THE INFLUENCE OF SOCIAL FACTORS ON THE PERFORMANCE OF A CENTER: A CASE STUDY OF THE "UNIVERSITY RESEARCH CENTER"

by

Hong-Lim Oei

Thesis submitted to the Faculty of the
Virginia Polytechnic Institute and State University
in partial fulfillment of the requirements for the degree of
MASTER OF SCIENCE

in

Science and Technology Studies

APPROVED:

Gary Downey, Chairman

Richard Hirsh

Kay Oehler

Robert Paterson

May, 1989

Blacksburg, Virginia
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Committee chairman: Gary L. Downey

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(ABSTRACT)

Factors involved in the development and performance of interdisciplinary university-based research centers were investigated by an analytical case study of one such center, the "University Research Center" (URC). A description of URC's life cycle and the various factors that affected its performance is presented. The sociocognitive ideals of university-based research centers emphasized the promotion of interdisciplinary research and education. The organizational reality, however, showed that a variety of other factors, both internal and external to a center, may significantly influence its operations. Factors internal to URC included leadership, support of loyal participants and their motivations to participate in interdisciplinary research. External factors included the effects of university departments and the availability of funds. The interpretation of these factors made it possible to construct generalizations about the organizational characteristics of university-based research centers. In order to function effectively, a university-based research center must manage its sociocognitive ideals and its
organizational characteristics simultaneously and with some degree of balance.
ACKNOWLEDGEMENTS

This thesis as well as my graduate studies in the Science and Technology Studies would not have been possible without the support of the Netherlands Technology Foundation and the faculty members of the Center for the Study of Science in Society (CSSS) at Virginia Tech.

Foremost, I wish to express my deepest gratitude to the members of my advisory committee, Drs. Gary Downey, Kay Oehler, Richard Hirsh and Robert Paterson for their comments and suggestions in shaping this thesis. I would also like to thank Dr. Robert Paterson as director of CSSS, Drs. Peter Barker and Albert Moyer for their many valuable insights. I wish to convey my gratitude to the late Dr. Nicholas Mullins, my initial advisor, for his advice in choosing a suitable research topic and setting-up the project.

Many faculty members of other departments at Virginia Tech gave generously of their time to explain and help me understand the dynamics of the Center I have investigated. For reasons of anonymity I could not mention their names. Several university administrators have provided me with
helpful information, and have allowed me to examine the files of the Center. I gratefully acknowledge their views and contributions to this thesis.

Special acknowledgement goes to the director of the Netherlands Technology Foundation, Dr. Kees le Pair, and the chairman and board members of the Foundation for awarding the fellowship that has enabled me to pursue this study.

Finally, thanks are given to all persons without whose help this thesis could not have been completed. I am extremely grateful to all of them.
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CHAPTER I

INTRODUCTION

It is common practice for most researchers to concentrate their work in a relatively small area of science. They focus on a specific field and use standard approaches for solving research problems. Their research results contribute to the advancement of the field, and they become experts in their specific areas.

Not all progress in science, though, is a result of this piecemeal broadening. Some of the most remarkable scientific achievements are accomplished by researchers with the imagination, capacity, and, most of all, courage to do research in an "interdisciplinary" way. Interdisciplinary investigators do not build "fences" around their specific research areas. Rather, they integrate useful tools from several disciplines to answer research questions or to solve research problems.
A great deal of interdisciplinary research has been very useful. For example, the discovery of X-rays is a result of physical research and technological advancement in glass blowing and vacuum techniques. To explain the spontaneous emissions of radioactivity, Rutherford, a physicist, needed a chemist, Frederick Soddy, for the chemical isolation of particular elements from other substances (Cline, 1987:19-20). The double helix model for DNA is deduced from its chemical structure and crystallographic data. A more recent example is the use of micro-organisms in chemical processes that has created a new bio-industry. Sometimes, interdisciplinary work has managed to establish its principles and research methods as a more permanent way to approach problems. On those occasions, interdisciplinary research becomes a sub-discipline, e.g. biochemistry, molecular biology, biophysics etc. Other interdisciplinary research has become so successful that it develops into a distinct scientific discipline, for example psychology and computer science. These examples show that interdisciplinary approaches are not new phenomena in research.

Interdisciplinary research has been performed at industrial laboratories as well as at universities and other institutions. In industry, interdisciplinarity is common practice. To achieve maximum production in the most efficient way, almost all divisions of an industry regularly
collaborate in joint efforts. At universities, researchers have always shown initiative to come together to share the same interests, or to solve research problems with combined effort. As a result, there have been groups of people from different disciplines working together. These groups are interdisciplinary in nature, but they may not be formally recognized as separate entities within the university structure. Although participants may publish joint papers, for example, no formal commitment obligates them to continue the collaboration. When specific expertise is needed, participation of someone from a particular discipline can be sought without any further obligations for future joint research. Thus, the group's composition may vary with each problem that has to be solved. In this way, interdisciplinary research is performed in an informal manner.

In the past few years, there has been a proliferation of university-based "centers" as a result of encouragement by the National Academy of Sciences (NAS, 1983) and the National Academy of Engineering (NAE, 1987). To NAS and NAE, a center implies an activity with a formal management and organizational structure. In contrast to informal research groups that usually have no administrative structure, a center is a separate entity in the university structure that is officially recognized by the university administration. These centers consist of one or more
disciplines. They are supposed to fulfill or complement industrial research with skills, knowledge and manpower. In other words, the centers are supposed to contribute to the utilization and transfer of new scientific knowledge to industry, and to the education and training of high quality professionals who are aware of the potential applications of their knowledge.

The theoretical justification for the establishment of these centers is based on several assumptions. It is generally believed that there must be a critical mass, or minimum number, of scientists working together to achieve an optimal production of knowledge. Furthermore, it is assumed that the production of scientific knowledge involves a combination of intellectual action and social processes such as negotiation and interaction, thus encouraging the concentration of scientists in one location. Finally, the presence of a leader as well as a theoretical concept as a guideline for research activities should keep the scientists together.

As an organization, a center is directly influenced by its immediate environment, i.e. the structure of the university. In particular, the existing departments of the university often act as barriers to interdisciplinary cooperation, and their varying configurations certainly affect the specific organizational structures of centers. A center is usually organized in one of two basic structures,
as a "quasi department" with resident research faculty, or as a "research cluster" with no fixed faculty and without the possibility for rewarding the participants in terms of tenure and promotion. Both of these structures can have significant influence on the operation and performance of a center.

Another obvious influence on the performance of a center is the availability of operating funds and funds for research. Typically, there are two sources of financial support, university resources and funds obtained through grants and contracts from funding agencies. Needless to say, a continuous and predictable flow of funds is one of the necessities for maintaining high quality research and keeping investigators and students as participants in the center's activities. Since funds come from two different types of sources, we can expect to find much variation in the patterns of influence that funding has on a university-based center. For example, funding patterns within a university provide one indicator of the influence of the university's academic structure on a center's performance. And evolving patterns of grants and contracts from funding agencies provide an indicator of the influence of societal preferences at large.

The purpose of this thesis is to identify the range of factors that affect the performance of university-based research centers by conducting an empirical investigation of
one such center. The primary analytic objective will be to distinguish between the influences of factors internal to a center and those external to a center in order to better understand the complexity of its internal dynamics. By delineating and investigating the types of influences on a particular university-based research center, we may begin to unpack the larger question of whether or not such centers realize established ideals of interdisciplinarity. For example, are university-based, interdisciplinary research centers indeed organizational structures that efficiently and successfully produce scientific knowledge? Is it the case that interdisciplinary centers serve as loci of significant scientific change? Finally, a detailed account of the factors that shape a particular university-based center may prove helpful to those faculty, administrators, and agency officials who must make decisions about the operations of other centers.
CHAPTER II

THE FRAMEWORK OF INVESTIGATION

The integration of disciplines has been attempted in many kinds of scientific research. Interdisciplinary research often seeks to combine conceptual frameworks, methods and tools from various disciplines for a variety of reasons. For example, scientists have become increasingly aware of the need for expert knowledge from disciplines other than their own in order to solve particular research problems. Besides a pure intellectual necessity, discipline integration may be employed as a practical means of increasing the efficiency of utilizing university resources, such as instruments, facilities and so forth.

In general, most scientists exhibit a positive attitude towards this research approach.1 However, not everybody

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1 Scientists have various reasons for being interested in integrating scientific disciplines. The most obvious reason is that the nature of the science they are working
shares this opinion. Some scientists argue that discipline integration is not always necessary or desirable in assessing research problems. In some cases a deep and specialized study of the subject matter from the standpoint of one discipline might be a better way to do research (Epton et al., 1983:44). There are also investigators who adhere to different values for scientific integration depending on whether it is employed for theoretical or practical purposes.2

In spite of the diverse opinions regarding the purpose of discipline integration, it seems that this particular objective is increasingly gaining acceptance in university research. To understand the nature of the integration of scientific disciplines, e.g. how it could develop, what constraints it would encounter in its growth, etc., one needs to consider several points. First, there are several terms that have been used to denote the integration of

in, is already traditionally interdisciplinary. Personal background, such as education and involvement with interdisciplinary work, are other reasons. Interdisciplinarity may also be a "way of research," assuming that single disciplinary approaches for most problems are unlikely to be successful [interviewer # 4].

