ABSTRACT

The objective of this study is to identify variances in the effect of government-industry cooperative R&D on technology transfer, and in the determinants of collaboration propensity in the United States and Japan. For this purpose, this study adopts an interorganizational-theoretic framework that assumes the effectiveness of technology transfer as a direct function of the frequency of cooperative R&D. The propensity of government-industry cooperative R&D formation is theorized as a function of government-industry cooperative R&D (GICR&D) contingencies which are in turn affected by task and institutional properties of government laboratories. Using statistical methods, this study analyzes the data obtained from the mailing surveys of 173 United States and 86 Japanese government laboratory directors.

Major findings of this study are as follows. Regarding the relationships between collaboration and transfer effectiveness, cooperative R&D was perceived neither as an effective, nor as a major mechanism for transferring technologies in Japan, and to a lesser degree, in the United States. The two countries were different rather than similar in the formation effect of task and institutional properties. Government laboratories in the United States were likely to form collaboration irrespective of research missions, whereas only basic research mission was positive in Japan. Red tape had a recognizable positive effect in Japan, whereas it had a discouraging one in the United States. Resource privateness was more influential than resource publicness as much in Japan as in the United States. Government parenthood was positive in Japan but results were not firm in the United States. Two countries were very similar in the effect of GICR&D

contingencies. Mission diversity, commercial project orientation, and organizational importance of resource acquisition were positive in both countries, with an exception of Japan being not significant in the importance of resource acquisition. Commercial project orientation was the most influential factor in the United States, and government parenthood was the most influential one in Japan.

PARTNERING GOVERNMENT LABORATORIES WITH INDUSTRY
A Comparison of the United States and Japan from a Government Laboratory View

by

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Dedicated to my Lord, Jesus Christ,

my parents,

my wife, Yongme,

and my daughter, Juwon

I. INTRODUCTION

1.1. A Government Laboratory Policy: Cooperative Research and Development

The rise of Japan as a technology-based economic world power and the resultant heightened international competitiveness have highlighted national differences in the ways that technology is developed, transferred and commercialized (Dosi, 1988; Link and Tassey, 1987; Press, 1987). One area in which these national differences appear to have been most conspicuous is cooperation between government and industry in technological innovation (Aram, Lynn and Reddy, 1992; Chiang, 1991; Dimancescu and Botkin, 1986; Hill, 1992; Link and Tassey, 1989).[1] Relationships between government and industry in Japan have generally been considered to be closer (Johnson, 1982; Nelson, 1984), and more conducive to improved competitiveness (Johnson, 1984; Okimoto, 1989), than in the United States and European countries. Mancur Olson (1982) argued that the consequences of the conflict between government and industry are stagflation and fall-off in growth and productivity in the United States. Freeman (1987: 31) captures the importance of such institutional arrangements for Japan as follows:

> When Britain opened up a major 'technological gap' in the first industrial revolution, this was related not simply to an increase in invention and scientific activities...but to novel ways of organizing production, investment and marketing and novel ways of combining invention with entrepreneurship. When Germany and the United States overtook

[1] While some would see an economic logic of cooperation, such as efficient use of resources and economies of scale, as the major motivation for cooperative research efforts (Stotesbery, 1988), international competitiveness was the most influential, if not the only, driving force for such activities (Dimancescu and Botkin, 1986; Link and Tassey, 1987), in that it was a heightened international competitiveness that has pinpointed the economic implications of such logical considerations.

> Britain...their success was also related to major institutional changes in the national system of innovation...Similarly today, when Japan is opening up a new 'technology gap', this is related not simply or even mainly to the scale of research and development, but to other social and institutional changes.

Close relationships between the Japanese government and industry in technological innovation, particularly symbolized by Japanese government-financed large scale projects, have fueled Western concerns that "cooperative R&D was akin to a secret weapon that would enable Japan to lead the world" (Ray and Buisseret, 1995). For example, the Japanese government's announcement (1981) of the Fifth Generation Computing Systems program was followed by some twenty national counter-measures in other industrialized Organization for Economic Co-operation and Development (OECD) countries (Ferné, 1989).

Coupled with the prevalent questioning of the government laboratory system in these countries (OECD, 1989), the presence of government research arms in Japanese large scale projects has led to a wave of reappraisal of the government laboratory system in the United States and European countries. The underlying premise of the laboratory performance evaluation was such that the government laboratory system is "not only a fact of life, but also an essential but frequently underestimated resource" (OECD, 1989: 7). There is of course skepticism about the image of the government laboratory system as a reservoir of knowledge being ready for industrial use (Papadakis, 1995). Meanwhile, it appears to be obvious that, by initiating or at least supporting research cooperation with industrial firms, the United States and European governments have attempted to enhance the transfer of technologies from government laboratories to industry.

These cooperative endeavors are being stimulated by the recognition of various potential benefits which an effective transfer of technology could bring to the nation. In the shorter run, it is expected that an effective transfer of technologies would enhance government research in terms of responsiveness and relevance to society's needs (Charles and Howells, 1992). In this sense, an effective transfer of government technologies will facilitate the integration of government laboratories into the national innovation system as a whole (OECD, 1989; Soderstrom, Copenhaver, Brown and Sorenson, 1985). In the long-run, the improvement in technology transfer through R&D collaboration will bring about the development and sustenance of technological leadership and, ultimately, promote global competitiveness (Charles and Howells, 1992; Dodgson, 1993; Link and Tassey, 1987).

1.2. Cooperative R&D As Laboratory Policy in Japan and the United States

The government-industry relations in Japan contrast significantly with the ones in the United States. The government-industry relations in the United States are often depicted as "market-dictating" or "adversarial", whereas those relations in Japan are considered "market-conforming" or "cooperative" (McCraw, 1986; Wilson, 1990). The United States government is concerned about the fact that the cooperative relationships between government and industry have transformed the image and reality of Japan from a "copy-cat" mainly of American scientific and technical (S&T) knowledge to a "head-to-head competitor" (McCraw, 1986; Patrick and Rosovsky, 1976; Thurow, 1993).

Under these circumstances, the involvement of the Japanese government in industrial technology innovation has kindled a so-called "industrial policy debate" (e.g. Johnson, 1984; Graham, 1992) in the United States, a country that has allegedly 'lost much' to Japan.[2] There have been a series of policy measures toward cooperative R&D amidst arguments that Japanese competitors of United States firms are not just private companies, but "organizational systems composed of both private and public sectors" (Rycroft and Kash, 1992).

The origin of cooperative R&D in Japan is usually traced back to the establishment of the Engineering Research Association (ERA) Act in 1961.[3] The act aimed at elevating the high technology capability of major Japanese firms up to the level of the major American firms (Goto and Wakasugi, 1988).[4] These ERAs were grafted in 1971 into the scheme of the National Research and Development Program[5] which was launched in 1966 as a series of more formalized, large-scale government-industry joint research ventures. The most highly hailed programs were the VLSI (Very Large Scale

[2] In contrast with the general perception of competitiveness crisis, Papadakis (1994) demonstrated that there was no sudden onset of manufacturing-wide structural non-competitiveness and that competitiveness crisis is characterized by intensified competitive decline for the auto, textiles, and electronics industries, and by competitive reversals for the electrical machinery and office and computing machine industries.

[3] Morris-Suzuki (1994) documents the evolution of voluntary research associations active in Japanese prefectures since the Meiji Restoration. Fukasaku (1992) documents a well-defined policy toward government-industry cooperation active in the prewar Japan.

[4] The purpose of Japanese cooperative R&D was different from the purpose of its progenitors, the British research associations, which were established to support technological innovation in traditional industries consisting mainly of small firms (Goto and Wakasugi, 1988: 198; Kodama, 1991).

[5] The utilization of the ERAs as the implementing tool for large-scale national programs has begun since the Pattern Information Processing System Project was launched in 1971 (Kodama, 1991).

Integration) program [6] and the Fifth Generation Computing Systems program. In addition to the MITI's national programs, there have been numerous large scale projects in a wide range of technology areas such as computer and electronics, manufacturing process, automobiles, aircraft, telecommunications, biotechnology, and other nationally needed technologies. In Japan, cooperative R&D between government and industry is proliferating as individual government ministries compete with each other for influence in leading areas of high technologies. One of the latest large-scale programs in Japan was the Key Technology Promotion Center. Many Japan observers predict a decline in the significance of interfirm cooperative R&D in the high-technology Japan. Intersector R&D collaboration is increasingly stressed in recent science and technology-related policy measures. For example, the Law for Facilitating Government Research Exchange of 1986 was to facilitate joint research and other research/personnel exchanges between government laboratories and industry.[7] The recent Basic Law of Science and Technology of 1995 re-affirms the importance of technology for the global competitiveness of Japanese firms and the critical role of R&D cooperation between government and industry thereof. More importantly, the nature of research is changing from applied research to basic research in R&D collaboration involving government laboratories.

[6] There were two VLSI programs then active in Japan: one run by the Ministry of International Trade and Industry (MITI) and the other run by the Nippon Telecommunications and Telegraph (NTT). The VLSI program indicated here belongs to the former category.

[7] Another noteworthy aspect of this Act is that it allowed government laboratories to hire foreign researchers at high-ranking positions within Japanese government laboratories.

Table 1.1. Major Japanese Policy Measures for R&D Collaboration

1961	The Engineering Research Association Act.
1966	The National Research and Development Program:
	The Very Large Scale Integration (VLSI) Project (1976-1979).
	The R&D Project on Basic Technologies for Future Industries (1981-1990).
	The Fifth Generation Computing Systems Project (1982-1992).
	The Real World Computing Program (1992-2002)
1981	The Exploratory Research for Advanced Technology (ERATO).
	Special Coordination Funds for Promoting Science and Technology.
1985	The Key Technology Research Facilitation Law, and the Establishment of the Key Technology Promotion Center.
1986	The Law of Facilitating Government Research Exchange (revised in 1992).
1995	The Basic Law for Science and Technology.

The United States policy concern over cooperative R&D was driven by dissatisfaction with the past experiences in technology transfer. It was further reinforced by the initiation of Japanese publicly-supported large projects and their subsequent performance. For example, in response to global competitiveness, government-owned, government-operated (GOGO) and government-owned, contractor-operated (GOCO) laboratories were given the right to license their commercially relevant technologies to small businesses and nonprofit organizations by the Bayh-Dole Act of 1980, and to the private sector by the Stevenson-Wydler Act of 1980. Coupled with the highly hailed success of the VLSI program, the Japanese formation of the Fifth Generation Computer Systems program was the direct motivation for the establishment of the privately-funded Microelectronics and Computer Technology Corporation (MCC). The National Cooperative Research Act of 1984 was intended to legally support the MCC and other collaborative ventures such as the Semiconductor Manufacturing Technology Consortium

(SEMATECH). The 1984 act was in turn the direct precursor of the Federal Technology Transfer Act of 1986 that allowed GOGO laboratories to form cooperative R&D agreements with industry and other actors. The National Competitiveness Technology Transfer Act of 1989 allowed GOCO laboratories to enter Cooperative R&D agreements with industrial and other organizations. Subsequent acts were primarily extensions and elaborations of these earlier policy measures.

Table 1.2. Major United States Policy Measures for R&D Collaboration

1980	The Patent and Trademark Laws Amendments Act (Bayh-Dole Act)
	The Stevenson-Wydler Technology Innovation Act
1982	The Microelectronics and Computer Technology Corporation (MCC)
1984	The National Cooperative Research Act
1986	The Federal Technology Transfer Act
1987	The Semiconductor Manufacturing Technology (SEMATECH)
1988	The Omnibus Trade and Competitiveness Act
1989	The National Competitiveness Technology Transfer Act
1991	The American Technology Preeminence Act
1993	The National Cooperative Production Amendments
1995	The National Technology Transfer and Advancement Act

As shown in Table 1.2, the overarching theme of government laboratory policies in the United States was the enhancement of domestic technology transfer through the use of government laboratories as “a partner in the commercialization of technology”(Rahm, Bozeman and Crow, 1988; Clinton and Gore, 1993). A report of the Council on Competitiveness (1992:3) states:

> America's Federal Laboratories have a new customer--U.S. industry. They also have a new mission--technology transfer. This new customer and new mission stand as clear reminders of the end of the Cold War. No longer is national security the overriding priority of the Federal labs; economic competitiveness must also become a vital consideration.

Government laboratories are being required to fulfill technology transfer as part of their mission. The number of cooperative R&D agreements with industry is becoming an important measure of laboratory performance (Branscomb, 1993; Ray, 1994). For this reason and others, government-industry cooperative R&D is proliferating in the United States to the point where critics think of such a growth as the "CRADA [Cooperative Research and Development Agreement] mania" (Beardsley, 1993).[8]

1.3. Research Questions

The current state of research on cooperative R&D has a number of limitations. The first limitation is a lack of systematic documentation of government-industry cooperative R&D.[9] Very few studies (e.g., Coursey and Bozeman, 1989; Charles and

[8] The total number of active CRADAs has been increasing from 108 in 198, 975 in 1991 (National Science Board, 1993, Appendix Table 4-29), to 2,607 in 1994 (Brody, 1996, Figure 8; This figure excludes the statistics for the National Aeronautics and Space Administration and the Social Security Administration). However, there has been a retreat from such a CRADA explosion that was forced by the new Republican-controlled Congress tends to see some of collaborative activities as "corporate welfare." For example, congressional funding for major cooperative projects --the Technology Reinvestment Project (TRP) of the Department of Defense and the Advanced Technology Program (ATP) of the Department of Commerce--has been considerably cut or is in danger of being eliminated. Although CRADAs are less controversial than TRP or ATP programs, the number of CRADAs formed by the Department of Energy laboratories has been declining since 1995, due to less money available for CRADAs (See Lawley, 1996).

[9] The literature of inter-firm cooperative R&D is vast. Dodgson (1993) provides a variety of issues, strategies, and policies regarding inter-corporate collaboration (also see Bidault and Cummings, 1994; Contractor and Lorange, 1988; Kleinknecht and Reijnen, 1992; Link and Bauer, 1987; Link and Tassey, 1989; Mariti and Smiley, 1983; Quintas and Guy, 1995). University-industry cooperative R&D has been well documented by Bonaccorsi and Piccaluga (1994), Faulkener and Senker (1994) and Dill (1990) from

Howells, 1992) deal with government-industry cooperative R&D from a laboratory policy perspective.[10] The literature also lacks an adequate concern with the Japanese government laboratory establishments as *systems*. Many studies on Japan have dealt with the government's micro-management of the economy, particularly industrial policies of the MITI, rather than paying attention to the technical arms of the government. A lot of scholarship claimed that government laboratories have been a critical factor in industrial technological innovation policy in Japan (Baranson, 1986; Audretsch, 1989; Crow and Nath, 1990; Lynn, 1983; Morris-Suzuki, 1994; Shinjo, 1988; Stotesbery, 1988), but they offered little empirical evidence to support the claim. The literature also asserts that cooperative R&D is the most effective means for technology transfer from government laboratories to industry in the United States and Japan (Cutler, 1988; Eagar, 1985); however, there is little empirical evidence concerning the effectiveness of cooperative R&D in the transfer of technology. With some exceptions (Bozeman and Pandey, 1994; Cutler, 1988; Papadakis et al., 1993-94, 1993), most studies on this issue remain anecdotal, descriptive or observational (Eager, 1985; Hane, 1993; Lynn, 1983; National Research Council, 1989).

The purpose of this study is to examine and explain the antecedents and outcomes of R&D cooperation between government and industry in the United States and Japan. This study has four analytical foci: First, it focuses on the government-industry

the perspective of industry; and by Charles and Howells (1992), Larsen and Wigand (1987), Wigand (1990), Geisler and Rubenstein (1989), and Langfitt, Hackney, Fishman and Glowasky (1983) with a more balanced focus.

[10] Others (Lee, Bae and Lee, 1994; Roessner, 1993b; Roessner and Bean, 1990) discussed government-industry cooperative R&D from the industry standpoint. Still others (Bozeman and Pandey, 1994; Gibson and Rogers, 1994; Gibson and Smilor, 1991; Smilor and Gibson, 1991) included government laboratories. industry and universities in their research.

cooperative R&D as the *positive* side of government-industry relations. Second, the major concern is with the *formation* stage of *formal* cooperative R&D activities. Third, the formation of cooperative R&D is approached from the viewpoint of *government laboratories*. Fourth, the focus is on *technology transfer* as a common rationale for the formation of the cooperative R&D, especially the *laboratory-to-industry* side of technology transfer flow.

Given these foci, this dissertation will deal with the following research questions: 1) Is cooperative R&D a crucial element in the transfer of technology from government laboratories to industrial firms? 2) How effective is cooperative R&D in transferring technologies and in what terms? 3) What government laboratories are more likely to form cooperative R&D with industry? 4) Is there any systematic pattern in the formation of cooperative R&D among government laboratories? 5) Is (or Was) the United States a different cooperative R&D regime from Japan or not?

This dissertation is organized as follows: Chapter Two provides an overview of the literature of the government-industry interactions in general, and those focusing on R&D collaboration in particular. Chapter Three presents a theoretical framework for analyzing the relationships among organizational antecedents, cooperative R&D, and technology transfer effectiveness. Chapter Four establishes a set of propositions concerning the relationships between cooperative R&D and technology transfer effectiveness. Chapter Five describes the data and measurements used in the analysis of these relationships. Chapter Six tests the propositions established in Chapter Four by employing statistical techniques. Chapter Seven explains and discusses the findings of the statistical analysis; it focuses on identifying and explaining the differences and similarities between the United States and Japan. Chapter Eight concludes the study with a discussion of policy implications for the United States government laboratory policy; finally there is a presentation of some of the limitations of this study, and suggestions for further research.

II. LITERATURE REVIEW

2.1. Government-Industry Relations In Japan and the United States

1. R&D Collaboration As A Positive Way of Looking At Government-Industry Relations

One of the tricky issues in studying the Japanese technological innovation is no doubt the way a researcher would define the government-industry relations in Japan. This issue appears very complicated when he compares the United States to Japan, both of which are generally recognized as "exceptional systems." In dealing with the American exceptionalism, King (1973a, 1973b) emphasized "ideas" or ideologies as the most influential factors differentiating the United States from other industrialized countries in his sample. Most American scholars usually extract the root of American "ideas" from the neoclassical political economy tradition. In this tradition, markets are the primary mechanism of exchange and efficient allocation of resources. In the event that the market fails the government's involvement becomes necessary, a circumstance that has been described as a "constrained choice" (Caporaso and Levine, 1992: 79). Theoretically government and market do not differ in terms of their end, which is the maximization of individual wants; but the role of government in the neoclassical theory remains a subsidiary one to individual wants. As Dye (1990) pointed out, the political economy of public policy in the United States is such that government and market tend to be perceived as distinctive actions, each of which is subject to different standards. Markets are guided by self-interest based on "voluntary exchange," and government is guided by the public interest based on an "authoritative allocation of values" (Easton, 1965). Relationships between government and market are depicted as dichotomous and often adversarial (see Lindblom, 1977). Some Japanese and Western researchers approach the Japanese government-industry relations from the neoclassical standpoint (Kosai and Harada, 1985 in Kosai, 1995; Trezise and Suzuki, 1976). The neoclassical approach is rare and does not seem to be tenable in Japan.

By contrast, revisionists explain this exceptionalism from the state-theoretic perspective which is based on the active role of state.[11] According to them, Japan as a strong, state-led, developmental and planned, or interventionist society presents a fine contrast to the United States as a weak, stateless, company-led or laissez-faire, regulatory, or noninterventionist society (Dyson, 1980; Katzenstein, 1978; Johnson, 1982; 1995; Okimoto, 1989; Zysman, 1983). The crux of the revisionist argument is that the state --with visionary “economic staff” (Johnson, 1982) and relatively few checks from either the legislative or judiciary bodies (Wilson, 1989)-- drafts and enforces laws, issues administrative guidance or regulations, allocates fiscal resources, and mobilizes the assistance from the private sector. The results are cooperation, and boundary blurring, between government and industry. To borrow Bingman's words, the relationship is

[11] Statists use some conceptually distinct terms, state, government, politics, or bureaucracy, on the one hand, and society, industry, market, firm, on the other hand, interchangeably.

"literally impossible to tell for certain where its government leaves off and its private sector begins" (Bingman, 1989: 93).

