# ORGANIZATIONAL INNOVATION IN THE JAPANESE BASIC RESEARCH: CHALLENGES AND PROBLEMS*

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## Abstract

While Japan is becoming a leader in engineering or development, it still lags behind western countries in the field of basic research. One of the most critical reasons for this lies in organizational characteristics and management styles in basic research institutes in Japan. Most of Japanese basic research institutes can be characterized as *bureaucratic organizations* which primarily pursue stability and continuity of researchers and research activities at the sacrifice of flexibility and fluidity. Much of the literature on R&D management has argued that such a lack of flexibility and fluidity in organizations has negative effects on performance as a result of the decrease of technical communication among researchers. In the case of basic research organizations, the decrease of external communication accompanied with excessive organizational ability is especially problematic in terms of research performance. Recently, however, totally new types of basic research institutes called *dynamic network organizations* have been increasingly established in Japan. The dynamic network organizations can be characterized by exceptional flexibility and fluidity in management systems. The most substantial example of the experiment of the dynamic network organization in ERATO (Exploratory Research for Advanced Technology), a government sponsored lab. By comparing ERATO and one of the most distinguished basic research institutes, MITI laboratory, which is a typical representative of bureaucratic organizations, this paper explores the effectiveness of the emerging dynamic network organization and the problems of the bureaucratic organization in Japanese basic research in terms of researchers' communication behavior and performance.

## 1. *Introduction: Problems and Challenges in Japanese Basic Research Organizations*

Recently, sources of competitive advantage of Japan have been shifting from manufacturing to R&D (Porter, 1990). Japan is now becoming a leader not only in manufacturing but also in engineering such as product and process development (Okimoto, 1986). On

the other hand, still lagging behind western countries, Japanese contributions in the field of basic research are less significant (Sakakibara, 1991).[1]  One of the most critical problems of Japanese basic research lies in management styles in basic research organizations in Japan. Most of Japanese basic research organizations, especially universities and national laboratories can be characterized as *bureaucratic organizations* which pirmarily pursue stability and continuity of research staffs and activities at the sacrifice of organizational flexibility and fluidity.  For example, considering human resource management in Japanese basic researcs organizations, almost all of them basically hold lifetime employment and uni-dimensional promotion systems based on seniority.  Under such bureaucratic management systems, once entering particular organizations, most of Japanese researchers stay with the same research organizations throughout their careers.[2]  Bureaucratic organizations which are now dominant in Japanese basic research include some advantages in the sense that it becomes easier to carry out basic research activities in accumulative, systematic, and continuous ways, in order to learn from and catch up with basic research in western countries. At the same time, however, bureaucratic organizations obviously include some serious problems since they exclude organizational flexibility and fluidity which are essentially important in basic research activities.

Considering theoretical aspects of R&D management, much of existing literature has consistently argued that such a luck of flexibility and fluidity in bureaucratic organizations has negative effects on research performance as a result of the decrease of professional communication among researchers.  In R&D activities, it is quite important for professionals to collect and process information from a variety of sources.  R&D professionals spend a large amount of their time to collect and process information through various media such as technical reports, publications, discussion with others, and so forth (Allen, 1977).  Among them, face-to-face oral communication through personal contact is especially important, because it permits timely information exchange, rapid feedback, and critical evaluation, as well as the opportunity for real-time recording and synthesis of information (Allen, 1970; Allen, 1977; Tushman, 1979).

Professional communication can be categorized into two types: internal communication among professionals in the same organization, and external communication with those who belong to other organizations (Katz and Tushman, 1979).  The importance or effectiveness of either type of communication varies depending on charactetistics of R&D tasks.  In the field of basic research, external 'professional communication becomes critically important in terms of research performance, while engineering activities such as development and technical service need internal communication rather than external (Hagstrom, 1965; Allen, Tushman, and Lee, 1979).  One explanation for this heavy reliance of basic research on external communication is that, compared with more organizationally specific tasks such as engineering, basic research can be defined as a more universal task, and therefore it becomes impossible and  inefficient ￠to  secure  information  self-sufficiently  within  individual  organizations (Thompson, 1967; Mansfield and Wagner, 1975; Allen, 1977).  In this sense, external com-

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[1] For instance, according to *The White Paper on Science and Technology* (1992), a survey by STA reports that, among 12 important areas of technology development, Japan has advantages over U.S. in 6 areas.  At the same time, however, among 13 important areas of basic research, U.S. is superior to Japan in 9 areas.

[2] Nagata (1991) shows that more than 85 % of Japanese researchers whose ages are less than 40 have never changed their organizations.

munication among professionals has been recognized as a key variable in exploring the relationship between organizational behavior and performance in the field of basic research.

However, existing literature shows that, as organizations lose flexibility and fluidity, both internal and external professional communication decrease under such stable situations, and after all, this tendency results in a significant decline of performance (Pelz and Andrews, 1976; Smith, 1979; Katz, 1982). In the case of basic research, the decrease of external communication accompanied with excessive organizational stability is especially problematic since it leads to a serious decline in research performance. This kind of organizational phenomenon is often called a Not Invented Here (NIH) syndrome (Katz and Allen, 1982), and suggests the limits of Japanese basic research within bureaucratic organizations which inevitably exclude organizational flexibility and fluidity. Recently, this kind of organizational problem has been often argued in Japan. A number of researchers and managers in Japanese basic research organizations have claimed that the bureaucratic management systems foster some introversive mentalities of researchers which discourage professional interactions over boundaries of organizations, and become obstacles in strengthening Japanese basic research (Iinuma, Iinuma, and Kusunoki, 1991).

On the other hand, however, some interesting organizational experiments to overcome such Japanese problems in bureaucratic basic research organizations have come into operation. Recently, basic research organization with totally new management styles have been increasingly established in Japan. These newly established basic research organizations can be characterized by exceptional flexibility and fluidity in management systems. I label them *dynamic network organizations*. The creation of dynamic network organizations includes an aspect of "organizational innovation" in basic research in Japan. The most substantial case of the dynamic network organizations is ERATO (Exploratory Research for Advanced Technology), which was founded by government, Science and Technology Agency (STA).

Paying attention to the organizational innovation in Japanese basic research, this paper explores the effectiveness of emerging dynamic network organizations and problems in bureaucratic organizations in Japanese basic research in terms of professional communication and performance. The research is based on a comparative case analysis on ERATO and one of the most distinguished basic research institutes in Japan, a laboratory of MITI which is a typical representative of bureaucratic organizations.

