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A Comparative Study on Formal Cooperative R&D by Government, Industrial, and University Laboratories in the United States

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ABSTRACT

Cooperative R&D has become a central issue in the public policy debate for enhancing the economic competitiveness of firms and countries since the 1980s all over the world. By developing a framework including the laboratory's mission focus along the process of technical change, external variables, and internal variables, this paper examines how public policies and other structural factors have influenced the cooperative R&D efforts exerted by government, industrial, and university laboratories in the U.S. Considering the increasing interest in the problem of 'whether there are any meaningful differences between public and private organizations' since the early 1980s, this paper searches specifically for patterned effects on cooperative R&D by variables representing the influence of market competition and political authority.

This paper finds that theories of cooperative R&D based on economic spillover or externalities can hardly explain the differences in the pattern of cooperative R&D by laboratories in the U.S., except for government laboratories in 1991. Traditional understanding of the role played by political authority and market competition has not been confirmed by this research either. Furthermore, there are interesting

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differences in the pattern of cooperative R&D behavior between government, industrial, and university laboratories in the U.S. This paper finds that R&D laboratories in the U.S. in the 1990s have responded quite aggressively to initiatives in cooperative R&D, and therefore also rejects the cliché that government authority has always resulted in impasse and conservativeness. Contrary to the general impression that private organizations are more competitive and therefore more adaptable and responsive to new challenges, industrial and government laboratories have not shown significant response to the structural factors as expected by the traditional view.

Key Words: Cooperative R&D, R&D Laboratories, Industrial Laboratories, University Laboratories, Science and Technology Policy

Introduction

In the United States, many basic industries fell behind foreign competition during the 1960s and 1970s in product and process technology. To regain the competitive edge, significant restructuring has occurred in the 1980s. One of the allegedly fastest ways of catching up has been the use of joint ventures. This mechanism has been used to improve the efficient utilization of existing technologies and enhance the effectiveness in creating new technologies that can be crucial in helping the economic competitiveness of this nation. Joint ventures involving two or three firms increased from under 200 per year in the 1970s to over 400 per year by the mid-1980s. After the enactment of National Cooperative Research Act of 1984, larger scale cooperative arrangements have increased significantly. Since cooperative R&D has been treated as such an important policy instrument, it is crucial to look empirically into what are the structural factors that have influenced R&D laboratories' motivations and efforts to engage in cooperative R&D. Since informal type of cooperative R&D agreements were not surveyed in the database (National Comparative Research and Development Program, NCRDP) used in this research, the focus of this paper will be restricted to formal type of cooperative R&D agreements.[1]

1 Informal cooperative arrangement poses another theoretical challenge, i.e. as a result of informality, the nature of cooperation can not be easily defined.

In this paper, cooperative R&D means any formal cooperative R&D agreements between the laboratory asked in the survey and other organizations (can be R&D laboratories, firms, universities, government agencies, or even foreign organizations). Before the early 1980s, policy environment in the United States had been rather exclusive for cooperative R&D. Under the ample sources of funding, R&D laboratories in different sectors (governments, universities, and industries) have evolved into a rather decentralized system of division of labor. Many of them (particularly the larger ones) in the three sectors have all developed rather autonomous and highly specialized organizational and technological capabilities. Traditionally, industrial laboratories have focused on the development of new products or processes that are closely related with the business of the sponsoring firm, pursuing the short term benefit of the parent firm. Government laboratories tend to emphasize particular technical issues associated with the mission of parent agencies or significant interests of the public. Their activities also tended to be longer run applied or directed basic research. University laboratories, under the leadership of individual research professors, set their minds on the basic end of advanced scientific research and the training of advanced scientific and technical personnel. The two sectors that are the most related with government funding, i.e. universities and government laboratories shared their main attention to longer term applied or basic research (Bozeman and Crow, 1990:25-56).

In this tradition, there was a bedrock faith in the industrial sector as the prime source of almost all important innovations. Not only was it widely believed that private corporations and the market could do her best at innovation if the government would just leave the market alone except when the market failed, but also did the anti-trust law (such as the Sherman Act and Clayton Act) forbid and vigorously pursued the development of cooperative ties between firms and other organizations that possess the potential to thwart the competitive dynamics of the market.

However, ever since the 1970s, the U.S. has been facing more and more critical economic challenges from abroad, especially Japan. From that time on, it has been widely believed that a great many aspects of the technological astuteness of industrial America have lagged rather far behind their Japanese counterparts. Stimulated by the Japanese success in the development of industrial technologies, policy makers in the U.S. started to emulate the Japanese experience which could be summarized by the eye-catching term, a new paradigm of 'cooperative technology development'. Under this new way of thinking, while new values emphasizing cooperation among university, industries, and government have been formed on the one hand, new policy initiatives based on cooperative paradigm have also been introduced. Starting from 1980, many acts such as Stevenson-Wydler Act (1980), Bayh-Dole Act (1980, 1984), Federal Technology Transfer Act (1986), Executive Order 12591 (Facilitating Access to Science and Technology, 1987), and National Competitiveness Technology Transfer Act (1989) have been enacted for accelerating technology development based on the cooperative ideal (Schriesheim, 1990:52-58). Underpinning these policy initiatives has been a great concern about how the tremendous R&D resources controlled by the federal government (including R&D funding, personnel, organizations, etc.) can be mobilized in the most effective and efficient manner for cooperative activities like cooperative R&D and technology transfer.

Still, there have been great reservations as to how government R&D institutions and resources can be tapped on for revitalizing the U.S. economic competitiveness. There has been a long tradition in the literature of public administration debating over what are the intrinsic characteristics of public organizations that make them different from private organizations. In this tradition, public organizations have been alleged to be less exposed to market pressure and therefore express less incentives for profits. Furthermore, public organizations tend to be treated as associated with higher organizational rigidity, lower adaptability to change, and lastly lower degrees of effectiveness and efficiency in their deployment of resources (Bozeman, 1987:4-22; Rainey, Backoff., Levine. 1976:233-244; Wamsley and Zald, 1973: 62-73; Hammer and Tassell. 1983:282-289; Murray, 1975:364-371). While scholarly works so far have not generated any conclusive results of the alleged negative sides of public organizations, the tradition and spirit of bureaucracy bashing continues to live, and lives well, particularly in the high tide of global privatization (Levine, Peters, and Thompson, 1991:256-303)

The purpose of this article is therefore to find out first, in the aforesaid context, systematic explanations for the variations in the number of cooperative R&D agreements undertaken by the U.S. laboratories through examining the labs' missions and their external and internal features, with a special focus on how various influences from the government such as funding and regulations have been affecting laboratories' behavior in cooperative R&D. This will be done by running cross-sectional regressions over samples drew from three different traditional sectors (university, industry, and government labs) over two different points in time (1988 and 1991). The results of this study can be helpful to policy makers in their search for better targets to promote cooperative R&D.