There have been many counter-arguments with regard to major empirical bases for the statist accounts (see Calder, 1993; Callon, 1995; Fong, 1990; Samuels, 1987; Weaver and Rockman, 1993). A major drawback of the statist theory lies in the fact that the conceptual angle used by its theorists was not appropriate to pick up the possible presence of weak-state incidences in the strong state and vice versa. The notion that there are "weak-state" components in the strong state was picked up by Okimoto (1989). Okimoto advanced a statist view of the government-industry relations by proposing the concept of a *network state*. In a network state, one is able to exercise power only in terms of its network ties with the private sector. Aoki (1988) theorized the government-industry relations with the concept of *bureaupluralism*. Under the bureaupluralism, the Japanese bureaucracy plays a dual role, i.e., a delineator of the public interest and a representative of the interests of its jurisdictional constituents. Unlikely his J-firm, such a decentralized[12] responses to policy issues are reinforced by the decentralization of personnel management. Interministerial coordination is achieved through quasi-pluralistic bargaining nested within the bureaucracy. From a different perspective, Samuels (1987) framed the Japanese government-industry relations as a process of *reciprocal consent*. He argued that firms give the state a jurisdictional authority over markets in return for their continuing control of those markets. According to him, it is the reason why the pervasive state can be "so congenial to private firms" (1987: 2).

[12] By "decentralized," Aoki means that decision making authority is "localized at the individual ministries with its own jurisdictions and political members, i.e., *zoku*."

Synthesizing government and market influences, Murakami (1987) proposed the *compartmentalized competition* hypothesis of the Japanese government-industry relations. Government prepares the playing ground by using weak guidance. Industrial firms compete with each other according to rules which are applied equally within an industry but differently between industries. The importance of private sector entrepreneurship constitutes the core ingredient of the *corporate-led strategic capitalism* advanced by Calder (1993).[13] Unlikely Calder, Sakakibara (1993) defined Japan as a *non-capitalist* market economy characterized by a "dual structure consisting of a large corporate sector and a public sector" (p. 11). The basic relationship between the two sectors is one of *comparative independence*, implying that the two sectors are engaged in compartmentalized competition in basically independent forms. This compartmentalized competition in turn necessitates a constant process of bargaining, both government and market choices being made reciprocal. Sakakibara argued that the Japanese model of government-industry relations is largely accounted for by the structure of government expenditure which slants largely toward "finance as an enterprise, along with public works " (p. 27). According to him, the statist viewpoint of government-industry relations in Japan would fit only the MITI-centered industrial policy.

A large part of such controversies among scholars originate to a great extent in the difference in time period, and in government activity area, which they covered in their

[13] Calder's typology of the government-industry relations in the area of credit allocation is dualistic in comparative terms. He argues that the notion of *corporate-led strategic capitalism* is the most appropriate to the comparison between Japan and other banking-dominated countries like Germany and Sweden, whereas his *clientilized state* proposition better fits the comparison with other developmental states like France and South Korea (see pp. 261-268).

studies. Most studies based on the statist theory focused on the 1950s and the 1960s,[14] and many counter arguments focused on the developments in government-industry relations after the 1970s and especially the 1980s (e.g., Calder, 1993; Callon, 1995). Policy areas under consideration also led to different accounts of the salience of sectoral variations or national variations in the government-industry relations in Japan and in the United States (see Wilks and Wright, 1987). In some cases, scholars observing the same policy area came up with a different interpretation of government-industry relations (e.g., Calder, 1993 versus Zysman, 1983; Krugman, 1986 versus Johnson, 1982 and Tyson, 1992). Grant (1989) points out a need to integrate both national and sectoral influences. Along the same lines, the presence of sectoral variations implies that the bureaucracy in Japan is not one but several bureaucracies (Sakakibara, 1993; Calder, 1993).

Researchers tend to discuss a wide array of industrial policy tools in the name of the government-industry cooperation in technological innovation. Cooperative R&D is a *form* as well as a product of the government-industry relations at the societal level. Focusing on cooperation between government research laboratories and industrial firms, we can find history-long cooperative relations between government and industry in both countries. Fukasaku (1992) documents the sustained presence of government-industry-university R&D collaboration even in the prewar Japan. Kosai (1995) depicts R&D collaboration since 1970s as a more positive relationship between government and industry than other types of government-industry relations present before 1960s. McQuaid (1994) argues that government and business, particularly big businesses, have

[14] However Johnson (1995) argue that his developmental state argument is still tenable in Japan.

been "uneasy partners in the United States," but the relationships have been symbiotic during the past half century since 1945. The symbiotic relationships have been varied and complex, being parasitic, mutually beneficial, or commensual, depending on policy areas. Government-industry R&D collaboration is described as a typical example of the mutually beneficial symbiosis in his scheme. Miller (1968) also stresses a long-standing history of government-industry collaboration. In a similar vein, Rycroft and Kash (1992) argue that the United States had a tradition of cooperative relationships between government and industry which also fit the American spirit. According to him, the turnaround toward the adversarial phase is a post-war incident which originated with a misinterpretation of the United States history of government-industry relations (particularly, Nelson and Winter, 1982). A recent report of the White House (1995) also re-affirms a historical root of cooperative relationships between government and industry in the United States:

> Joint public and private cooperation in research and development dates back to the birth of the Republic. It led to the invention of the American system of manufacturing...by the government's Connecticut River and Harper's Ferry armories and civilian inventors like Eli Whitney. Half a century later, in 1863, it was a public-private partnership that guided the federal establishment of land-grant universities to improve the practice of agriculture and engineering, and supported further investments after the turn of the century in agricultural extension services and cooperative research.

2. Stylized Facts of Government-Industry R&D Collaboration in Japan and the United States

While government-industry cooperation is a time-honored practice in technological innovation, it seems that two countries have been in a different track of technological innovation. The growth of the literature on R&D collaboration has produced a number of "stylized facts" which contrast Japan and the United States. The first of the stylized facts is that there is the closed and interactive communication between government and industry, or between industrial collaborators, in technology innovation in Japan. Boyd (1987) characterized the Japanese government-industry cooperation as a high degree of *collaboration* through *interactive communications* with *limited access* (also see Morris-Suzuki, 1994: 187). As Boyd (1987: 64-65) puts it, the isolated interaction has facilitated the movement of ideas between government and industry in Japan. On the other hand, collaborative R&D ventures between industrial firms and between firms and government laboratories in Japan are questioned in terms of collaborativeness and interactiveness embedded in the stylized facts (Aldrich and Sasaki, 1995; Fong, 1990; Ray and Buisseret, 1995). Rather such a truly collaborative venture is reported as a recent development in Japan (OECD, 1989). However, such an isolated interactive communication might have contributed to secure the commercial orientation of the government R&D (Lederman, 1994), and also of the R&D activities within the whole national innovation system

The second ingredient is the *commercial content or orientation of R&D* in the Japanese national innovation system, the critical factor that arguably the United States system lacks (Goto and Wakasugi, 1988; Mowery and Teece, 1992). The commercial content or orientation of research largely means complementarity of government R&D to the private sector R&D, focus on applied and development research rather than basic research, or the lack or paucity of government mission oriented research, especially military-defense concerns, in research activities at the national and governmental level. According to Samuels (1994: 320), there in Japan is *one* economy which serves both civilian and military consumers and that links firms, regions, and the nation, whereas there are the civilian and military *economies* in the United States. In a *one* economy system, the development of military technology is *embedded* in the development of commercial technology. The system suits the development of dual-use technology, the type of technology that is a promising candidate for precommercial research.

The third ingredient of the stylized national contrast is the government support for the development of generic technologies by industry in Japan (Chiang, 1991; Johnson, 1982; Nelson, 1984; Samuels, 1994). Generic technology has potential to be widely applied across industry, but it is weak in terms of intellectual property. The Japanese emphasis on generic technology development was strategic in that generic technology was considered to be a stepstone for assimilating foreign S&T knowledge, and for catching up the Western technological powers, particularly American firms. The development of generic technology has been a major policy focus for interfirm or intersector cooperative R&D in Japan. These cooperative R&D ventures were the major recipients of government subsidies in Japan (Levy and Samuels, 1991; see also Aldrich and Sasaki, 1995; Hane, 1993-1994; Ouchi and Bolton, 1988; Peck, 1986). By contrast, science and technology in the United States has been void of the strategic intent by government. A report by the Center for Strategic and International Studies (1993: 11) laments that "Yet our society tends to treat its S&T assets not as strategic investments to meet national goals but as a side issue--as if a strong science and technology base is a naturally self-perpetuating adjunct to other activities" (also see Shapley and Roy, 1985). Mowery (1992) argues that the United States national innovation system is an "unintended" effect of antitrust and military procurement with little explicit economic objectives in mind.

Finally, another stylized fact of the Japanese R&D collaboration is the prevalence of informal type of collaboration. Macdonald (1992: 52) warns that Japanese R&D collaboration is supported by "less formal links" already in action and by "informal information networks." Macdonald (1992: 54-55) goes on to argue that formal collaborative agreements will damage the existing information networks which are akin to the invisible colleagues of academics, contrary to information exchange in formal collaboration at which information is given away in order to receive other information. Cooperative R&D ventures are largely dominated by informal cooperative research arrangements (Hakansson and Johanson, in Contractor and Lorange, 1988: 369; Link and Bauer, 1989; Macdonald, 1992). There is also a growing indication that linkages among government laboratories, industry and universities are now becoming more formal, more frequent, more planned (Fusfeld and Haklisch, 1984; Rhea, 1991). In the formal cooperative R&D, interactions between government laboratories and industrial firms are given official sanction by the parties involved and in some cases the relationships between the two parties are mediated through certain coordinating mechanisms (Marrett, 1971). It is argued that formalized interorganizational relationships can provide an atmosphere where more committed and repeated interaction may facilitate informai interactions (Berman, 1994; Hall, Clark, Giordano, Johnson and Roekel, 1977; Hughes, 1995).[15]

The preceding discussion of the "stylized facts" raises a number of important questions concerning government-industry R&D collaboration to be investigated in the next chapters. The first question to raise is “Is (or Was) the formal type of R&D collaboration between government laboratories and industrial firms in Japan effective in terms of transferring technologies to industry?” The second question is “What laboratories are likely to form R&D collaboration ventures with industry?” “Is R&D collaboration with industry prevalent among government laboratories, or limited to certain types of government laboratories?” “What kinds of research mission are suitable to the precommercial research on generic technology between government laboratories and industrial firms?” Particularly related to the Japanese government’s increasing concerns with the promotion of fundamental or basic research since 1980, was this policy focus on research mission reflected in R&D collaboration between government laboratories and industry?[16] Inquiry into these questions will provide insights into the growing trend of formal collaborative R&D ventures between government laboratories and industry in the United States.

[15] For a rebuttal of this argument, ‘formality enriching informality,’ see Macdonald (1992).
[16] However the author of this dissertation does not intend to provide a full-fledged account of research mission change, and its effect on R&D collaboration and its effectiveness, because the dissertation relies for analysis on the data obtained from a one-shot survey for each country.

2.2. Theories and Research on Government-Industry R&D Interactions

1. Collaboration Formation and An Effective Collaboration

The importance of the formation of collaborative ventures for their subsequent effectiveness has been long acknowledged by organization theorists who tried to identify determinants of interorganizational relations (e.g., see Guetzkow, 1966; Marrett, 1971; Schermerhorn, 1975; Rogers and Whetten, 1982; Oliver, 1990). The underlying assumption of earlier theorists was that interorganizational relationships are themselves good for the effectiveness of participating organizations (see Hall, 1991). Another prevailing focus of earlier theorists is on the identification of factors which encourage or discourage to enter the interorganizational relations. In a similar vein, Geisler and Rubenstein (1989) reviews the literature regarding major barriers (or facilitators) in R&D cooperation between universities and industry.

Recent developments of interorganizational relations or social partnership analyses tend to pay greater attention to the possibility that such determinants may have an impact on the stages along the collaboration process. Waddock (1989; 1991) suggests that different combination of the bases for collaboration (i.e., issue salience and interdependence) lead to different types of collaboration structures (i.e., programmatic, federational, and systemic). Different types of collaboration structures has different meaning in terms of effectiveness. Focusing on conflict resolution and vision sharing, Gray (1985; 1989) provides a domain-based, process-oriented approach to interorganizational collaboration. To her, the collaborative process consists of the problem setting, direction setting, and implementation phases. Gray notes that an effective collaboration depends upon the presence and strength of conditions at appropriate phases during the collaborative process. Bonaccorsi and Piccaluga (1994) hypothesize that different motives of a firm to enter a university-industry collaboration will affect different performance dimensions (i.e., knowledge generation, knowledge transmission, and knowledge propagation). Håkanson (1993) argues that characteristics of partnering organizations affect the chances for a cooperative R&D venture to succeed by alleviating or aggravating problems to be encountered during the implementation of a cooperative venture. He saw technical competence, financial strength, and strategic intentions, as major partner characteristics. A cooperative venture encounters cultural difference, (technical financial) capacity deficiencies, change in technological commercial conditions and in strategies and priorities, and mistrust regarding using access to proprietary technologies (i.e., ownership change). Using a number of indirect measures of partner characteristics, he found that collaborating with well-known partners (i.e., prior contacts) reduces the risks of failure, thus helping avoid implementation difficulties.

A systematic study of collaboration should consider the collaboration process in its entirety--formation, implementation, maintenance, termination or continuation. On the other hand, the formation of collaboration can have significant bearings on the whole process, in that contingencies affecting the formation tend to bear upon the subsequent process of collaboration. Before we discuss the contingencies of relationship formation, it is necessary to define collaboration and communication in the context of R&D collaboration. The literature includes a wide variety of collaboration and communication within the purview of government-industry cooperation. Particularly with regard to Japan, collaboration and communication range from R&D collaboration, to the utilization of advisory bodies, and to administrative guidance. The concern of this study will be mainly with the collaboration, and communication therein, between government laboratories and industrial firms, which is the main idea of the following communication perspective.

2. Collaboration as a Communicative Field: A Communication Perspective

Communication is seen as an integral part not only of internal functioning of organizations but also of interorganizational activities (Katz and Kahn, 1978; Wigand, 1979). Interorganizational communication is frequently suggested as a distinctive feature of technically oriented government agencies and technology transfer activities (Bobrowski and Bretschneider, 1994; Bozeman and McGowan, 1982; Wigand and Frankwick, 1989; Williams and Gibson, 1990).

Building on the *convergence* approach to communication of Rogers and Kincaid (1981), a group of communication theorists of technology transfer (Gibson and Smilor, 1991; Williams and Gibson, 1990; Gibson and Rogers, 1994) --primarily the MCC researchers-- have advanced a communication theory of technology transfer. By convergence, Rogers and Kincaid meant a movement of the parties involved in communication toward one point, or of one individual toward another, to unite in a common interest or focus. This process proceeds through iterative feedback, "a dwindling series of under-and-over corrections converging on the goal" (Rogers and

Kincaid, 1981: 62). The distinction between the sender and receiver is blurred, thereby both becoming "transceivers" (Williams and Gibson, 1990: 16). To these theorists, technology transfer as a special type of communication is seen as an ongoing, interactive communication process of technical "information" or "knowledge" between the sender and receiver (also see Larsen and Wigand, 1987; Weick, 1990) rather than a movement of physical artifacts (Fusfeld, 1986). They draw the importance of convergence communication from the fact that technology application and commercialization require continuous interaction between the source and the destiny (Gibson and Rogers, 1994). Collaboration is defined as a (quasi-) organizational form or structure in which barriers to technology transfer are identified and removed through such an interactive communication.

Rogers (1983: 19) stresses that communication of innovations usually involves interaction between heterophilous individuals or organizations. Heterophily (e.g., the difference in technological base between collaborators) is a necessary condition for gains from technology sharing between collaborating parties. But it also accompanies different "system norms" (the established behavior patterns for the members of a social system, Rogers: 1983: 27) or different "coding systems" (systematic properties to which organizations determine the amount and type of information they receive from the external environment and transform it, Katz and Kahn, 1978: 433-434). Gibson, Rogers and their colleagues (Gibson and Smilor, 1991; Gibson and Rogers, 1994) argue that major problems of previous technology transfer efforts (see Devine, James and Adams, 1987; Gibson and Rogers, 1994) are related to the assumption that there is a linearity in communications between these heterophilous technology transfer agents. Rebutting earlier communication theorists (e.g., Berlo, 1960; Shannon and Weaver, 1949; Schramm, 1971), Kincaid (1979, in Rogers and Kincaid, 1981) pointed out that such a linear type of communication process has a vertical communication bias, a source-deterministic (or receiver-dependence) bias, a bias toward communication objects isolated from the context, bias toward the messages per se, persuasion bias, psychological bias, and one-way mechanical causation bias.[17] Gibson and his colleagues argue that the effectiveness of technology transfer can be enhanced by creating an organizational situation where interactive communication is facilitated among the parties involved in collaboration (Smilor and Gibson, 1991).

Granovetter's (1973) "weak-tie-strength" proposition presents a different aspect of collaboration as a communicative field. Granovetter's argument rests on the proposed curvilinear relationships between tie strength (no tie, weak tie, and strong tie) and its impact on diffusion. The strength of a tie is defined as a "combination of the amount of time, the emotional intensity, the intimacy (mutual confiding), and the reciprocal services which characterize the tie" (p. 1361). He posits that a strong tie tends to occur between similar people who in turn tend to cluster together so that they are all mutually connected. The information obtained through a network structure of the type described is more likely to be redundant. Thus, the network of strong ties is not likely to be a channel for innovation. By contrast, weakly tied persons are more likely to move in a network other

[17] For example, earlier communication theorists like Shannon and Weaver (1949) and Berlo (1960) envisioned communication as a process in which the sender does "affect with intent" (Berlo, 1960: 12) the behavior of the receiver, or as a one-way mechanistic causation like a "bullet shot at a target" (Schramm, 1971).

than their own. Weak ties more often constitute "local bridges" to parts of a social system that are otherwise disconnected. A weak tie is therefore likely to provide new information from disparate parts of the system. Wigand and Frankwick's (1989) study of communication networks in the United States microelectronics industry re-affirmed the importance of the strength of weak ties between government and industry. They found that the government-to-industry linkage was highest in contact frequency but lowest in link strength;[18] that the industry-to-government linkage was relatively infrequent but important for industry; and that compared to the other types of linkages, the government-industry linkages were more frequent but weaker. These findings imply that these weak ties could be activated quickly when needed, so that cooperation between government and industry may play a critical role in technology commercialization and then economic development.

Watkins (1991) describes R&D collaboration as a communicative field from a different angle. Reinterpreting Williamson's (1975; 1985) transaction costs theory from a communication perspective, Watkins (1991) posits that it is the economization of technological communications costs that determines the formation and subsequent efficiency of R&D collaboration between firms. According to Williamson (1975; 1985), coupled with increased environmental uncertainty and frequency of recurrent transactions, asset specificity will increase the likelihood of movement from the

[18] In their study, the frequency of contacts was measured by the mean number of contacts per respondent, and the strength of a link was measured by contact frequency weighted by perceived importance and divided by number of links.

marketplace to intermediate interorganizational structures[19] (and ultimately to hierarchical forms of organization). According to Watkins (1991), the barriers to innovation diffusion are structural or organizational as well as technological. He argues that "technical knowledge" is embedded in the situation for which it is developed, congested , and limited in the community of firms for which they have value. Thus interfirm cooperation will lower costs associated with communication and learning, and it will provide more optimal levels of R&D than will markets or hierarchies.

The work of communication theorists under review tends to deal with the determinants of an effective technology transfer in the relationship setting per se. Researchers working on the MCC case have focused on communicative quality or ease as the major criterion. For example, Avery and Smilor (1990) posit that a choice of effective technology transfer mechanism is determined by "technology transfer continuity" (the degree to which communication in technology transfer is relatively discrete or interactive). Transfer continuity is determined by "technology level" (the degree to which technology is basic as compared to applied) and "equivocality" (the degree to which technology is subjective as compared to objective). They suggest that the subjective and basic technology research is best suitable to cooperative R&D through which the parties involved in technology transfer communicate interactively. Rogers and his colleagues (Gibson and Rogers, 1994; Gibson and Smilor, 1991) added to it communication interactiveness, participant motivation, and cultural/ geographical/

[19] The intermediary structures such as interorganizational relationships were not a theoretical ingredient in Williamson's earlier work (e.g., 1975), but the importance of intermediary structures was recognized in his later work (e.g., 1985).

strategic distance. With emphasis on asset specificity, Watkins (1991) also points out the importance of generic technologies. Bornaccorsi and Piccaluga (1994) hypothesize that the performance of R&D collaboration will depend upon knowledge tacitness, universal applicability of knowledge, and appropriability issue.

A question is "what government laboratories will be suitable for the technological, cultural, and motivational properties of R&D collaboration? The subsequent three theoretical perspectives explicate the contingencies inducing the relationship formation from the viewpoint of government laboratories.