## 2.   Research Methods

### 2.1   Comparative case analysis

The method used in the research is comparative case analysis based on "theoretical sampling." In other words, this research conducts an in-depth analysis of a sharply contrastable pair of basic research organizations which were carefully selected in the light of theoretical relevancy. The purpose of this research is to inductively derive a series of hypotheses out of empirical data, rather than to rigidly test specific hypotheses. Since this research is oriented toward hypothesis-finding, comparative case analysis based on theoreti-

cal sampling is more effective as a research method than others such as survey research investigations with large samples obtained from random sampling techniques (Glaser and Strauss, 1967). This method enables a researcher to shed light on critical differences between the cases, and to inductively explore various, complicated factors underlying the differences (Eisenhardt, 1989; Kanai 1989). Furthermore, since this kind of organizational innovation in Japanese basic research, the creation of dynamic network organization, is precisely a quite contemporary and experimental phenomenon, it is safe to say that this research focuses on a revelatory and unique case. In such a case, case analysis can be an effective research method (Yin, 1984).

The comparative case analysis was carried out by setting a conceptual taxonomy which contrasts the two ideal types of research organizations, the bureaucratic organization and the dynamic network organization, from the perspective of managerial characteristics in terms of organizational flexibility and fluidity. As shown in the next section (see Table 2), the taxonomy consists of six dimensions: (1) recruitment and staffing, (2) assignment, (3) employment, (4) promotion, (5) inter-individional transfer, and (6) sustainability of research activities. This taxonomy itself can be considered as a generic taxonomy including theoretical constructs to generally contrast various research organizations from the perspective of organizational flexibility and fluidity resulting from management systems. However, the taxonomy can be positioned at an empirical level as well as at a theoretical level, since is was empirically derived from the actual observation and comparison of the two organizations selected for the research.

## 2.2  Research settings

The organizations selected for the comparative case analysis are ERATO (the dynamic network organization), a basic research organization sponsored by STA, and MITI Laboratory (the bureaucratic organization), one of the most distinguished basic research organizations in Japan.[3]

In the first stage of the study, a pilot research including interviews and field-observation was conducted in order to select an appropriate pair of cases in the light of theoretical relevancy. In the pilot research, I collected various information concerning almost all of research organizations (n=5) that could be recognized to have substantially introduced flexible and fluid management systems such as a time-limited research groups, employment systems based on individual-based contracts, and so forth.[4] Among them, I selected ERATO as a representative of the dynamic network organization, because it was the pioneering and the most substantial case of dynamic network organizations. According to interviews with managers of the four remainders, they could be regarded as followers of ERATO in the sense that they had been consciously learning from ERATO's experience.

At the same time, I explored an appropriate case of the bureaucratic organization which, could be considered as a theoretically comparable counterpart. As a result, MITI-L was selected as a representative of bureaucratic organizations. The reasons were as follows.

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[3] "MITI Laboratory" is a provisional name.
[4] These five organizations were ERATO, International Frontier Research, Center for Photo-dynamics Study, Kanagawa Academy of Science and Technology, and Osaka Bioscience Institute.

First, as discussed in the next section, MITI-L is in striking contrast to ERATO in terms of organizational flexibility and fluidity. Along the six dimensions included the taxonomy, MITI-L appears to hold typically bureaucratic management systems.

Secondly, apart from such organizational and managerial characteristics, MITI-L is so similar to ERATO that the comparative analysis can avoid effects from other factors which were not directly related to the interests of this research. The task characteristic of MITI-L is consistent with that of ERATO in the sense that both were conducting basic research,[5] and the specialties of research activities in MITI-L are similar to those of ERATO. Both organizations are divided into several research departments including 20–30 researchers. In both organizations, research groups, the smallest organizational units of research activity, have specific research themes and consist of 5–10 researchers. Furthermore, there is no difference in the amount of research funds. The average budget per one researcher is approximately $150,000 in both organization. In sum, between ERATO and MITI-L, there is little difference in aspects mentioned above, while they offer remarkable contrast in managerial characteristics on which the comparative analysis focused.

Finally, MITI-L is precisely one of the most distinguished basic research organizations in Japan, and it has established remarkable reputations in the field of basic research. In order to evaluate the effectiveness of ERATO's organizational experiment in comparison with a bureaucratic organization, it would be important to set a strong counterpart.

## 2.3 Data

The data used in the comparative case analysis were collected from three sources. Accessing multiple sources of data, this research pursues the benefits of methodological triangulation (Fielding and Fielding, 1986). First, qualitative data were collected through the intensive, semi-structured, open-ended interviews with researchers and managers in both organizations (n=44). The interviews typically lasted between an hour to two hours, but some lasted as long as four hours. In some cases, even after completing the first interviews, some information was collected by additional interviews.

Second, archival data such as published or unpublished internal reports on ERATO and MITI-L were also collected. Importantly, both organization had conducted general surveys about their research activities and researchers. Archival data also include the pamphlets and brochures prepared by both organizations.

The third source of data is questionnaire survey. Interviewing with some managers and researchers in each organization, the contents and wordings of the questionnaire were checked and elaborated in advance in order to fit respondents' native terms as well as possible. Questionnaires were delivered to researchers who had spent more than one year in either ERATO or MITI. In most cases, questionnaires were delivered by asking a few person in each organization to distribute randomly and collect them through mail boxes. Some questionnairs were handed and collected directly during the interviews. The data obtained

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[5] The survey data show that respondents' perceptions indicate that both ERATO and MITI-L are basic-research-oriented organizations to the same degree. I measured "orientation toward basic research" by setting a question with a Likert-type seven-point scale that "in your organizations, applicability of research themes hardly come into question." The results are 4.85 (s.d.=1.57) in ERATO and 4.46 (s.d.=1.54) in MITI-L (t=1.43; p>0.10).

from questionnaires are used mainly for exploring the differences between ERATO and MITI-L in the frequency of professional communication as well as researchers' performance.

The numbers of respondents of the survey into ERATO and MITI-L are 108 and 119, respectively. Average age of respondents is 33.8 (standard deviation=4.63) in ERATO and 37.0 (6.54) in MITI-L. Although respondents in ERATO are three years younger than those in MITI-L on the average (t=−4.29; p<0.01), as shown in the next section, it can be assumed that this difference in the age reflects differences in management systems concerning recruitment and staffing. Looking at the distribution of respondents' organizational positions, 11.1% (n=12) of ERATO's respondents are research leaders, 21.3% (n=23) are research sub-leaders, and 67.6% (n=73) are common researchers. In MITI-L, 14.3% (n=17) of respondents are research leaders, 22.7% (n=27) are sub-leaders, and 63.0% (n=75) are common researchers. There is no statistically significant difference between the two organization (chi-square=0.67; p=0.71).

In the comparative case analysis, these three kinds of data were used in complementary ways. Qualitative data obtained from interviews and archives were typically used in generally grasping and describing the difference between ERATO and MITI-L in organizational and managerial characteristics. Quantitative data from the questionnaire survey were used for statistical analyses which were to explore the degree of the differences and relationships of variables. And again, qualitative dafa were heavily used in interpreting the results of the statistical analyses.