Before getting into the formal discussion, the organization of this paper will be mentioned briefly. In the first section, I will develop a broad framework of structural variables through a survey of the literature that encompasses major theories relating to R&D laboratories' pattern of activities and behaviors. Then, hypotheses about cooperative R&D by labs will be developed based on such a review. In the second section, the statistical procedure will be discussed and empirical results will be reported. Comparisons of the empirical results and the conclusion will be discussed in the third section.

I. Theoretical Framework

Technical change is a highly complex and uncertain process (Kline and Rosenberg, 1985). The modeling of factors molding such processes is a very difficult task.

Based on the focus to search for any meaningful differences between public and private laboratories, Bozeman and Crow (1990:25-56) developed a taxonomic classification of R&D labs and tried to examine the patterns of efforts in cooperative R&D by different types of R&D labs under such a classification scheme . Their taxonomy is based on two criteria. One is the level of publicness of R&D labs. This criteria measures the influence of various political authorities such as budget appropriation, contracting, regulation and others on the behavior of laboratories. The other one is the influence of market on R&D labs. This criteria measures how labs are exposed to the pure profit incentives and competitive forces of the market. There is no doubt that such a taxonomy can be very useful in analyzing the cooperative R&D efforts of labs. However, there are still many other important factors that may have affected the cooperative efforts by R&D labs and have not been given sufficient considerations within this taxonomy. For example, the differences in size and mission focus may be critical factors determining the behavior of laboratories, and therefore their efforts in cooperative R&D also. Yet, the taxonomy developed by Bozeman and Crow has not taken these complications into consideration. Henceforth, the major idea of this paper is to expand the framework developed by Bozeman and Crow (1990:25-56) somewhat and include other variables that may also have major impacts on incentives for cooperative R&D by labs in the U.S. and Japan. To do so, there will be a short review in the following section covering three major areas of theories that may have significant implications for the behavioral patterns of R&D laboratories.

A. Mission Focus along the Stages of the Technical Change Process

According to Berstein and Nadiri (1988:419-434), there has been a significant gap between the social and private rates of return to R&D investments as a result of various factors such as spillover effects (externalities), the dependency on complementary assets, anti-trust policies, and the inability to appropriate all the surplus generated by the dissemination of R&D results. Such a gap has been a cause to the insufficient spending in R&D investments, and therefore, contributes significantly to the concern about underspending in R&D and the insufficient dynamics for national competitiveness.

There are many ways to remedy such a gap, including direct or indirect subsidies to restore incentives; strengthening incentives to engage in *ex post* cooperation (e.g. expanding and strengthening intellectual property rights or giving firms greater leeway and control in structuring *ex post* rent sharing arrangements); and encouraging greater *ex ante* R&D cooperation, which refers to any agreement to share the benefits of a future R&D project. Royalty-free cross-licensing is a good example of *ex post* measures for mitigating such an incentive problem. Traditional joint ventures, research consortium and so forth are good examples of ex ante kind of approaches for making up the insufficient motivation in R&D. This paper will focus on the factors that influence the *ex ante* cooperative behavior by R&D labs.

What benefits can *ex ante* cooperative R&D serve? According to Katz and Ordover (1990:137-203) and Bozeman, Link, and Zardkoohi (1986:263-266), the closer the activity is to the basic end (initial stage) in the process of technical change, the more public the nature of the potential knowledge is, i.e. such knowledge will be less appropriable directly. Since there has been such a popular realization that the basic end of R&D will probably tend to be underinvested, the tendency to invest in cooperative R&D in this stage to internalize R&D spillovers should also be higher. Consequently, I formulate the first hypothesis about labs' efforts in cooperative R&D as in the following:

[Hypothesis 1] The more important the earlier stages of technical

change in the missions of laboratories, the more efforts such laboratories will invest in cooperative R&D.

However, cooperative R&D is not a free good. It needs to be planned, organized, and executed. The process by which an *ex ante* agreement is reached or how the institutions that govern the cooperative research are structured will have significant bearings on the costs of the cooperative R&D project. During this process, various types of transaction cost will be incurred. To be able to take advantage of cooperative R&D, the expected benefits of any participant has to be greater than the costs of all efforts and risks. These problems can be classified into two major areas that include external and internal factors.

B. External Factors

THE LEVEL OF PUBLICNESS AND THE LEVEL OF MARKET INFLUENCE

As mentioned before, according to Bozeman and Crow (1990:25-56), the most important external influences on cooperative R&D efforts by laboratories may include the level of market and governmental influence (publicness) that shape the fundamental structure and activities of R&D organizations. Political influence tends to push R&D organizations to focus more on factors in the public domain, e.g. political agenda-setting, particularly the political interests of their sponsors or parents. Since government has generally been considered to be the shelter against competitive pressures from the market, it is reasonable to hypothesize that

[Hypothesis 2] R&D laboratories with less publicness will put out more efforts in cooperative R&D, while those with more publicness will do less in cooperative R&D. On the other hand, R&D laboratories perceiving higher market influence will do more cooperative R&D, and vice versa.

GOVERNMENT REGULATORY PROCEDURES

Since R&D laboratories can either receive various levels of public funding from different levels of government for some of their activities or are regulated by public statutes,[2] one of the factors determining the efforts in cooperative R&D by laboratories is government policies that impose constraints on cooperative activities by labs. Coursey and Bozeman (1989:3-19)

2 E.g. anti-trust regulations, inter-state commercial regulations by FCC, etc.

further points out that there may be other barriers, such as communication bottlenecks between laboratories and their partners and difficulties in the areas of patent and other proprietary rights policies that may also have impeded the drives for cooperative R&D by R&D laboratories. The focus here will be restricted to two kinds of government regulatory practices, i.e. government health, safety and environmental regulations (BAR10) and government accounting and paper work requirements (BAR12). Therefore,

[Hypothesis 3] The higher the regulatory barriers that R&D laboratories are facing, the less efforts they will put forth in cooperative R&D.

C. Internal Factors

LEVELS OF INTERNAL BARRIERS

Furthermore, there may be many internal barriers such as inability to stay abreast of rapidly growing scientific and technical knowledge (BAR5); red tapes that may cause too much delays in either management or performance of R&D (BAR14); and high administrative costs of R&D that may increase the costs and reduce the benefits of cooperative R&D (BAR6).