3. The Organization Technology Perspective

Theoretical Arguments The organization technology perspective to technology transfer is based upon the work of contingency theorists, especially the theorists using the "contingent"[20] proposition of contingency theory (Burns and Stalker, 1961; Lawrence and Lorsch, 1967; Perrow, 1967; Thompson, 1967; Woodward, 1965). The underlying premises of the "contingent" proposition are that there is "no best way" to organize in all situations, and that the organizational performance --effectiveness or success-- depends on the fit between internal structure and the environmental conditions. A fit will enhance performance, and a misfit will lower performance. The interpretation of the organizational environment varies among contingency theorists. Different contingency

[20] By "contingent" this study means one of the argument modes employed by contingent theorists: "congruent" and "contingent." The congruent mode tries to identify the structural characteristics appropriate to environmental conditions, whereas the contingent mode explains the variations in organizational performance caused by the interactions of organizational structure and environmental conditions (Scott, 1990: 111-112). The "contingent" proposition is consistent with Drazin and Van de Ven's (1985: 515) "selection approach to fit" and Donaldson's (1985: 140) "design approach."

theorists emphasize different aspects of organizational environment such as organization technology (Perrow, 1967; Thompson, 1967; Woodward, 1965), organizational size (Blau and Schoenherr, 1971; Hickson, Pugh and Pheysey, 1969), technological and market situations (Burns and Stalker, 1961; Lawrence and Lorsch, 1967), and institutional environment (Scott, 1990). However, the dominant theory of contingency has emphasized technology as the major determining factor of organizational structures (Scott, 1990). The characteristics of technology were defined according to uncertainty, complexity, and interdependence. In short, organization technology affects the characteristics of organizational structure which in turn affect organizational effectiveness.

The earlier studies and later developments in the "contingent" theory approach (Abernathy and Utterback, 1988; Donaldson, 1995; Lawrence and Lorsch, 1967; Woodward, 1965) emphasized a positive role of organizations in adapting themselves to the environment through the movement from a misfit toward a fit. Noting the inverse relationships between differentiation and integration, Lawrence and Lorsch (1967) found that the high-performing firms, which function under a more diverse environment and with a more differentiated internal structure, tend to employ the more elaborate strategies for integration. Child introduced the role of strategic choice by decision-makers or the dominant coalition as "a necessary element in any adequate theory of organizational structure" (Child, 1972: 19). According to Child (1972), the strategic choice involves not only the establishment of structural forms, but also the manipulation of environmental features and the choice of relevant performance standards. Ansoff (1968) argues that organizations adopt strategies which reflect partly their environment and partly their goals. Thompson (1967) states that under conditions of interdependence and uncertainty, organizations under the rationality norm try to achieve predictability and self-control through regulation of transactions at their boundaries, e.g., by buffering, by building organizational slack, or through other activities which match fluctuations in the environment.

The sequential relationships among the components of the contingent organization technology model vary according to authors (see Child, 1972; Donaldson, 1995; Dumbleton, 1986; Miller, 1984; Pennings, 1992). Disagreements center around the way "strategy" is defined by researchers. Writers focusing on the "intentional" aspect of strategy tend to favor the sequence strategy-technology-structure-performance (see Child, 1972; Donaldson, 1995). Researchers focusing on a more "structural" aspect of strategy advance the sequence technology-(structure-)strategy-performance (see Miller, 1984). Building on the latter sequential relationship, Bozeman (1994) argues that organizational technologies or goals influence a choice between organizational strategies. In an evaluative study of government technology transfer, Bozeman (1994) predicts that a choice among technology transfer strategies within a government laboratory, one of which is cooperative research, is determined by the laboratory's structure and its motives of technology transfer. In his contingency formulation, the structural characteristics and transfer motivations of a government laboratory are in turn determined by the nature of its research missions as organizational goals. As a result, the nature of transfer strategies is determined by structure and motivations, subjected to research missions of government laboratories. Bozeman assumes that technology transfer effectiveness is dependent directly upon the technology transfer strategies employed by the government laboratories which is in turn a function of organizational structure and missions.

Empirical Research The contingency theory, especially one based on the "contingent" proposition, is often considered to be the "normal science" of organization theory (Donaldson, 1985: ix; also Pennings, 1992). However, few empirical attempts were made to test the theory in the public sector organizations, including the government laboratories, with some exceptions. The work of Bozeman (1994) concerning technology transfer of government laboratories is the only empirical research that applies the contingency theory to the context of government laboratories. The underlying premise of his work is that technology transfer effectiveness is determined by the nature of transfer strategies adopted by laboratories. According to Bozeman, which strategies will be used depends on laboratories' structural profile and transfer motivations, both of the latter being subjected to the nature of their research missions. Instead of considering the mediating effect of those strategies, this work focuses on explaining determinants of technology transfer effectiveness. He suggests that from the substantive standpoint, the government policy for cooperative R&D appears to have a somewhat positive effect on technology transfer from government laboratories. From the theoretical perspective, the contingent theory of organization technology worked poorly. The empirical research has failed to support the assumption of sequential causation implicit in the theory.

Evaluation Numerous criticisms have been leveled against the contingent proposition of the organization technology theory (e.g., Donaldson, 1976; Ford and

Slocum, 1977; Pennings, 1992; Scott, 1990). Since there is only one empirical attempt on the subject matter in question, it is difficult to make a sound assessment of the theoretical perspective based on empirical evidence. The work of Bozeman (1994) highlights some limitations of the contingent organization technology perspectives to technology transfer. A major limitation of the contingent organization technology theory is its failure to figure out the importance of organizational strategies as a mediating variable between antecedent variables and organizational effectiveness. Rather, the contingency theory under review tends to focus on identifying the determinants of organizational effectiveness. This focus leads to another limitation of the theory: its heavy reliance on bivariate deterministic formulas to identify the inherently multivariate relationships. Contingency theorists tend to use bivariate analyses in dealing with the trivariate relationships inherent in the contingent proposition. Using bivariate correlations, they ignored the dynamics of the "contingent" structure of argument. In addition to the issue of statistical modeling, classificatory problems associated with technology and structural variables (and sometimes strategy variables) often resulted in the lack of empirical support for the trivariate relationships between technology, structure (and/or strategy), and performance as formulated in the contingency theory (Bozeman, 1994; Donaldson, 1976). Another problem with technology variables, and organizational goal variables,[21] is that a focus on the "dominant" technology as used by

[21] There is an overlap between concepts of technology used by contingency theorists and meanings of goals or functions. While some tried to straighten the overlap out (Hickson, Pugh and Pheysey, 1969), the distinction between organization technology and organizational goal is not so clear. For example, technical research missions in the government laboratories are seen as organizational goals by the work of Bozeman (1994) but just as types of research activity by the work of Papadakis (1995).

Woodward (1965) may not reflect the norm in the real world organizations such as factories (Marsh and Mannari, 1981) or government laboratories (Mark and Levine, 1984).

4. The Exchange-Theoretic Perspective

Theoretical Arguments The exchange theoretic perspective to technology transfer is rooted at two related theoretical propositions: exchange theory (e.g., Levine and White, 1961) and resource dependence theory (e.g., Aldrich, 1976; Pfeffer and Salancik, 1978). These two models share some basic premises about the relations between organizations and environments: Environmental turbulence (Emery and Trist, 1965), resource scarcity and its importance for survival or goal achievement of organizations (Yutchman and Seashore, 1967), other organizations as the sources of needed resources (Levine and White, 1961; Pfeffer and Salancik, 1978), and organizational exchange as the main mechanisms of resource acquisition (Cook and Whitmeyer, 1992: 114; Hall, 1991: 229). These two models differ from each other in terms of the nature of interorganizational interdependence postulated in each theory group, and in terms of the way organizations deal with the elements of their environment.

The exchange theory emphasizes the "normal" aspect of interdependencies between organizations that are based upon interorganizational differentiation and division of labor (Aldrich, 1979: 267). Exchange theory is based on the work of Levine and White (1961) about the dyadic relationships between health and welfare agencies.

According to Levine and White (1961), the formation of exchange[22] relations among organizations is determined by alternative resources available, functional specialization, and subsequent domain consensus. Resource scarcity "impels the organization to restrict its activity to limited specific functions" (Levine and White, 1961: 587). The primary function of an organization determines the amount of organizational exchange and the kinds of exchange elements. Thus it determines a degree of dependence on other exchanging organizations (Levine and White, 1961: 592-593). The dependence of an organization upon other organizations is reduced by the availability of alternative resources (e.g., the availability of resources from parent organizations), which in turn reduces the need to enter exchange with other organizations. Meanwhile, organizations need domain consensus before entering the exchange relations (Levine and White, 1961: 600). As formulated by Levine and White, exchange is similar to the functional and "symbiotic" interdependence (Guetzkow, 1966: 31) in that organizations complement each other. Relying on Perrow's (1961) classification of organizational goals, Schermerhorn (1975) makes a similar statement by proposing that cooperation will occur among organizations with complementary official goals or common operative goals.

The fact that the exchange of resources involves far-reaching consequences was developed by another group of exchange theorists focusing on the exchange and power aspects of interpersonal relationships. Noting the reciprocity as an important ingredient

[22] While Levine and White (1961) define organizational exchange as any voluntary activity involving unilateral, reciprocal, or joint interaction, later exchange theorists (Blau, 1964; Cook, 1977) tend to limit its definition to the voluntary activity involving the "reciprocation" of extrinsic rewards--rewards instrumental to the goal achievement. In this respect, Blau (1964: 6) asserts that "assumption of exchange theory that social interaction is governed by the concern of both (or all) partners with rewards dispensed by the other(s) becomes tautological if any and all behavior in interpersonal relations is conceptualized as an exchange, even conduct toward others that is not at all oriented in terms of expected returns from them."

of social relations, Emerson (1962: 32) argues that power resides in the other's dependency. According to him, an unbalanced power relation prompts an actor to engage in power-balancing operations. Weak actors may diffuse dependency into new relations in a network; they may form a coalition with others against the stronger actor; they may withdraw from the current relations; or they may give a higher status to strong actors. Reformulating Emerson's schema from the standpoint of exchange conditions, Blau (1964) states that one's supply of needed resources to another creates the former's undeniable claim to power on the latter when the latter does not have any of the elements of independence--reciprocation, alternative sources of resources, the use of force, or no need for resources.

Grafting the interpersonal power-dependence scheme into the interorganizational context, Thompson states that "an organization is dependent on some element of its task environment (1) in proportion to the organization's need for resources or performance which that element can provide and (2) in inverse proportion to the ability of other elements to provide the same resource or performance" (Thompson, 1967: 30). Van de Ven and Walker (1984) demonstrate that the perception of dependency in resource exchange relations spurs the initiation of interorganizational relations.

Resource dependence theorists (Aldrich, 1976; Aldrich and Pfeffer, 1976; Pfeffer and Salancik, 1978; Thompson, 1967) argue that an organization's dependence for resources upon other organizations and its subsequent inclusion in interorganizational structures for the acquisition of resources usually lead to a loss of autonomy by granting power to those resource suppliers. This shapes a political economy of interaction among organizations (Benson, 1975) in which they are engaged in a constant struggle for resources and subsequently for autonomy (Pfeffer and Salancik, 1978). Power and control possibilities are inherent in a situation of resource dependence; therefore, organizations in an interorganizational political economy may seek (or avoid) some interdependencies (Aldrich, 1979; Blau, 1964; Van de Ven and Walker, 1986). In this sense, resource dependence theorists (Benson, 1975; Aldrich, 1976) tend to regard domain consensus as an outcome of interorganizational relations rather than their cause.

According to resource dependence theorists, organizations may use various strategies for managing resource dependence. Organizations may establish subunits to screen out information and protect internal operations from external influences (Thompson, 1967; and Pfeffer and Salancik, 1978). Schermerhorn (1975) predicts that the presence of boundary spanning roles or capacities is an important correlate of interorganizational cooperation. Also, organizations may be engaged actively in arranging a negotiated environment through merging, diversifying, and other strategies designed to disperse dependence and acquire power (Pfeffer and Salancik, 1978; Thompson, 1967).

While the resource dependence theory recognizes that the environment provides many constraints and uncertainties (Aldrich and Pfeffer, 1976: 89), the theory assumes that organizations make a strategic choice (Child, 1972). Building upon Weick's (1969: 64) notion of "the human enacting the environment," Pfeffer and Salancik (1978: 13) argue that organizational environments are created through a process of attention and interpretation, a point also advanced by Child (1972). Organizations can maneuver their organizational environment to maintain autonomy and manage power and dependence. It follows that organizations are affected by their environments according to the ways in which managers, or dominant coalitions, formulate strategies, make decisions, and implement these decisions.

Attempting an environmental taxonomy of the U.S. national R&D laboratory systems, Bozeman (1987) focuses on the dimension of "publicness", a mix of political and economic authority, as a critical external constraint and contingency faced by organizations. According to him, the publicness dimension affects organizational behaviors, structures, and performance. He suggests in his case study of government laboratories that in terms of resource publicness, those laboratories with a balanced mix of public and private funds are more likely to be R&D cooperatives and produce generic types of outputs. Bozeman and his colleagues (Bozeman and Crow, 1990; Crow and Bozeman, 1991; Crow and Bozeman, 1987) discovered the very same thing in their research. In a study of technology transfer from U.S. universities and government laboratories, Bozeman and his colleagues (Bozeman and Crow, 1991b) assert that any S&T activities, including technology transfer, are affected by the goal orientation as determined by environment, dependence constraints such as public and private influences, and dependence management efforts. In their research, government laboratories' R&D collaboration with industry is considered as a source of boundary spanning with respect to technology transfer.

Focusing on cross-sectoral collaborations for solving social problems, Logsdon (1991) maintains that the formation of a cross-sectoral collaboration is determined by individual organizations' interests in solving a social problem and by their perceived interdependence with other organizations. Relying on Oliver's (1990) work, Logsdon proposes that an organization's interests in problem solving can be accounted for by the stakes in efficiency, stability, and legitimacy (Oliver's category of contingencies) , and its interdependency is associated with a degree of reciprocity and power asymmetry (Oliver's category of conditions). Logsdon argues that neither interests nor interdependence alone can account for a complete rationale for organizational involvement in collective social problem solving, proposing that collaboration likely occurs when there are both high interests and interdependence. Coexistence of high interests and interdependence may be achieved by moving from low interdependence through high interdependence to high interests, or by moving from low interests to high interests to high interdependence.

Empirical Research As with the organization technology perspective, few empirical studies address the theoretical issues of the exchange theoretic perspective on government and industry R&D collaboration. However, several empirical comparisons of public and private organizations have been undertaken in cooperative research between university and microelectronics industry (Larsen and Wigand, 1987; also Wigand, 1990) and university-based science parks (Van Dierdonck, Debackere and Rappa, 1991).

A few of the studies falling within the exchange theoretic perspective are more analytical and go beyond the simple descriptions of motivations and satisfactions of the parties involved. Bozeman and his colleagues (Bozeman, 1987; Bozeman and Crow, 1990; Crow and Bozeman, 1991; Crow and Bozeman, 1987) have been concerned about profiling the U.S. R&D laboratory as a system from the perspective of the "publicness" theory. They identified twelve R&D laboratory types that had different mixes of environmental inputs, i.e., political and economic authority. Each cluster of R&D laboratories in government, universities and industry had a distinctive profile of missions. structure, R&D cooperation and R&D output. They found that cooperative research activities are likely to be a function of the mix of government funds and industrial funds.

A more comprehensive empirical examination of government-industry linkage from the exchange theoretic perspective is Bozeman and Crow's (1991b); in this work, Bozeman and Crow test their environmental input taxonomy of the science and technical establishment from the perspective of resource dependence theory. Their underlying assumption was that S&T activity, including technology transfer, is a function of environmental constraints flowing from the laboratory's market and political influences. On the whole, their hypothesis was strongly supported by their analysis: They found that the nature of variables in the model was strongly --and largely in the expected direction-- related to the choice of technology transfer to government and to industry, respectively. On the other hand, cooperative R&D (as one of the boundary spanning activities in the model, and measured by the total number of inter-laboratory agreements) turned out to be an only marginally significant predictor of technology transfer to either government or industry.

Evaluation A major limitation of the resource dependence theory is its neglect of organizational goals (Hall, 1991: 282). Viewed in terms of research missions, organizational goals provide the raison d'être and the foundation of technical competence of government laboratories (Mark and Levine, 1984). Research missions of government laboratories have been the most salient task in OECD countries' effort to enhance the relevance and effectiveness of government laboratories (OECD, 1989). The government laboratory missions are assigned and changed with relations to the S&T needs of their parent agencies. As a result, goal dependence is as important as resource dependence, a point advanced in the work of Bozeman (1987).

The assumption of the resource dependence theory that organizational independence is a primary consideration in the decision to establish or forego interorganizational relations seems to be problematic. The dependence of government laboratories on parent agencies and government is *not* necessarily a *bad* thing. Such a dependence helps these laboratories secure their core research functions (Bozeman, 1987; Sanders and Robison, 1992). In some cases, resource dependence depends on the extent to which government laboratories are allowed to use government funds at their discretion (Rubin, 1990). This suggests that the relationship between a loss of autonomy and the frequency of linkage formation may be more dynamic than the theory would assume to be. In Shenhav, Lunde and Goldberg's (1989) study of Israeli research institutes, the direct effect of external funding [23] on publication rates was observed only in the academic sector. Thus they argue that the amount of external funding is not a useful measure of dependence in non-academic institutes, i.e., industry and government laboratories. In a study of Canadian social service agencies, Oliver (1991) suggests that the relationship may vary according to the equivalent loss of autonomy between partners.

[23] In their study, external funding was operationalized by the amount of external funds out of the total research budget and number of sources)

the availability of strategic alternatives, the importance of uncertainty reduction over autonomy, and the nature and importance of benefits obtainable from linkage formation. Bielefeld (1990) argues in a study of nonprofit organizations that the interorganizational effect of resource dependence varies with the institutional environments of organizations. As Hall, Clark, Giordano, Johnson and Van Roekel (1977) pointed out earlier, the exclusive use of exchange theoretic arguments to explain government-industry relations may be inappropriate in the context of government laboratories, because exchange theory is most relevant to relationship formation under conditions of organization choice. Mandating a relationship not only increases the frequency of interactions between respective organization (Aldrich, 1976), but it also may reduce an organization's perception of power over its environments (Whetten and Leung, 1979).

5. The Institutional Perspective

Theoretical Arguments Institutional theorists [24] (DiMaggio and Powell, 1983; Meyer and Rowan, 1977, in Powell and DiMaggio, 1991) propose that beliefs or rules prevailing in the organizational environment affect the structure and behavior of organizations, irrespective of technologies and resource exchange relationships. They differentiate institutional environments from technical environments. According to Scott and Meyer (1983, in Scott, 1991: 167), technical environments are "those within which a product or service is exchanged in a market such that organizations are rewarded for

[24] There are "many faces" of institutional theory depending on theorists' conceptualization of institution and institutionalization (see Scott, 1987). In this section, this study reviews only institutional theorists whose theoretical focus is focused on "rules and cultures" rather than "task environments".

effective and efficient control of the work process." By contrast, institutional environments are "characterized by the elaboration of rules and requirements to which individual organizations must conform if they are to receive support and legitimacy[25] from the environment." They further assert that in institutional environments, organizations are rewarded for "establishing correct structures and processes, not for the quantity and quality of their outputs".

Since it is institutional legitimacy, rather than task environment, that determines the survival or effectiveness of organizations, organizations may adopt inconsistent or even conflicting practices to gain, maintain or enhance legitimacy (Meyer and Rowan, 1977, in Powell and DiMaggio, 1991). As DiMaggio and Powell (1983) put it, legitimacy pressures often lead to "institutional isomorphism" --the phenomenon of organizations in the same organizational field adopting a similar practice.

There are several mechanisms through which legitimacy may be institutionalized into organizations. DiMaggio and Powell (1983: 150-154) assert that organizations are homogenized through coercion, mimicry or professional norms. Scott (1987: 501-507) elucidates institutionalization according to influence mechanism:[26] The first type of influence is the imposition of organizational structure. Certain environmental agents, nation-states or corporations, "impose structural forms or practices on subordinate organizational units." DiMaggio and Powell (1983: 150-151) refer to this type of

[25] Because of the conceptual fragmentation among institutionalists, the literature of institutionalize does not provide a firm conceptual mooring for its core concept, *legitimacy*. Suchman (1995) provides an extensive survey of institutional theory and hint at synthesizing such a diverse literature.
[26] This section deals only with three of the mechanisms suggested by Scott (1987) that fit the purpose of this study, the rest of which are the "acquisition", "imprinting", "incorporation", and "bypassing" of organizational structure.

influence as coercion which takes both formal and informal pressures by government laws or by cultural expectations. Scott (1987) distinguishes between two types of the imposition (imposition by means of authority, and imposition by means of coercive power), and gives emphasis on the former, "authority relations." According to him, "structural forms imposed by authority are more likely to occur more rapidly and to involve higher level of compliance." The second influence mechanism is the authorization of organizational structure: In this mechanism, the subordinate unit "voluntarily seeks out the attention and approval of the authorizing agent" (Scott, 1987). DiMaggio and Powell (1983: 152-153) note that this type of normative influence stems from professionalization. The third is the inducement of organizational structure: Environmental agents can create structural changes in organizations by "providing incentives to those that are willing to conform to the agent's conditions" (Scott, 1987). Funding agents "specify conditions for remaining eligibility for continuation of funding....Usually the recipient organization must provide detailed evidence concerning continuing structural or procedural conformity to requirements" (Scott, 1987; also see DiMaggio and Powell, 1983: 150). However, the impact of this mechanism on the organizational performance is unlikely to be strong and lasting, because the mechanism is "only one of many funding streams", and because organizations are prone to "co-mingle" funds from various sources (Scott, 1987).