2 Bechtel [1986:3] presents the following arguments. On the one hand, some scientists see interdisciplinarity as a kind of "epistemological panacea" to cure all types of scientific problems. But on the other hand, there are scientists who view interdisciplinary research ambivalently. For practical purposes, i.e. problem solving, they consider an interdisciplinary approach valid, yet they are skeptical whether this approach has the same value for theoretical purposes.
disciplines. This might create confusion among users and audiences. To avoid confusion it may be helpful to consider using common terms for particular types of discipline integration. Secondly, one has to consider how science has become compartmentalized into "disciplines" and what roles university-based scientific disciplines, housed in "departments," play in interdisciplinary research. Thirdly, the sociological and cognitive factors in the development of "specialties" and the implications these factors have in integrating disciplines need to be considered. Lastly, the particular framework through which discipline integration will be sought should be considered.

ARTICULATION OF TERMS

Various terms have been employed in the literature to express "discipline integration," e.g. "multi," "cross," "inter," "trans," and "pluri"disciplinary. The most commonly employed, and accordingly the most confusing expressions, are multidisciplinary and interdisciplinary. What is the difference between multidisciplinary and interdisciplinary activities? Is an interdisciplinary activity the same as a multidisciplinary activity plus some kind of integration? Epton, Payne and Pearson (1983) have explored possible answers to this question. According to
these authors, the diverse terminology currently used to denote discipline integration is not merely a semantic problem and may cause methodological confusion among the scientists and scholars who associate the terms with different meanings.

There have been several attempts to clarify the nomenclature of discipline integration. For example, Rossini and Porter (1984:27) have proposed the following relationship between "multi," "inter," and "trans" disciplinarity on the basis of the outcomes of research.

In **multidisciplinary** research the disciplinary components are performed independently and joined externally through appropriate editorial linkages. Each separately authored component could stand in isolation from others.

**Transdisciplinary** research involves the development of an overarching paradigm encompassing a number of disciplines.

**Interdisciplinary** research falls between these extremes. Its components are linked internally and substantively without being subsumed under a

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3 With "editorial linkages" the authors mean an organization of the various components (from the participating disciplines) in a rational order with a suitable introduction to the overall effort prefixed and an appropriate conclusion appended, thereby using a consistent terminology [Rossini and Porter, 1979:72].
supradisciplinary paradigm. It might be likened to a 'seamless woven garment' in contrast to the 'patchwork quilt' of multidisciplinary research.

The same authors (Rossini et al., 1983:177) also advanced simpler definitions in order to clarify the situation:

Multidisciplinarity is the result of the interrelation of disciplinary components where they are linked externally only without any serious attempt to make internal linkages between the various analyses. Interdisciplinarity involves the internal and substantive interlinking of the various disciplinary analyses so that each considers the results of others in its own development.

Birnbaum (1983:49) has sought to discriminate the definitions of "multi" and "inter"disciplinarity by focusing on research effort:

Interdisciplinary as opposed to multidisciplinary research refers to research teams in which the effort is integrated into a unified whole. Multidisciplinary research refers to research in which scholars from different disciplines work independently and are joined together externally through editorial linkages.

By focusing on either the outcome or the overall research effort, however, both Rossini et al. and Birnbaum may have overlooked the importance of potential variations in sub-tasks at several stages during the activity of
integration. That is, in the midst of the whole effort of integration, some sub-efforts or sub-tasks may be mainly multidisciplinary in content while others may be primarily interdisciplinary.

Epton et al. (1983:9) have recognized difficulties in classification posed by such internal variations. In order to avoid the resulting methodological problems, they suggested that "the terms multidisciplinary and interdisciplinary should not be used evaluatively." Rather, the two terms should be used only to describe the organizational form in which the integration is carried out. Therefore, Epton et al. (1983) advanced the following definitions:

Crossdisciplinary tasks can be carried out using either of two different organizational forms:

The 'pure' multidisciplinary form -- in which portions of the task are carried out by organizationally separate units each of which includes practitioners of only one discipline.

The 'pure' interdisciplinary form -- in which the elements of the task are carried out within a single

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4 Epton et al. (1983) employed the terms multi- and interdisciplinary as qualifiers of the manner (or, intention to do it in a certain manner) in which the integrating task is being carried out. In other words, the terms multi- and interdisciplinary are used to denote the organizational form in which the task is being carried out. For the content of the task, they have applied the term crossdisciplinary. Thus, one may speak of crossdisciplinary "tasks," "projects."
Throughout this thesis, use of the term interdisciplinary will follow the definitions offered by Epton et al. That is, it refers explicitly to integration of disciplines irrespective of the cognitive forms taken by the actual research involved.

UNIVERSITY-BASED SCIENTIFIC DISCIPLINES

In this section the concept of "scientific discipline" is explained in a descriptive way without an attempt to present a historical or philosophical account of the establishment of the disciplines.5 The purpose of

5 Whitley (1984:12) presents a historical account of discipline development. Post World War II scientific work is characterized by an "over specialization": sciences have become increasingly differentiated internally and perhaps fragmented. This is not only an intellectual necessity as part of the explosive growth of science, but it is also a socially constructed way of organizing scientific knowledge. Whitley argues that the rise and development of disciplines is concomitant with the emergence of academic careers at universities. In principle, individuals do not compartmentalize their skills and concerns into discrete fields limited by discipline boundaries.

Bechtel (1986:10,13) defines the basic units of science, the disciplines, on the following criteria: (1) the objects studied, (2) the cognitive activities involved, and (3) the social and institutional organization. He concludes that the definition of disciplines by these criteria is only possible if the social and cognitive circumstances of these criteria are considered. Thus, "we cannot identify such sets of objects without considering the factors that lead scientists to group them together. Some of these factors have a basis in nature, but they are also influenced by both the cognitive and social features of disciplines" and "while
discussing the scientific discipline is to introduce the reader to the implications or consequences of the disciplinary structure of science for the performance of interdisciplinary research.

In most discussions regarding scientific disciplines, the concept of "discipline" is simply taken for granted. However, an analysis of interdisciplinary research requires an understanding of what disciplines are and what role they perform, particularly in a university setting. It is now widely accepted that the discipline is a fundamental unit of social and cognitive organization in science. The development of such divisions of knowledge is not only a result of the systematic study of the sciences, but it is also a social construction that serves to validate the professionalization of science.

Within a discipline, scientific goals and procedures are determined by the community of scientists sharing a disciplinary identity. Hence, the production of scientific knowledge and the standard of scientific work are controlled within the discipline. The institutionalization of disciplines at universities has led to the formation of "academic departments." As a result, the academic

much can be learned about the features of disciplines by a purely cognitive and logical investigation, it is widely recognized that scientists identify problems, apply their research methodology, and present their findings and theories in a social milieu, which needs to be considered as well."
department has become the place where "quality control" over the academic performance of its members is exerted. For example, decisions concerning tenure and promotion are made within the discipline. Furthermore, the recruitment and training of students involves traditional disciplines. The discipline is thus the component of the scientific profession where intellectual norms, reputation and statuses of faculty, as well as training of successors of the discipline and allocation of resources, are decided.

In the performance of interdisciplinary work, an investigator crosses the boundaries of his or her discipline. This enterprise is not without risk. As Whitley (1984:16) writes, "To conduct research on topics which transcended these boundaries or to develop skills and techniques which lay outside institutionalized commitments was to risk reputation and hence, career." Scientists who are traditionally trained according to the norms and procedures of a single discipline may judge interdisciplinary work suspiciously; for example, as being too shallow and having little scientific content. Accordingly, publications with co-authors from disciplines other than their own may not get a fair evaluation from such scientists. Since tenure and promotion are based on academic performance, participation in interdisciplinary

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6 Bechtel [1986:23,29] came up with similar conclusions. He does not encourage researchers who lacks tenure to get involved in crossdisciplinary endeavors.
research can be a problem, especially for untenured faculty.

In sum, the traditional disciplinary boundaries of academic departments can serve as significant obstacles to the performance of interdisciplinary work.

**SOCIOCOGNITIVE FACTORS IN THE DEVELOPMENT OF DISCIPLINES**

Despite the compartmentalization of science into disciplines and into the academic structure of departments, scientists often seem open to scholarly input from different disciplines. Crane (1969:349), for example, writes:

Most problem areas are open to influences from other fields. The desire for originality motivates scientists to maintain contacts with scientists and scientific work in areas different from their own in order to enhance their ability to develop new ideas in their own areas.

It is now commonly accepted that contacts between disciplines are generally developed and maintained by small groups of scientists. Such groups have been identified as the "scientific elite" (Price, 1963; Merton, 1973) or the

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7 The "social stratification" of the scientific community is widely recognized. Only a minority of scientists are responsible for the production of scientific knowledge and publications in scientific literature. Price [1963] claims that the square root of the whole population of scientists produce 50% of the scientific discoveries. Merton [1973:445] advances the "Matthew effect" that says
"invisible college" (Crane, 1969), and they sometimes evolved into "scientific specialties." For a review of definitions of "specialties," see Chubin (1976:448). Chubin writes, "In short disciplines form the teaching domain of science, while smaller intellectual units (nestled within and between disciplines) comprise the research domain. Within the sociology of science, these units have been termed "scientific specialties."" Similarly, Whitley (1984:12) writes, "While disciplines could be seen by many as the basic academic unit of scientific training and of everyday scientific work and knowledge structures. . . many observers now see scientific specialties or research areas. . . as the fundamental units of scientific advance."

Hence, scientific disciplines are the basic academic units of science where student education and academic careers are established. Scientific specialties on the other hand, form the locus of scientific change that may eventually result in the formation of new disciplines.

A specialty is characterized by an intensive interaction and communication among its members as well as with members of other specialties. If this communication that those scientists who are well-known receive more credit for their work than those who are less well-known. Hence, the Matthew effect strengthens stratification. ("For unto everyone that hath shall be given and he shall have abundance: but from him that hath not shall be taken away even that which he hath," according to the Gospel of Saint Matthew, Chapter 25, verse 29).
crosses disciplinary lines, interdisciplinarity may be a norm rather than an exception for members of specialties. But how do specialties themselves develop within a discipline? Are there certain factors that determine specialty-formation?