## 3.   *Bureaucratic Organization vs. Dynamic Network Organization:*
## *Overall Description of Managerial Characteristics*
## *in ERATO and MITI-L*

Setting the taxonomy which contrasts the bureaucratic and the dynamic network organization, this section describes the overall comparison of organizational characteristics and management systems between ERATO and MITI-L. Based on the taxonomy which focuses on the flexibility and fluidity in management systems, Table 1 shows the summary of the comparative description of the management systems in ERATO and MITI-L. It would be important to mention again that this taxonomy is by nature a conceptual framework contrasting the bureaucracy and the dynamic network. The cases of ERATO and MITI-L are considered as empirical references of the two ideal types of research organizations. Framed in this way, the bureaucratic and the dynamic network organization are extreme points along the dimension of flexibility and fluidity in management systems, and therefore, the comparison of ERATO and MITI-L consistently offers striking contrasts. In fact, there is a spectrum of research organizations between both types. It would be safe to say that most research organizations would fall somewhere between ERATO and MITI-L.

### 3.1   ERATO: the dynamic network organization

ERATO was founded in 1981 by Japanese government, STA. As a government-sponsored organization for basic research, it is emphasized that research activities in ERATO are not application-oriented. At the time of the research, ERATO runs 16 research depart-

ments (called "projects" in ERATO's term),[6] each of which generally includes 15–20 researchers. The specialities of research projects covers wide scope of natural sciences, including physics, chemistry, and biology. Each project is directed by a project leader, and includes three research groups directed by group leaders.

In association with organizational flexibility and fluidity, the most distinctive characteristic of ERATO lies in the point that every project is subject to "the five-year rule." All projects are time-limited, and automatically finished and dispersed without exception after five years. One of the managers of ERATO explained the intention behind the ave-year rule as follows:

> "Five-year might seem too short in the light of Japanese common sense in the field of basic research. But, the primary purpose of ERATO is to make research activities more flexible and fluid in order to overcome evils in traditional Japanese basic research organizations which have been too much stable. In Japan, now we need some compulsory systems to exclude naturally emerging orientations of researchers toward over-stable, over-comfortable situations."

Researchers are extensively recruited through public advertisements. Those who want to join ERATO are directly and intensively interviewed by a project leader for assessment and screening. In the screening processes, project leaders especially consider applicants' future research plans, rather than their past achievements, career backgrounds, or

TABLE 1.  COMPARISONS OF MANAGERIAL CHARACTERISTICS:
BUREAUCRATIC ORGANIZATION AND DYNAMIC NETWORK ORGANIZATION

| Dimensions | MITI Laboratory: Bureaucratic organization | ERATO: Dynamic network organization |
|---|---|---|
| *Recruitment/staffing* | —intensively recruiting researchers once in a year (in April) | —always open to applicants |
| | —basically open only to those who have graduated from schools | —open to every applicant in every type of research organization (including doctoral students and foreigners) |
| | —criteria for assessment and screening are quantitative scores of formal examinations | —assessment and screening by intensive interviews with a project leader |
| *Assignment* | —according to researchers' academic backgrounds and disciplines | —according to researchers' proposals for their future research in a project |
| *Employment* | —lifetime employment | —full-time employment contract (for five years at the longest) |
| *Promotion* | —seniority-based | —capability-based |
| | —intra-departmental/uni-dimensional | —project leaders are recruited from outside |
| *Inter-departmental/ inter-group transfer of research staffs* | —none (no systems/rules) | —in response to researchers' requests (usually, at the time of renovating employment contracts) |
| *Longevity of research group* | —open-ended (no systems/rules to limit research terms) | —projects are compulsorily finished and dispersed after five years |
| *Key words* | —flexibility/fluidity | —stability/continuity |

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[6] Among these 16 projects, four projects were omitted from the survey, because it was less than a year since they had started.

academic disciplines. Consequently, each project becomes to consists of a large variety of researchers, in terms of career backgrounds or disciplines. ERATO is open to researchers in national institutes, companies, or universities, including foreigners, post-docs, and graduate students.[7] Even in course of each project work, researchers can also be recruited through the same procedures in response to applications. Thus, the timing of recruitment is not specified, and in principle, ERATO's projects are always open to applicants. Although there is no formal condition on eligibility of applicants, relatively young researchers under age of 35 are encouraged to apply.

Researchers are employed based on time-limited contracts with ERATO. Researchers typically make two-year contracts with ERATO, but they can be shorter or longer up to five-year according to requests of researchers. Every researcher is forced to engage fully in the research in ERATO, and therefore researchers in ERATO can not have the concurrent posts in other organizations. In other words, those who are going to join ERATO have to formally resign from the former organizations in advance, and they must hunt new outside posts after completing their work at ERATO. However, researchers from companies can join ERATO as "the delegated researchers" without resigning their companies, and they can return to their mother companies after finishing their research in ERATO's projects. But, even in this case, researchers must engage full-time in ERATO's projects. It is emphasized that research itself must be independent of interests of other organizations, and that ERATO is by no means a organization for joint research between multiple organizations. Checked carefully in the rpocesses of recruitment, researchers from companies are prohibited from br[nging in their work assigned by their mother companies into ERATO. As described above, management systems in ERATO are designed so as to enhance individual-oriented research activities as well as organizational flexibility and fluidity.

A particular research theme is assigned to each researcher in accordance with his or her own research proposal. In each project, allocation of research funds is fully delegated to a project leader or group leaders. Research funds or resources can be flexibly allocated to researchers, according to the attractiveness of research proposals by project members. In other words, it is primarily necessary for researchers to submit attractive proposals to their leader, if they are to secure more resources. Researchers' annual salaries are decided based not on seniority, but on project leaders' opinions about researchers' capabilities, potentials, and contributions to projects. Promotion of researchers to group leaders or sub-leaders is also decided by a project leader on capability-basis.

Because a project leader has extraordinarily strong influences over project work, management staffs of ERATO consider the selection of project leaders as one of the most important decisions. Frequently attending academic meetings or conferences, first they list up preferable candidates, and then ask them to prepare research proposals. A project leader is finally decided by the advisory board consisting of 20 outside experts. Among 16 project leaders, 8 joined ERATO from universities, 4 from national laboratories, and 4 from companies. A new project leader is always staffed by recruiting from outside at the starting point of the project. In this sense, there is no internal promotion in course

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[7] In order to recruit foreign researchers, public advertisements are also conducted on distinguished international journals such as *Nature, Physics,* and so forth.

of project work, such as from a group leader to a project leader.  Only project leaders can hold concurrent posts in their mother organizations.