As such,

[Hypothesis 4] The higher the internal barriers are, the less will R&D laboratories engage in cooperative R&D.

INTERNAL RESEARCH ORGANIZATION

In general, unlike general standardized products or services, one of the major characteristics of cooperative R&D is that there always involves high degrees of complexity and uncertainty. The promotion of cooperative R&D requires a significant amount of creativity, risk-taking and leadership. In other words, entrepreneurship matters the most. Therefore,

[Hypothesis 5] R&D labs that are able to organize their R&D activities through as many types of organizational design, will show a higher tendency to engage in cooperative R&D.

In a research on the partners that engage in cooperative R&D with academia, Friedman and Friedman (1985:35-42) finds that for the most part the companies that participate in cooperative research are from the Fortune

500. Teece (1986:286-305) also argues that large firms are more likely to possess the relevant specialized and cospecialized assets within their boundaries for taking advantage of the benefits of cooperative R&D. Furthermore, larger labs tend to possess significant long-term R&D experiences and capacities in evaluating the potential risks, benefits and costs of new projects, and have longer history and reputation. Finally, from the perspective of asymmetry in power and control, large labs also have the advantages in influencing the major missions and direction of cooperative projects. Consequently, large labs should therefore have shown more efforts in cooperative R&D. Finally, Based on these reasons, I assume that

[Hypothesis 6] Larger labs (measured by the total budget of a lab, TOTBUD) tend to engage more in cooperative R&D.

In summary, the over-all framework can be summarized in the following equation:

Efforts in formal R&D agreements = F (Major Research Mission, External Factors, Internal Factors).

THE SAMPLE AND DATA

The data used in this study were collected as part of the National Comparative R&D Laboratory Project (NCRDP). Two datasets that cover approximately the same laboratories at two different periods of time were compiled with some differences in the method of survey . The collection of the first dataset started from June, 1987, completed in February, 1988. The second dataset was completed in May, 1991. These two datasets will be treated as representing the same population at two different points in time.

The data were collected by questionnaires, both mailed and phone.[3] Major research center directories such as Gale Research Directories and Bowker's Directories were used to define the population of R&D laboratories. R&D laboratories are defined according to ownership or affiliation. There were 16,597 R&D laboratories in the population. Through carefully designed sampling procedures, useful data from 194 university laboratories,

3 The first dataset was collected by telephone survey. The second dataset was collected by mailed survey. As a result, the measurement and accuracy of the first dataset may be less satisfactory than those of the second one.

149 government laboratories, and 574 industry laboratories were collected. These responses include 125 of the largest 200 laboratories in the U.S. The median size of R&D laboratories in the sample is 78 in terms of numbers of permanent employees. The size distribution of R&D laboratories in the overall sample or in each sector both are quite skewed. Laboratories such as Los Alamos National Lab, 3M, IBM's Watson Research Center numbered more than 5000 employees. The size distribution of R&D laboratories according to their total budgets are also heavily skewed toward the larger ones. The median budget is $2 million. However, ten percent of them had only a few hundred thousand dollars while the largest ones among the largest 200 had an average of $186 million per annum. The average percentage of government funding received by all laboratories is 46%, 16% for industrial laboratories (Bozeman and Crow, 1990:25-56) .

THE SPECIFICATION OF VARIABLES

As pointed out earlier, there are three categories of variables influencing the behavior of cooperative R&D by R&D laboratories. Seven variables representing the different stages in the R&D process,[4] i.e. basic research (BASIC), pre-commercial applied research (PAPPLD), commercial applied research (CAPPLD), development (PROTO), providing technical assistance to government agencies (TECHASST), providing technical assistance to this laboratory's parent organization (TECHASST1), providing technical assistance to private firms and industrial organizations (TECHASST2), transfer technology to government organizations(TECHTRF1), and transfer technology to private firms or industrial organizations (TECHTRF2), are framed for measuring the mission orientation of R&D laboratories. For each variable, the lab will be asked to answer, for example, whether for the lab basic research is: the single most important mission (4), an important mission (3), a somewhat important mission (2), a mission of little importance (1), or not a mission at all (0).

The second set of variables representing external influences include publicness, market influence, and government regulatory procedures. The influence of publicness is measured by the average of percentages of budget, equipment, and facilities financed by public funds, government contracts,

4 For the exact definition of all the variables used in this study, please see Code Book (3/5/88) and Code Book (5/6/91) of NCRDP. While these variables are based on 0-4 grades in the second survey of NCRDP, they are based on 0-1 scores in the first survey of NCRDP.

and grants (PUBLICNESS). In addition, this research adopts the same approach as Bozeman and Crow (1990:25-56) towards operationalizing market influence (MARKET), i.e. market influence is measured by the difference between the two variables measuring respectively how labs treat the production of knowledge useful in developing commercial products and processes and how labs treat their contribution to the advance of fundamental scientific knowledge as the criteria for their organizational effectiveness.[5] Two variables regard to government regulatory procedures will be included in this study, one measuring barriers from government health, safety, environment regulations (BAR10), the other government accounting and paper work requirements (BAR12).

The third set of variables includes internal barriers, size of the laboratory (TOTBUD), and organizational design. Internal barriers include lab's inability to keep abreast of current scientific knowledge (BAR5), high administrative costs (BAR6), and too much red tapes (BAR14). Organizational design (RESORG) is operationalized by the sum of dummy variables measuring how research laboratories organize their R&D activities, i. e. the principal investigator-led research groups; departments, divisions, or branches; and finally the ad hoc type of organizational structure for research. Lastly but not the least important, since it is obvious that the numbers of cooperative R&D agreements reported by labs are such natural counts as 0, 1, 2, 3, 4, 5,... the probability distribution of the number of cooperative R&D agreements reported for the last year (times of arrival) can be appropriately approximated by a Poisson distribution (Maddala, 1983:51-55; Green, 1990:707-709) and a Poisson regression model is constructed below for testing the two datasets that were mentioned before.