Many authors have studied the development of a specialty. This is an important and interesting topic, since specialties may ultimately lead to the formation of new disciplines. For example, Griffith and Mullins (1972:959) have shown how major changes in disciplines have been generated by small, active "socially coherent groups." In the late 1940s, the "phage group" under the leadership of Max Delbruck at the California Institute of Technology, originated molecular biology (Mullins, 1972). Similarly, the Copenhagen School under the leadership of Niels Bohr "has literally been immortalized in song and story as the birthplace of much of modern physics" (Griffith and Mullins, 1972:962). In conclusion, it appears that a "core" group of researchers who are in the same location, may be the organizational locus for major scientific shifts and

8 Although the few individuals, or the core scientists seem to be responsible for reform and advancement of the sciences, it can be argued that the contribution of "outsiders" (or, the "scatter" [Crane, 1969]) is an important factor in scientific progress. As Chubin [1976:448] writes: "The core researchers may derive innovations from the margins of their specialty."

Kuhn has observed the same phenomenon [1970:90]. He writes, "Almost always the men who achieve these fundamental inventions of a new paradigm have been either very young or very new to the field whose paradigm they change."
changes.

In the case of molecular biology, the phage group consisted of physicists who were looking for "scientifically interesting new avenues of research" in the field of biology. The physicists expected a physical solution that might answer the question, "What is Life?" The case of the phage group shows that scientists will cross disciplinary boundaries and organize themselves into a coherent group when they share a common research interest. Hence, the formation of specialties may involve interdisciplinary research. Bechtel (1986:30-31) has advanced other cognitive reasons for crossing disciplinary boundaries. Besides the need of expert knowledge from other disciplines to aid investigators in solving research problems, scientists may seek mechanisms applied in other fields to explain phenomena occurring in their own disciplines, or, as a result of integration with other fields, they may develop theories that will further guide their disciplines.

Griffith and Mullins (1972) elucidate another factor in the formation of specialties, namely the leadership role. They identify two different leadership styles: "intellectual" and "organizational." In order to survive, the core group should have an intellectual and an organizational leader, whether or not in the same person
The intellectual leader (or leaders) (i) lays the original conceptual foundations for work, (ii) makes public statements on theory and research, which normally result in an acknowledged theoretical break, and (iii) approves and validates others’ work. Moreover, an intellectual leader frequently functions as the central communicator within the group, although this role, which is partially a social one, may be dispersed among members of the group. The organizational leader arranges times, funds, and facilities for research and means for communicating findings and ideas. He arranges appointments in such a way that specific scientists obtain jobs in specific locations, organizes research programs and obtain funds, and guides the organization of meetings. Mullins (1973) has argued that the survival of the core group as initiator of a new discipline depends on several other factors as well. Resources are necessary, especially in the form of capable researchers and graduate students. In addition, the group needs its own theoretical concept to

9 Edge and Mulkay [1976:ch.9] made the same classification of leadership styles. An "intellectual or cited" leader is a leader who actively participates in research, and is therefore an "insider" for the group. An "administrative or supportive" leader is a leader who has a coordinating and stimulating task without participating in research activities. This leadership style might create a social distance between leader and members.
Mullins (1973:25-26) explained a "theoretical concept" as follows:

A theoretical orientation... different from that of the parent discipline -- developed and directed by an intellectual leader, verbalized in a program statement and supported by intellectual successes.

Furthermore,

An announcement or evident break in a given theoretical framework can be an important social mechanism... because it erects a barrier between those who accept it and everyone else. In addition,... a theoretical break provides personal motivation for fellow scientists [Griffith and Mullins, 1972:960].

Mullins thus claims that finding solutions for empirical research questions alone is not sufficient for the continuity of research and the survival of the group. A theoretical concept is also necessary.

Ben-David and Collins (1966:451) emphasize institutional dimensions in their interpretation of the formation of specialties. In their "role hybridization" thesis, they claim that the motivation of scientists to transfer to another research area is determined by the job prospects and the career distribution, i.e. the perceived greater chance of making a career in a new research area. Thus, Ben-David and Collins accounted for the creation of
psychology in the late nineteenth-century in Germany as a result of Wilhelm Wundt's migration from physiology, where opportunities and career advancement were limited, to a less prestigious discipline, philosophy, because he had a greater chance of making a career. Pointing to the importance of institutional factors, the authors concluded, that "a new idea is not sufficient to start the take-off into sustained growth of a new field; a new role must be created as well."

To conclude this section, the development of specialties, or disciplines, may involve any or all of the following factors:

(1) the existence of a critical mass or core group of researchers, (2) the presence of an intellectual and organizational leader, (3) the availability of a theoretical concept as basis of the research, (4) the availability of resources, (5) the possibility of the creation of a new role for the investigators, and (6) cognitive factors such as the need of specific knowledge to solve research problems. Since the formation of specialties may involve crossing disciplinary boundaries, these factors may be equally important in assessing the progress of interdisciplinary research.
Generally, the practice of science proceeds along disciplinary research traditions. This means that scientific work is performed at an academic department according to the rules and procedures of a discipline. However, the performance of interdisciplinary research may not fit into disciplinary traditions. What possible organizational and intellectual "frameworks" then, suit interdisciplinary research?

Unfortunately, there is no universally applicable strategy for the integration of disciplines. Rossini and Porter (1979:77) have suggested four ideal types of socio-cognitive frameworks within which interdisciplinary research can take place: (1) "common group learning" generates a common intellectual property belonging to the research group; (2) "formal modelling" can structure interrelationships, and, thereby, serve as an integrating framework; (3) "negotiation among experts" take place at the common boundaries between component analyses as these substantively affect each other's findings; and (4) "integration by the project leader" establishes one person as the sole repository of composite knowledge, obtained through one-to-one interactions with assorted experts. Although the authors acknowledge that each particular attempt at discipline integration needs its own
organizational strategy depending on the nature of the project, they do not propose organizational means for achieving the sociocognitive ideals they seek.

Continuing their account of interdisciplinary activity in organizational terms, Epton et al. (1983) suggest a way of devising organizational frameworks for interdisciplinary integration. Specifically, they focus on the interaction between the organization and the social environment in which the organization exists. They maintain (1983:21), for example, that "What the organization can do for the environment depends on what the environment is prepared to do for the organization." That is, the organization and its immediate environment are in a state of mutual dependence. This means that the institutional structure within which interdisciplinary research is performed should be ideally in a state of balance, or mutual support, with its environment, i.e. the university and the academic departments of the university. However, since the traditional disciplinary boundaries of departments are likely to be obstacles to the performance of interdisciplinary research, the university structure may often serve as an "external" constraint on the development and achievements of interdisciplinary research.

There may be other external factors as well, both inside and

10 Assuming that the institutional setting for the organization of interdisciplinary work is the university. Depending on the institutional setting, the organization could be industry-based, government-based, or exists as an interinstitutional unit [Epton et al., 1983].
outside of the university that play shaping roles.

But the performance of an organization is not only influenced by external constraints. "Internal" constraints, i.e. those originating from the internal dynamics of the organization itself, may also play important roles. As Mullins (1972; 1973) and Griffith and Mullins (1972) have shown, the formation of a specialty depends on several factors, such as the skill of leadership, the way members relate to each other, etc. It appears that the same array of factors may contribute to the internal dynamics of the organization of interdisciplinary research (Epton et al., 1983).

In sum, the performance of an interdisciplinary research organization is likely to depend both on the interactions with the external environment of the organization and on the internal dynamics of the organization itself.

STATEMENT OF THE PROBLEM

Drawing together these various strands of research, this thesis investigates the internal and external factors that shape the process of disciplinary integration within a single organization, a university-based research center. As shown above, existing research on interdisciplinary
activities tends to focus on the sociocognitive frameworks of such research. Although some authors point to the importance of organizational factors on sociocognitive developments, they do not elaborate the tension between the university and interdisciplinary work as a consequence of the institutional structure of the latter entity.

In this thesis I will provide empirical evidence that the institutional structure of the center under investigation has far-reaching consequences for the performance of the center. I do this by systematically distinguishing between external and internal factors. For example, I will explore the importance of financial support in the existence and performance of the center, an influence that has always been taken for granted by analysts. Financial support for a center comes mainly from two sources, the university and funding agencies. In this thesis, I argue that the university and funding agencies acting as part of the external environment of a center, play a direct role in shaping the development of research in the center and can serve as a crucial factor in the center's continued existence. The center's immediate environment, the university, thus exerts constraints on the center in at least two possible ways: through the university's departmental structure and through its willingness to support the center financially.

In the discussion above, I outlined some of the
internal factors that may contribute to the formation of a center, such as leadership and group composition. I will present empirical evidence that these factors play an important role in the performance of the Center that I have investigated. In addition to these factors, which previously have been examined in such works as Mullins (1972; 1973), Griffith and Mullins (1972) and Chubin (1976), I contribute another important factor, the career motivations of scientists for participating in interdisciplinary research. I argue that this factor contributes to the internal dynamics of a center and that it may shape the functioning of a center.

METHOD OF INVESTIGATION

I chose to study a single center in order to gain an intimate understanding of its developmental process. Another option was to conduct a quantitative survey of many centers, but this method would not provide me with as much information about internal structure as a detailed study of one center. Therefore, I adopted the approach of a case study, i.e. an analytical case study of a research center located at Virginia Tech. For reasons of anonymity, the center I have investigated will be called "University Research Center" (URC). The Center's research topic is in
the natural sciences. Since URC is only one of many centers at Virginia Tech, it is not necessarily representative of centers in general. But, at the same time, URC is a center with a complete life cycle and has existed for almost twenty years. It has stages of inception, growth and development, diminution and re-emergence. This circumstance provided me with the possibility to examine the longitudinal development of a center. A longitudinal study enabled me to identify the full range of internal and external factors that may influence the performance of a center.