In sum, ERATO is a typical dynamic-network-type of organization which pursues extraordinary flexibility and fluidity at the sacrifice of stability and continuity of research activities.  It is widely recognized that, compared with Japanese basic research organizations, universities or other basic research orgnaizations in western countries hold more flexible and fluid systems, in general.  However, it would be important to mention that ERATO holds much more flexible and fluid systems than western organizations.  For instance, a group leader who had spent more than 10 years at an American university before joining ERATO referred to the uniqueness of ERATO as follows:

> "Talking about ERATO's systems, for example, management systems such as contact-based employment, or capability-oriented evaluation or rewards, may be close to so-called American system.  But, ERATO is nothing but a social or an organizational experiment, which is also different from American universities.  An entirely new project starts without any basis by gathering various researchers including those in companies, and after five years, it is forced to dispersed.  And then, another project gets started. In this way, ERATO has unusually dynamic systems obviously including quite experimental ideas.  We would be guinea pigs for this social experiment named ERATO."

Recently, experts in western countries have been interested in ERATO as a case of organizational innovation in basic research (Stenberg, 1990).  For example, a report by the Ministry of Commerce of U.S. (*J-Tech Panel Report on the Japanese ERATO Program*) pointed out the ERATO was an entirely new type of organizational experiment.  Similarly, *Nature*, one of the most influential journals of science, recently reported on ERATO as follows:

> "Japan has been extraordinarily active in the creation of new kinds of research support during the past decade.  One of the most striking of these is the ERATO project." (Vol. 359, October 1992, p. 575)

3.2  MITI-L: the bureaucratic organization

As mentioned earlier, MITI-L is one of the most prestigious basic research organizations in Japan.  MITI-L is divided into more than 20 rexearch departments, each of which has a particular specialty.  Similar to ERATO, a department typically consists of three or four research groups including 5–10 researchers, each of which is directed by a group leader and a few sub-leaders.

In MITI-L, in contrast with ERATO, researchers are recruited only once in a yaer, at the beginning of the organizational calendar.  Those who want to enter MITI-L are assessed and screened through some standardized, formal examinations which are primarily to evaluate applicants' knowledge on particular specialties.  In the process of the screening, only quantitative scores of the examinations are took into consideration and no qualitative assessments such as direct interviews are conducted.  In principle, MITI-L is open only to new graduates who have just received academic degrees from their universities, while ERATO is always open to various applicants.  Once applicants are employed, MITI-L

guarantees lifetime employment to all employees without exception.

Researchers recruited through this process first go through a short-term introductory training, and then assigned to particular departments based on their requests.   In the process of assignment, however, researchers' requests can not go over to detailed information regarding their actual research activities such as research themes on which they wish to work.   Consequently, a newly employed researcher is usually assigned to a particular group in a particular department, according to his or her formal discipline in a graduate school. A research leader in MITI-L explained this kind of assignment as follows:

> "Even if we had information about their research interests in detail, it would be difficult to consider that in the actual decision of assignment.   Because each group has been already working on a particular theme for a long time, consistently as a group, without regard to freshman's proposals.   In this sense, it is usually difficult for a group to always take freshman's various claims into consideration.   If a freshman tried tob ring his own research theme in a group, the research work in the group would face a sort of disorder.   We recruit a freshman not for his or her own research, but for our research. I don't think this way of doing things is always good, but under the situations in our lab, it would be more efficient to assign them by looking at their disciplines in their universities."

In ERATO's case, the decisions concerning the assignment of research themes and allocation of research funds or resources depend primarily on the attractiveness of individual researcher's proposal to the research leader.   In MITI-L, however, such decisions are tend to be made by consensus among researchers.   As the interview data quoted above also suggests, in MITI-L, research themes and resources are fixed in advance, in accordance with particular organizational goals at the level of departments or groups, not with researchers' proposals on hteir own initiatives.   In this way, research activities in a research group in MITI-L are strongly coordinated and structured by formal hierarchical mechanisms within the organization.

In MITI-L, achievements of individual researcher are evaluated by a research leader of his or her department.   But such evaluations are done only in a vague, informal style, and criteria of evaluation are not standardized at all.   This may be because the evaluation itself has little meaning in the sense that it is not substantially related to actual aspects of management practices, such as promotion or salary.   In MITI-L, seniority and tenuer are precisely the most important criteria concerning the decision of promotion and salary. Every researchers can be promoted to a sub-leader in a research group at the age of 33, on the average.   However, the greatest deviation in the age of the promotion can not be more than two.   Under the uni-dimensional promotion systems, a researcher in MITI-L promoted from common researchers to research sub-leaders, to research leaders, by taking the place of his or her former supervisor.   Furthermore, there is no formal system or rule concerning interdepartmental transfer of researchers.   Researchers in MITI-L stay with one research group throughout his or her career, in general.   Those who have experienced transfer to other departments or groups are only exceptions.

In MITI-L, there is neither formal system or institution for the reformation of research departments, nor formal regular evaluation systems for checking the performance of departments or groups, while ERATO has the five-year rule.   Organizational reformation at the

TABLE 2.   COMPARISONS OF ORGANIZATIONAL CHARACTERISTICS

| In your organization... | ERATO: dynamic network organization (n=108) | MITI-L: bureaucratic organization (n=119) | t-value |
|---|---|---|---|
| Researchers are very competitive | 4. 81  (1. 16) | 4. 19  (1. 22) | 3. 92*** |
| Research work is strongly individual-oriented | 5. 15  (1. 09) | 4. 34  (1. 28) | 5. 11*** |
| Decision-making is strongly group-oriented | 3. 28  (1. 32) | 4. 42  (1. 52) | −6. 06*** |
| Assessment is strongly capability-oriented | 5. 01  (1. 08) | 4. 35  (1. 46) | 3. 82*** |
| Assessment is clearly fedback to a researcher | 4. 75  (1. 09) | 3. 75  (1. 32) | 6. 14*** |
| There are agreat variety of researchers in terms of backgrounds and/or orientations | 5. 53  (1. 09) | 4. 89  (1. 51) | 3. 62*** |

*Note* 1.   Each item is measured by a Likert-type seven-point scale (1 for "strongly disagree" and 7 for "stlongly agree").
2.   Numbers in parentheses are standard deviations.
3.   Significant levels are indicated by asterisks: *$p<0.10$, **$p<0.05$, ***$p<0.01$.

departmental level such as creation of new research departments or integration/aboliiton of existing departments can be typically realized when the organization of MITI-L as a whole undergoes overall reformation.   In the past, however, this kind of organizational transformation was realized only exceptionally, in 1970 and 1990 with a 20 years' interval.