It is assumed that the number of cooperative R&D agreements reported by laboratories for the last year $Y_1, Y_2, Y_3, \ldots Y_n$ have independent Poisson distributions with parameters $\lambda_1, \lambda_2, \lambda_3, \ldots \lambda_n$ Therefore,

$$Prob(Y_i = y_i) = e^{-\lambda_i}\lambda_i^{y_i}/y_i!, \quad (1)$$

$$ln\lambda_i = \beta_0 + \sum_{j=1}^{k}\beta_j x_{ij} + \varepsilon, \quad (2)$$

where y_i is the number of cooperative R&D agreements, $y_i = 0, 1, 2, 3, \ldots,$

x_{ij} is the value of the jth explanatory variables with the ith observed

5 See (Bozeman and Crow, 1990:55), note 45.

lab, $j=1,\ldots, k$; $i=1,\ldots, n$,
β_0 and β_j are the coefficients,
ε the disturbance term.

The likelihood function can be derived by multiplying the probability of acquiring all observed elements of the sample, i.e.

$$L=\prod_{i=1}^{n} Prob(Y_i=y_i),$$
$$=\prod_{i=1}^{n}(e^{-\lambda_i}\lambda_i^{y}/y_i!). \quad (3)$$

Take the log value of both sides of equation (3), then we have

$$lnL=-\sum\lambda_i+\beta_0\sum Y_i+\sum\beta_j\sum x_{ij}Y_i-\sum ln(Y_i!) \quad (4)$$

Differentiating (4) with respect to β_0, β_j, then we have the first order condition for the maximization of ln L as expressed in the following two equations:

$$\sum_i Y_i=\sum_i\hat{\lambda}_i, \quad (5),$$
$$\sum_i x_{ij}Y_i=\sum_i x_{ij}\hat{\lambda}_i \quad (6), \text{ where}$$
$$\hat{\lambda}_i=\hat{\beta}_0+\sum_{j=1}^{k}\hat{\beta}_j x_{ij} \quad (7),$$

After taking the second derivative of (4), it is not hard to see that the Hessian matrix, $\sum\lambda_i x_i x_i'$ is negative definite for all β and x. It is also easy to see that (5), (6), and (7) can not be reduced to linear functions of $\hat{\beta}_0$ and $\hat{\beta}_j$, therefore, the Newton's method of approximation is adopted here for solving the values of $\hat{\beta}_0$ and $\hat{\beta}_j$. Notations of all the variables and their meaning are listed in Table 1.

II. Findings and Implications

Empirical outcomes with significant results are reported in the attached tables. In the following, I will explore the major findings of this research and their possible implications. The discussions of government R&D laboratories, industrial R&D laboratories, and university R&D laboratories will be arranged in a sequential order. Cross-sectional comparisons will then follow.

Table 1. List of names, meaning, and measurements of variables.

DEPENDENT VARIABLE:	
LABAGREE	Number of formal cooperative R&D agreements in a year.
EXPLANATORY VARIABLES:	
Mission Focus:	All the variables in this category are measured by a discrete scale ranging from 0 to 4, meaning from not a mission at all to the single most important mission.
BASIC	How important is basic research a mission of the laboratory?
PAPPLD	How important is pre-commercial applied research a mission of the laboratory?
CAPPLD	How important is commercial applied research a mission of the laboratory?
PROTO	How important is development research a mission of the laboratory?
TECHASST	How important is providing technical assistance to government agencies a mission of the laboratory?
TECHASST1	How important is providing technical assistance to the parent organization a mission of the laboratory?
TECHASST2	How important is providing technical assistance to private firms and industrial organizations a mission of the laboratory?
TECHTRF1	How important is providing technological transfer to government agencies a mission of the laboratory?
TECHTRF2	How important is providing technological transfer to private firms or industrial organizations a mission of the laboratory?
External Factors	
PUBLICNESS	The influence of public authority, measured by the average of percentages of budget, equipment, and facilities financed by public funds, government contracts, and grants.
MARKET	Market influence, measured by the difference between the two variables representing respectively how labs treat the production of knowledge useful in developing commercial products and processes and how labs treat their contribution to the advance of fundamental scientific knowledge as the criteria for their organizational effectiveness.
BAR10	Barriers from government health, safety, environment regulations, measured by a discrete scale ranging from 0 to 4, meaning from not a barrier at all to a very serious barrier.
BAR12	Barriers from government accounting and paper work requirements, measured by a discrete scale ranging from 0 to 4, meaning from not a barrier at all to a very serious barrier.
Internal Factors	
BAR5	Lab's inability to keep abreast of current scientific knowledge, measured by a discrete scale ranging from 0 to 4, meaning from not a barrier at all to a very serious barrier.

BAR6	High administrative costs, measured by a discrete scale ranging from 0 to 4, meaning from not a barrier at all to a very serious barrier.
BAR14	Too much red tapes, measured by a discrete scale ranging from 0 to 4, meaning from not a barrier at all to a very serious barrier.
RESORG	How entrepreneurial the lab is in meeting organizational requirement of different type of initiatives in cooperative R&D? This variable is measured by the sum of dummy variables asking whether research of labs is organized in the following approaches, i.e. principal investigator-led research groups; departments, divisions, or branches; and the ad hoc type of organizational structure.
TOTBUD	Size of labs, measured by the level of total annual budget.

Impact of Mission Focus

In 1991, the most significant factor contributing to the number of formal cooperative R&D agreements by government laboratories is the priority they assigned to pre-commercial application, i.e. generic technologies as their major research mission (PAPPLD). According to Cordes and Watson (1989:22-24), generic technologies are technologies that organize fundamental scientific and engineering principles into conceptual and laboratory models from which product and process applications are eventually derived. In other words, they are part of the intermediate technologies that link basic and applied industrial R&D. Since a bulk of government R&D laboratories have already been engaging in such kind of activities, reinforced by their public positions and budget constraints, it is reasonable for them to form formal joint ventures with other organizations. The finding that targeting at precommercial application as the major organizational mission for government labs in the 1991 sample has the most significant and positive impact on the number of cooperative R&D by government R&D laboratories is quite consistent with Cordes and Watsons' argument. However, the same variable is not significant at all for government laboratories surveyed in 1988. It is reasonable to conjecture that the change in the significance of organizational mission may be a result of recent policy initiatives to boost cooperative R&D. This may also be an indication that government R&D laboratories may have changed their attitudes toward using cooperative R&D for pursuing applied research. The development of existing prototypes/ products/ processes (PROTO), the provision of technical assistance (TECHASST, TECHASST1, TECHASST2), and the transfer of technology (TECHTRF1, TECHTRF2) are generally classified into the later ends in the process of technical change. From Table 4, government laboratories surveyed in 1991 that marked the development of existing prototypes, modifying existing products/processes, or applications (PROTO)[6] as important missions of their organizations have expressed a significantly higher propensity to engage in cooperative R&D. Similarly, government laboratories in 1991 that ranked the provision of technology transfer to government organizations as their major missions (TECHASST) have engaged in more cooperative R&D agreements. This is quite contrary to my original hypothesis, i.e. labs oriented more toward the commercial end of the R&D process should have lower incentives to engage in cooperative R&D.