The multiplicity of institutional environments is emphasized by Friedland and Alford (1991). According to them, different institutional spheres have different institutional logic. For example, the institutional logic of the market is the commodification of human activity, and the institutional logic of government is the regulation of human activity by legal and bureaucratic hierarchies. Due to the different institutional logic, different institutional actors have different interests in influencing organizational structures, and they employ different mechanisms to influence organizational structures. These differences necessitates different structural arrangements (Scott, 1987: 508-509).

Empirical Evidence There are also few empirical studies that tackle R&D collaboration or technology transfer through an angle of institutional theory. Some piecemeal empirical evidence can be found in the work of Bozeman (1994). He found that legal coercion in the form of technology transfer legislation had little significant impact on technology transfer efforts by the United States government laboratories. de Kervasdoué and Billon's (1978) study of the impact of the French science policy on the development of research discipline appears to support the institutional theory. They concluded that the policy pressures toward increased social relevance of science have played a secondary role. According to them, the existence of institutions and of a strong scientific tradition (the discipline of cancerology in their case) encouraged a joint effort on the part of research workers and physicians; but the basis for such a joint effort was much weaker in the discipline of respiratory diseases.

Table 2.1 summarizes the preceding review of literature. The organization technology perspective is technology-deterministic.[27] Technology is operationalized as organizational goals or research missions of government laboratories. R&D

[27] See the introduction of Woodward (1980) for a rebuttal to the prevailing argument that Woodward's contingent proposition is technology deterministic.

collaboration is considered to be a strategy which is determined by technology, or by the fit between technology and structure. The institutional perspective is institutional-deterministic, and it centers around the concept of legitimacy. R&D collaboration is posited as the structural or behavioral compliance of organizations to institutional interests. The exchange-theoretic perspective is managerial-centered. R&D collaboration is theorized as a mechanism for managing dependence, mainly as a boundary spanning mechanism.

Table 2.1. A Summary of Organizational Perspectives Reviewed in This Study

Perspective	**Organization Technology**	**Exchange Theoretic**	**Institutionalism**
Main Idea	Technology Determinism	Dependence Management	Institutional Determinism
Major Contingency	Technology	Interdependence: Resource Needs/ Independence	Legitimacy
Strategies for Activating Major Contingencies	Structural/ Strategy Change	Exchange: Resource/Power Acquisition	Compliance/ Response to Inducement
Major Operational Variables of Contingency	Dominant Organizational Goals/Missions	Heterogeneous Sourcing/ Functional Diversification	Institutional Interests; Structural/ Behavioral Requirements
Theoretical Locus of Interaction	Organizational Strategy	Boundary Spanning Activities	Internal Institu-tionalization
Logical Structure	Technology-> Structure/ Strategy-> Performance	Dependence/ Resource Needs-> Exchange-> Survival/Goal Achievement	Legitimacy-> Behavioral/ Structural Compliance-> Performance

The theoretical perspectives also have implications for the comparison of R&D collaboration in the United States and Japan. Organization technology perspective matches the theory of societal convergence in terms of technology determinism. The societal convergence theory postulates that technology will make organizations isomorphic across national boundaries in terms of organizational structure and its outcome. Thus technology becomes "the powerful force for cross-cultural homogeneity" (Lincoln, 1990: 260). In the case of government-industry cooperative R&D, the direction of convergence is reversed. Japan is the progenitor of government-industry cooperative R&D in the United States. Thus, the relationships between technology -- dominant or diversified-- and the formation of cooperative R&D to be observed in Japan will find the same or at least similar pattern in the United States. The exchange-theoretic perspective may shed light on the national difference in research funding, and the probability of government laboratories cooperating for revenue in Japan, the context in which funds rarely change hands between government and industry. Comparative implications of institutional theory are two-fold. First, the conventional dichotomous viewpoint of government-industry relations in two countries may assume that government influences would be conducive to R&D collaboration in Japan, while this would be not the case in the United States. The second implication is related to the early- or late-adopter proposition advanced by Tolbert and Zucker (1983). If their proposition is tenable for the present purpose of cross-cultural comparison, the perspective may give us insights into a question about whether Japan as an earlier adopter of cooperative R&D is motivated by rational (or technological in the current purpose) reasons, while the United States as a later adopter is motivated by institutional pressures.

2.3. The Integration of Theoretical Perspectives

The communication perspective under review allows a researcher to theoretically separate R&D collaboration from other policy measures of government-industry cooperation in technology innovation. This perspective conceptualizes collaboration as a quasi-organizational structure of intersector communication. Technology transfer (or diffusion) is seen as a special type of communication concerned with the spread of messages that are new ideas. A technology is a special type of message (Rogers, 1983: 89) which is communicated through communication channel. An advantage of collaboration lies in its potential for enhancing "two-way" or interactive communications between the developer and the user in a process of technology development. Communication is a process of convergence, "a process in which participants create and share information with one another in order to reach a mutual understanding" (Rogers, 1983: 5). Thus, communication becomes an integral part of collaboration. Within this interorganizational relationship, the parties to collaboration communicate interactively to achieve a common objective. Conceptually, technology transfer occurs when a collaborative venture is terminated. As suggested by Morone and Ivins (1982), however, collaboration will contribute to the elimination of the need of transferring technology intended toward commercial applications. In this sense, as Larsen and Wigand (1987) argue, technology transfer will be inherent in cooperative R&D. As a corollary, the effectiveness of technology transfer can be a direct function of R&D collaboration between government laboratories and industry.

Meanwhile, three organizational-level theoretical perspectives reviewed will provide major contingencies of the formation of cooperative R&D ventures with industry. The organization technology perspective provides a way to examine the technological contingencies of R&D efforts in a collaborative setting. Its focus on dominant technology will be supplemented with a consideration of the diversity of technologies within an government laboratories, as Marsh and Mannari (1981) suggested. The exchange-theoretic perspective provides a resource acquisition contingency as a determinant of the formation of R&D collaboration. In this dissertation, the interpretation of resource dependence is one of the 'normal' interdependence between government laboratories and industry, rather than of interorganizational power pursuit by the former over the latter. The organizational effect of resource dependence is complemented by considering the institutionally-imposed or induced behavioral changes, the focus of institutional perspective.

III. A THEORETICAL FRAMEWORK

3.1. Government-Industry Cooperative R&D: Definition and Characteristics

1. Defining Government-Industry Cooperative R&D

Government-industry cooperative R&D refers to any arrangements, formal or informal, through which "at least one government laboratory and one industrial firm jointly acquire technical knowledge" (Coursey and Bozeman, 1989; also Link and Bauer, 1989: 5). Technical knowledge is usually considered to be generic technology. Generic technology refers to "the organization of knowledge into the conceptual form of an eventual application and the laboratory testing of the concept" (Link and Tassey, 1987: 19). Generic technology is characterized as a base for industrial technology of "less basic and more functional" nature (Alic, 1990; Link and Tassey, 1987). It is quasi-public in terms of the nature of financing and performing sector, and it is intermediary according to research spectrum and technological maturity. Generic technology will be applicable to a wide range of materials, products, or industry. Ouchi and Bolton (1988) suggest that this type of technology is *leaky* in terms of the protection of intellectual properties, and that it necessitates collaboration among industrial firms. Because of its quasi-public and intermediary character, generic technology is most appropriately produced in cooperative R&D activities.

Government-industry cooperative R&D generally focuses on precommercial (or precompetitive) R&D on generic technologies. Precommercial R&D refers to "research and development activities up to the stage where technical uncertainties are sufficiently reduced to permit preliminary assessment of commercial potential and prior to development of application-specific commercial prototypes" (Council on Competitiveness, 1993: 17). This dissertation confines government-industry cooperative R&D to formalized joint activities such as joint research ventures, research consortia and other formal activities which involve the development and acquisition of technical knowledge between government laboratories and industrial firms.[28]

[28] While there are various forms of cooperative R&D activity, the major legal form of cooperative R&D is joint research ventures and research consortia (Mariti and Smiley, 1983).

Government-industry cooperative R&D has a number of technical, structural, temporal, and motivational characteristics. Government-industry cooperative R&D is a form of vertical quasi-integration (Onida and Malerba, 1988). Government laboratories stand upstream and industrial firms stand downstream in technology development. Contractor and Lorange (1988: 15-19) note that this vertical relationship in international joint ventures will make strategic contributions such as 1) access to materials, 2) access to technology, 3) access to labor, 4) access to capital, 5) regulatory permits, 6) access to distribution channels, 6) brand recognition, 8) establishment of links with major buyers, and 9) access to existing fixed marketing establishment.

Government-industry cooperative R&D is a type of quasi-integration in that it involves partial involvement by both parties (Contractor and Lorange, 1988; also see Hall, 1991: 236; Rogers and Whetten, 1982). It is in an intermediate position along a spectrum of inter-organizational relationships encompassing one-off consultancy advice at one end and full mergers at the other (Contractor and Lorange, 1988; Williamson, 1975 and 1985). Unlike intercorporate cooperative R&D ventures, government-industry cooperative R&D does not proceed to the point where the parties involved merge into one organization. On the other hand, cooperative arrangements can form a roughly continuous progression of various forms of cooperation along the spectrum of technological innovation. The form of cooperation will likely change over time in accordance with changes in skills, resources, and levels of involvement at each stage of the innovation process (Soderstrom, Copenhaven, Brown and Sorensen, 1985).

Government-industry cooperative R&D is an *ex ante* activity. Government laboratories and industry agree to share the costs and results of an R&D venture prior to the actual R&D effort. Thus, it is discerned itself from *ex post* types of cooperative R&D, such as *ex post* royalty-free cross-licensing (Katz, 1986; Link and Bauer, 1989).

Government laboratories are often legally or politically *mandated* to form cooperative R&D with industrial firms. The presence of mandates does not necessarily guarantee government-industry interactions. But, mandates may serve as an important basis for government-industry R&D collaboration, because they typically involve some type of resource flow and monitoring (Hall, 1991: 230). Government laboratories are the sub-units of larger parent organizations; they are influenced by policies of the parent government laboratories. Government laboratories can also seek funds on their own for their maintenance and survival. In this sense, the involvement of government laboratories in cooperative R&D can be understood in terms of a subordination-autonomy dynamics.

2. The Collaborative Nature of Technology Transfer Activities

Cooperative R&D has technology transfer as a common aim (Chesnais, 1988; Contractor and Lorange, 1988; Dimancescu and Botkin, 1986; Fusfeld and Haklisch, 1985). Technology transfer in this study is defined, from an organizational viewpoint, as "the transfer of physical devices, processes, 'know-how', or proprietary information about devices or processes from one organization to another" (Bozeman and Crow, 1991b: 232). Government-industry cooperative R&D aims at tackling the collaborative problems of technology transfer by responding to the industry pull for government laboratories' technologies while jointly working on mutually interested technical areas.

The collaborative nature of the technology transfer problem can be boiled down to three related but distinct issues. First, technology innovation is becoming a *metaproblem.* By metaproblem, we mean that the knowledge, risks, and costs associated with technology innovation is beyond the reach of an individual firm in an age of growing scientific uncertainty and technical complexity. The shortened life cycle of technology innovation increases the importance of a firm's outsourcing of needed S&T knowledge. Industrial technology development is increasingly dependent upon the science base (Dosi, 1988; Bonaccorsi and Piccaluga, 1994; Mansfield, 1991; Narin and Noma, 1985) or generic technology (Link and Tassey, 1987).[29] Government laboratories are recognized as an essential source of S&T infrastructure which will serve as a new area of expertise for industry. There is empirical evidence indicating government laboratories as an important S&T knowledge source for industry. Government laboratories accounted for 18% to 50% in three studies of innovations undertaken in the United Kingdom (see Pavitt and Walker, 1976: 22). Surveys of industrial firms in the United States (Roessner, 1993b; Roessner and Bean, 1990) documented an increased importance

[29] Harvey Brooks (1994) points out that science can contribute to technology at least six ways: 1) new knowledge that serves as a direct source of ideas for new technological possibilities, 2) source of tools and techniques for more efficient engineering design and a knowledge base for evaluation of feasibility of designs, 3) research instrumentation, laboratory techniques and analytical methods used in research that eventually find their way into design or industrial practices, often through intermediate disciplines, 4) practice of research as a source for development and assimilation of new human skills and capabilities eventually useful for technology, 5) creation of a knowledge base that becomes increasingly important in the assessment of technology in terms of its wider social and environmental impacts, and 6) knowledge base that enables more efficient strategies of applied research, development, and refinement of new technologies.

of government laboratories as a knowledge source for industry. Surveys of Japanese firms (Crow and Nath, 1990; Niwa and Goto, 1993) showed that government laboratories are perceived by firms as important a source of S&T knowledge as industrial firms and universities.[30]

Second, government technologies have limited transferability due to value and contextual mismatch between government laboratories and industrial firms. Transferability problems can arise from both government laboratories and industrial firms. On the part of industrial firms, transferability problems center around the lack of recognition of government S&T assets (Spann, Adams and Souder, 1993), the inability to evaluate commercial appropriateness of these assets (Godkin, 1988), or the limited compatibility of government technologies with the firms' needs (Rogers, 1983: 211-232). On the government laboratories' part, transferability problems stem from government mission orientation other than the profit-orientation of firms (Godkin, 1988; Papadakis, 1995), lack of market orientation in the researcher's minds (Olken, 1983), lack of an appropriate model of commercial evaluation of their technologies (Finneran, 1986), or limited ability to identify secondary utilization potential for government technologies (Godkin, 1988). This mismatch between government laboratories and industry leads to the contextual dependency of technological innovations and the resultant limited transferability of government research. As Sahal (1981: 58, 198) demonstrated, the 'know-how' driven in the development of one technique can not be wholly transferable to the development of another technique (the principle of technological insularity).

30 See Rees and Debbage (1992) for the survey results showing the unimportance of government laboratories as a knowledge base for industrial technology development.

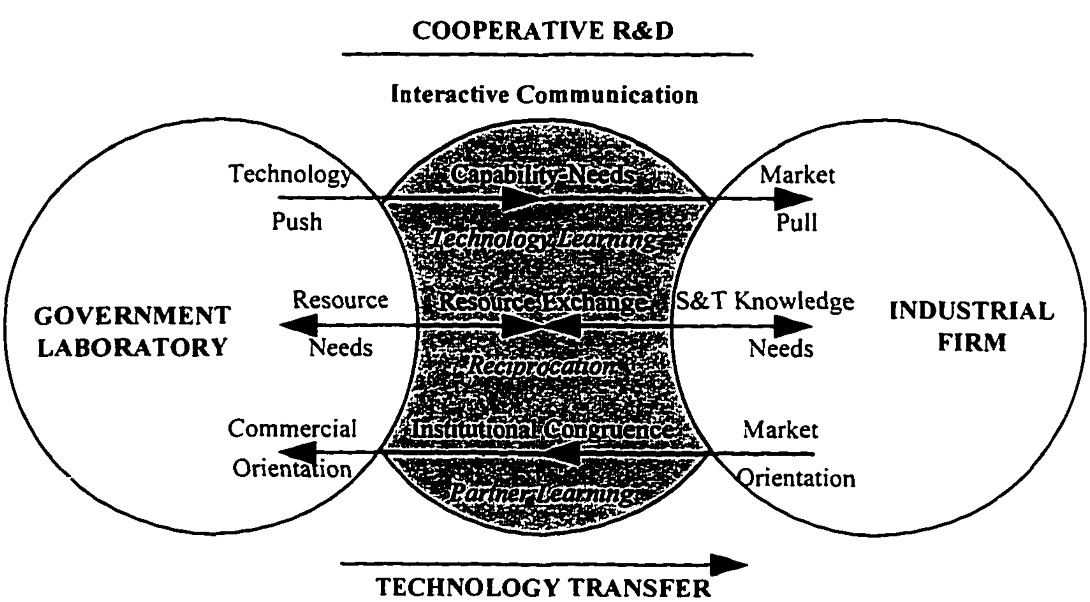
Technological development is also a process of irreversible transformations (the putty-clay principle of technological innovations). Technology is not monolithic, and it is highly compartmentalized and context- or origin-specific. Technical know-how is often difficult to extract for other applications. Similarly, Morone and Ivins (1982) argue that the opportunities and problems of 'technology transfer differ from the transfer of technology to spin-off applications' to 'the transfer of technology intended for the market' (also see Papadakis, 1995). Due to this misfit, barriers to commercialization of government technologies tend to be encountered more frequently during an earlier stage at which technologies are selected (Spann, Adams and Souder, 1993). User involvement in an earlier stage of R&D process becomes an integral part of solving technology transfer problems.

Third, the existing methods for technology transfer have proved to be insufficient. According Devine, James and Adams (1987), the previous technology transfer policies have evolved through three modes of technology transfer. The appropriability mode focused on the production and supply of research. Policy emphasis was placed on the importance of the quality of research conducted by government laboratories. The commercialization of government research results by industrial firms was seen as driven by competitive market pressures. The most important role of government was to finance and perform state-of-the-art research. Deliberate transfer mechanisms were neither necessary nor practical. Technology was transferred by means of publications, video tapes, and other passive means requiring little involvement of users. The dissemination mode of technology transfer recognized the importance of deliberate mechanisms for technology transfer. But its premise was that technology would flow from government laboratories to industrial users like "water through a pipe." Government laboratories or their parent agencies determined what R&D might be useful to users, packaged and publicized research products, and made it available to users. The knowledge utilization mode of technology transfer stressed the importance of developer-user interactions, but it assumed that technology would move hand-to-hand --in one direction-- to become a developed idea and eventually a product. According to Gibson and his colleagues (Gibson and Smilor, 1991; Gibson and Rogers, 1994), these three modes of technology transfer assume technology transfer as a linear process. The linear modes of technology transfer are not appropriate where technical complexity and scientific uncertainty are growing, and where government technologies are context-dependent.

3.2. The Conceptual Relationships Among Government Laboratory, R&D Collaboration, and Industrial Firms

In Chapter Two, we have indicated that technology transfer effectiveness is determined by the interactions between government laboratories and industry. Cooperative R&D was conceptualized as a quasi-organizational form in which government laboratories and industry communicate interactively toward a common interest. Cooperative R&D has been posited as the most suitable solution to the collaborative problems of technology transfer. The significance of interactive communications in technology transfer lies in the possession by government laboratories of S&T potential for industrial technology development, on the one hand, and the firms' difficulty in assimilating such a S&T potential due to institutional differences, on the other hand. This makes linear technology transfer mechanisms ineffective. As Van de Ven and Walker (1984: 60) indicated, government laboratories' S&T knowledge is likely to be complementary to the S&T needs of the industry, when they are at least moderately similar domains. Interactive communication facilitates learning between the parties involved through iterated feedback, thereby promoting the probability that collaboration results will be assimilated. In this respect, cooperative R&D becomes a process of "learning by interacting," or "learning by communicating" (Ciborra, 1991; Gray, 1989: 237-240; Contractor and Lorange, 1988; Lundvall, 1988). Figure 3.1 suggests that government-industry cooperative R&D is a intermediary form of organization in which S&T capability and needs are matched, institutional congruence is sought by government laboratories through the adoption of commercial orientation, and the parties involved in collaboration reciprocate each other.

Figure 3.1. Relationships Among Laboratory, Cooperative R&D, and Industrial Firms



Technologically, government-industry cooperative R&D is a technology push by government laboratories with technical capabilities in response to the market pull based on the industry's S&T needs. Differences in technical capability between government laboratories and industry can be resolved through technological learning or learning about technical tasks in hand (Ciborra, 1991; Doz and Schuen, in Dodgson, 1993: 51; Hughes. 1995). Technological learning enhances, expands, and transforms the existing knowledge base of the participating organizations by increasing the amount and kind of information at their disposal (Lundvall, 1988; Gray, 1989; Kodama, 1991). In other words, R&D collaboration does not lead only to the acquisition of needed S&T knowledge or skills, but also to the fusion of technology-- i.e., the creation of new horizons of technology or new industry through the combination of different disciplines or industries (Kodama, 1991).