In sum, in sharp contrast with ERATO, management systems in MITI-L are designed to primarily and consistently pursue stability of research staffs and activities.   In other words, MITI-L can be regarded as the typical bureaucratic organization, which are designed to suppress organizational flexibility and fluidity.   While the comparative description on managerial characteristics in both organization mainly depends on qualitative data from interviews and archives, some quantitative data from the questionnaire survey also show the differences in organizational characteristics between ERATO and MITI-L.   As shown in Table 2, researchers' perception of organizational characteristics also indicates significant differences between both basic research organizations along these dimensions, which are consistent with the above description.   Researchers in ERATO are more competitive ($t=$ 3.92; $p<0.01$) and individual-oriented ($t=5.11$; $p<0.01$) in doing their work, and at the same time, they are evaluated more clearly ($t=6.14$; $p<0.01$) based on more capability-oriented criteria ($t=3.82$; $p<0.01$).   On the contrary, research activities in MITI-L are directed and coordinated by more group-oriented decision-making ($t=-6.06$; $p<0.01$). The variety of researchers' backgrounds or orientations in ERATO is greater than that in MITI-L ($t=3.62$; $p<0.01$).   Looking at the distribution of universities from which respondents graduated, the concentration ratio (top five universities) is greater in MITI-L (75.6%) than in ERATO (48.1%).   Surprisingly, more than 75% of respondents (n=119) of MITI-L graduated from five Japanese top schools in the field of the natural sciences, University of Tokyo (n=40), Tokyo Institute of Technology (n=20), Kyoto University (n=12), Osaka University (n=12), and Tohoku University (n=10), all of which are national universities.

## 4.   *Professional Communication and Performance*

The striking contrast regarding organizational and managerial characteristics between

ERATO and MITI-L suggests that there are also some critical differences between both organizations in professional communication among researchers and their performance. As this paper reviewed in the beginning, existing literature of R&D management has consistently suggested that the lack of organizational flexibility and fluidity in bureaucratic organizations has significantly negative effects on performance through the decrease of external professional communication which is essentially important for basic research activities. Thus, MITI-L as the representative of bureaucratic organizations can be assumed to face a series of serious problems called the NIH syndrome. On the contrary, the organizational innovation of ERATO as the dynamic network organization can be assumed to overcome such problems in bureaucratic organizations, by activating professional communication with researchers outside of the organizations which would result in higher performance.

## 4.1 Differences in professional communicarion and performance

In analyzing the differences in frequency of researchers' professional communication, I used nine variables included in the questionnaire which were assumed to relate to professional communication:

(1) frequency of professional communication with researchers *within* the organization who belong to the *same* research group

(2) frequency of professional communication with researchers who *supervise* the respondent

(3) frequency of professional communication with researchers *within* the organization who belong to *different* research groups

(4) frequency of professional communication with researchers *outside* of the organization with the *same* research specialty

(5) frequency of professional communication with researchers *outside* of the organization with *different* research specialties

(6) number of times of attendance at academic meetings or conferences during the past one year

(7) number of times of attendance at formal meetings within the group, the department, or the organization during the past one year

(8) average number of times of lunch with colleagues in a week

(9) engagement in joint research with researchers outside of the organization

As for the communication variables (1) to (5), each variable was measured by a Likert-type seven-point scale (1 for "less than once in a year," 4 for "once in a week," and 7 for "many times in a day"). Variables (6) to (8) were measured by the actual number of times. variable (9) was a dummy variable to be measured by 1 for "Yes" or 0 for "No." As a result of factor analysis, there emerged five factors with eigenvalues more than 1.00 (see Appendix). Checking factor loadings after Varimax rotation, I used the score of Factor 1 as a measure called "external communication," and the score of Factor 2 as "internal communication" in the following analysis.

Table 3 shows the results of a T-test for the differences in mean frequencies of internal and external communication between ERATO and MITI-L. As expected, there is a sig-

TABLE 3.   COMPARISONS OF MEAN COMMUNICATION FREQUENCIES

| Communication measures | ERATO: dynamic network organization (n=108) | MITI-L: bureaucratic organization (n=119) | t-value |
|---|---|---|---|
| Internal communication | 0. 10  (0. 89) | −0. 09  (1. 08) | 1. 47 |
| External communication | 0. 12  (1. 11) | −0. 11  (0. 86) | 1. 71* |

Note 1.   Factor scores are used as communication measures.
　　　2.   Numbers in parentheses are standard deviations.
　　　3.   Singificant levels are indicated by asterisks: * <0.10, **p<0.05, ***p<0.01.

nificant difference in external communication, and the external communication measure of ERATO is greater than that of MITI-L. Although the difference is not significant (p= .14), the internal communication measure of ERATO is also greater than that of MITI-L. These findings shows that, compared to MITI-L as the typical bureaucratic organization, the dynamic network organization of ERATO includes a tendency to facilitate researchers' communication in general, and such a tendency is significant in the case of external professional communication. On the contrary, external communication appears to be suppressed in the bureaucratic organization.

Both existing organizational theory and the interview data suggest some complementary explanations for this difference in external communication. First, by creating extraordinarily fluid work situations, the dynamic network organization can be assumed to escape from phenomena such as behavioral stability or selective exposure to outside information, which negatively relate to external communication. Researchers interacting over a long period under stable work situations will develop standard work patterns that are familiar and comfortable, and come to rely more and more on their customary ways of doing things (Thompson, 1967; Katz, 1978; Pfeffer, 1981). It is posited that one of the consequences of such behavioral stability is that researchers become less receptive toward communication that may not fit their stabilized patterns of behavior, and become increasingly isolated from outside sources of relevant information, due to the lack of organizational fluidity (Katz, 1980). In the case of ERATO where projects are started and compulsorily finished according to the five-year rule and management systems such as work assignment and staffing are practiced in flexible manners, there might be no room for such phenomena to occur at all.

Secondly, the dynamic network organization can be assumed to make external communication easier, since it consequently comes to consist of a great variety of researchers in terms of career backgrounds and orientations enough to enhance their skills to communicate with researchers outside of the organization. In the dynamic network organization, there necessarily emerges a large variety of researchers, because they have been collected into a research group through flexible and fluid recruiting/staffing systems. Given this situation, each researcher is forced to establish some skills to communicate efficiently with colleagues who have different backgrounds and orientations. If they have consciously established skills to communicate with those who have different backgrounds and orientations in the context of daily work, such skills may also contribute to exclude mental and/or verbal impediments in external communication, and may result in facilitating external communication. According to the interview data, many researchers in ERATO consistently pointed that "the universal linguistic system" was one of the important characteristics of ERATO. A researcher typically noted as follows:

"This group consists of various people with different career backgrounds, different disciplines, or different ways of thinking. So, everyone becomes in need of learning some techniques to communicate with different people in terms of backgrounds or orientations, especially in the early stage of project work. I feel that people in ERATO, including me, have gradually come to speak or express their ideas in more universal ways even in daily situations, in order to overcome such gaps in communication. Now I think I was using more local terms in discussing with colleagues before joining ERA-TO, just because I could communicate smoothly and quickly by using more local terms such as jargons or something. There was no problem like here at ERATO, but at the same time, that would be some kind of barrier of interactions beyond labs. I think that is the critical difference between ERATO and other labs."

