and Wilemon's (1987) systems model of research effectiveness suggest that single organizational factors can act as either drivers or barriers depending on their relative position on a positive to negative continuum. This is a reasonable proposition and is suggested in the work of Hurley (1997) and Mouly and Sankaran (1998). Essentially a single organizational characteristic, say information flow, can act as a driver or a barrier depending on whether it is manifested in a positive, efficient, constructive manner (driver) or is manifested in a dysfunctional, ineffective, and destructive manner (barrier). By viewing results from the current study from the perspective of Thamhain and Wilemon's (1987) systems theory, we might suggest that the increasingly positive characteristics of Morale, Information Flow, Supervision, Meetings, and Involvement contribute to a positive increase in the performance of research conducted within that organizational environment and do not hinder, or act as barriers to research performance. Current findings also offer support for Hurley's (1997) hypothetical model of scientific effectiveness, confirming the influence of the organization while also recognizing that the relatively low correlations found in the current study allow for the influence of other non organizational/ individual factors on research performance.

The provision of empirical evidence in support of the relationship between the organizational environment of university departments and their research performance is of increasing relevance and importance. Within a New Zealand context, the advent of government initiatives such as the PBRF has provided anecdotal evidence of both positive and negative consequences for research environments. Such initiatives, if they are to meet their stated aim of improving research performance, must recognize and account for the impact they have on the management and organization of science. Despite recent attempts by the New Zealand Tertiary Education Commission to evaluate the impact of the PBRF on the research environment, it appears that little thought is given to the micro level impact of such policies on individual scientists and researchers.

The current findings should be viewed cautiously in light of the limitations of the study. The identification of significant correlations between organizational factors and a measure of research performance is of significant importance to the literature on the management of science, but does not prove or imply a causal relationship between the variables under examination. The structure of the current study can neither show temporal order in the variables nor can it eliminate all alternative explanations. However the logical association between these factors is well presented in the literature. Another weakness of the current study is the lack of a complete range of research performance across departments. As mentioned previously the departmental measure of research performance used in the current study is the departmental Research Assessment Exercise (RAE) scores for UK University departments. These scores range from 5* to 1. However in practice the numbers of 1, 2 and 3b ranked departments are few in number. This is likely due to the onerous nature of the RAE process and the probability that departments that surmised their RAE score would be a 1 or 2 would deem the funding associated with such a rank to be incommensurate to the effort exerted on the RAE submission. An examination of the size of such departments also reveals the general trend that low scoring departments are generally comprised of fewer staff. This has implications for the degree to which a limited number of respondents can be viewed as providing an accurate representation of the characteristics of the organizational environment. These factors contributed to the researcher's inability to collect sufficient data to provide a complete range of research departments from the very highest ranking to the lowest ranking, which does limit the ability to generalize results.

The voluntary nature of participation must also be taken into account when examining the current results. It is possible that the responses gathered may represent the experiences of a subpopulation of research scientist within each department and not accurately reflect the general experience of all scientists within each department. Of further note is the use of the RAE rankings as a measure of research performance at the departmental level. Attempts at quantifying the measurement of scientific research vary considerably and include basic publication counts, citation counts, measurement of impact factors, complex bibliometric analysis of scientific fields, patent counts, funding awards, science medals etc. what is clear from communications with scientists in various fields is that there is

no one universally acceptable method of measuring research performance/effectiveness. With this in mind the RAE can be viewed as a flawed but nonetheless acceptable measure of research performance.

In addition to addressing the weaknesses of the current study, future research in this area requires a greater focus on the nature of the relationship between the research environment and research performance. As the current study indicates, the linear examination of variables shows small but significant correlations. Alternative examinations of this data are currently underway in the attempt to shed further light on this relationship. It is also recommended that future studies look to integrate the examination of both the individual contributions to research performance and the organizational contributions to research performance. While these factors have been examined in isolation, a more integrated approach would allow for a greater understanding of the relative influence or variance accounted for by these variables.

In conclusion, the findings presented here represent advancement in our understanding of the way in which the characteristics of an organizations environment may be related to the performance of scientists within that organization. Current findings suggest that the characteristics of the organizational environment can be seen to be related to research performance, and can distinguish between the lower and higher performers in the scientific arena. However the low to moderate correlations reported here also suggest the influence of alternative variables, including further organizational as well as non-organizational variables, in explaining the nature of scientific effectiveness.

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