However for government laboratories, it may not be too unreasonable to conjecture that due to the lack of marketing, distribution, and other types of proprietary mechanisms for industrial extension before and after the development of prototypes, government R&D laboratories tend to develop joint-venture type of relationships with other participants who possess complementary capabilities that government R&D laboratories need. Further, new technologies (or materials) may involve high degree of uncertainties, particularly potential liabilities. The latter will provide the incentives for potential deployers of new technologies to get into formal agreements with others in order to share the risk of unexpected hazards. As such, the significant and positive impact on government laboratories' effort in cooperative R&D from their mission focus of developing existing technologies is not totally out of expectation.

While government R&D laboratories surveyed in 1991 that took the provision of technical assistance to other government organizations (TECHASST) as their important missions are found to engage more in cooperative R&D, those that treated technological transfer to the private sector as their important missions (TECHTRF2) tended to enter into fewer cooperative R&D agreements. This finding seems to suggest a rejection of [Hypothesis 1]. Even though further investigation is required, I proceed to give a possible reason here, just for the sake of stimulating some further discus-

6 For example, federal agencies were involved in setting up demonstration projects for nuclear power generation plant, the financial support for the development of microprocessors, VLSI, etc. State agencies such as NYSERDA has also been involved in developing prototypes, materials, and processes like flexible fuel vehicle, incinerators for energy reuse, the reuse of ashes from incinerators, and large area photodetector arrays, etc. See (Technology and Information Policy Program, Case Studies).

Table 2. University Laboratories, 1988 and 1991, *>90%, **>95%, *>99%**

Log Likelihood for Exponent: −176.832 (1991)
−95.743 (1988)

Variable		Estimate	Std Err	Chi Square	Pr>Chi	
BASIC	1991	0.344	0.543	0.402	0.526	
	(1988)	−0.193	0.149	0.451	0.502	
PAPPLD	1991	0.667	0.394	2.862	0.091	*
	(1988)	−0.681	0.119	0.014	0.707	
CAPPLD	1991	0.134	0.363	0.136	0.713	
	(1988) #					
PROTO	1991	0.254	0.361	0.496	0.481	
	(1988)	0.378	0.193	0.324	0.569	
TECHASST	1991	0.353	0.585	0.365	0.546	
	(1988)	0.248	0.169	0.287	0.592	
TECHASST1	1991	0.377	0.454	0.689	0.407	
	(1988)	−0.826	0.126	0.137	0.711	
TECHASST2	1991	0.438	0.710	0.381	0.537	
	(1988)	−0.085	0.158	0.194	0.660	
TECHTRF1	1991	0.229	0.225	1.039	0.308	
	(1988)	0.531	0.215	0.408	0.523	
TECHTRF2	1991	−0.878	0.513	2.932	0.087	*
	(1988)	0.035	0.484	0.005	0.942	
PUBLICNESS	1991	−0.006	0.019	0.101	0.751	
	(1988)	−0.011	0.006	3.268	0.071	*
MARKET	1991	−0.458	0.536	0.729	0.393	
	(1988)	−0.178	0.159	1.256	0.263	
BAR5	1991	0.091	0.559	0.027	0.871	
	(1988)	−1.105	0.467	5.606	0.018	**
BAR6	1991	0.871	0.745	1.369	0.242	
	(1988)	−0.085	0.315	0.072	0.788	
BAR10	1991	0.063	0.404	0.025	0.875	
	(1988)	0.345	0.390	0.783	0.376	
BAR12	1991	0.011	0.659	0.0003	0.987	
	(1988)	0.907	0.418	4.722	0.030	**
BAR14	1991	−0.266	0.552	0.232	0.630	
	(1988)	0.064	0.305	0.044	0.835	
RESORG	1991	−0.547	0.753	0.527	0.468	
	(1988)	−0.280	0.238	1.382	0.240	
TOTBUD	1991	0.000	0.000	7.131	0.008	***
	(1988)	0.000	0.000	0.134	0.714	***

#PAPPLD (1988) included both pre-commercial applied research (PAPPLD) and commercial applied research (CAPPLD). The latter two variables were not differentiated in the NCRDP survey of 1988. This applies to the following tables too.

Table 3. Industrial Laboratories, 1988 and 1991, * > 90%, ** > 95%, * > 99%**

Log Likelihood for Exponent: −116.624 (1991)
−139.138 (1988)

Variable		Estimate	Std Err	Chi Square	Pr>Chi	
BASIC	1991	0.077	0.151	0.261	0.609	
	(1988)	0.365	0.285	0.164	0.200	
PAPPLD	1991	0.042	0.122	0.122	0.727	
	(1988)	0.709	0.579	1.498	0.221	
CAPPLD	1991	0.057	0.192	0.089	0.765	
	(1988) #					
PROTO	1991	−0.116	0.191	0.370	0.543	
	(1988)	0.030	0.266	0.013	0.911	
TECHASST	1991	−0.126	0.164	0.585	0.445	
	(1988)	0.005	0.369	0.000	0.990	
TECHASST1	1991	−0.031	0.122	0.065	0.800	
	(1988)	−0.010	0.110	1.284	0.257	
TECHASST2	1991	−0.016	0.014	1.284	0.257	
	(1988)	0.514	0.294	3.049	0.081	*
TECHTRF1	1991	−0.193	0.213	0.820	0.365	
	(1988)	−0.078	0.292	0.072	0.789	
TECHTRF2	1991	0.272	0.267	1.035	0.309	
	(1988)	0.072	0.250	0.082	0.774	
PUBLICNESS	1991	0.000	0.010	0.000	0.992	*
	(1988)	−0.011	0.007	2.846	0.092	*
MARKET	1991	0.093	0.151	0.381	0.537	
	(1988)	−0.185	0.109	2.878	0.090	*
BAR5	1991	−0.305	0.120	4.548	0.010	***
	(1988)	−0.026	0.247	0.011	0.916	
BAR6	1991	0.057	0.147	0.148	0.701	
	(1988)	0.058	0.277	0.045	0.833	
BAR10	1991	−0.049	0.137	0.125	0.724	
	(1988)	0.222	0.248	0.804	0.370	
BAR12	1991	0.103	0.131	0.624	0.429	
	(1988)	0.049	0.278	0.031	0.860	
BAR14	1991	0.014	0.165	0.007	0.933	
	(1988)	0.035	0.484	0.005	0.942	
RESORG	1991	0.060	0.187	0.070	0.791	
	(1988)	0.227	0.177	1.644	0.200	
TOTBUD	1991	0.000	0.000	17.174	0.000	***
	(1988)	0.000	0.000	0.083	0.773	