Thirdly, it is assuned that, even after joining the dynamic network organization, it can be easier for researchers to maintain close connections with people working for organizations to which they once belonged, thus they can secure much more opportunities to communicate with outside professionals through the connections. In ERATO's case, researchers can stay at ERATO for five years at the longest, because each project is subject to the five-tear rule. According to the interviews, many researchers in ERATO mentioned that they could work on the project of ERATO without losing close ties with the ex-colleagues, because it could not be so long time since they had left the former organizations. Moreover, researchers with various career backgrounds bring their own networks they established before joining ERATO. In consequence, making the most of others' various professional networks as well as their own ones, researchers may be able to multiplicatively increase the number of opportunities or channels to communicate with outside professionals. Given organizational flexibility and fluidity in terms of project longevity and staffing, the dynamic network organization may enable researchers to easily access to a large variety of outside information sources by increasing communication channels through various professional networks which they bring into the organization.

On the other hand, it can be assumed that researchers in the bureaucratic organizations may inevitably come to suffer from the behavioral stability and the insufficient skills for external communication, as well as relatively limited opportunities and channels for external communication. These factors suppressing external communication may be underlying the finding that the frequency of external communication is less in MITI-L than in ERATO.

Given the existing studies on professional communication and performance, the differemce in external communication shown above also suggests the significant difference in researchers' performance between ERATO and MITI-L, since external communication is a critically important factor for researchers to achieve high performance. Performance of researchers in both organizations were measured by counting the number of respondents' publications. Since they are engaged in basic research, the number of publications is one of the most important performance indices.

The questionnaire includes four variables relating to the number of publications: (1) publications on domestic (Japanese) academic journals, (2) publications on international academic journals, (3) papers presented at domestic academic meetings or conferences, (4) papers presented at international academic meetings or conferences.[8] These four variables indicated by each respondents were aggregated. In aggregating these variables, each paper

or article included in either (1) or (3) was counted as 0.5 point, while each paper in (2) or (4) was counted as 1 point. This was because a number of researchers interviewed noted that there was some difference in the significance of papers between international and domestic journals or meetings. According to the interviews, tehy typically claimed that a single paper in an international journal or meeting would be equal to two papers in domestic journals or meetings, by and large. In the analysis, I used the number of publications aggregated in this way as a performance measure.

As shown in Table 4, there is a statistically significant difference in the researchers' performance between ERATO and MITI-L in the predicted direction. On the average, ERATO's performance (3.99) is significantly higher than MITI-L's (2.77). The difference in researchers' performance appears consistent with the result of the comparative analysis on professional communication. These findings suggests that the difference in the frequency of external communication between ERATO and MITI-L would actually relate to the difference in researchers' performance.

In addition, I also surveyed the other researchers' performance in the past one year before joining ERATO by using the same performance measure, in order to compare that with the performance of ERATO's original respondents (n=118) shown in Table 4. This additional survey was carried out separately from the original questionnaire survey, and the sample was limited to those who has been working for the four projects in ERATO lasting for less than one year (n=24). As a result, the mean performance of 24 respondents in the past one year before joining ERATO turned out to be 2.38 (standard deviation=2.09) which is significantly lower than the performance of ERATO's respondents in the original survey (t=3.77; p<0.01). Interestingly, it is also lower than that of respondents in MITI-L (t=1.96; p<0.05). These findings suggests that those who joined ERATO may not be so excellent in advance, and ERATO's relatively high performance may be brought about not simply by staffing superior researchers, but by activating their potential and enhancing their capabilities.

Combining the findings so far, it could be assumed that ERATO as the dynamic network organization actually facilitates researchers' external communication by increasing organizational flexibility and fluidity, and the facilitated external communication would result in relatively high performance. At the same time, the excessive organizational and managerial stability in MITI-L could be assumed to hinder external communication which would be critically important for basic research, and in consequence, result in lower performance.

TABLE 4. COMPARISON OF MEAN PERFORMANCE

|  | ERATO: dynamic network organization (n=108) | MITI-L: bureaucratic organization (n=119) | t-value |
| --- | --- | --- | --- |
| Mean performance | 3. 99 (3. 49) | 2. 77 (3. 35) | 2. 67*** |

Note 1. Numbers in parentheses are standard deviations.
　　2. Significant levels are indicated by asterisks: *p<0.10, **p<0.05, ***p<0.01.

[8] Respondents were asked to indicate the numbers of these four types of publications to which they gave major contributions.

4.2   Relationship between professional communication and performance

In order to analyze the above assumption regarding the differences in both professional communication and researchers' performance between ERATO and MITI-L, I examined impacts of professional communication on the performance in each organization in more detail.   Table 5 shows the results of regression analysis for ERATO and MITI-L, separately. In the regression model, the dependent variable is researchers' performance and the independent variables are internal and external communication.   Interestingly, the results obtained from regression analysis shows that communication measures do not relate equally to performance of ERATO and MITI-L.   As predicted, external communication has a significantly positive impact on researchers' performance in ERATO, while internal communication has no significant effect on performance.   These findings are consistent with the arguments so far.

According to the interview data, most of researchers in MITI-L, especially young researchers below the age of 35, clearly pointed out that, more or less isolated from outside professional information sources, they were in need of more external communication, and one of the most serious problem in MITI-L would lie in such insufficiency of external communication.   Surprisingly, however, external communication has a significantly negative impact on researchers' performance in MITI-L, while internal communication holds a significantly positive impact.   Since the findings show that external communication by researchers in MITI-L hinders performance contrary to the proposition, now it becomes impossible to simply assume that the relatively low performance of MITI-L may result from less frequent external communication.

The most simple explanation for this negative association between external communication and performance is that researchers in MITI-L would somehow communicate with outside researchers only to access meaningless or inappropriate information at all.   In the light of existing studies, however, this kind of explanation must be far from the reality.   In fact, the interviews with researchers in MITI-L confirm that nearly all of them consider external professional communication as one of the most useful means in generating ideas or solving problems.   If so, the alternative hypothesis may be that, in the case of MITI-L, such a negative association would result from some organizational mechanisms intervening

TABLE 5.   MULTIPLE REGRESSIONS ON PERFORMANCE BY INTERNAL AND
EXTERNAL COMMUNICATION

| Independent variables | ERATO: dynamic network organization (n=108) | MITI-L: bureaucratic organization (n=119) |
|---|---|---|
| Intenal communication | 0. 51     (0. 33) | 0. 72*** (0. 26) |
| External communication | 1. 69*** (0. 26) | −1. 48*** (0. 33) |
| Constant | 3. 73 | 2. 67 |
| R-square | 0. 36 | 0. 27 |
| F-value | 30. 40*** | 22. 11*** |

Note 1.   Factor scores are used as communication measures.
     2.   Numbers indicated are regressi on coefficients.   Numbers in parentheses are standard errors.
     3.   Significant levels are indicated by asterisks: *p<0.01, **p<0.05, ***p<0.01.

the relationships between professional communication and performance. This hypothesis assumes that there appears the mysteriously negative relationship between external communication and performance, only due to the existence of such intervening organizational mechanisms in MITI-L, although external communication itseif would be still important for researchers in MITI-L. In examining this hypothesis, it may be helpful to put a question: "Who communicate more frequently than others?" I analyzed differences in frequency of internal and external communication and performance across organizational positions of researchers, separately for both organizations. Table 6 shows the results of variance analysis using a one-way ANOVA to test for significant mean differences across three position categories.