I have gathered information about URC through a series of interviews. During the period of the study the interviewees were researchers affiliated with URC. Others who have been affiliated with the Center in the past were also interviewed. I have talked to URC's director and to one of the initiators of the Center. University administrators have supplied me with valuable information and have given me permission to study the written documents about URC (letters, memos and other written communication).

I have interviewed eleven persons who are, or who have been, related to URC's activities. The choice of interviewees started in an arbitrary manner, but developed further through a "snowball effect." The persons who were interviewed suggested other persons whom they thought could provide me with other kinds of information. The standard, open ended, questions were designed to clarify the internal
and external constraints on the Center's performance, but most persons told their experience with URC in a story-telling style. All interviews were recorded and transcribed. The duration of nearly all of the interviews was approximately one and a half hours. Data from these interviews were categorized, for example in data about leadership, about motivations, and so forth, and then further organized for presentation in this text.
CHAPTER III

URC's LIFE CYCLE

SETTING THE STAGE

The idea of coordinating interdisciplinary research in university-based research centers oriented to the needs of government and industry is a relatively new phenomenon. Yet, at the same time it has a long genealogy. Scientists have brought themselves into association for the purpose of furthering research since the earliest days of the scientific revolution. The first scientific societies were established in the seventeenth-century when science was a pursuit of gentlemen and amateurs. Professional associations have been in existence since the establishment of the Accademia dei Lincei in Italy in 1603 (Greenberg, 1967:12). By the time other scientific societies were founded in the 1660s, their purpose became oriented
towards the promotion of science and technology. The Royal Society in England (f. 1660) (Berman, 1978) and the Royal (or, Paris) Academy of Sciences (f. 1666) (Hahn, 1971) were both intended to advise the state in technological matters that would have potential military and industrial benefits, such as navigation, gun powder, and artillery. Similarly, in the United States the National Academy of Sciences (NAS) was chartered by Congress two centuries later in 1863. It was established as a honorary institution whose purpose was to provide scientific and technological advice to the government. Hence, providing scientific or technical information to government and industry has been one of the earliest scientific functions.

In nineteenth-century United States, the government was similarly interested in the application of science to practical problems. Basic science was rarely

11 The Academy was to report on scientific and technological matters in response to requests from any department of the government, but government did not often ask [Skevington, 1973:11; Greenberg, 1967:12]. During World War I, the Academy first realized that its honorary and advisory functions were not quite compatible, therefore it established the National Research Council (NRC) to serve as its major operating arm [Greenberg, 1967:13].

12 In the growing economy of a young country, technology and the application of science, which was mainly imported from Europe, was more important than the pursuit of basic science. The earliest instance of federal government support for non-governmental institutions in the United States can be traced back to the 1830s when the Secretary of Treasury contracted the Franklin Institute for the investigation of the cause of steam boiler explosions [Dupree, 1957:50]. Further government involvement in science during the nineteenth-century was through a number
supported by government. The practice of basic science was usually a part-time occupation carried on by amateurs and academicians who justly complained that "their research efforts were impaired by the necessity of earning a living" (Greenberg, 1967:56). However, by the last quarter of the nineteenth-century, basic science began to receive increasing attention from philanthropists and industry.14

During World War I, a brief allegiance developed of "scientific bureaus" in agriculture and through the extension functions of land-grant universities. Both establishments were to serve practical needs of farmers [Geiger, 1986:60].

13 The term "pure" or "basic" science/research is used here in contrast to "applied" science/research. "Basic research [refers to the pursuit of] . . . knowledge for its own sake. Applied research is directed to satisfying a stated need, such as finding a cure for a disease or discovering new ways to make planes fly faster" [Dickson, 1971:8].

14 This change was brought about by comparison with Europe. The lack of scientific universities in the United States increasingly attracted American students to study in Germany. The recognition of basic research in the United States was marked by the founding of the Johns Hopkins University in 1876, and particularly the Hopkins Medical School in 1883. The prestige of European institutions such as the Pasteur Institute (f. 1888) in Paris, and the Koch Institute for Infectious Diseases (f. 1891) in Berlin had greatly influenced the founding of American research institutions. At the time, Andrew Carnegie and John D. Rockefeller sought socially desirable objectives for the wealth they had acquired. As a result, philanthropist-endowed institutions such as the Rockefeller Institute for Medical Research and the Carnegie Institution of Washington were established for the advancement of basic science [Geiger, 1986].

At the same time, the development of industrial research and development laboratories provided an additional stimulus. Companies like General Electric and Bell Telephone recognized that expertise in basic research could improve their competitive positions [Greenberg, 1967; Wise, 1980].
between basic science and government as scientists joined the war effort. The scientists contributed to the development of new war technologies, but after the war the partnership between military and civilian scientists broke down. Cutbacks in military expenditures after the war forced military research and development bureaus to reduce their activities drastically. Chief among the budgetary difficulties, according to Kevles (1976:148), "was the disjunction between, on the one hand, the freedom demanded by civilian scientists and, on the other hand, the insistence of the armed services on controlling their own research. . . . [Thus] while the civilian scientists were willing to put up with secrecy in wartime, in peacetime they refused to submit to such regimentation." It took another wartime experience to establish a lasting partnership between government and basic science.

From 1941-1943, during World War II, numerous laboratories were founded. These included Los Alamos, Argonne and Oak Ridge laboratories. Scientists in these laboratories worked in large interdisciplinary teams on projects with military aims. At the same time, laboratories for research with military utilizations were established at universities. The Radiation Laboratory, or "Rad Lab," at MIT was intended to manufacture a radar device that would use microwave radiation for the detection of German night bombers that were attacking England (Kevles, 1978:302-303).
At the Metallurgic Laboratory at the University of Chicago, the main purpose was to transform non-fissionable Uranium-238 into Plutonium that would fission like U-235 and could thus be used in an atomic bomb. The Metallurgic Lab and the Rad Lab were the first instances of "research centers" at universities.

The success of research centers, both at universities and at laboratories like Los Alamos, convinced the policy makers at the federal government of the importance of basic science and its utilization. They recognized that science and technology deserved government support, i.e. that public funds should be employed to support the acquisition of knowledge and the application of knowledge for public purposes (Greenberg, 1967:56).

After World War II, policy makers in the federal government, industry, scientific community, and public at large began to think about future research activities. Experience during the war showed that large interdisciplinary teams, complex instruments, generous funding and extensive facilities had brought about the

15 An obstacle in making a U-bomb was the separation of the two isotopes of Uranium: fissionable U-235 and non-fissionable U-238. By transforming U-238 into Plutonium, a difficult separation procedure of the two isotopes is avoided.

16 Daniel Kevles [1978:326] wrote, that it was A.H.Compton's (a physicist) initiative to create the Metallurgic Lab so that investigation of the U-separation by geographically isolated groups could be explored in a concerted fashion.
desired research results. "Bigness had become indispensable in many fields of research" (Greenberg, 1967:97), and science had become "Big Science." Through the efforts of Vannevar Bush, the institutionalization of support for basic research from the military services, and the establishment of the National Science Foundation (NSF), federal support for interdisciplinary work in basic science expanded significantly. Research centers multiplied.

The goals of these centers, though, shifted over the past few decades from war-applied technology to include economic goals. The success of the post-WW II centers has been based on a commonly accepted belief that economic activity, especially in high-technology sectors, depends

17 Greenberg [1967:11] for example, has made this popular distinction between "big science" and "little science."

"Big science is expensive science, involving large teams of scientists and technicians working with great facilities such as oceanographic vessels, nuclear accelerators, and radio telescopes. These cost a great deal to build and they cost a great deal to run. . . . Little science, on the other hand, involves fewer people per project and far less costly equipment, the extreme in this category being the lone theoretical mathematician whose tools are paper and pencil."

Price [1963:20,21,31] have advanced a more sophisticated explanation. He has claimed that science grows in an exponential fashion, and that this exponential growth eventually reaches some limit, or a ceiling, "which is the ultimate value of the growth beyond which it [science] cannot go in its accustomed fashion." After this saturation level, science can undergo a complete reorganization (and starts another exponential growth), or it can die. If science follows the path of reorganization, then, Price writes, "the state called Big Science actually marks the onset of those new conditions that will break the tradition of centuries and give rise to new escalations, violent hunting, redefinitions of our basic terms, and all the phenomena associated with the upper limit."
increasingly on inputs of knowledge through research and development and training of highly qualified professionals.

One approach in the United States has been the establishment of Engineering Research Centers (ERCs) and Science and Technology Centers (S&T Centers). ERCs are supposed to enhance the competitiveness of American industry through strengthened programs of engineering research and education (NAE, 1983). The establishment of S&T Centers was proposed by President Reagan in his 1987 State of the Union message (NAS, 1987:vii). S&T centers are patterned after ERCs and are now being set up with the aid of NSF (Hoch, 1988:150).

As previously indicated, the work described in this thesis is a study of the University Research Center. URC was not created as a response to NAE or NAS stimulation. It was established in 1970, and it has continued to function as a center since then. Although URC is not a product of NAS or NAE's idea of centers, URC has characteristics similar to either S&T Centers or ERCs. URC is interdisciplinary in nature, and has close ties with industry. Alongside research and education, it has a strong service mission, to serve not only industrial demands but also societal needs.