Table 4. Government Laboratories, 1988 and 1991, *> 90%, **>95%, *>99%**

Log Likelihood for Exponent: −35.279 (1991)
−88.654 (1988)

Variable		Estimate	Std Err	Chi Square	Pr>Chi	
BASIC	1991	−0.020	0.145	0.020	0.888	
	(1988)	−0.282	0.358	0.621	0.431	
PAPPLD	1991	0.393	0.111	12.579	0.0004	***
	(1988)	0.124	0.5000	0.061	0.805	
CAPPLD	1991	−0.119	0.102	1.360	0.244	
	(1988) #					
PROTO	1991	0.274	0.148	3.423	0.064	*
	(1988)	−0.090	0.399	0.050	0.822	
TECHASST	1991	0.377	0.187	4.057	0.044	**
	(1988)	0.378	0.481	0.615	0.433	
TECHASST1	1991	−0.103	0.142	0.519	0.471	
	(1988)	0.658	0.486	1.836	0.175	
TECHASST2	1991	0.926	0.698	1.327	0.249	
	(1988)	0.006	0.006	0.950	0.330	
TECHTRF1	1991	−0.412	0.186	4.894	0.027	**
	(1988)	−0.030	0.430	0.005	0.944	
TECHTRF2	1991	−0.176	0.244	0.519	0.471	
	(1988)	0.438	0.410	1.142	0.285	
PUBLICNESS	1991	−0.022	0.010	5.289	0.016	**
	(1988)	0.013	0.006	5.504	0.020	**
MARKET	1991	−0.345	0.144	5.767	0.022	**
	(1988)	−0.141	0.129	1.192	0.275	
BAR5	1991	−0.264	0.169	2.439	0.118	
	(1988)	−0.224	0.353	0.403	0.526	
BAR6	1991	0.088	0.161	0.300	0.584	
	(1988)	0.871	0.323	7.283	0.007	***
BAR10	1991	0.243	0.417	0.340	0.559	
	(1988)	0.326	0.414	0.620	0.431	
BAR12	1991	−0.148	0.159	0.858	0.354	
	(1988)	0.575	0.347	2.743	0.098	*
BAR14	1991	−0.209	0.165	1.601	0.206	
	(1988)	−0.153	0.276	0.305	0.581	
RESORG	1991	0.491	0.218	5.055	0.025	**
	(1988)	0.121	0.233	0.270	0.604	
TOTBUD	1991	0.000	0.000	9.614	0.002	***
	(1988)	0.000	0.000	0.268	0.605	

sions. Technical assistance does not inherently tend to be continuous deals. In other words, technical assistance depends to a lesser degree on long-term, intensive, and informal interactions among key participants. As a result, government R&D laboratories that ranked technical assistance as one of their major missions engaged more in cooperative R&D, while R&D laboratories that ranked technology transfer as one of their major missions tended to rely more on informal kind of transactional mechanisms. This also confirms one of the major conclusions of various case studies on cooperative efforts in the process of technology, i.e. the importance of public or private entrepreneurial champions in the process of technical change.[7] They are people who can build up their social networks for pooling the information, know-how, resources, and social connections together to take advantage of potential possibilities in a relatively smooth and more informal fashion, without being tied up with the cumbersome legal type of formal bargaining process.

The empirical results do not confirm any significant impacts from all the mission variables included in the theoretical framework of this study for government R&D laboratories surveyed in 1988. This may quite possibly be an indication of a significant change in the attitude of government R&D laboratories towards using cooperative R&D as a mechanism for achieving their missions.

With respect to university laboratories, those with a mission focus on pre-commercial applied research tended (PAPPLD) to impose a significantly positive influence on the number of cooperative R&D engaged in 1991. Consider the fact that university laboratories generally have been a significant pool of expertise and facilities focused more toward the basic end of the process of technical change, such a result is quite compatible with our theoretical expectations (i.e. [Hypothesis 1]). However, as it comes to those university laboratories surveyed in 1988, the estimate for the coefficient of PAPPLD is negative, not significant however. Again, this may be an indication of the change in university laboratories' attitude toward adopting cooperative R&D as means for achieving their missions. Facilitated by the increasing pressure of shrinking budget, many university faculty members,

7 An interesting phenomenon is that these core participants in the process of technology development have a strong tendency to be 'technological cowboys' who like to play 'solo' or do things based on their personal social networks. See (Technology and Information Policy Program, Case Studies).

instead of engaging in purer type of fundamental research by themselves or with their closely associated colleagues, started to reach out to the greater society for the research support they need.

Like government laboratories in 1991, university laboratories that treated the provision of technological transfer to private firms or industrial organizations as important missions (TECHTRF2) in 1991 tended to engage in fewer cooperative R&D. As argued before, the presence of long-term, informal relationships may have solicited university R&D laboratories to engage in cooperative R&D in a rather informal fashion too.

For the industrial sector, there is no significant effect being detected from both datasets. This is consistent with industrial laboratories' proprietary focus, i.e. their activities are generally very close to the marketable end of products/processes innovation. The only significant effect being found is the estimate of of TECHASST2, the provision of technical assistance to the private firms and other industrial organizations. The estimate is marginally significant but positive. Industrial laboratories often times find it more feasible to choose outside partners for joint-ventures when they face fussy relationships with their marketing or sales counterparts in the same firm hard to deal with. This is particularly the case when they have already accumulated experiences, infrastructure, and trustful relationships, through frequent technical contacts, with non-technical customers equipped with financial, manufacturing, or marketing capabilities that are complementary to the industrial laboratories.

External Influence

Government R&D laboratories surveyed in 1991 with higher levels of market influence (MARKET, as compared with those that only measured their organizational effectiveness by their scientific performance) tended to try less cooperative R&D. In other words, those government R&D laboratories that worried more about their market positions had shown the same type of attitude as their industrial counterparts, i.e. the more the laboratories have to pay attention to the appropriability of their outputs, the less likely they will be engaging in formal cooperative R&D agreements (since this will increase the possibility of rival competition and reduce the profitability of their outputs). However, for government laboratories surveyed in 1988, the influence of market pressure was not significant at all.