Institutionally, government-industry cooperative R&D is an attempt to create the "private sector orientation" (Goodman, 1988) within the government laboratory system through which institutional congruence in orientation is sought between government laboratories and industry. Institutional differences can be resolved through institutional learning or learning about the partner (Ciborra, 1991: 70; Doz and Schuen, in Dodgson, 1993: 51). Institutional learning increases transferability of technology innovations between government laboratories and industry by lessening the context-dependence of technology innovations. Learning about the partner may have a far-reaching effect on the structure of government laboratories (as well as industrial partners). Collaboration allows the parties involved to learn from R&D collaboration how to manage the relationship between the partners and facilitates changes in the existing structure and processes of each of the parties (Ciborra, 1991; Westney, 1988).

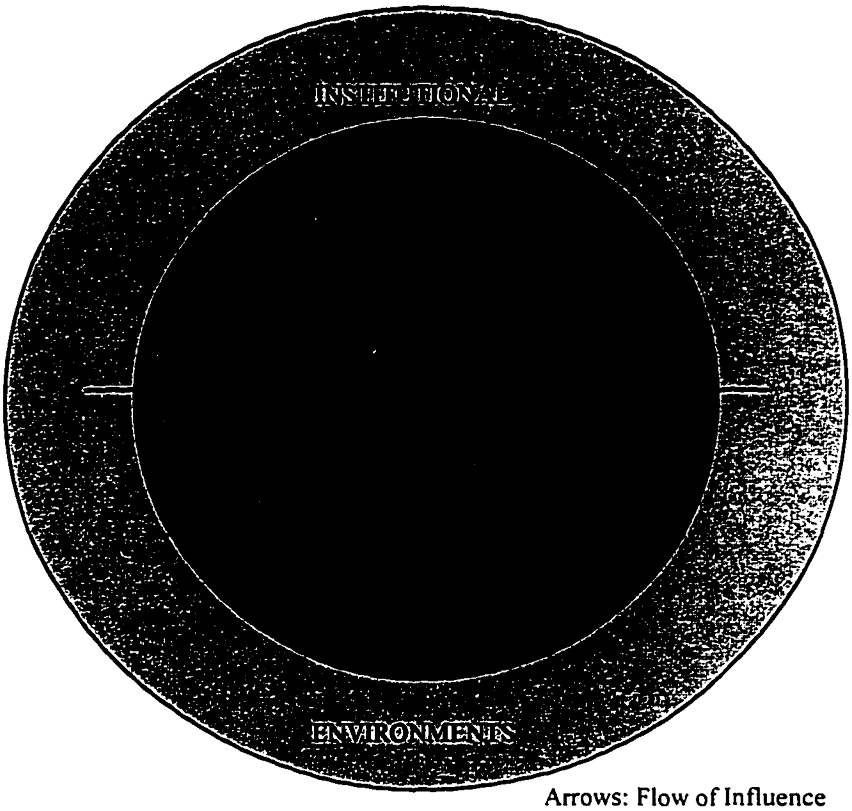
When it is formalized, collaboration is based on the exchange of needed resources (Hall, 1991: 229). Government laboratories exchange their S&T knowledge and skills for financial, technological, or physical resources which industry can directly or indirectly provide in return for the acquisition of laboratory S&T knowledge. When the probability of assimilation from cooperative R&D is increased, the value of the exchange is enhanced (Watkins, 1991).

Since cooperative R&D brings government laboratories and industry together in the process of technology development, the processes of technology development and technology transfer are intertwined in R&D collaboration. From its outset, the process of technology development is managed toward successful transfer (David, 1986; Charles and Howells, 1992: 7; Padmanabhan and Souder, 1994). Technology transfer becomes a continuum of interrelated processes at the cooperative R&D setting rather than discrete steps (Rubin, 1991; Werner and Bremer, 1991; William and Gibson, 1990). As Gray (1989: 21-23) implies, therefore, collaboration between government laboratories and industry will enhance the parties' acceptance of the solution and their commitment to carry it out 1) by improving the quality of solutions through a broad comprehensive analysis of a problem, 2) by developing their ability to respond to more diversified areas, 3) by ensuring that each party involved is considered in any agreement, 4) by enhancing each party's acceptance of the solution and their willingness to implement it through participation, and 5) by enhancing the potential to discover novel, innovative solutions.

3.3. The Task and Institutional Contexts of Government Laboratories and the Government-Industry Cooperative R&D (GICR&D) Contingencies

In the literature review, we have pointed out that an effective cooperative R&D is largely dependent upon the issues affecting its formation. Three theories under review have suggested that the activities of government laboratories are affected by three task and institutional contexts such as organizational technology or goals, external resources as dependence-independence sources, and external requirements as behavioral-structural constraints imposed by external funding sources. In the context of government laboratories, important as organizational goals are research missions (Bozeman, 1994). Among a variety of external resources, the most salient is research funds. These task and institutional contexts interact to create the government-industry cooperative R&D (GICR&D) contingencies. The GICR&D contingency refers to "the underlying causes that induce government laboratories to form cooperative R&D with industry" (Oliver, 1990: 241). The GICR&D contingencies include S&T capability based on the diversification of research missions, the orientation of research projects in response to institutional interests embedded with external resources, and the organizational importance of resource acquisition. Figure 3.2 shows the relationships among the institutional environments, task and institutional properties, and GICR&D contingencies.

Figure 3.2. Task-Institutional Contexts and GICR&D Contingencies



1. Task and Institutional Contexts of Government Laboratories

Lane, Beddows and Lawrence (1981) argue that a S&T institute operates in three task and institutional contexts, each of which is guided by a corresponding logic. One is the technical space that represents the physical phenomena on which government laboratories focus their R&D effort. Technical logic concerns the rules or laws governing the structure of thinking employed in the research activities on the physical phenomena. S&T institutes function in the organizational space which is comprised of a set of internal relationships, structures, and processes. Organizational logic gives coherence and continuity to these institutes. Another context within which a S&T

institute operates is the political space. The political space consists of the social, economic, and political actors with which the S&T institute must contend. As the guiding strategy for the political space, political logic constitutes the way in which relations are maintained vis-à-vis the institutional environment.

Institutional Environments

The major institutional environments of government laboratories consist of extra-departmental entities, parent organizations, and industry. As indicated in Chapter two, the relationships among three external entities vary according to the particular policy issue, industry, and country. The relationships of government laboratories with these institutional entities are such that government laboratories are subunits of their parent organizations and that parent organizations affect the relationships of government laboratories with extra-departmental entities and industry. These institutional entities are the major sources of organizational legitimacy, research funding, and institutional constraints imposed to government laboratories. Government laboratories are usually created by laws governing their parent organizations, or by special laws governing the establishment of these laboratories themselves. In either case, the responsibility for the management of research programs in the government sector falls into the individual government departments, and government laboratories are subject to line management by their parent agencies (Charles and Howells, 1992). The main functions of parent agencies vis-à-vis their laboratories are the formulation of the agency's program and the subsequent assignment of research missions to their laboratories; the justification and funding of the R&D activities by their laboratories; and the evaluation of research performance of laboratories (Mark and Levine, 1984: 195-200).

Research Missions

Research missions in this dissertation are defined as a research type that government laboratories were assigned to fulfill. Defined by research type, research missions can be classified into basic research, applied research, and development missions (National Science Board, 1993: 94).[31] Basic research is defined as the type of research aimed at "gaining more complete knowledge or understanding of the subject under study, without specific applications in mind." Applied research refers to the type of research aimed at gaining knowledge or understanding to determine the means by which specific, recognized need may be met." Development refers to the "systematic use of the knowledge or understanding gained from research directed toward the production of useful materials, devices, systems, or methods, including the design and development of prototypes and processes."

The research missions are specified in the official statement upon creation. The research missions of government laboratories are determined primarily on the basis of the research needs felt by their parent agencies or government (OECD, 1989; for Japan, Commission on the History of Science and Technology Policy, 1991; for the United States, Dupree, 1980; Mark and Levine, 1984). Their research needs are assigned as core

[31] The definitions of research types are also the definition used in the present surveys of the Japanese and American government laboratories. Others usually classify government laboratories' research missions into basic research, applied research, development, technology assistance, and technology transfer (GAO, 1994a; see Bozeman and his colleagues cited in this dissertation).

organizational goals to government laboratories. As Simon (1964) implied, research missions as organizational goals do not only guide the behaviors, but also become constraints to be satisfied in a process of decision making within government laboratories. In this sense, research missions play a formative part of the strategic domain of individual laboratories--problem area addressed, population served, product offered, and technologies employed (Levine and White, 1961; Thompson, 1967). Once it is institutionalized, a research mission becomes one of the least malleable organizational cores (Mark and Levine, 1984; also see Scott, 1981; Pennings, 1980).

Different types of research activities differ with respect to risk profile (Arrow, 1962; Nelson, 1959), required creativity and expenditure level (Maidique and Patch, 1988: 243-244), and proximity to commercial applications or products[32] (GAO, 1994a; Steele, 1975), as well as organizational characteristics (Packard, 1983; Siepert, 1964). Basic research is high in technical and commercial risk, researcher's autonomy and creativity required, and the codifiability of research products. It is low in cost (except for the big science), appropriability, and commercial proximity and directness. Development is high in appropriability of products, commercial proximity and directness, and costs and overrun potential. It is low in commercial and technical risks, autonomy and creativity required, and codifiability of research results. Applied research is in between basic research and development.

[32] Articles and books are considered to be the major products from basic research; patents are from applied research; prototype devices and materials, algorithms, software, demonstrations are from experimental development work (GAO, 1994a; Papadakis, 1995). Meanwhile the drafters of a GAO report (GAO, 1994a) indicated that patents can be produced in all types of R&D activities, and Papadakis (1995) found that development mission laboratories in the United States have diverse research missions, thereby producing a variety of research products.

Table 3.1. The Characteristics of Laboratory Missions By Research Type

	Basic	Applied	Development
Risk Dimension			
Technical	High	<------------------------------>	Low
Commercial	High	<------------------------------>	Low
Organizational Dimension			
Autonomy	High	<------------------------------>	Low
Creativity	High	<------------------------------>	Low
Products Dimension			
Codifiability	High	<------------------------------>	Low
Appropriability	Low	<------------------------------>	High
Cost Dimension			
Expenditure level	Low	<------------------------------>	High
Overrun	Low	<------------------------------>	High
Commercial Dimension			
Proximity	Low	<------------------------------>	High
Directness	Low	<------------------------------>	High

External Resources

The most important kind of external resources of government laboratories is research funds. The sources of research funding for government laboratories can be various. They include government, industry, universities, nonprofit organizations, and foreign governments or firms. With some exceptions (e.g., Germany), the major funders in most OECD countries are government and industry. Different sources of funding tend to employ different methods of funding. Government laboratories receive research funds in the form of basic institutional funding, program funding, or contract funding (OECD. 1989: 37-42). Basic institutional funding is designed to finance the basic operations of government laboratories as specified in the official mission statement of government laboratories; it covers personnel, financial resources, equipment, and capital investment of government laboratories. Program funding refers to the research funds allocated mainly to research programs designed in accordance with the priority objectives of government, such as the Japanese ERATO program and the European ESPRIT (European Strategic Programme for Research and Development in Information Technology) program. Contract funding refers to income obtained from research activities in the form of research contracts with industry and other government agencies.

Parent agencies play an important role in regard to basic institutional funding. Basic institutional funding is annually allocated to a government laboratory under the government's total budget and then divided between the laboratory's various activities by its management or its parent agency. Basic institutional funding has relatively few strings attached to funds (Huffman and Just, 1994; Rush, Hobday, Bessant and Arnold, 1995). With the recent decline in basic institutional funding, there is a trend toward moving to program funding and contract funding in the OECD countries. This shift in research funding is not only the result of government budget austerity in OECD countries, but also the result of policy orientation toward a greater social relevance of research activities within government laboratories. To government laboratories, funds other than institutional funding --particularly contract funding-- have special value in a tightly controlled operation and research budget, due to the fact that such funds may allow government laboratories to manage discretionary funds. To policy makers, these types of funding are more effective in integrating the government laboratory system into the national innovation system, and the national campaign for global competitiveness.

Bozeman (1987) incorporates the influences of these external resources into the concept of the publicness of organizations. He suggests that publicness, rather than ownership, is the important influence on the behaviors and performance of organizations. An organization's publicness is determined by its "mix of political and economic authority" (Bozeman, 1987: 80). The external imposition of authority into organizations is equivalent to the external endowment of authority that these organizations are given (Bozeman, 1987: 86). Thus, each type of authority affects the behavior of organizations because the exercise of each type of authority is invariably accompanied by certain constraints associated with authority.

The extent to which external funding involves external influence on the R&D function of government laboratories differs not only according to methods of funding, but also with the extent to which a government laboratory is integrated into the S&T policy formation mechanism (Rush, Hobday, Bessant and Arnold, 1995). Government laboratories of resourceful parent organizations are less likely to rely on program and contract funding from industry for funds. On the other hand, when the raison d'être of parent organizations is frequently questioned by political entities, their government laboratories can be affected by the behavioral requirements attached to basic institutional funding. Basic institutional funding is not an annual process with little change from year to year (Rubin, 1990: 27); this is in part because of the political nature of the budget process, part of which is the allocation of research funds. As Rubin (1990: 58) pointed out, the national budgetary process gives some participants more control over what projects get funded and where; it structures the competition between agencies and programs; and it influences or is believed to influence policy outcomes.

External Requirements

As institutionalists argued, external resources are accompanied with external constraints. The monitoring and evaluation of the research performance of laboratories is another main function of parent organizations. The periodic direct government appropriation becomes a primary financial tool for the control of R&D activities and over the government laboratories themselves. Basic institutional funding requires government laboratories to comply with public accounting regulations and administrative requirements (OECD, 1989: 37). Because of budget austerity, government monitoring is increasingly focusing on the research missions of government laboratories. Monitoring and intervention have the unique transactions costs in the public sector organizations including government laboratories which are called government red tape (Borcherding and Pommerehne, 1982). Government red tape refers to bureaucratic pathologies such as "rules, regulations, and procedures that remain in force and entail a compliance burden for the organization but have not efficacy for the rules' functional object" or "...serve no object valued by a given stakeholder group" (Bozeman, 1993: 283-284).[33] One impact of red tape is procedural delay or slow-moving bureaucracy (Andrews, 1979; Bozeman and Crow, 1990; Bozeman and Bretschneider, 1994).

Government red tape can arise from organizational hierarchy (Siepert, 1964).[34] Viewed from inside the organizations, red tape is characterized as rule-boundedness in

[33] Bozeman (1993) distinguish between extensive rules and procedures as the bureaucratic physiology and red tape as the bureaucratic pathology, whereas earlier researchers (Vieg, 1946; Waldo, 1959; Kaufman, 1977; Borcherding and Pommerehne, 1982; Goodsell, 1985) included both pathological and beneficial aspects in the conceptualization of red tape.

[34] In addition, Lorsch (1986) attributes the roots of red tape to personal resistance to change in the established practices of technology transfer.

the form of formalization, and a hierarchy of authority and control as represented by the number of hierarchical levels within organizations. Red tape is difficult to distinguish from the bureaucratic physiology that may be ubiquitous in other sector large organizations. As Bozeman (1993) argued, the bureaucratic physiology, such as the extensive use of rules, may be a beneficial part of red tape in its common sensual interpretation.

According to Waldo (1959: 354-355), public administration is "government by procedure." Waldo differentiated among three features of administrative procedures. The first feature of administrative procedures is that they are the "laws of activity" applied to the individual organization members and the organization as a whole. Second, administrative procedures are the "physiology of organization" which brings the structures to life. The third feature of administrative procedures is that procedures are "institutional habits"; when they become habits, procedures become ends in themselves, hindering the adaptation to changed circumstances.

Since administrative procedures are primarily imposed to administrative organizations by external entities, government red tape is more frequently attributed to the politically imposed administrative pathology (Bozeman, 1993; Wilson, 1989). In this sense, it is the system, not the bureaucrats, that makes government inefficient and red-taped (Gore, 1993; Osborne and Gaebler, 1992). Wilson (1989: 121) traces the political roots of red tape within government organizations:

> These complexities in hiring, purchasing, contracting, and budgeting often are said to be the result of the "bureaucracy's love of red tape." But few,

> if any, of the rules producing this complexity would have been generated by the bureaucracy if left to its own devices, and many are as cordially disliked by the bureaucrats as by their clients. These rules have been imposed on the agencies by external actors, chiefly the legislature. They are not bureaucratic rules but *political* ones.

Recent reports concerning government laboratories (Galvin, 1995; OECD, 1989; Packard, 1983) observed that these functions that parent agencies exert over their laboratories can affect the autonomy of government laboratories vis-à-vis their government parents. The micro-management of laboratories by their parent agencies or the government as a whole, and the interest group politics surrounding these parent agencies, are the major sources of rigidities and discontinuities in the research management of government laboratories (OECD, 1989: 46).

Laboratory's Organizational Size

As the operation scale of an organization (Price and Mueller, 1986), the size of individual government laboratories influences and is influenced by the research missions, research funding, and the externally imposed requirements of government laboratories. Government laboratories with more of an emphasis on development mission tend to be larger than those laboratories with more basic research mission. The availability of research and operation funds determines the size of the laboratory in terms of full-time personnel, facilities, and equipment. Large organizations tend to be major recipients of government funds, and they are subject to external influence attached to external funds.

Thus, large government laboratories are likely to become frequently subject to external constraints or changes in the government policy.[35]

The organizational size of government laboratories also affects the conditions under which government laboratories operate. Mark and Levine (1984: 200-207) note that government laboratories are more likely to be autonomous in their operation vis-à-vis their parent agencies or sponsoring organizations, where the size of resources devoted to R&D are large in relations to the agency's budget. There are certain size requirements in technological innovation and therefore in building up S&T capability.[36] Only large government laboratories possess the necessary capacities required for technological innovation such as general, specialized and co-specialized assets (Rees and Debbage, 1992; Teece, 1986). The production of innovative outputs is proportionate to the size of the research inputs to R&D activity (Howe, in Frye, 1985). There is a threshold of R&D below which expenditure on R&D will not yield any fruitful outcome (Freeman, 1982). Larger organizations have an advantage in making process innovations (Scherer, 1970: 353). White (1975: 171-172) argues that budget as a financial tool of control is of limited usefulness in controlling research except in ensuring that resources are used on the right projects; thus research budget as a control mechanism is more useful towards the development end of the research spectrum.

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[35] On contrary, proponents of bureaucratic imperialism (Dimock, 1952; Holden, 1966; Rourke, 1984; Thompson, 1967; Weber in Gerth and Mills, 1958) suggest that large organizations try to assert control over not only their own jurisdiction but also other organizations and jurisdiction. Their argument can be boiled down to Downs' Law of Interorganizational Conflict: Every large organization is in partial conflict with every other social agent it deals with (Downs, 1967: 216).

[36] There are also questions about the arguments for technological innovativeness in favor of large organizations (Cooper, 1964; Rothwell and Zegveld, 1981),

The organizational size of government laboratories mediates the relationships between task and institutional properties and GICR&D contingencies. Larger government laboratories tend to have organizational slacks. Slack resources allow organizations to initiate innovative or "unprogramed" activities by reducing internal conflicts caused by the transfer of resources to such new activities (Downs, 1967: 138; March and Simon, 1958: 185). Organizational slack also makes it easier for organizations to adjust to an unexpected increase in their workforce without obtaining added appropriations (Downs, 1967). Large government laboratories are more capable of diversifying research missions (e.g., Haveman, 1993). Also, the size of government laboratories affects a decision regarding the size and number of project teams (Collcutt and Reader, 1967). Government laboratories with more researchers are able to form more diverse projects by multidisciplinary project teams.

2. The Components of the GICR&D Contingencies

Given the size of government laboratories, the research missions, research funding sources, and externally imposed behavioral requirements interact to form the government-industry R&D collaboration contingencies. As indicated in Figure 3.2, the interactions among task and institutional environments lead to three contingencies that function as the bases for government laboratories' formation of cooperative R&D with industry. The GICR&D contingencies include government laboratories' S&T capability based on the diversification of research missions, the importance of resource acquisition as organizational effectiveness, and the commercial orientation of research projects relative to government orientation of research projects.