In the following sections, URC's life cycle is

18 In these centers, participation by industry, state government and other institutions are encouraged. Mostly, this will include financial support, although intellectual involvement is emphasized [NAS, 1987].
examined. The life cycle of URC consists of several phases. Phase one describes its inception in the early 1970s, i.e. how it was created and under what circumstances. Phase two describes the first decade after its establishment while the Center was in a period of growth and development. Very large cross-discipline, cross-department and cross-college projects were performed during this period. Phase three describes the five-year period following about 1980, when URC lost momentum. Its activities diminished and it struggled with lack of cooperation of scientists. In the second half of the 1980s the Center showed efforts of revitalization, which is the subject of Phase four. In each phase of URC's life cycle, the crucial factors are discussed. These factors have contributed to the determination of the existence and performance of the Center.

PHASE ONE: THE EARLY YEARS OF URC

The years of 1967-1968 were the inception years of URC, which began even before the initiators had actually thought of establishing an interdisciplinary center. At the beginning of this period, the goal was to build a good basic academic program within their home department, so they began to accumulate people specializing in their field. One of
the newcomers was a professor who would become the leader and director of URC. He was brought in for his recognized reputation among fellow scientists in his research area. Later, he was the person who brought up the idea to establish a "center."

Thus, in the late 1960s the effort was directed primarily towards the accumulation of scientists with the same research interest, and who did similar work. The establishment of a center for interdisciplinary research did not occur to them at that time. One of the initiating faculty members remembered, "... it was always my idea that those people will all work as a sort of critical mass. We didn't think of it at first as a 'center'... but what we want to do is gather people who were good researchers in [one specific research area]..."19 So a group in a department formed the nucleus for the eventual formation of URC. About the group, the same person said further, "I thought we had that really nice solid group of people who would work together."20

The initial objective in forming the group was to gain a reputation for the home department. By establishing a critical mass of very good scientists, strength might be achieved in a certain area. As a result, achieving a high reputation both for the group and for the home department

19 Interviewee #10.

20 Interviewee #10.
might be accomplished. Building on the strength and organization of the departmental group, the URC was formed.

The URC was officially authorized by the Board of Visitors of Virginia Tech in 1970. The main reason to establish URC as a separate entity was for the outreach capabilities to other departments that it would facilitate. As a separate entity, URC would probably also have more freedom of action compared to the initially established group which was a program within a department. URC, in spite of its status as a separate entity, was physically located in what was now the major cooperating department, its former home. As a separate entity, it had a director, assistant director, and secretarial position available. The director and assistant director held faculty appointments in the cooperating department.

Although URC was officially authorized as a university center, the university was not the driving force behind its establishment. Rather, it was the initiative of URC's director that has led to the realization of URC. The university administrators had merely formalized the existence of the Center. One of the original faculty members said, "... I do not think the University ever had really a lot of things to do with establishing the Center. It really came from us, and particularly from [URC's director]. He felt that it would be well to have a 'center' for research in that area set-up [as a ] sort of separate
URC's director remembered that, "... the executive vice president and the president [of the University] both wanted more interdisciplinary work...." It appeared that the university administrators wanted centers to enhance interdisciplinary research on campus, but faculty members were responsible for mobilizing support for each center. Financially, URC was primarily supported by grants and contract research funds from funding agencies, such as NSF and industry. The director was very active and successful in securing these kinds of funds. Supported by these funds, research was done and graduate students stipends were awarded. Participation of faculty, though, was on a voluntary basis. Only the positions of director, assistant director and secretary were paid from university, or departmental, sources. Most other needs of URC, such as technician support, equipment and so on, were paid with money from grants or contract research projects.

The most important factors in the inception of the Center are summarized in the following table (Table 1). The first three factors, i.e. the presence of a critical mass, research theme and strong leader, are internal factors. Financial support for the center may be classified as an external factor.

21 Interviewee #10.

22 Interview with URC's director.
Table 1. Crucial Factors in Phase One of URC's Life Cycle.

<table>
<thead>
<tr>
<th>URC started with:</th>
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<tr>
<td>internal factors,</td>
</tr>
<tr>
<td>1. a strong leader/director</td>
</tr>
<tr>
<td>2. a critical mass of researchers</td>
</tr>
<tr>
<td>3. a research theme</td>
</tr>
<tr>
<td>and external factors,</td>
</tr>
<tr>
<td>4. no significant financial support by the university</td>
</tr>
<tr>
<td>5. significant funds from funding agencies</td>
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Through the first decade of its existence, URC was very successful. It was productive in publications, in teaching graduate student courses, setting-up educational mini-course series for public school teachers, organizing workshops for teachers, scientists, industry, government, and so on. For example, between 1970-1977 URC sponsored or co-sponsored seventeen symposia and/or workshops. It conducted a "Seed Grant Program," which was established to fund research proposals submitted by principal investigators to pursue interdisciplinary work in the research area of URC. Fifteen projects were funded to individuals from 1970-1977. Furthermore during this period, twenty five research projects were funded with external resources totalling more than $1,000,000 (Anonymous, 1977). "In the three years immediately following 1976-1977 some very large grants were in a number of departments and colleges. The largest of obtained which involved large numbers of facultythese involved fifty- four faculty in fourteen departments in three colleges," wrote URC's director.23 He also reported that in the late 1970s grant funding was in excess of five hundred thousand dollars per year.24

Several favorable factors have contributed to the rapid

23 URC file.
24 Ibid.
growth and development of URC. As mentioned before, its
director has been, and remains, very active and successful
in the acquisition of funds from funding agencies. This
capacity is related to his prominence as a scientist. He is
respected for his scientific achievements by his peers, as
well as by industrial and governmental funding agencies.
The very high productivity of URC in terms of publications
and securing grants can thus be attributed to the activity
of mainly one single person, the director, who is primarily
the intellectual leader of the Center. Funds acquisition is
part of the task of an administrative leader, therefore in
this sense the director can also be regarded as the
administrative leader of the Center. The assistant
director, though, seems to be mainly responsible for the
organizational tasks.

All interviewees agreed that the director continued to
be the driving force behind URC. One said, "Well, right now
the center is running on the energy and under the guide of
[its director] from the conception."25 Another one said,
"... [The director] has always been able to maintain the
level [of external funds] that he has wanted to maintain in
any particular time."26 It appears that URC's director has
never had difficulty in attracting funds and getting
research results published. He himself said, "... I feel

25 Interviewee #3.
26 Interviewee #4.
that a center director has to be active in publication, at least this center [as a] research center. And if I stop publishing, and stop doing the work myself, I fail to get money. . . ."27

In the first decade of its existence, URC's research was in a "hot" area. Society in general was concerned about the problems in that area, major national legislation had been passed, and money for research was available from industry and government. Indeed, funds were abundant, and URC had practically no competitors in securing them. An interviewee recalled, "There was a lot of money from industry and government. And there wasn't a lot of people taking advantage of that money. . . . So [URC's director] was probably one of the few people in the country of university level that was doing that much work at that time."28

The abundance of funds and the presence of a well-known scientist at the Center had two side effects: the recruitment of capable researchers and graduate students. For researchers who were just beginning their careers, collaboration with someone as well-known as URC's director made it easier to get research proposals funded and to get research results published. For graduate students, numerous stipends were available. Most of these were supported

27 Interview with URC's director.

28 Interviewee #8.
through grants as graduate research assistantships. Moreover, the students knew that they would be more marketable after graduation when they had been affiliated with the Center. A member of the Center said that he would regularly receive phone calls from industries offering jobs for potential graduates.

In sum, the most important internal factor in the growth and development of the Center was the presence of its director who was a particularly successful intellectual leader. Because of his prominence as a scientist, he could easily acquire financial support from funding agencies. These funds were sufficient to cover all activities of the Center; therefore the lack of university support in this phase of the Center's development was not so pressing. Capable investigators and students were also available for high quality performance of the Center. In addition to these internal factors, external factors, such as popularity of the research field and absence of competitors, have contributed to the advancement of the Center. These factors are summarized in the following table (Table 2).

29 URC does not offer degrees. Most affiliated students graduate from its major cooperating department.

30 Interviewee #5.
### Table 2. Crucial Factors in Phase Two of URC's Life Cycle.

**Factors in URC's growth:**

**internal factors,**

1. successful intellectual leader/director
2. presence of an administrative leader/assistant director
3. capable researchers and graduate students

**and external factors,**

4. abundance of financial support from funding agencies
5. popularity of research area
6. no competitors
PHASE THREE: THE DIMINUTION OF URC

After the "booming" 1970s, URC entered a phase of diminution in the early 1980s. There were no longer large interdisciplinary projects that involved several departments and colleges. There were fewer projects, publications, and seminars.

One can indicate several causes for the downturn. The complexity of these factors, though, makes it difficult to avoid misunderstanding. Therefore, I have classified the factors into four groups: (1) funding, (2) leadership, (3) institutional structure, and (4) type of research at the Center. This classification does not mean that the four groups are separate from each other. On the contrary, they are so interconnected that without this classification one might find the whole complex of causes hopelessly confusing.

(1) The decrease in available funds is the most tangible and easy to comprehend. In the early 1980s, financial support from funding agencies became less abundant. There were two obvious reasons for the diminishing trend. Firstly, industry, government and society at large lost interest in the area of research. Secondly, the presence of competitors increased. Thus, even while support from funding agencies in general was decreasing, URC faced increasing competition from other universities and private consulting bureaus in securing
these funds. Said a former member, "... I think the reasons are that there's probably not so much interest now. ... as there was in those days. There's a lot of competition now for the money that's out there. ..."31

However, more important than support from funding agencies is the financial support from the university. From the very beginning, the university has never given much support to URC, "verbally yes, but not tangible."32 A member of the Center explained it this way, "If the university had a great desire to make the Center larger and more powerful, then I would say that [what] the university could have done was, give more positions to the Center and things like that. ... But they were never willing to increase the budget, to put more people, to put more staff into the Center, give the Center any great deal of space. ... So it [university] started [formally agreed on the establishment of] the Center, but then it never nurtured the Center. ..."33 While funds from funding agencies slowly dried up, the already small university support also decreased. The position of assistant director was eliminated in 1983. It is not altogether clear what led to the elimination of this position.