Does the degree of Publicness make any difference?

The degree of receiving government financing (PUBLICNESS) has been found to have a significantly negative impact on the efforts in cooperative R&D by government R&D laboratories surveyed in 1991. However, part of government financing, i.e. government contracts, by definition are themselves formal cooperative R&D agreements. Theoretically, government contracts should be excluded as part of the explanatory variable since it is itself part of the dependent variable. However, in both of the datasets, no information is available for performing such a task. Consequently, it has to be borne in mind that estimates of variables representing government financial influence will be over-estimated. The influence of government financing on the efforts of cooperative R&D by government R&D laboratories in 1991 should be even more negative. This gives the hypothesis about PUBLICNESS [Hypothesis 2] a strong support from this particular sample. However, the same variable is found to have significantly positive effects for the U.S. sample surveyed in 1988.

Putting together, such empirical results seem to suggest that the level of government laboratories' publicness does not have consistent impacts on their formal efforts in cooperative R&D. This may turn out not to be very supportive of the argument made by Bozeman and Crow (1990:25-56) which assets that "organizations influenced by political authority will tend to focus on the public domain, political agenda-setting (with special attention to the political interests of its sponsor or parent) and the maintenance by the use of political resources." But this doesn't mean that the concepts of publicness embodied in Bozeman and Crow's framework should be totally rejected. Particularly, as discussed before, government R&D laboratories have been found to have changed their attitude toward using cooperative R&D and other types of joint efforts as instruments to achieve the various dimensions of their major missions. Notice also that the problem of cooperative R&D has become a national agenda for improving the economic competitiveness of American manufacturing industries in the late 1980s (Bozeman, 1991:1-5), the positive impacts from higher levels of publicness in 1988 shouldn't be surprising. However, in 1991, as government laboratories went through organizational transformations that fused cooperative R&D well into their newly adjusted missions, government laboratories regained their sensitivity toward the constraints from publicness. From such a perspective, the idea of publicness and its influence on government laboratories have been supported by the findings of this research.

The influence of public authority (PUBLICNESS) on university laboratories' cooperative R&D behavior in 1988 also confirms [Hypothesis 2]. The estimate is positive and yet not significant in 1991. What this implies is not clear. Market influence (MARKET) is a negative but not significant factor for cooperative R&D by university laboratories in both 1988 and 1991.

In terms of the impact from publicness on cooperative R&D, industrial laboratories in 1988 have shown a significantly negative effect from statistical findings. This confirms my hypothesis about publicness again [Hypothesis 2]. However, a non-significant but positive result has been reported for the 1991 sample. This seems to be an indication of the reversal over the attitudinal change posed by government laboratories as pointed out before.

Interestingly, the finding of market influence on industrial laboratories' efforts in cooperative R&D in 1988, similar to the case of government laboratories in 1991, also rejects my [Hypothesis 2]. The possible reason has already been mentioned in the section on government laboratories.

Internal Influence

Another factor, size as represented by the annual budget of R&D laboratories (TOTBUD) also has a significant and positive influence on laboratories' propensity to engage in more formal R&D agreements for all three sectors in 1991. However, such positive impacts did not exist for all three sectors in 1988.

The estimate with respect to coefficients of the variable representing the barriers caused by government health, safety, environment regulations (BAR10) is significantly positive in 1991 while insignificant in 1988 for government laboratories.

Theoretically, for short-term time series data, government health, safety, environment regulations will result in negative impacts on the efforts in cooperative R&D by government laboratories. The reason is that such regulations normally increase the immediate transaction costs of cooperative R&D. However, since this empirical study is based on cross-sectional samples, different labs should be allowed to show different positions in their responses to government health, safety, and environmental regulations. Further, if we take into account the fact that most government laboratories have the mandate to improve public welfare according to the law, and if time is allowed for resource adjustment, moderate gaps[8] between field practice and statutory mandate may be a stimulation for R&

D laboratories to try to take advantage of opportunities for improving the quality of life through approaches including technological joint ventures.[9] This may be an indication of government laboratories' efforts in meeting their major duty of enhancing public welfare through targeting at technological opportunities that are highly supportive of government regulations. However, most of the research and development activities involved in these joint efforts tend to contain significant levels of risks. Particularly, potential liabilities may be one of the major concerns for those key participants in such activities. Consequently, it is reasonable for government R&D laboratories to rely more on formal cooperative R&D in fulfilling their tasks.

The influence of the flexibility in organizational design for R&D activities within government R&D laboratories (RESORG) on cooperative R&D has been found to be significantly positive in 1991. This is consistent with our former hypothesis [Hypothesis 5]. However, there is no significant estimate in 1988. Again, this may represent a very unique change in the attitude of US R&D laboratories toward why cooperative R&D can be adopted. However, since this is not a time series analysis, the exact dynamics between flexibility in organizational design and government laboratories' effort in cooperative R&D can not be exactly identified. Theoretically, the direction of causality may go both ways.

Government laboratories in both periods have not shown any significant impact from barriers against achieving maximum R&D productivity by staying abreast of rapidly growing scientific and technical knowledge (BAR5). Government laboratories that ranked government accounting and paper work requirements as important barriers for achieving the maximum R&D productivity of their laboratories (BAR12) tended to do more cooperative R&D based on the 1988 sample, while not for those surveyed in 1991. As pointed out by Cordes and Watson (1989), the heightened awareness of budget retrenchment carried out by various levels of governments has increased the pressure on R&D laboratories funded mainly by government revenues (i.e. university and government R&D laboratories) to find ways of

8 It is possible that if the government regulation is too restrictive and therefore the barriers it create will be too costly for R&D laboratories to overcome, there may be negative incentives. However, most regulations are compromises between various interests, and they are rarely very extreme. Further, even allowing for possible negative impacts at the moderately extreme end of the barrier continuum, the overall slope may still be positive.

9 See (Technology and Information Policy Program, Case Studies).

privatizing those originally pure public activities. It is possible that government laboratories that were eager to expand their roles in the improvements of national competitiveness might find that government accounting and paper work requirements in the context of fiscal retrenchment may have been a serious bottleneck against such an effort, and therefore, developed strong incentives to engage in formal cooperative R&D agreements with private organizations in order to cut the size of the inefficient public sector.

But for the government sample of 1991, no significant effects has been detected. This may imply that government laboratories were either no longer zealous about the 'privatization' business or didn't feel or take the fiscal stress as serious as before. However, further research are required for supporting such a conclusion in a more robust way.