S&T Capability Based on Research Mission Diversity

Research missions of government laboratories are neither fixed over time, nor monolithic within a government laboratory system. Government laboratories can incrementally diversify the research mission in response to their task and institutional environments. For technical reasons, government laboratories tend to have multiple functions and perform research in various areas in tandem with their major research mission (Finneran, 1986; OECD, 1989). Government laboratories may displace old research missions in favor of new S&T areas whose horizons have been opened and widened by the previous core research missions. For example, the computing capabilities then auxiliary to the development of nuclear weapons gave birth to the High Performance Computing research as a new research mission by the Los Alamos National Laboratory.[37] Core research missions of government laboratories are determined by the S&T needs of the government itself; the diversification of research missions also depends in part upon government or parent agencies (Mark and Levine, 1984). Thus government funding enables government laboratories to diversify their research mission areas (Rush, Hobday, Bessant and Arnold, 1995: 28). From a different perspective, Bozeman and Crow (1991b) hypothesize that government laboratories manage their resource dependence upon external sources by diversifying funding sources and research missions,

[37] However the drafters of the Galvin report (Galvin, 1995) do not regard this research area as a new research mission for the Los Alamos National Laboratory.

with boundary spanning activities. Government laboratories diversify funding sources to protect their core research mission against government funding instability (Thompson, 1967). Because of "external endowments accompanying external influence" (Bozeman, 1987; Friedland and Alford, 1991), the diversification of funding sources is likely to cause the diversification of research missions in government laboratories.

Mark and Levine (1984: 224-225) argue that a successful government laboratory has an ability to diversify its mission in tandem with its core mission. More importantly, a laboratory's ability to diversify the mission constitutes its S&T competence in the long run, according to them (Mark Levine: 1984: 224-225):

> [T]he tendency of a successful technology development laboratory is to apply the word "mission" in both a very narrow and a very broad sense. In the former case, the emphasis is on getting the immediate job done; in the latter, it is more a matter of maintaining the organization's technical competence over the long run. Why is this competence building so important? Because it positions the organization to exploit its own discoveries and, as desirable, to move into new areas....Viewed in this light, mission and capability tend to blend into one another. It cannot be emphasized too strongly that, while most research organizations live to an extent from an inherited intellectual capital, this can lead to stagnation and decline without the stimulus of new ideas. Building on an organization's scientific competence then becomes almost as important as any programmatic mission, because it is the principal way of assuring that such missions can be accomplished.

Similarly, Bozeman and Coker (1992) demonstrate that the most advanced, high-technology government laboratories tend to be involved in a variety of research missions (Bozeman and Coker, 1992). Since high-technology involves interconnectedness of technological advances as well as market and technological uncertainties (Link and Tassey, 1987; Nelson, 1984), the development of high-technologies demands interdisciplinary research and thus diverse research missions.

According to Simon (1964: 7), the goal of an organization should be understood as a set of related goals. He argues that "In the decision-making situations of real life, a course of action, to be acceptable, must satisfy a whole set of requirements, or constraints...[T]he choice of one of the constrains, from many, is to a large extent arbitrary. For many purposes its is more meaningful to refer to the whole set of requirements as the (complex) goal of the actions." The significance of the research mission of government laboratories as a whole set of organizational constraints is acknowledged in a growing tendency toward inseparability or boundary blurring among the individual research missions. The process of technological innovation is increasingly characterized as one of cross-fertilization and cross-pollination among technological capabilities within the overall R&D spectrum (Brooks, 1994; Price, 1984; von Hippel, 1988; Shapley and Roy, 1985). Van de Ven (1988) argues that the micro-logic of *parts* creates macro nonsense of the *whole*, and thus the *requisite variety* is required to "avoid having the whole be less than or a meaningless sum of its parts." Westphal and his colleagues (1990) assume that an organization's technical capabilities are better measured by using "aggregate" technological capabilities in R&D activities. They suggest that individual capabilities be considered as being "related to," instead of being "included within," aggregate capabilities (Westphal et al., 1990: 83; also Van de Ven, 1988: 112).

Project Orientation

A research project refers to the means by which new knowledge, products or processes are generated (Dumbleton, 1986: 189). A number of characteristics of research projects have significant bearings on the behaviors of S&T organizations. Research projects are usually set up for a limited time and for specific objectives. Once they are implemented, research projects are difficult to terminate during the implementation process (Buell, 1970; Seiler, 1965: 129).

The selection of research projects is a critical decision area for R&D management in the research organizations for a number of reasons. Limited availability of funds relative to the number of proposed projects demands choices among the proposed projects. Particularly in a period of budgetary austerity, government laboratories in most industrialized countries are increasingly under continual pressures to select research projects within the allocated resources. The process of selecting research projects involves planning, organizing, directing, and controlling laboratory activities and other related resources to achieve the research missions or other specific objectives (Shenhar, 1993). The process of project selection combines research planning, fund allocation, and project selection. Selected projects set the direction which the subsequent research effort will take, and also the extent and balance which it will have (Seiler, 1965: 129). As Twiss (1974) emphasized, a project can have a major impact on the business of an organization as a whole. In this vein, Seiler (1965: 128) indicates that project selection becomes the key to research performance or effectiveness. Thus, research projects constitute the focal points toward which the specific demands of the funding or sponsoring agencies or entities, as well as the activities of government laboratories, are directed (Mullins, 1984).

Sanders and Robison (1992) argue that external research funding creates the value dependence of research for the receiving organizations. According to Sanders and Robison (1992: 46), the value dependence of research may have an extensive effect on the core activities of research organizations which range from "the determination of the most apt way of considering a scientific domain and the choice of which theory best serves the ends chosen, [and] the choice of the researcher, to the determination of what kind of building the researcher ought to work in." Recognizing the multiplicity of institutional actors, Friedland and Alford (1991) argue that different institutional actors have different institutional logics. According to them, the institutional logic of the market is the commodification of human activity, and the institutional logic of government is the regulation of human activity by legal and bureaucratic hierarchies. Due to different institutional logic, different institutional actors have different interests in influencing organizations, thereby calling up different structural or behavioral arrangements (Scott, 1987: 508-509). A similar account was advanced by Bozeman (1987) who argued "external endowments being equivalent to external constraints". According to Bozeman (1987: 93-94), political influence accounts for much of (1) the increased accountability to external political actors, (2) increased interdependence, (3) concern with externalities, (4) closer ties to political cycles, (5) increased public visibility, and (6) increased concern with equity and other such prescribed social goals (Bozeman, 1987: 94). On the other hand, economic authority is associated primarily with: (1) increased concern for technical efficiency, (2) entrepreneur-manager oversight, (3) market valuation of labor, (4) production incentive, and (5) market-based evaluation of performance."

The value dependence of research for the receiving organizations is neither inevitable nor perverse. As resource dependence theorists and institutionalists (Bozeman, 1987; Meyer and Rowan, 1977, in Powell and DiMaggio, 1991; Pfeffer and Salancik, 1978) pointed out, government laboratories can adhere to their own traditional domain while adapting a little to the external influences, thereby maintaining a degree of organizational autonomy. Sanders and Robison (1992) argue that a secured research budget obtained from external sources can strengthen the bargaining power of receiving organizations in research contracts with external funders. Lane, Beddows, and Lawrence (1981) observed three interesting dynamic relationships between external influences and program management. According to them, laboratories and stakeholders can be in a relationship of domination. Under this situation, stakeholders force their priorities on a program and dominate the program. Contrarily, laboratories and stakeholders can be positioned in the debilitating relationships, which Lane and his colleagues call the relationships of rejection. In this case, a research program and significant constituency groups disengage from each other and become mutually isolated. Their final type of relationship is the symbiotic relationship. When symbiosis exists between laboratories and stakeholders, laboratories and stakeholders benefit from research programs without these programs being dominated unilaterally by either laboratories or stakeholders.

External influences do not necessarily contradict each other. As institutional theorists reviewed in Chapter Two suggested, organizations tend not to respond to all institutional pressures, but they respond to institutional pressures instrumental to the achievement and maintenance of organizational legitimacy. Organizations adopt new practices necessary to gain a minimum level of legitimacy in a new institutional environment while they retain the core practices in their traditional area. Bozeman (1987) suggests that the resource mix is as important as the level of resources in determining the behaviors and performance of organizations. Bozeman and his colleagues (Rahm, Bozeman and Crow, 1988; Crow and Bozeman, 1991) demonstrated that government funds and industrial funds are not necessarily the countervailing forces, and that government laboratories with a balance of political and economic influence would perform better. An infusion of either influence into organizations does not necessarily reduce the other, but it opens the organization to an array of additional influences (Bozeman, 1987). Since the process of selecting projects in government laboratories is subjected to political and economic influences, balancing the project portfolio between these influences is important for the management and policy strategies of government laboratories.

Resource Acquisition As Organizational Effectiveness

Yuchtman and Seashore (1967) argue that the acquisition of resources instrumental to the functioning of organizations is an important goal for organizations. As they pointed out, resource acquisition may enhance the negotiation position of organizations with external organizations in their environments. For S&T institutions, the acquisition of research funds will help these institutions obtain and maintain the quality researchers and facilities, and it will increase the bargaining power with their external funders (Sanders and Robison, 1992). To Sheppard (1995), the negotiation position of organizations vis-à-vis external resource providers is critical to organizational effectiveness and subsequent organizational survival. He demonstrates that insufficient resources to implement a desired strategy to meet the demands of external resource providers will lead to organizational ineffectiveness and eventually organizational failure. He argues that if the demands of resource providers are being met, then the organizations will be able to acquire or maintain recourses so that they will be effective and will survive. Thus, resource acquisition and subsequent negotiation power ensure the effectiveness and survival of organizations.

In light of the mix of resources instrumental to organizations, the organizational forms of government laboratories are *imprinted* at the time of their founding. As Scott (1981: 157-158) pointed out, organizations differ with combinations of resource requirements--financial and technical as well as personnel. The mix of initial resources from which a government laboratory is created has lasting effects on the attributes of organizations. The form and shape that government laboratories acquire at the time of their founding are likely to be the structure they retain over the course of their life span (see Scott, 1981: 158). Given the initial resource mix, the stability of major resources and the ability to garner necessary resources depends on the nature and goals of the organization. As Meyer and Rowan (1977 in Scott, 1991) put it, more institutionalized organizations may have fewer difficulties securing institutional support from their environments. The purposes, structure, and processes of these organizations are chosen simply because they are socially valued.

3.4. The Effectiveness of Cooperative R&D Viewed from the Perspective of Technology Transfer: Perceived and Objective Measures

This study has started our discussion in this chapter with the assumption that technology transfer is the underlying rationale for forming cooperative R&D activities between government laboratories and industry. While technology transfer at the collaborative setting is a two-way relationship between the parties involved, this study has focused on the government-to-industry side of technology transfer for the reasons described earlier. From the organization-centered perspective, technology transfer was defined as the transfer of physical devices, processes, know-how, or proprietary information about devices or processes from government laboratories to the market.

While there is relatively agreed-upon conceptualization of technology transfer,[38] the definitions of technology transfer effectiveness vary among disciplines and researchers. This phenomenon arises partly from the multiplicity of meanings of technology transfer effectiveness (Bozeman and Fellows, 1988; O'Keefe, 1982; Reisman

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[38] For conceptual discrepancies of the concept of technology transfer, see Bozeman and Crow (1991b), Zhao and Reisman (1992).

and Zhao, 1991; Zhao and Reisman, 1992). We can think of this fragmented situation as the "effectiveness contradictions" (Hall, 1991: 246) in technology transfer (see Charles and Howells, 1992: 164; Spann, Adams and Souder, 1993). Like other public policies, technology transfer can be better assessed by incorporating multiple legitimate perspectives of effectiveness into the evaluative methodology used (Rossi and Freeman, 1993).

On the hand, since there is a long time lag between technology transfer and its economic effect,[39] we need certain perceived measures of the effectiveness of technology transfer occurring at present, along with the objective measures of transfer effectiveness. Viewed from the organizational perspective, the different understandings of transfer effectiveness revolve around the question of whether the transfer of technology is conceptualized as *delivery* or as *impact* (Ezra, 1975; Mogavero and Shane, 1982).

The most common perception of technology transfer is that it is effective if technologies are "out-the-door" (Bozeman and Fellows, 1988), i.e., if technologies are delivered from government laboratories or a cooperative R&D setting to industrial firms. This criterion concerns *outputs* or the "countable" (Carr, 1992). The effectiveness of technology transfer is reflected in the number of intellectual properties or information assets such as brochures and licenses. The commercial impact of those *countables* is unclear and is not taken seriously, because government laboratories are not usually engaged in the post-transfer development work. As a result, the out-the-door model, one

[39] The full-fledged commercial impact of technology transfer may take 30 years (National Research Council, 1989: 14).

equating transfer with effectiveness, may well reflect the viewpoint of government laboratories involved in technology transfer activities.

An alternative perception is that technology transfer is effective if the transferred products or processes are commercially viable and profitable. As Kimball (1970: 1243) put it, technology itself may be the least important element in the over-all transfer process: "The technology transfer process is social and economic in form and purpose. rather than scientific or technical." In this model or what can be called "market-impact" model (Bozeman and Fellows, 1988), the commercial impact of transferred technologies is clear, because it focuses on the *outcome* or *impact* of transferred technologies through the application and implementation of transferred technologies by industrial firms or industry. The outcome of technology transfer may include revenues from licensing, or the extent to which problems facing firms have been solved (shorter range measures), cost savings, time savings, productivity gain (middle range measures), the value added of commercial products and processes, the number of jobs created, the growth of market share, or, ultimately, increased profit or revenue (longer range measures) (Bruce, Leverick, Littler and Wilson, 1995: 39; Carr, 1992; Link, 1995). Contrary to the out-the-door model, market impact in most cases is not easy to quantify in the short run. Since technology transfer is ultimately oriented toward increased market impact by user firms. the market impact of transferred technologies becomes an important test of technology transfer activities of government laboratories.

Table 3.2. Commercial Impact Continuum and Transfer Effectiveness Measures

Characteristics	Out-the-Door	Market-Impact
Form of Influence	Output<-------------------------------->Outcome	
Nature of Transfer	Delivery<------------------------->Application	
Countability	High<------------------------------------->Low	
Commercial Impact	Unclear<-------------------------------->Clear	
Orientation	Developer<------------------------------->User	

Meanwhile, technology transfer can be considered to be effective in terms of the number of licensed technologies. As one of the most common ways of transferring technologies, licensing[40] is used as a mechanism for transferring technologies by organizations which have limited manufacturing or marketing capabilities, or those that have existing product lines not compatible with the invention (Francis, 1977: 201). The research activities of government laboratories usually end at the stage of experimental development in which prototypes or feasibility demonstrations are developed. Beyond the stage, technologies are patented (or copyrighted or trademarked) and marketed to private firms who license the inventions for ultimate manufacture and sale. According to Charles and Howells (1992: 4-6), patents and other forms of licensed proprietary knowledge form an intermediary level between the *pre-innovation technology transfer phase* which involves primarily intraorganizational flows associated with R&D and pre-launch marketing/production and the *post-innovation technology transfer phase* which consists of the diffusion of existing innovations from one organization to another. Licenses can become important financial assets, depending upon the character of

[40] Carr (1992) sees licenses as an indicator of the out-the-door measure, in that they are "countable" things. However, licenses can be distinguished from other informational assets, such as brochures, in that they contain much more proprietary information.

government budgetary process. In countries where government laboratories are allowed to use at least part of the royalty incomes at their disposal, the number of licenses may be used as an important measure of effectiveness. Licensed technologies tend to be used by industrial firms with the hope of realizing immediate gain, depending on their manufacturing and marketing capabilities. The sale of patents or technological licenses is considered to be a good reflection of the earnestness of government laboratories in their commercial technology transfer activities (Bozeman, 1994).[41]

Figure 3.3. Conceptual Relationships Among Perceived and Objective Criteria

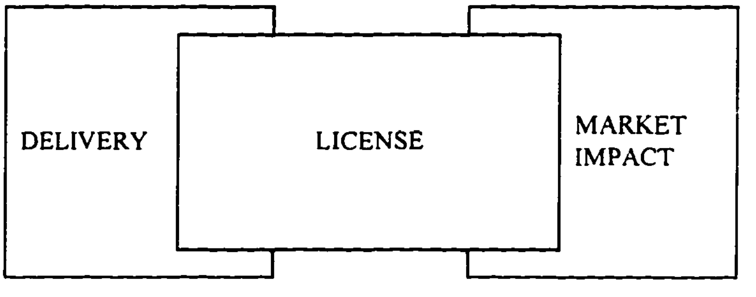


Figure 3.3 shows the conceptual relationships between the perceived measures and the objective measures of technology transfer effectiveness. Sometimes it is difficult to draw the line between *delivery* perception and *commercial impact* perception. For example, increase in the number of technologies taken out of the laboratories may lead to substantial market impact of those technologies transferred (Bozeman and Fellows,

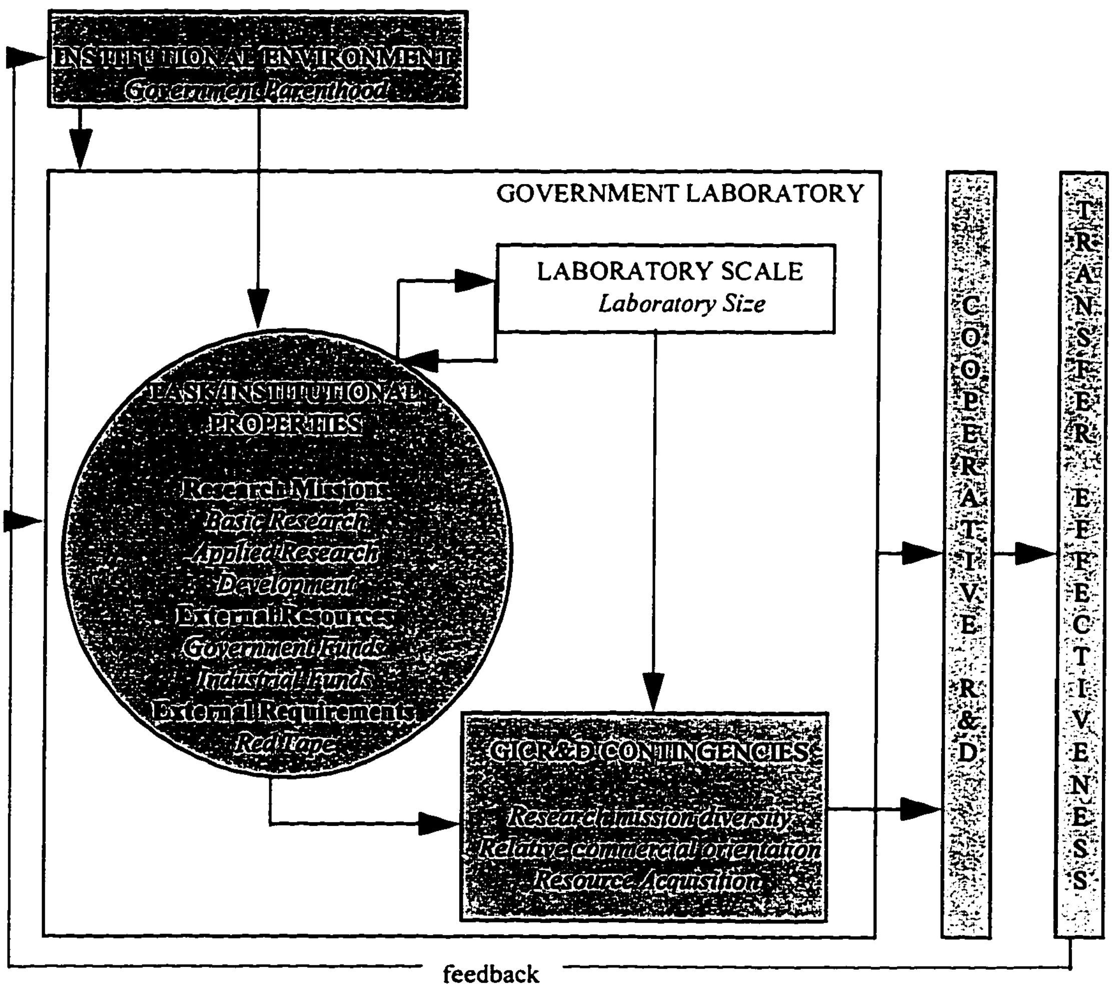
[41] Patent data will serve a measure of internal technical capacity, when they are considered in conjunction with the subsequent licenses and royalties (Carr, 1992). However, patent data in most respects are of limited applicability in assessing government R&D efforts (Finneran, 1986; Papadakis, 1993; Roessner, 1993a). Additionally, the national differences, particularly between the United States and Japan, in the definition of patent, the purpose of patent policy, and the method of protecting patents make the use of patents as a measure questionable (Chiang, 1995; Wakasugi, 1992).