In his interview, URC's director said that the loss of

31 Interviewee #8.
32 Interviewee #4.
33 Interviewee #8.
the assistant director "caused" URC to lose large interdisciplinary projects. One of the functions of the assistant director was that of a "back-up" person, or an "alter-ego," i.e. a person who could act for the director in his absence. Other functions were to assist in the preparation of proposals, publications, and budgets. He was also responsible for overseeing the activities of the staff, graduate assistants, and post doctoral fellows. Hence, in the presence of the director, who is the intellectual leader of the Center, the assistant director primarily functions as an administrative leader. According to the director, a back-up person is of utmost importance in securing large grants. For large interdisciplinary projects, granting agencies always want to know who the director is and who can act in his or her absence. "Without the back-up person," said URC's director, "one can't get the big grants."34

On the other hand, the director appeared to have agreed that the position of assistant director was no longer needed because "the Center was not getting the types of grants that required that position to be occupied."35 From this statement, it seems that because of the loss of large grants, the position of assistant director was no longer needed and was thus eliminated, and perhaps not the other way around.

34 Interview with URC's director.
35 URC file.
(2) Leadership is probably one of the most important factors in URC's life cycle, not only during its inception and development, but also during its diminution. A major difficulty was the interpersonal conflicts. In the first place, since the Center was physically located at the major cooperating department, pragmatic problems were unavoidable. For example, the allocation of space for URC, the controversial division of returned overhead money between the Center and its major cooperating department,36 and the collective use of equipment, were some of the sources of friction. However, one could not rule out that it was probably URC's very success that had provoked the conflicts. Said one member, "... it was sort of a 'new body on the block'... who comes in and takes over a lot of the stuff the other people didn't like... ."37

Secondly, the director had difficulties in keeping

36 The returned overhead from grant or contract research funding through the Center is divided between the research division of the university, the state government and the Center. The Center has negotiated with the university that it can keep a large percentage, for example, 60%, of the overhead. The state of Virginia gets 30% and the research division 10%. The returned overhead money is controversial because, should the grant have come through a department, the division of the overhead would be different. Depending on the department the split would be, for example, the state government 30%, the research division 20%, the college 25% and the department 25%. Thus, the division of returned overhead money is better for grants that are routed through the Center. Yet in such case, the department and the college do not receive their fair share of credit for that funding, while these projects use department resources [Interviewee #4; URC-documents].

37 Interviewee #8.
together the initial core or critical mass of research participants. From the view of participants, the main problem was a "personality matter," as they called it.38 It seems that the participants did not feel comfortable working for URC's director. Possibly, the loss of the assistant director who was mainly the administrative leader of the Center, have contributed to the disassociation of the core group. In fact, the director himself was not a very good administrative leader.39

Thirdly, the participants also lost interest in the Center's research. They were young and inexperienced when they joined the Center. "[It was] the greatest thing in the world to advance our careers," said an interviewee, "because [URC's director] was there, and he has a big name. . . ."40 But when they matured, they had their own goals, and "it wasn't always involved doing what somebody else wants you to do. . . ."41 Possibly, the participants also lost interest because of the type of research they were doing. Almost all of the work was directed towards solving a problem that industry or government had at a particular time, and such work became very repetitive.

(3) The institutional structure of the Center also

38 Interviewees #6, 8 & 10.
39 Interviewee #10.
40 Interviewee #8.
41 Interviewee #8.
provided a source of problems. Since URC is not an academic unit, and has no resident faculty, its projects depend on the voluntary cooperation of researchers. An interviewee said, "[URC's director] doesn't have control over those people [researchers] whatsoever. All he can do is suggest and convince people that it is a good idea. . . ."42 On top of this, tenure and promotion considerations and departmental barriers may discourage a researcher from participation (see below, chapter 4). In short, URC had to cope with a lack of cooperation. It could not get the researchers needed for certain large projects. In this connection, the director said, "... there's a lot of grants that we could easily get, but we can't take, because we can't get the cooperation. . . because people can't participate or they won't, they're afraid to participate because they don't have tenure. . . ."43

The lack of cooperation of researchers, and the dissociation of the initial core group, led to the loss of the critical mass for an efficient functioning of URC. This may explain the inability of the Center to secure grants for large interdisciplinary projects, and accordingly the elimination of the position of assistant director. Yet at the same time, URC's director explains the loss of the position of assistant director as a consequence of the

42 Interviewee #8.

43 Interview with URC's director.
reward system. The assistant director held a faculty position in the major cooperating department which was responsible for the decision on his promotion. Although the director supported his case, the department declined to promote him. When promotion of the assistant director was not granted, the assistant director left the university. As a result of the loss of the back-up person, no large grants were acquired, etc. In this case, one might conclude that alongside the considerations mentioned above, the inherent tension between the departmental structure of the university and the organization of interdisciplinary research had indeed far-reaching consequences.

(4) The nature of research may also have caused dissatisfaction among the participating scientists. Most of the work was solving problems, and gradually this type of work became very repetitive. Also, according to an interviewee, such work did not really match with the "philosophy" of most of the core group researchers, which was to learn more about the nature of the processes involved. He said, "... a lot of stuff we were generating was indeed new and helpful information. But after a while it started getting very repetitive anyway, it wasn't really that critical anymore. ..." 44 Another interviewee added, "... in exchange for that [money] we often have to do

44 Interviewee #8.
specific testing for that company. . . ."45

The nature of the research, i.e. repetitive testing and problem solving, had also produced the impression among the participants that there was no overall program specific to URC. The erosion of a coherent overall program may have contributed to the dissolution of the core group. "There weren't really internal goals and ideals set up, and so that. . . almost guaranteed that there [was going to] be a pulling apart of people. Because there was [sic] no goals that could keep us together. . . ."46

As the following table (Table 3) shows, there are internal and external factors that have contributed to the diminution of the Center. The first five factors indicated in the table may be considered as internal factors. Following the internal factors, are the factors external to the Center. Both sets of factors proved to be crucial in this phase of URC's life cycle.

**PHASE FOUR: REVITALIZATION OF URC**

After troublesome times of diminishing resources, loss of core research staff and large interdisciplinary projects, URC tried in the second half of the 1980s to re-establish

45 Interviewee #3.

46 Interviewee #8.
Table 3. Crucial Factors in Phase Three of URC's Life Cycle.

<table>
<thead>
<tr>
<th>Internal Factors</th>
<th>External Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Loss of administrative leader/assistant director</td>
<td>6. No reward system</td>
</tr>
<tr>
<td>2. Loss of critical mass</td>
<td>7. Diminishing resources</td>
</tr>
<tr>
<td>3. Lack of cooperation</td>
<td>8. More competitors</td>
</tr>
<tr>
<td>4. Interpersonal conflicts</td>
<td></td>
</tr>
<tr>
<td>5. Repetitive nature of research</td>
<td></td>
</tr>
<tr>
<td></td>
<td>9. Loss of large interdisciplinary projects</td>
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</tbody>
</table>
its strength and prestige by bringing in other areas of interest. Research affiliations new to the Center were added in order to enrich and expand the Center's research domain. These research programs had always been components of the Center's research, but previously they had not received much attention or emphasis.

In 1985, newly created positions of "associate director" were established. Three associate directors from different departments were appointed. At the same time, these associates were representatives of the newly emphasized research components. With these affiliations, the Center was renamed in 1986. Its new name indicates one of the new components of URC's activities.

The reorganization and name-change of the Center have implications both externally and internally to the Center. Externally, URC's name-change has altered the Center's image in public relations, and it may have benefited URC's activities in grant-acquisition. Through its new name, URC emphasizes an activity that funding agencies or other institutions outside URC had not known about earlier.

Internally, the new affiliations were supposed to help the Center re-establish close ties with other departments, and eventually faculty were engaged for participation in interdisciplinary projects. Apparently, URC was trying to neutralize its lack of cooperation by broadening its outreach to other departments through the newly appointed
associate directors. One member said, "He [the director] may have seen this as a way to... broaden the base, and to get more people involved..."47

The revitalization efforts of the Center, i.e. its re-organization and name-change, are summarized in the following table (Table 4).

EPILOGUE

The revitalization activities of URC have only been partly effective, however. The addition of new research components has kept the Center going, but it has not regained the vitality of the 1970s. It seems that loss of the core or critical mass of researchers continues to have significant deleterious effects on the Center's performance. The close "bonds" or collaborations that occurred among the early core participants have not yet been restored among the current researchers. The frequency and intensity of communications among director, associate directors and affiliated members vary. Some members meet with URC's director whenever they feel it is necessary, and they are quite satisfied with this arrangement. Others rarely meet with the director. It is quite interesting that most members whom I have interviewed do not know many of the

47 Interviewee #8.
Table 4. Crucial Factors in Phase Four of URC's Life Cycle.

Factors in the revitalization of URC:

1. re-organization
   - affiliation of new research components
   - appointing associate directors

2. name change
other members of URC. Some have never heard of the names of other affiliated members. It seems clear that the "socially coherent group" of the initial URC has not been restored in the new Center.