Keeping abreast of current scientific knowledge (BAR5) is a significant barrier for cooperative R&D by university laboratories in 1988, but not a significant factor in 1991. This may indicate the possibility that university laboratories were becoming more oriented toward practical knowledge.

Like government laboratories surveyed in 1988, the impact of high administrative costs (BAR6) results also in higher levels of cooperative R&D by university laboratories in 1988.

As far as internal barriers are concerned, difficulties in keeping abreast of current scientific knowledge (BAR5) do have a significantly negative influence on the number of cooperative R&D engaged by industrial laboratories at the one-percent confidence level. This confirms my [Hypothesis 4]. This can be an evidence to the observation that as the frontiers of technology are becoming more fast-paced and complex, not only has it been more difficult for organizations to maintain monopolistic control on a particular technology but also organizations have to keep themselves so up-to-date that they are ready to take advantage of outside technologies in a timely fashion.

III. Comparisons and Conclusions

After examining the empirical results of the structural factors that may have influenced the numbers of formal cooperative R&D engaged by industrial, university, and government laboratories in the U.S., some of the hypothesis laid out in the beginning of this paper have been confirmed by the empirical findings of this research. The others are rejected.

Quite out of expectation, basic research as a mission of the laboratory

(BASIC) is uniformly non-significant for all three sectors. This may be a suggestion for us to look further beyond the arguments for cooperative R&D laid out before, i.e. spillovers and the need of complementary assets. It is quite possible that the potential scope and the goals of basic research may be so wide and ambiguous that it may have been very difficult already for potential partners to initiate any meaningful dialogue, not to mention formal agreements. Contact can only start when clues, basic ideas, and questions about the feasibility of a potential subject have been well-developed and potential partners can evaluate the pay-offs and the associated possibilities.

As far as the variation of laboratories' mission focus along the whole process of technical change is concerned, hypotheses and predictions according to the existing literature do not come out strongly confirmed. In fact, there is no such clear pattern that would allow us to extract any interesting patterns of influence on cooperative R&D by mission focuses along the different stages of technical change. This suggests that there may be more complicated mechanisms to technological pioneering than those implied by the straight-arrow model of technical change based on the simple spillover or externality effects. In addition, more than industrial and university laboratories, government laboratories have responded quite differently between 1988 and 1991 to structural variables that are considered to be important forces driving laboratories' efforts in cooperative R&D. It is also quite clear from the findings that the most significant changes are related to the significance of their mission focuses along the various phases of technical change.

Even though market pressure (MARKET) is only significant in cases of industrial laboratories in 1988 and government laboratories in 1991, its impact on all three sectors during both periods are all negative. On the other hand, the influence of publicness is significant for university laboratories in 1988 (−), industrial laboratories in 1988 (−), government laboratories in 1988 (+) and 1991 (−). Such findings have broken the age-old clich that organizations more influenced by public authority will pay higher attention to political imperatives or obligations instead of innovation and organizational competitiveness. The popular stereotype that holds organizations more exposed to market influence to be equipped with higher motivations to engage in adaptive behavior under competitive pressure has not been confirmed by this study either.

Another finding to be noted is the significant role played by the size of laboratories in 1991. This factor is not significant for all three sectors in

1988. In another research based on the same theoretical framework and statistical procedure, laboratory size has also been found to be a highly significant factor in explaining the behavior of cooperative R&D by Japanese government laboratories. Again, though the empirical test itself does not provide any possible explanation, this may be the result of changes in attitude toward cooperative R&D among large laboratories. It is not clear why this is so. However, this may generate certain concerns among those who are interested in relying on small and medium-sized enterprises as major instruments for either industrial renovation or economic restructuring. Further inquiry along this direction will be worthwhile for topics such as the sustaining or regaining of economic competitiveness.

In contrast, only a few structural variables could explain the behaviors of industrial and university laboratories under this framework. For industrial laboratories, only three variables are significant for each period. The most significant influence of cooperative R&D under this framework is the difficulty to keep abreast of current scientific knowledge (BAR5, only for 1991). The other one is size (TOTBUD, only for 1991). With regard to university laboratories, only external barriers such as government accounting and paper work requirements (BAR12, for 1988) and internal barriers like the difficulty to keep abreast of current scientific knowledge (BAR5, for 1988) are significant in the direction as hypothesized at the 5% significance level.

Such obvious contrasts between the empirical findings of laboratories in the above three sectors induce even more interesting questions to be asked: what are the factors contributing to such changes in the U.S. federal labs system? Why does this framework seem to apply so well to the case of government laboratories in 1991, yet, almost fail to explain the activities in industrial and university laboratories? Could there be elements or dimensions that are important for industrial and university laboratories yet neglected by the theoretical framework adopted in this research? Even before the possible structural change in US government laboratories in 1991, national government laboratories do not look very different from their counterparts in the industrial or university sector. Why are there such differences cross sectors? Further research will have to be conducted for answering such questions.

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比較美國國家、產業、大學實驗室在共同研發差異上的因素

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摘　要

共同研發自一九八〇年代以來，在如何提高個別公司或國家整體經濟競爭力的辯論中，已成爲世界各國公共政策上的主要議題之一。本研究發展了一個簡單的理論架構來探討什麼因素造成美國國家實驗室、產業實驗室、大學實驗室在共同研發的努力上，有所差別。此架構包括三類因素：各實驗室對科技變遷過程中不同階段的重視程度，影響各實驗室行爲的內在與外在因素。鑑於八零年代以來，在公共行政或企業管理學界興起一股對公、私組織到底有任何不同的研究熱潮，本研究在外在因素中，特別注意考察在承受不同程度市場競爭壓力與政府公權力影響下，各實驗室在共同研發的努力上是否也有特定的差別。

本研究發現，建構在經濟外溢效果或經濟外部性的共同研發理論並不能解釋美國各實驗室在共同研發上的差別。公權力與市場競爭壓力的影響也沒有一致而顯著的影響。不但如此，美國的國家實驗室、產業實驗室、大學實驗室在共同研發的行爲模式上有很大的不同。特別是美國的國家實驗室在一九九〇年前後有顯著不同的表現。本論文發現美國的國家實驗室在一九九〇年代在共同研發上有相當積極的作爲，這發現排除了在公權力影響下組織會較保守、被動、不能動彈的陳腔濫調。反而產業實驗室、大學實驗室的實證結果卻大大異於一般人對非官方組織較具彈性、較能反映環境變遷壓力的印象。

關鍵詞：共同研發、國家實驗室、產業實驗室、大學實驗室、科技政策