1988). However, such a progressive evolution of effectiveness may be a disjointed and stochastic one; thus the delivery of technologies is conceptually different from the commercial impact of technologies delivered (Bozeman and Coker, 1992). For example, technologies simply delivered to users can be counted as outputs by government laboratories, but those technologies can be outputs with no useful outcome from the user's perspective. The commercialization of licensed technologies developed at the cooperative setting is confounded by a variety of collaboration-related factors, such as the firm's technical absorptive capability and manufacturing capabilities. As indicated in Figure 3.3, the license measure of transfer effectiveness represents an in-between perspective of the delivery and impact side of transfer effectiveness. Licenses are countable things, and they reflect the commercial significance of technologies. But their market impact is still unclear, because the commercial viability of licensed technologies depends upon the industrial firms' manufacturing and marketing capability, market structure, and other market-related factors.

IV. HYPOTHESES CONCERNING GOVERNMENT-INDUSTRY COOPERATIVE R&D IN JAPAN AND THE UNITED STATES

Figure 4.1 schematizes the theoretical relationships among government laboratories' task and institutional properties, GICR&D contingency variables, cooperative R&D, and technology transfer effectiveness. It posits that the effectiveness of technology transfer is a function of cooperative R&D which in turn depends on the GICR&D contingencies, i.e., S&T capabilities based on the diversity of research missions, the commercial orientation of research projects (given the government orientation present in the selection of those projects), and the organizational importance attached to resource acquisition.

Figure 4.1. A Theoretical Model of Laboratory's Task and Institutional Properties, Cooperative R&D, and Transfer Effectiveness



These GICR&D contingencies are determined by the task and institutional properties and the parenthood of government laboratories, when the effect of laboratory size is controlled. The nature of the parent organizations of laboratories is considered as an important factor that affects the task and institutional properties of government laboratories. Task and institutional properties of government laboratories are comprised of a core research mission(s), external resources, and external requirements. External resources are allocated to research missions within procedural constraints imposed by external resource sources. Defined as research types, core research missions consist of basic research, applied research or development missions. Major funding sources of government laboratories are government (or parent organizations) and industry. The procedural impact of external sources on the internal R&D management is reflected in government red tape.

Based on this theoretical model, this chapter establishes a set of hypotheses concerning 1) the relationships between cooperative R&D and technology transfer effectiveness, 2) the relationships between the GICR&D contingency variables and cooperative R&D, 3) the relationships between the R&D task and institutional properties and cooperative R&D propensity, and 4) the relationships between the parenthood of government laboratories and cooperative R&D.

4.1. Relationships Between Cooperative R&D and Transfer Effectiveness

Hypothesis 1AJAP: Japanese government laboratory directors will asses government-industry cooperative R&D more positively in terms of *market impact* than in terms of out-the-door.

Hypothesis 1A_{USA}: The United States government laboratory directors will assess government-industry cooperative R&D more positively in terms of *out-the-door* than in terms of market impact.

Hypothesis 1B: Government-industry cooperative R&D will more likely to produce *licenses* in Japan than in the United States.

Frequent cooperative R&D of government laboratories with industry will be effective in transferring technologies. First of all, the frequency of collaboration will increase the possibility of government technologies being transferred to industry by resolving transferability problems of government technologies mentioned in the previous chapter. By involving industry from earlier stages of technology development and through learning by interacting (or communicating), government laboratories can enhance the commercial orientation of government research and the ability to identify secondary utilization potential for government technologies. On the other hand, firms become more knowledgeable about government S&T assets, can promote their ability to evaluate commercial appropriateness of these assets, and can easily digest complicated technologies and apply government technologies toward commercial purposes. This process resolves the transfer limitations imposed by context-dependency of government technologies. Thus frequent collaboration will contribute to the development of technologies that are *transferable* to the marketplace, by facilitating technological, institutional, and structural learning by government laboratories and industrial partners.

In addition, the frequency of interactions implies the importance of government laboratories to industry, as Hall (1991: 234) argued. The process of technology transfer is economic as Kimball (1970) suggested. Firms will be engaged in cooperative R&D with government laboratories in order to influence the existing market or the future market and ultimately make profits. Since firms' decision to adopt technology is mainly economic (Kimball, 1970: 1241), technologies adopted by industry are more likely to be the ones *desired* in the marketplace, as well as the ones being of technical quality. Thus, government laboratories with frequent collaboration with industry are more likely to be important sources of information or skills relevant to the economic needs of industry.

While the positive effect of frequent relationships on technology transfer is applicable to both countries, it seems that Japan and the United States tend to place different weight on the out-the-door aspect and the market impact aspect of technology transfer effectiveness. The national variations in the perceptions of transfer effectiveness can be accounted for by the national differences in 1) the nature of technology transfer, 2) the major objectives of technology transfer, and 3) a degree of political pressures imposed on government laboratories in relation to their performance.

In JAPAN, the **nature of technology transferred** is often characterized as more *informational*. The government laboratories are rarely involved in the transfer of technology in the form of physical technology or complete knowledge necessary to produce new products in the private sector (Morris-Suzuki, 1994: 186). Rather the dominant form of technology transfer in Japan is a technical forum or meeting. These technical forums take different forms. Cutler (1988) and Eagar (1985) emphasize technical meetings organized by professional societies, with a strong leadership of eminent university professors as chairpersons of these meetings. Morris-Suzuki (1994:

186) states that think tanks and discussions groups, consisting of government laboratory and industrial researchers, provide a forum in which S&T information is exchanged. An OECD report (1967: 152) indicated the importance of advisory councils or committees utilized by individual ministries in transferring technologies from government laboratories to industry. Interesting here is that directors of government laboratories acted as chairpersons of the various committees organized by industry. Kodama (1991) stresses the criticality of ERAs in technology transfer in which government laboratory directors play a part as chairpersons. Through the use of various technical forums, government laboratories diffuse nonproprietary information and normalize S&T capabilities among industrial firms (Eagar, 1985; also Hane, 1993-1994).

The **objective of technology transfer** is to "achiev[e] *resilience* through the maintenance of *diversity*" rather than controlling the information-generation in the marketplace (Vertinsky, 1986: 54). Similarly, Watanabe, Santoso and Widayanti (1991) argue that Japan's R&D policy is mainly an *inducing* policy and it stimulates invisible impact. The Japanese government stimulates an indirect and long-term impact through structural change rather than direct investment in the private sector. As a result, the objectives of technology transfer in Japan may reflect the perspectives of industry in technology development and application.

The **political pressures** toward the performance of government laboratories appear to be *weak* in Japan. While a low degree in political pressure on government bureaucracy can be largely accounted for by the stability of political system; the systemic character of S&T policy process is also important. In Japan, the assessment of S&T

policies is progress is a continual part of the consensus mechanisms used to establish the S&T policies (Lederman, 1994: 282). Special councils are formed periodically to assess the government S&T policies, but their recommendations are not binding to individual ministries and their research laboratories. As Aoki (1988) implied, individual ministries tend to have the leveraging authority in determining their course of action in the decentralized system of Japanese government decisionmaking. In some government ministries such as the MITI, the Ministry of Foreign Affairs, and the Ministry of Finance, their secondants to the higher level of policymaking agencies --e.g., the Science and Technology Agency-- play an important part as boundary spanners (Johnson, 1982). Although the national performance in S&T is continually assessed, government organizations are not pressured to demonstrate the accomplishment of goals (Jun and Muto, 1995: 127). Based on the MITI experience, Tanaka (1989) characterizes the Japanese project evaluation process as "in-house self-assessment" and "consensus-seeking" (also see Nagasu, 1984). The evaluation of research projects is made by government laboratories in close cooperation with their parent agencies and their advisory bodies. Advisory bodies is more involved in the formation and evaluation of special and project research activities (mainly applied and development research), and their main role is to recommend the future directions for research activities (Nagasu, 1984). This suggests that political *visibility* and the *countable* effectiveness of technology transfer are not a major concern of government laboratories in Japan. Coupling these three characteristics with the commercial content of government research mentioned in Chapter Two, we can hypothesize that Japanese government laboratories will be more prone to perceive technology transfer effectiveness in terms of "market impact" rather than "technology delivery."

In the **UNITED STATES**, the **nature of technology transfer** appears to be more *physical-technology oriented* (Fusfeld, 1986; Skagen 1985 in Frye, 1985), even though many other forms of technology transfer are utilized (see Bozeman and Fellows, 1988). As implied in a series of technology transfer acts since 1980, the transfer of technology from government laboratories to industry has focused mainly on the utilization of government laboratory technologies for commercial use by industrial firms (Bagur and Guissinger, 1987). The *objective of technology transfer* has been to *make* government technologies *available* to industry. In this sense, the predominant focus is still placed on the accessibility of government technologies, i.e., technology push, while the policy initiatives for cooperative R&D take the importance of market pull into account. The *political pressures* toward government laboratories' performance appear to be strong in the United States. Due to the short cycle of the political life and the regular change in political power, government S&T policies are more oriented toward short-term results. Government laboratories are pressured to demonstrate observable results of technology transfer. The conception of technology transfer as "technology delivery" reflects the intentions of policymakers in the United States (Bozeman and Fellows, 1988). There is no continuous, systematic assessment of S&T policies (Lederman, 1994), but government laboratories are frequently subjected to ad hoc evaluations such as the Packard Commission (1983), the Galvin Commission (1995), and the General Accounting Office. Also there have been some discussed but not-attempted privatization efforts such as the transformation of the intramural research functions of the National Institute of Health into a private graduate school, and the recently discussed reorganization efforts of the Department of Energy laboratories. Taking these three characteristics together with the government-mission orientation of laboratory research mentioned in Chapter Two, we can hypothesize that government laboratories in the United States will be more prone to perceive technology transfer effectiveness in terms of "technology delivery" rather than "market impact."

Second, frequent cooperative R&D will produce more **licenses**. There are at least three reasons. First, government laboratories are not allowed to proceed to the commercial production stage beyond the experimental development stage. Nor do government laboratories have enough capabilities for marketing and manufacturing research results into commercial products. Licensing serves the revenue-raising motive of government laboratories through income obtained from royalties. However, the importance of licenses to government laboratories can be different from industrial firms, depending on the budgetary requirements. Second, licensing is a typical mechanism for technology transfer in the context of a formal cooperative R&D (Mariti and Smiley, 1983; also see Contractor and Lorange, 1988). Since cooperative R&D involves multiple actors, each party's rights to research results are executed and protected by licenses. Industrial firms try to recoup research expenses spent on cooperative R&D or to influence the existing market by commercializing the research results. In this process, license serves the profit-making motives of participating firms, and particularly exclusive licensing plays an important part in establishing or maintaining technological leadership of licensees. Third, in the context of government-industry cooperative R&D, licensing serves certain public policy purposes of government. In most industrialized countries, when cooperative R&D ventures are financed by the government, research results or patented technologies stemming from these ventures belong to the government. Depending on the policy orientation of each country, governments may also use licenses to disseminate cooperation research results to participating firms and even to non-participating firms with royalty payments and with certain time lags. What may differentiate most between the United States and Japan is related to the last aspect of licenses.

In JAPAN, licenses are particularly important for government R&D policies. Researchers in government laboratories place greater emphasis on patents rather than academic publications (MacDowell, 1984: 169). In most cases, patents obtained from government-industry cooperative R&D belong to individual ministries responsible for the venture. The Japanese government uses license as a major means for *diffusing* the research results of cooperative R&D to non-participating firms, and stimulating competition among firms (Hane, 1993-94); this is what Eagar (1985) calls "*normalizing*" S&T capabilities across industrial firms whether or not they were participants in the venture. The Japanese government has established the Research Development Corporation of Japan (JRDC, created in 1961) to promote the industrial exploration of government-developed patents.

In the UNITED STATES, the importance placed on licenses is much more associated with its *metrical significance as a tangible proxy measure for a more* *immediate economic impact* (see Prosser, 1995), and with its effect of revenue raising from royalty incomes. In the United States, government laboratory researchers tend to give priority to the publications of scholastic journals (Morone and Ivin, 1982). Thus, trade-offs between publications and patents remain an important issue even after the National Technology Transfer Act of 1986 that institutionalized researchers' performance in technology transfer activities as an important criterion for performance evaluation.

We can not judge the relative importance of the "innovation diffusion motive" of Japan and the "proxy economic impact" of the United States for the production of licenses. We will assume that Japan is more likely to produce licenses than is the United States, in that the growing concern over licenses in the United States is also a reflection of the fertility of patents and subsequent licenses in Japanese cooperative R&D ventures.

Table 4.1. summarizes the factors which may affect the adoption of perceived and objective measures of technology transfer effectiveness in the United States and Japan.

Table 4.1. Factors Affecting the Adoption of Perceived and Objective Measures of Transfer Effectiveness in the United States and Japan

Factor	Japan	United States
PERCEIVED MEASURES		
Relative Importance	**Market Impact**	**Delivery**
Nature of Technology Transfer	Informational	Physical
Objectives of Technology Transfer	Resilience	Accessibility
Political Pressure on Performance	Weak	High
OBJECTIVE MEASURE		
Impact on Formation Propensity	**High**	**Low**
Policy Implication	Normalization	Economic Impact
Uses	Diffusion	Metrical

4.2. Relationships Between Task and Institutional Properties and Cooperative R&D Propensity

1. Government Parenthood and Cooperative R&D Propensity

Hypothesis 2_{JAP}: In Japan, government laboratories with a government parent are less likely to form cooperative R&D with industry.

Hypothesis 2_{USA}: In the United States, the government parenthood of laboratories will have no effect on the propensity of government laboratories to form cooperative R&D with industry.

In both countries, governments establish special organizations in order to meet their special R&D needs in the public interest that can not be readily satisfied by government in-house activities or private sector contractors. These organizations are subject to government regulations other than the ones applied to government ministries or agencies. Common in both countries is that, compared to government agencies, these special organizations are given a greater autonomy and flexibility in financial and personnel management whereas they are still under the special supervision of government or affiliated government agencies. Among these special organizations, the most important are special public corporations, nonprofit organizations, and "hybrid" (National Research Council, 1989) organizations in Japan, and the Federally Funded R&D Centers (FFRDC) and extension services in the United States, respectively.[42]

Certain differences have significant implications for the effect of government parenthood on the cooperative R&D propensity. The first difference is their **research**

[42] In the following discussion, we focus primarily on the special public corporations.

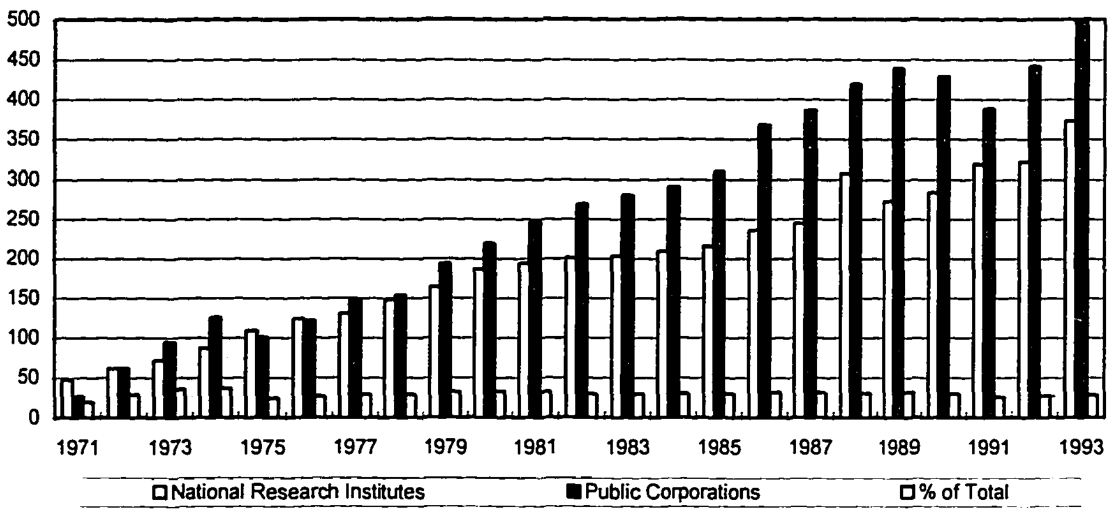
orientation. Special public corporations are designed to perform the government's *specific research mission of national problem solving* in such areas as energy, space, nuclear power, or new technology development. FFRDCs perform R&D activities in similar research areas, plus military R&D concerns, as Japanese special public corporations, but they have a more *administrative orientation*: orientation toward the objective and independent performance of research activities that are integral to *the missions and operations of their sponsoring agencies*. Thus, while special public corporations in Japan are primarily established by *special laws*, the FFRDCs are created under *management contracts* of individual government agencies with industry, university, or nonprofit organizations.

The second difference between special public corporations and FFRDCs can be found in the pattern of **research funding**. Japanese special public corporations are completely funded by government special accounts and industry, with a varying degree of mix. For example, the privatized NTT, and the reorganized Institute of Physical and Chemical Research (RIKEN reorganized as a nonprofit organization in 1958) are financed by government and industry. In most cases, the profits gained by the public corporations through their business operations are held as reserve funds after the compensation of losses that have been brought forward (Shibata, 1993; Administrative Management Agency, 1982: 48). Although FFRDCs are not federal agencies, 70 percent or more of their research is financed by the government including a relevant government agency and they are required to be free from organizational conflicts of interest.

The third difference is that Japanese special public corporations including the NTT and the NHK are involved in "administrative guidance" and are subjected to the Japanese practice of *amakudari* (descending from the heaven) (Johnson, 1978; Shibata, 1993: 32-33). While the FFRDCs are created by federal agencies, there is no such a practice as *amakudari* in the United States.

The fourth difference is their **importance to the national R&D system**. Since the 1970s, special public corporations as R&D performers have been responsible for approximately *30* percent (*28* percent in 1993) of the national R&D (Figure 4.2). Since the 1970s, the FFRDCs share of the national R&D has been approximately *6* percent (*5* percent in 1993) in combination of industry, university, and nonprofit FFRDCs (Figure 4.3). As shown in Figure 4.2, in terms of the size of R&D expenditures, the special

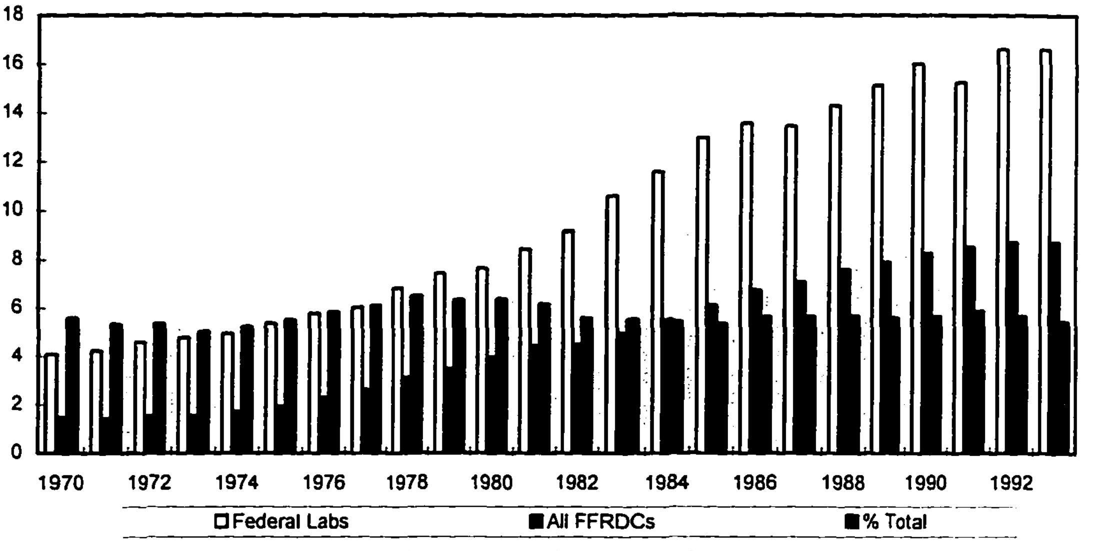
Figure 4.2. R&D Expenditures of NRIs and Special Public Corporations (Billion Yens)



Note: The Japanese reporting system classifies three privatized public corporations--the NTT, the Japanese National Railways, and the Japan Tobacco and Salt Public Corporation into the private sector.
Source: Management and Coordination Agency, The Statistical Yearbook of Japan, 1972-1995.

public corporations have exceeded the national research institutes (NRIs) since the 1970s. In the United States, the federal laboratories have spent twice as much as the FFRDCs.

Figure 4.3. R&D Expenditures of Federal Laboratories and the FFRDCs (Billion Dollars)



Source: National Science Foundation, Science and Engineering Indicators, 1993.

For these reasons, Japanese special public corporations play a vital role for the implementation of governmental functions as independent entities of the government. With mixed public-private enterprise such as the NHK or the NTT, special public corporations tend to constitute a critical part of the government-business relationships in Japan (Johnson, 1978: 16). Thus, these organizations are more likely to form cooperative R&D with industry. By contrast, laboratories with non-government parent organizations will behave in a similar way to those with government parents.