At present, there are no regular meetings or seminars for or by URC's members. It appears that the Center has not yet succeeded in engaging participants and restoring cooperation. In addition, URC's new image seems not so attractive as it might be. There are no particular, unique instruments that may make the Center attractive to other researchers. For some members, however, the Center has still much to offer, including joint proposals, joint publications, and so on. But for others, participation in URC has not made a lot of difference in their research activities.

In sum, the new URC serves different and varying functions for its current membership. As an interviewee put it, "The problem is that the Center is used somewhat unevenly by people who are involved. . . . I have an option, I can work here [own department]. [URC's director] does not have an option. . . . So I don't feel that the Center has evolved to the point where it is useful to my field, and I am not sure what it will take to get there."48

48 Interviewee #1.
CHAPTER IV

FINDINGS AND CONCLUSIONS

This chapter summarizes findings and presents conclusions. The findings consist of a survey of factors that influenced the development of a center, as evidenced by the experience of University Research Center. The factors are divided into two groups: internal and external.

The internal factors influencing a center’s development include intellectual leadership, administrative leadership, a critical mass of scientists, a research theme, and a theoretical concept serving as the basis for research. An additional set of internal factors that emerged through the case study of URC consists of motivations that scientists exhibit for participating in a center.

The external factors discussed are divided into two groups: (1) effects of the departmental structure of the university, and (2) effects of funding levels. The
university departments as part of the immediate environment of a center, influence the development of a center in several ways, including the institutional structure, funding levels and the reward system of a center. Factors from the wider environment of a center, i.e. from outside the university, include funding from outside agencies, popularity of the research area and the presence or absence of competitors.

Authors such as Mullins (1972; 1973), Griffith and Mullins (1972), Chubin (1976) and Crane (1969) have reported that certain factors are necessary in the formation of specialties. The analysis of URC, shows that the same factors proved to be important in the development of the Center. In other words, these factors contributed to the internal dynamics of the Center, and ultimately to its accomplishments. A set of factors that has not been reported previously by the above mentioned authors is the motivation of scientists to participate in interdisciplinary research. This thesis thus advances another internal factor that may influence the performance of a center.

Epton et al. (1983) have referred to the interdependence between the organization of a center and its immediate environment, the university departments. Following this idea, I will describe two possible institutional structures in which a center can be embodied. Both structures are directly affected by the university
departments, and both of them have strengths and weaknesses. Another external factor that I will discuss is the funding patterns of outside funding agencies and of the university.

After the presentation of findings, the chapter concludes with a summary discussion of both the ideals and the realization of university-based research centers. This discussion considers the relationship between the organizational features and the ideal sociocognitive objectives of interdisciplinary research.

**INTERNAL FACTORS**

Various factors determine the internal dynamics of a center. Several of these factors have been described during the analysis of the case study.

**Leadership**

It appears that the presence of a leader is one of the most important factors in the functioning of the Center. In URC's case, the director is the driving force behind the Center. His prominence in the scientific world has made him highly regarded by fellow scientists, governmental and industrial partners. As the "intellectual", or "cited" leader of the Center, he is responsible for the enormous output (books, scientific articles, graduate student courses
etc.) of the Center. He is also the person who has secured most of the external grants for the Center.

URC's case study has shown another factor that is indispensable for its long-term performance. It seems that interpersonal conflicts have contributed to the dissociation of the core group of researchers. Without the core scientists, URC has not been able to maintain its high performance. Presumably, a good "administrative," or "organizational" leader could have prevented the conflicts and would have kept the core group together.

In sum, the two types of leadership indicate the co-presence of social and cognitive factors in the Center's performance, i.e. the intellectual leader as a cognitive factor and the administrative leader as a social factor.

Core group

The importance of a core group of scientists is particularly shown in the revitalization efforts of URC. After most of the initial core scientists had left URC, the Center had not been able to gain support from a group of researchers like the initial core group provided. In the new URC, most affiliated members worked on their own. Some members needed the Center only for grant proposals as a "name" of an organization with which they are affiliated. Some members have never heard of other members. In short, communication among affiliated members had become relatively
scarce.

If the availability of a core group of investigators is necessary for the optimal performance of the Center, it is important to know the reasons for the dissolution of the core group. Why was the core group dissolved? One possible answer is already suggested, the interpersonal conflicts. Yet another probable answer is the lack of an "internal program" or "theoretical concept" that serves as a guideline for the Center's research activities. URC's activities have always been oriented towards solving problems within a certain research theme. Initially, solutions for these problems were novel scientific findings. However, in the long run the work appeared to become repetitive. The participants felt that there was no "internal program or goal" of the Center, and as a result they drifted away.

To summarize, the performance of the Center has been affected by communication and interaction among participants as social processes, as well as by cognitive factors such as a research theme and theoretical concept.

**Motivations**

I have made a distinction between "scientific" and "academic" motivations. Scientific motivations are those which are directly related to the science, or to the practice of science. Academic motivations, on the other hand, are those which are related to other activities of
researchers as members of the university community. Overlap between scientific and academic motivations is inevitable, yet for the sake of clarity I have kept the two motivations separate.

Scientific motivations.

One obvious scientific motivation is solving research problems. As a URC-member said, "The idea behind... funding [interdisciplinary research] is to bring (two) people together, to cooperate in a study so they would learn from each other. And we (both) learn a lot from each other. Perhaps it's not so much new knowledge, but using knowledge that already exist to solve our problems, and to get a better understanding."49 Not surprisingly, most interdisciplinary research areas are new fields, where unknown answers to many questions still exist.

Another scientific motivation, closely linked with the drive to solve problems, is expertise exchange. The person quoted above continued, "I am lending them my expertise to strengthen the Center. The Center in its turn is helping me to do research I felt like needs to be done, and provides me with some expertise and viewpoints that I wouldn't ordinarily have."50 Sharing expertise, instruments, technicians and administrative support are advantages of

49 Interviewee #3.
50 Interviewee #3.
(and thus, motivations for) interdisciplinary research.

Yet another scientific motivation is to coordinate ties with fellow researchers who address the same problems from different viewpoints. One of the reasons for establishing URC was that the Center has a much wider outreach than an individual could possibly have. It is much easier for the Center, compared to individual researchers, to attract investigators from several departments to cooperate in joint projects. Furthermore, a researcher might possibly feel more at ease doing non-standard departmental research under the protection of the Center.

Academic motivations.

Having a well-known person in the Center, especially when the person is the director, is a great support in writing proposals and setting-up projects. An experienced scientist can give advice in the preparation of a strong proposal and may suggest suitable researchers for collaboration in certain projects. He or she may also give an opinion as to whether one should pursue a project or not, and so on. Naturally, joint proposals with someone well-known will receive more attention, and may eventually be funded more easily. The same applies for joint publications. Peer reviewers may appear to trust, and accordingly, give such publications a higher rating than work of an unknown researcher (Merton, 1973).
Another academic motivation for doing interdisciplinary research depends on the popularity of the research area. For "hot" research areas, i.e. areas that are in demand by industry, government, or society at large, a great deal of research money is practically always available. As a result, it is attractive to do research in such areas, since it is easier to get funds from industry or government agencies. Furthermore, the acquisition of these grants helps to attract capable graduate students because many stipends become available for them. In addition, students who enter a "hot" research area know that they will be very marketable after graduation.

Another motivation to join interdisciplinary teams is to increase the base of one's research activities. Rather than working merely within the standard discipline, researchers may want to expand their activities into non-traditional research areas.

A summary of the internal factors that contribute to the development and the performance of the Center is outlined in the following table (Table 5).

**EXTERNAL FACTORS**

In this section two main external factors are discussed, (1) the university departments, and (2) the availability of funds. The university departments affect
Table 5. Internal Factors Influencing the Performance of the Center.

Leadership
Cognitive: intellectual leader
Social : administrative leader

Core group
Cognitive: research theme
theoretical concept
Social : communication
interaction

Motivations
Scientific: solving research problems
expertise exchange
coordinate ties
Academic : joint proposals and projects
joint publications
funds acquisition
increasing base of research activities
the Center in at least three different ways, through the institutional structure of the Center, the reward system, and financial support. Two main sources of funds are discussed, university funds and those from industry and government agencies.

The university departments

"I had two choices when the Center was formed," said URC's director in an interview. "One way [was] to form a center [as] a department... but it could easily be called a 'center'-- and hire[d] a specific mixture of disciplines." If a center is considered to be a unit not equivalent to a department, he said, "A center should have the flexibility to put on the people that the problem calls for, not the people who are there. . . . So, I chose th[is] route." Hence, a center could resemble a "department" with a fixed combination of faculty members from several disciplines, or it could be a "truly interdisciplinary" center with no fixed faculty, or a "cluster." URC is a center with the latter institutional structure.

Theoretically, a cluster is the ideal way to organize interdisciplinary research. The strength of an

51 Interview with URC's director.

52 Bechtel [1986:36] used the term interdisciplinary research clusters. Following Bechtel, in this thesis truly interdisciplinary centers without resident faculty are also denoted as "clusters."
interdisciplinary cluster is that it can gather the best possible combination of scientists from various university departments for each interdisciplinary problem. By nature, interdisciplinary work demands a variety of expertise. With no fixed faculty, a cluster can choose the best researchers suitable for each project. In actual practice, though, the realization of this ideal is far from easy.

Generally, interdisciplinary clusters have a major cooperating department. In the case of URC, the Center is physically located in proximity to its major cooperating department. As a result, pragmatic matters such as the allocation of laboratory space to the Center and the joint use of equipments, have created problems that may have led to the decline of URC.