As for ERATO, the two communication measures reveal no significant differences across the three position categories. The results indicate that researchers in ERATO equally communicate with professionals inside and outside of the organization, regardless of their positions. As for MITI-L, on the other hand, both communication measures reveal sharply significant differences across the three positions. Tabls 6 shows that common researchers communicate more frequently with colleagues within MITI-L than leaders and sub-leaders. On the contrary, researchers at higher positions, especially research leaders, communicate much more frequently with outside professionals, and in consequence, external communication is strongly biased to research leaders. In short, while organizational positions have nothing to do with professional communication in ERATO, in the case of MITI-L, there is a certain kind of "division of labor" between common researchers, sub-leaders, and leaders, in terms of professional communication.

Furthermore, performance measures of both ERATO and MITI-L indicate strongly significant differences across the three position categories, as shown in Table 6. Interestingly, however, the direction of the differences in ERATO is sharply opposite to that in MITI-L. In MITI-L, the performance of common researchers is much higher than that of other position categories, and research leaders indicate the lowest performance. In

TABLE 6.   MEAN COMMUNICATION AND PERFORMANCE AS A FUNCTION
OF ORGANIZATIONAL POSITION

| Organization          Measures | Categories of organizational position | | | F-value |
| --- | --- | --- | --- | --- |
| | Common researcher | Sub-leader | Leader | |
| ERATO: dynamic network organization (n=108) | n=73 | n=23 | n=12 | |
| Internal communication | 0.03 | 0.22 | 0.26 | 0.59 |
| External communication | 0.01 | 0.17 | 0.64 | 1.69 |
| Performance | 3.18 | 5.19 | 5.95 | 5.10*** |
| MITI-L: bureaucratic organization (n=119) | n=75 | n=27 | n=17 | |
| Internal communication | 0.13 | −0.43 | −0.53 | 4.66** |
| External communication | −0.35 | −0.01 | 0.80 | 15.67*** |
| Performance | 3.52 | 2.14 | 0.47 | 6.99*** |

Note 1.   A one-way ANOVA is used.
    2.   Factor scores are used as communication measures.
    3.   Significant levels are indicated by asterisks: $*p<0.10$, $**p<0.05$, $***p<0.01$.

sharp contrast, the performance of leaders or sub-leaders in ERATO is much higher than that of their subordinates. These results suggest that there are critical differences in a role of a research leader between ERATO and MITI-L. A research leader in ERATO is precisely a star researcher as well as a formal director of his research project or group. In the case of ERATO, as already suggested in the former section of this paper, the base of leaders' power or leadership may lie in their own research capabilities. However, a research leader in MITI-L is nothing but a managing director of the research group who is hardly engaged in actual research activities. His leadership may come from the formal authority in the organizational structure, not from his own capability in current research activities.

The findings so far suggest that external communication in MITI-L would be realized by a limited number of research leaders as the windows of research groups for information outside of the organization. It could be further assumed that such research leaders would communicate with outside people not because they themselves need outside information in doing actual research activities, but simply because they are formal representatives of their research groups. On the contrary, researchers at different positions in ERATO equally contact with outside information sources, in order to satisfy their own needs for getting new ideas and information which are relevant to their actual project work.

While each researcher in ERATO communicates dircetly with outside professionals, it is assumed that there could be a two-step information flow in MITI-L in terms of external communication, in the sense that a research leader in MITI-L would play a role of a gatekeeper (Allen and Cohen, 1969). This assumption is consistent with the findings that there is a significant difference in performance measure between ERATO and MITI-L, because existing literature have confirmed that external communication via gatekeepers negatively affects performance in the field of basic research (Allen, Tushman, and Lee, 1979; Tushman and Katz, 1980).

Interestingly, however, the data obtained from the survey reveals that, there is a significantly negative correlation between external and internal communication in MITI-L (correlation coefficient$= -0.40$; p$<0.01$), while there is a strongly positive correlation in ERATO (correlation coefficient$=0.39$; p$<0.01$). These results shows that internal and external communication are split in MITI-L,˙while researchers in ERATO communicating frequently with outside professionals also communicate with colleagues at the same time. In MITI-L, therefore, it can be assumed that outside information collected mainly by research leaders would not circulate through their groups, and surprisingly, they do not perform even as gatekeepers at all. This split between internal and external communication in MITI-L may relate to the argument that research leaders in MITI-L are managing directors rather than researchers actively working on actual research activities. In any case, these findings suggests that outside information mainly collected by leaders would not actually circulate within research groups in MITI-L, and eventually, such outside information would be just stocked by research leaders in vain. In ERATO, on the contrary, outside professional information is more actively internalized regardless of organizational position, and at the same time, such internalized professional information is actively circulating through groups to be used for idea generation or problem-solving in actual research activities.

Furthermore, there would be good reason for the fact that external communication by common researchers in MITI-L is much more limited than that by leaders or sub-leaders.

Given the organizational structure where research leaders are 'in charge of a significant part of external communication as formal representatives of resrarch groups, some qualitative data from interviews also suggest that it would be wiser for common researchers not to communicate so frequently with outside professionals, since such behavior would be equal to threatening and disturbing the organizational order of authority. In the interviews, some young researchers in MITI-L mentioned that, feeling "some kinds of invisible barriers," they had naturally become to keep away from external communication, although they were in need of a variety of outside information at the same time. Some other young researchers said that they had external communication much more frequently than other young colleagues in MITI-L, but that they could not help facing problems if they were to communicate with outside professionals as frequently as they liked, because such behavior might disturb "the order and harmony of the research group." One of them, age 33, typically mentioned as follows:

> "I often go out, seeking for new ideas or spurs for my research. But, generally speaking, those who like such things gradually become regarded as 'outsiders' or 'black sheep' of a group, and gradually isolated from a communication network within the group. In laboratories like MITI-L, research is actually well organized into group work, so if we were once isolated from a teamwork, it would become difficult to do what we want to, because we could not get research supports and resources enough to do that. So, we can not make the most of ideas or information from outside in the actual research work, without carefully negotiating with a boss or other colleagues. I always feel some difficulties in doing research in harmony with other people in the group."

In short, these findings so far suggest that MITI-L is facing the problem of "sunk external information," which refers to the tendency that a large part of information obtained through external communication is inevitably left unused. In summary, there would be two interrelated reasons for the problem for "sunk external information." First, external communication in MITI-L is strongly biased to senior researchers representing their groups as research leaders. Nevertheless, they are not competent researchers but administrators of their group who are hardly involved in actual research activities, and consequently, less integrated into communication networks within research groups. Furthermore, since research leaders in MITI-L do not perform even as gatekeepers, there emerges a significant split between internal and external communication. Therefore, a large part of external information comes to be "sunk" there at the position of a research leader. This may be the reason why external communication mysteriously appears to have negative impact on performance. However, this would be a spurious association, and in fact, external communication must also be meaningful for researchers in MITI-L. Secondly, given such a clear "division of labor" in external communication, relatively young researchers contacting frequently with information sources outside MITI-L would become isolated from leaders and other colleagues and less integrated into actual research activities within their group, since their behavior would be regarded as disturbance to the organzational order which puts priority on teamwork. Thus, external information accessed by young researchers also tends to be sunk without being sufficiently utilized for actual research activities. After all, it might become quite reasonable strategies for researchers in MITI-L to depend on internal communication and to refrain from communicating so frequently with outside

professionals.

In any case, the most essential factors underlying the significant difference in perform-
ance between ERATO and MITI-L would consist in the differences in organizational mech-
anisms embedded in each organization, rather than the apparant difference in the frequency
of external communication. The difference in the absolute frequency of external perform-
ance shown in Table 3 would relate to the difference in performance, at least to some degree.
However, the analysis so far suggests that the relatively lower performance of MITI-L would
result from its organizational mechanisms increasing "sunk external information," rather
than merely from insufficient external communication. On the contrary, free from such
impediments to full use of outside information, ERATO as the dynamic network organiza-
tion can be assumed to have advantages over bureaucratic organizations like MITI-L, not
only in facilitating external communication but also in enhancing the actual utilization of
external information. The essence of ERATO's organizational innovation lies in the fact
that it overcomes organizational mechanisms embedded in the bureaucratic organization
which incur the problem for "sunk external information."

## 5. *Implications*

It has been widely recognized that one of the most serious problems in bureaucratic
organization in Japanesse basic research lies in less frequent communication with outside
professionals. Therefore, it has been often argued that researchers in Japanese basic re-
search organization should communicate with outside professionals more intensively and
extensively. A number of managers in Japanese basic research organizations have also
considered this as one of the most promising solutions to break organizational deadlock.
However, such arguments are potentially misleading. The thrust of findings derived from
the comparative analysis emphasizes that the problems of bureaucratic organization are
more complicated and deep-rooted than generally imagined. The findings suggest that
the bureaucratic organization does not only impede external professional communication,
but also inevitably becomes deprived of the effectiveness of external communication itself
by restraining utilization of important outside information, which results in increasing "sunk
external information." This is not simply a matter of degree or frequency of external
communication, but a more complicated structural problem resulting inevitably from organ-
izational and managerial characteristics of the bureaucratic organization. Under such
conditions within the bureaucratic organization, if managers were to facilitate external
professional communication by researchers, it would rather contribute only to further de-
clines in performance. Otherwise, it may be more important for Japanese basic research
organizations to transform their management systems in order to introduce more organ-
izational flexibility and fluidity, at least to some extent.

In contrast to the bureaucratic organization, the organizational experiment of ERATO
suggests that the dynamic network organization could overcome such organizational mech-
anisms by realizing organizational flexibility anf fluidity to an extraordinary degree. What
is important to recognize from this analysis is that the dynamic network organization could
enable researchers to make full use of external information, as well as to communicate more
frequently with outside professionals. In this sense, the findings in this analysis emphasize

the effectiveness and the possibility of dynamic network organization like ERATO more than expected. The expreiment of ERATO includes an important insight of enhancing Japanese basic research activities through the creation of dynamic network organizations. Japan is now in need of increasing the number of dynamic network organizations which may offer an alternative to strengthen basic research.

Although it is quite reasonable for bureaucratic basic research organizations in Japan to increase their organizational flexibility and fluidity by transforming their management systems, the above arguments should not be taken to mean that all of bureaucratic organizations in the field of basic research are to shift to dynamic network orgnaizations. Such overall transformations would be neither feasible nor effective, since dynamic network organization can not be entirely independent of established bureaucratic organizations. The organizational flexibility and fluidity in the dynamic network can be realized on condition that there are many bureaucratic organizations outside with which it can interchange researchers. Moreover, bureaucratic organizations include certain kinds of advantages over dynamic network organizations such as sustainability of long-term research activities, possibility to pursue challenging or exploratory research themes, as well as easiness to accumulate relevant knowledge systematically and continuously. Since this analysis has focused on relatively short-term performance measure, it might underestimate the effectiveness of bureaucratic organizations such as MITI-L. In sum, it would become more or less necessary to achieve and maintain a good balance between the two different types of organizations, in other words, a balance between stability and flexibility or fluidity.

One of the most important challenges for future basic research in Japan would be to establish complementary and interdependent relationships betwee bureaucratic and dynamic network organizations, where researchers can move from bureaucratic organizations to dynamic network, or from dynamic network to bureaucratic, while either type typically pursues its advantages at the same time. Such complementary relationships between bureaucratic and dynamic network organizations suggest the possibility of a totally new inter-organizational matrix structure in the field of basic research in Japan. The creation of dynamic network organization in the Japanese context also includes potential to generate such highly original social systems in Japanese basic research.

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*APPENDIX*

FACTOR ANALYSIS OF COMMUNICATION VARIABLES

| Variables | F1 | F2 | F3 | F4 | F5 |
|---|---|---|---|---|---|
| (4) professional communication with researchers outside of the organization (the same specialty) | 0.87 | 0.12 | 0.04 | 0.23 | 0.07 |
| (5) professional communication with researchers outside of the organization (different specialties) | 0.84 | 0.10 | 0.09 | 0.25 | 0.06 |
| (6) attendance at academic meetings | 0.81 | −0.05 | −0.12 | −0.07 | −0.14 |
| (1) professional communication with researchers within the organization (the same group) | 0.06 | 0.77 | 0.21 | −0.15 | 0.18 |
| (2) professional communication with researchers within the organization (different groups) | −0.18 | 0.76 | −0.39 | −0.04 | 0.01 |
| (3) professional communication with supervising researchers | 0.35 | 0.64 | 0.15 | 0.10 | 0.01 |
| (8) lunch with colleagues | −0.03 | 0.07 | 0.93 | 0.05 | −0.05 |
| (9) engagement in joint research | 0.22 | −0.08 | 0.05 | 0.93 | −0.08 |
| (7) attendance at formal meetings | −0.01 | 0.13 | −0.05 | −0.07 | 0.97 |
| Eigenvalues | 2.34 | 1.64 | 1.13 | 1.04 | 1.02 |
| Percentages of variance explained | 29.4% | 30.1% | 12.6% | 9.6% | 8.1% |
| Cumulative percentages | 29.4% | 49.4% | 62.1% | 71.7% | 79.8% |

*Note* 1. The principal component analysis is used. The numbers are factor loading after Varimax rotation.
2. Fn stands for Factor n.