Another problem in interdisciplinary clusters, is the lack of an adequate reward system for its participants. Researchers who participate in projects of interdisciplinary clusters have a dual loyalty. They are accountable to their home department where tenure and promotion decisions are made, and they are also responsible for their work in the Center where no merits regarding tenure and promotion can be gained. Recognition for center research can be achieved only when home departments approve of the effort. As a consequence, untenured faculty members may be discouraged from participation in such centers. Furthermore, participation is on a voluntary basis. URC's director
cannot force anybody to participate. Consequently, sometimes it is not possible to form a team with the required expertise. Moreover, once a team is formed, one may not necessarily expect a consistent performance and functioning of the team throughout the duration of the project. Certainly, a major factor in the efficient conduct of a team oriented research project is the ability of the members to work as harmoniously as possible with each other.

In addition to tenure and promotion considerations, departmental barriers might discourage people from participation in clusters. Naturally, the Center's director should choose the best researchers for the Center's projects. Since participation in such projects means a commitment to the Center for at least the duration of the project, home departments of the investigators might have reservations about faculty members working on the Center's projects. Hence, even when a scientist has already agreed to participate in a project, there still may be resistance from the home department.

A solution for these problems is probably the establishment of centers as "interdisciplinary departments"53, i.e. centers with resident faculty members who are qualified for tenure and promotion. The most tangible advantage of having a center with a quasi-departmental structure is the availability of a fixed team.

53 Expression of URC's director.
of scientists. They form a stable team of researchers who are accustomed to work in an interdisciplinary fashion. This is very important in competitive grant applications since one can rely on such a team for consistent functioning. Moreover, each member has only one single accountability, i.e. to the center. Each member is hired as a faculty member of the center, and evaluations for tenure and promotion is the center's responsibility.

A limitation of a center with its own resident faculty lies in the fixed combination of researchers. As previously mentioned, each interdisciplinary research problem requires a different combination of expertise. A fixed team of resident research faculty, cannot be as flexible, and accordingly, not as good in attacking diverse interdisciplinary problems.

As the following table (Table 6) shows, both institutional structures of centers have strengths and weaknesses. The choice between these two structures is therefore hard to make.

**Funding**

URC started with practically no direct support from the university. Most funds came from industry or government agencies through grant and contract research projects. In the first phase of URC's life cycle, i.e. in its growth and development stage, the Center had sufficient funds from
Table 6. Possible Institutional Structures of Centers (P&T=
Promotion and Tenure).

<table>
<thead>
<tr>
<th>INSTITUTIONAL STRUCTURES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interdisciplinary</td>
</tr>
<tr>
<td>&quot;department&quot;</td>
</tr>
<tr>
<td>e.g. URC</td>
</tr>
<tr>
<td>- a fixed faculty</td>
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<tr>
<td>- P&amp;T possibilities</td>
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</table>

**Strength**
- stable and consistent functioning team
- possibility of forming a perfect team of required expertise

**Weakness**
- limited capacities of fixed team
- no reliable, stable team :
  - voluntary participation
  - departmental unwillingness
outside agencies, consequently university support was not that important. However, in phase two, when URC entered a diminution phase, outside funding as well as university funds diminished.

Several factors can contribute to the diminishing financial support from outside funding agencies. In URC's case, the decrease in the popularity of its research area and the presence of more competitors were the main factors. At the same time, university support was cut back with the elimination of the position of assistant director. One of the consequences was the falling apart of the core participants of the Center.

In fact, for interdisciplinary clusters such as URC, financial support from university resources became particularly important when outside funding decreased. Such centers have to rely on voluntary participation of scientists from several disciplines or on researchers who are paid from grant or contract money. When a contract or grant ends, participation of these latter researchers are likely to be discontinued. And since interdisciplinary clusters cannot reward its participants in terms of tenure and promotion, participation of investigators from other departments is not particularly attractive.

On the other hand, a center with a permanent staff of investigators may have less financial pressure on its performance even when grants or contracts from funding
agencies for one or another reason diminish, because the salaries of resident faculty are paid from the university budget.

As the following table (Table 7) shows, external factors influencing the Center's development can be classified as those factors which are consequences of the university departments as part of the immediate environment of the Center, and factors originating in the wider environment of the Center, i.e. outside the university.

The immediate environment of the Center, the university, affects the performance of the Center in at least two ways: (1) through the institutional structure of the Center itself, and (2) through financial support. In the wider environment of the Center, funding agencies affect the Center's performance through grants and contract research funds which are related to the popularity of the research area and the absence of competitors.

SOCIOCOGNITIVE IDEALS AND ORGANIZATIONAL REALITIES

Ideally, a center ought to be a mechanism for encouraging interdisciplinary research and education. When describing this "mechanism" one understands a sheltered, or central place, a unit, a formal entity recognized by the university; or a means, a way; or even some kind of a
Table 7. External Factors Influencing the Performance of the Center.

<table>
<thead>
<tr>
<th>Factors in the immediate environment of the Center, i.e. the university departments,</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. the institutional structure</td>
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<tr>
<td>2. the reward system</td>
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<tr>
<td>3. funding by the university</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Factors in the wider environment of the Center, i.e. outside the university,</th>
</tr>
</thead>
<tbody>
<tr>
<td>4. funding by industry and government agencies</td>
</tr>
<tr>
<td>5. popularity of research area</td>
</tr>
<tr>
<td>6. competitors</td>
</tr>
</tbody>
</table>
catalyst function to enhance interdisciplinarity, i.e. to
draw researchers from several disciplines together. As an
affiliated member of URC aptly put it, "It is a mechanism
primarily to bring people together who might not normally
work together, or might find some other barriers. . . ."54

The best way to realize interdisciplinary research
within a center is to create collaborative research
projects. As a URC-participant said, "... the Center has
to generate a single project that researchers share, [and]
the best way is to keep the project in the Center."55 In
this way, researchers share each others expertise -- which
might not be possible otherwise. Moreover, at centers such
as URC, most research is focused on solving research
problems generated by academia, government and industry.

Furthermore, a center ought to be a place for
interdisciplinary education of students. The ultimate goal
of interdisciplinary training is to prepare students as
professionals who are able to think and solve problems in an
interdisciplinary way. An interdisciplinary trained mind
should be able to see the different aspects of a problem,
and to attack each part of the problem with suitable tools,
if necessary from different disciplines.

In short, a center provides a locus for seeking to
achieve the sociocognitive ideals of interdisciplinarity,

54 Interviewee #1.

55 Interviewee #1.
such as solving interdisciplinary research problems, facilitating mutual research projects, expertise exchange and providing interdisciplinary education.

However, since these ideals must be realized in a university-based organization, organizational factors play important roles in shaping the organization, i.e. the center. In this thesis I have sought to identify the range of factors that influence centers. These factors are summarized in Tables 5 and 7. It is important to recognize that in this presentation I have sought only to identify the range of factors that could prove relevant to any particular center. I have not examined the range of possible relations among these factors nor have I attempted to determine their relative importance by, for example, devising weighing measures. Nevertheless, even simply identifying lists of potential factors can provide participants, administrators and policy makers with some guidance in devising strategies to deal with specific problems and in formulating the structure of new centers. As previously indicated, these factors include both social and cognitive factors.

For the long term performance of a center, both administrative and intellectual leaders are necessary. Furthermore, it appears that support of loyal participants is necessary for a maximum performance of a center. Perhaps a core group may not be imperative to the functioning of a center, but at least some identifiable researchers who
regularly participate in a center's projects are of particular importance. Communication and interaction between participants, as well as a theoretical concept as basis for research activities, appear to be indispensable.

It is also important to note that a single person can be responsible for the major part of a center's production and for the acquisition of most external funds. This has at least one important implication. It implies that a mere quantitative measure of the performance of a center, i.e. by counting the number of produced articles, or the amount of grants acquired, does not reflect accurately the internal dynamics of a center.

As indicated before, university support is an important factor in the functioning of a center. Even when a center is created as a "bottom-up" action of a single person, in contrast to a "top-down" action in which university administrators initiate a center, the university could have given more support. For example, to make a center more attractive to participants, unique instruments, the availability of laboratories, technicians, etc., may have encouraged cooperation of researchers. On the other hand, one cannot deny the fact that the university cannot support all initiatives equally well. Therefore, it is important for the university administrators to anticipate the conditions of the establishment and the discontinuation of a center before they formalize the existence of such a unit.
If a center performs below a certain level of excellence, it is also the task of the university administration to discontinue the existence of such centers.

The interpretation of the aforementioned range of factors affecting a center's performance makes it also possible to construct generalizations about the organizational characteristics of university-based research centers.

Since the availability of funds is an important factor for performing research in general, a center frequently serves as an administrative structure to attract necessary research funds. As a consequence of recent encouragements to establish centers, the word "center" seems to work like a magic word for funding agencies. Funding agencies possibly assume that the availability of a center is a guarantee for a central place, or at least some kind of coordination of the proposed research project.

In the context of the departmental structure of universities, the exercise to establish centers may be just an attempt to achieve more structure in the university hierarchy. At least for the community outside the university, it looks more structured to have formally organized centers, rather than undiscernible teams all over campus. Thus in this case, a center functions as a formal entity to help maintain prestige, competitiveness, and institutional clarity. For researchers, teaming up in a
center is sometimes a necessity to overcome bureaucratic barriers. It may also help them to reach their goals more efficiently. A center then, is a protective umbrella for scientists who pursue interdisciplinary research.

The motivations of scientists to participate in interdisciplinary research projects, show that a center may function as a locus for career development. A center may function as an administrative structure to attract funding, or as a means to improve the image of its participants in publications and accordingly to get more recognition among peers. A center may also be a place to broaden one's base for research activities, to coordinate ties with other researchers, to exchange expertise, or to solve research problems.

In order for a center to function effectively, it must perform all these functions simultaneously and with some degree of balance.
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