2. Individual Research Missions and Cooperative R&D Propensity

Hypothesis 3JAP: In Japan, development mission laboratories will be more likely to enter cooperative R&D with industry than applied research mission laboratories and, even more so, than basic research laboratories.

Hypothesis 3USA: In the United States, basic research mission laboratories will be more likely to enter cooperative R&D with industry than applied research laboratories and even more so, than development mission laboratories.

As defined in Chapter Two, government-industry cooperative R&D focuses on a precommercial research on generic technology. This type of research covers basic research through research activities near the development stage of R&D spectrum. Since the span of this type of research runs a wide range of R&D activities, the types of laboratory research missions appropriate to collaboration can be varied correspondingly.

There can be at least two accounts that favor certain types of laboratory research missions. The first account is associated with the *inappropriability* problem of a typical profit-maximizing firm with the returns on the investment in research. The appropriability account serves an influential theoretical justification for government support for inter-firm R&D collaboration. As Arrow (1962) and Nelson (1959) argued, because of the uncertainty, indivisibility, and inappropriability of research results, a typical profit-maximizing firm is not likely to invest in research at a socially optimal level. Research is assumed to be a process of producing information which is an indivisible commodity. Since information is a pure public and non-rival good, a typical firm is not able to have complete control over the flow of information. Incompleteness of control over the flow of information results in the social rates of return to research being greater than private rates of return (Bernstein and Nadiri, 1988; Griliches, 1958). When private rates of return to research are expected to be lower than social rates of return, the profit-maximizing firm will not be likely to invest in research. The under-investment in research will lead to the production and provision of S&T information at the socially sub-optimal level. The basic research activity demands a high degree of creativity and risk taking, but basic research results are highly accessible, if not costless (Pavitt, 1991), to other organizations. Basic research is most likely to be inappropriable and to be produced suboptimally. Because of the public-good nature of basic research results, collaboration based on basic research can avoid competition at the research stage, and enhance the sharing effect of research results. As research activities get closer to the development end of R&D spectrum, inappropriability wanes and the possibility of collaboration decreases. The outcomes of development activity are more appropriable by an inventing organization than the results of the other research activities. When firms of different S&T strength form collaboration, some firms can pick up and develop research results at an earlier stage of R&D. When they are of the same S&T strength, participating firms are more likely to compete with each other and come up with the form of rival designs (Edward, 1950). When collaboration is nearer the production stage, collaboration may cause role conflicts and benefit conflicts among participants (Edward, 1950: 171). Inappropriability prevails to a greater extent in research activities at the basic-end of the R&D spectrum rather than in its development-end activities. Thus, more basic research government laboratories are more likely to be a partner of industrial firms, and more development mission laboratories are less likely to enter cooperative R&D with industry.

The second account for appropriate laboratory research missions is related to the *commercial proximity* argument that the involvement of industrial firms in collaboration are based on their economic motivations, as Kimball (1970) argued. The commercial proximity account posits that the results of basic-end research are not appropriate to the commercial desire of industrial firms. Commercial proximity of research results increases in research activities nearer the development end of R&D spectrum. Industrial firms are not likely to devote scarce resources and valued research personnel to undertakings which are still far away from the commercial applications. Development mission activity is one of the government laboratories' activities related to the development of commercial products (see GAO, 1994a). Development mission laboratories also have fewer barriers to interactions with industry such as technology transfer activities than basic or applied research laboratories (Coursey and Bozeman, 1992). Thus, more development mission government laboratories are more likely to be a partner of industrial firms, and more basic research mission laboratories are less likely to enter cooperative R&D with industry.

Which account explains appropriately Japan and the United States depends on the national similarities and differences in the posture toward market failures, the historical formative motifs and mission strengths of the government laboratory system, and the R&D composition within government laboratory systems. In terms of the **attitude toward market failures**, JAPAN is more *preventive* and the UNITED STATES is more *ameliorative* (Okimoto, 1989). The Japanese government tends to intervene into the market in anticipation of market failures. In the United States, government tends to into intervene the market only in cases where the market fails or where national security is concerned. This national difference well reflects the **formative motifs** of government laboratories in two countries. In both countries, the creation of government laboratories was largely motivated to fulfill certain practical purposes, but the content of those purposes differ. In JAPAN, the formation of government laboratories was consistently oriented toward *economic development*, and was motivated to *develop technologies which would be useful for the needs of industrial firms* (Fukasaku, 1992; Tuge, 1968). For example, the formation of earlier industrial laboratories was motivated by the perceived limitations of government laboratories in dealing with industrial technological needs (Fukusaku, 1992). In the UNITED STATES, government laboratories originated as the result of *war or a crisis* perceived by the public as major (Mark and Levine, 1984: 25). Thus, government policies related to government laboratories have been much more based on *situational* justification (Dupree, 1980). By contrast, in Japan, the issue of national security was frequently addressed in regard to the availability of scientific information or technologies in need.

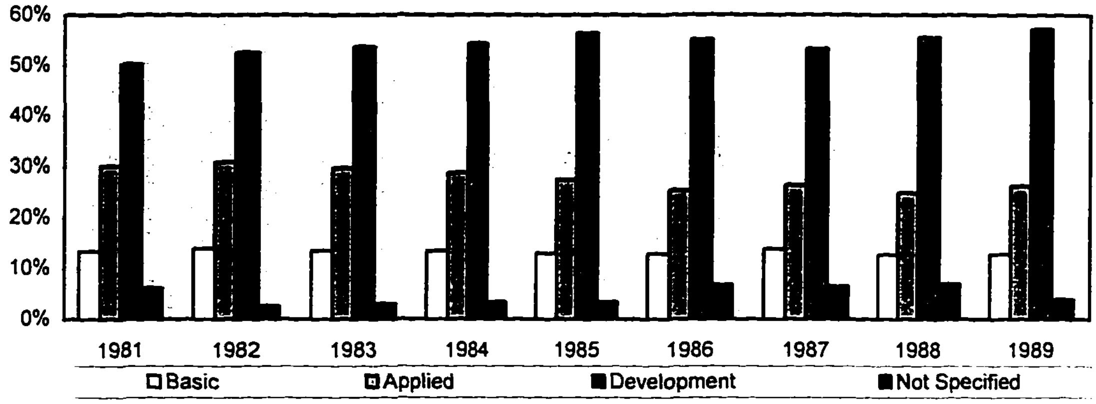
This national difference has been imprinted in the overall **research strengths** of the government laboratory system. In JAPAN, the historical research strengths of government laboratories have been in *applied research* and *development*. Emphasis on technology (or applied research and development) over science (or basic research) has been well reflected in the government control of scientific activities in the Shogunate era, and in the economic "catch-up" drive in the Meiji era (under the banner of "rich nation and strong army") and particularly in the postwar period (Commission on the History of Science and Technology Policy, 1991; Tuge, 1968). In the catch-up period, the major roles of government laboratories were the feasibility testing of imported foreign technologies and the adaptation of foreign technologies to domestic industrial use. These roles of government laboratories have extended into publicly-funded large-scale projects since the 1960s. For example, in the case of laboratories of the Agency of Industrial Science and Technology, their legal names still remain as the test and research laboratories although these testing laboratories have changed names from test laboratories to research laboratories (Eto, 1993: 285). According to Eto (1993: 283), test laboratories are industry-related laboratories designed to develop intermediate or appropriate technologies for under-developed industries rather than advanced technology for top enterprises Since the 1970s and particularly the 1980s, Japan's official policy has emphasized the criticality of scientific research in its sustained economic development, in conjunction with the criticisms of a free-rider of western scientific knowledge leveled by other industrialized OECD countries (see the White Papers in Science and Technology since 1980). As part of it, a report by the Council for Science and Technology, *On the Way National Experimental and Research Institutes Should Operate From a Medium- to Long-Term Perspective* (August 28, 1987), has recommended that basic research be strengthened in the government laboratories. While the White Papers in Science and Technology emphasize a new responsibility of government laboratories in *high-risk and* *large-scale* R&D, these large-scale projects tend to be in *applied* areas that are expected to be useful to future industries (National Research Council, 1989: 13).

In the **UNITED STATES**, the research strengths of government laboratories have been in *basic and applied research, with a slant toward the former.* While the research focus of government laboratories has been on applied research (Dupree, 1980), the basic-research-is-the-best mentality has prevailed in government laboratories, since the campaign of the promotion of basic research by Vennevar Bush (Shapley and Roy, 1985). According to Mark and Levine (1984: xi), the greatest strength of the government laboratory is in basic and applied research, and not in product development with rare exceptions. A large part of development expenditures within government laboratories comes from the Department of Defense, Department of Energy, and National Aeronautics and Space Administration. Much of non-defense research focus of other government laboratories is basic research (Papadakis, 1995; Rosenbloom, 1996). While there have been a series of legislative acts stressing the private sector orientation (technology transfer or commercialization) since 1980, basic research in the national R&D system including the government laboratories has also been emphasized as the foundation of American technological leadership (Clinton and Gore, 1993).

In terms of the **composition of R&D activities**, there are more similarities than differences between the government R&D systems in two counties. During the 1980s, the average expenditures spent to each research activity in Japan and the United States were 13 percent and 17 percent for basic research, 30 percent and 29 percent for applied research, and 54 percent and 62 percent for development, respectively (Figure 4.4 and

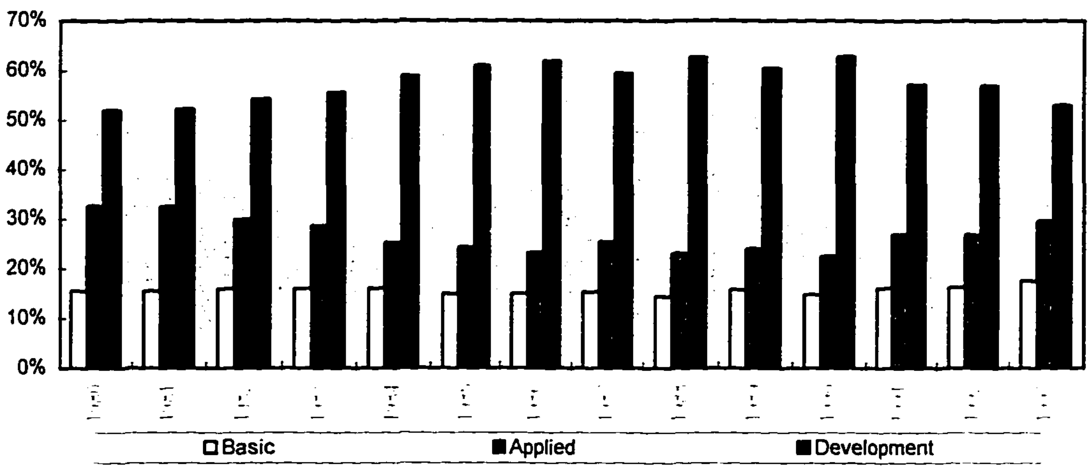
4.5). Considering that the 'development' category in the United States appears to include activities other than development, the composition of R&D activities and its trends during the 1980s are very similar between Japan and the United States.

Figure 4.4. R&D Expenditures of Government Laboratories by Research Type: Japan



Note: The OECD statistical data include the NRIs, local government laboratories, and special public corporations in the government laboratories.
Source: OECD, 1991, 1993, 1995, *Basic Science and Technology Statistics*

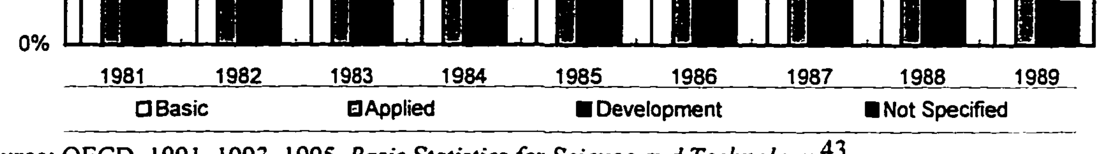
Figure 4.5. R&D Expenditures of Government Laboratories by Research Type: United States



Source: OECD, 1991, 1993, 1995, *Basic Science and Technology Statistics*

On the other hand, the United States and Japan are different in the national share of each research activity during most of the 1980s. As shown in Figures 4.6 and 4.7, the national share of each research activity has been declining or stagnant in both countries during the 1980s. One conspicuous national difference is the significant share of 'unspecified' research activities in Japan. The Japanese government laboratories occupied on average 16 percent of the national total 'unspecified' research activities, ranging from 4 percent (in 1989) to 26 percent (in 1985). When the expenditures for "not specified" research activities --ones that are more likely related to large-scale projects-- are included in the category of applied research and development, the share of

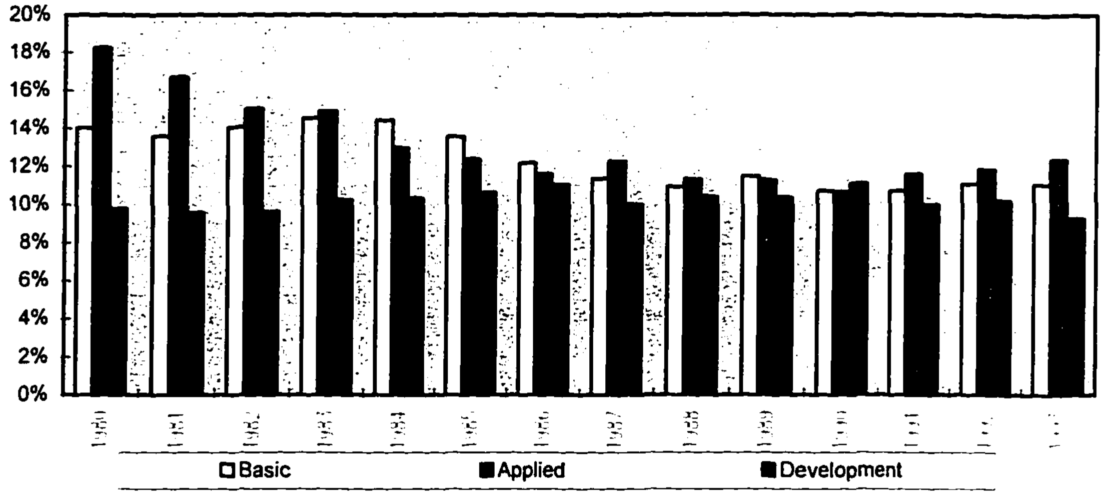
Figure 4.6. Government Laboratory Share as a Percentage of the National Total R&D Expenditures by Research Type—Japan



Source: OECD, 1991, 1993, 1995, *Basic Statistics for Science and Technology*.[43]

[43] There were changes in the Japanese reporting standards of R&D statistics. In 1959, the category of companies was extended from firms capitalized at 10 million yen and above upto firms capitalized at 1 million yen and above. The public corporations were transferred from the category of public sector laboratories to the category of the private sector. In 1963, the category of higher education was extended to include higher technical schools (established by legislation in 1961) which combine the last three years of secondary school and the firs two years of university.

Figure 4.7. Government Laboratory Share as a Percentage of the National Total R&D Expenditures by Research Type--United States



Source: OECD, 1991, 1993, 1995, *Basic Science and Technology Statistics*

applied research and development activities becomes quite large. The average share in the national total expenditures by research type in Japan and the United States was 10 percent and 13 percent for basic research, 11 percent and 14 percent for applied research, and 9 percent and 10 percent for development, respectively. Especially the share of basic research in Japan dropped to 8 percent at the end of the period.

Finally, as indicated in the discussion of "stylized facts," the JAPANese government laboratory system has the commercial content of research. The commercial content of research in government laboratories is the outcome of "*one economy*" system (Samuels, 1994), on the one hand, and it is maintained through the utilization of various advisory bodies (Lederman, 1994), on the other hand. This systemic characteristic of the Japanese laboratory system may make the research results of government laboratories *less context-dependent*. In the UNITED STATES, technology development in development mission laboratories is *more context-dependent*. As Shaw (1987) pointed out, military spin-offs are likely to occur when there is a match between military criteria and civilian criteria for technological innovation. Thus military spin-offs to civilian purposes favor the same elements of private sector and overshadow others. In the *two economies* system, as Samuels (1994) pointed out, military technology development is characterized by spin-away, thereby reducing the possibility that military technologies will be spun-off.

Thus, we will hypothesize that the effect of individual research missions on the collaboration propensity will be guided by the appropriability account in the United Sates and by the commercial proximity account in Japan.

3. External Resources

Hypothesis 4_{JAP}: In Japan, resource publicness will have a greater effect on the propensity of government laboratories to enter cooperative R&D with industry than resource privateness.

Hypothesis 4_{USA}: In the United State, resource publicness will have a lesser effect on the propensity of government laboratories to enter cooperative R&D with industry than resource privateness.

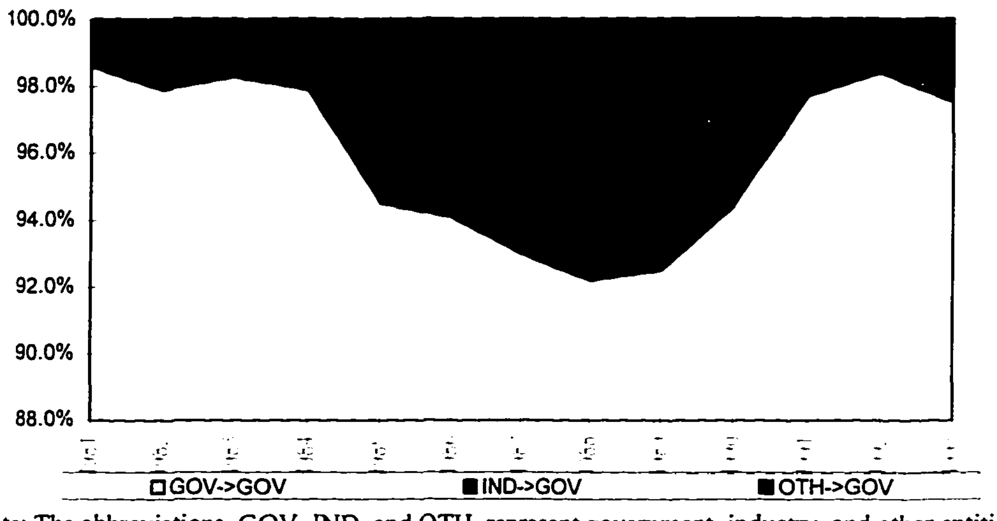
In Chapter Three, we pointed out that the major external sources of resources for government laboratories are government and industry. As Bozeman (1987) pointed out, the external resources accompany the external influences that determine the behaviors and performance of government laboratories: i.e., resource publicness and resource privateness. The impact of resource publicness and resource privateness on the formation of cooperative R&D are subject to the political economy of a nation.

The major national difference is that the **UNITED STATES** tends to see resource publicness and resource privateness as *dichotomous*, while **JAPAN** tends to regard the external influences as *unitary*. According to the public-private dichotomy, public resources are guided by the logic of political decision-making which can be characterized by the authoritative allocation of social values. Private resources are guided by the logic of the market. Government laboratories under greater resource publicness will be more likely to focus on the public domain research activity, political agenda-setting, with special attention to the political interests of their sponsor or parent, and the maintenance by the use of political resources (Bozeman and Crow, 1990: 35). On the other hand, government laboratories under greater resource privateness will be more likely to focus on the market-oriented research activity. In the government laboratory system, the portion of industrial funds tends to be small. According to Rahm, Bozeman, and Crow (1988), with even a small amount of industrial funds, industrial funding impacts to a great extent the behaviors and performance of government laboratories well beyond its relative monetary contribution. Similarly, Osborne and Gaebler (1992: 181-185) argue that industrial funding will make government organizations customer-driven by enhancing accountability to customers; by depoliticizing the choice-of-provider decision; by stimulating organizational innovation; by giving customers more choices; and by reducing waste. This implies that "in the absence of direct financial stakes, the mission of the public agency is more easily subverted" (Bozeman, 1987: 52), whereas any degree of involvement by the private entities will drive the economic efficiency in the operations of public organizations. Organizational effectiveness in the production of generic products increases as government influence increases, and effectiveness in the production of market-oriented R&D products increases as economic authority increases (Bozeman, 1987). Thus, government laboratories under greater resource publicness will be less likely to enter cooperative R&D than those under greater resource privateness.

The unitary view of the relations between resource publicness and resource privateness focuses on the use of public resources in the interests of the private sector. In the unitary view, government laboratories under greater resource publicness will also be likely to focus on the concerns of their sponsor or parent, but their research activities are more likely to have the commercial content and to promote the interests of the private sector. As discussed in Chapter Two, policy making is localized within the bureaucracies with related industry and political party members, and thus the agenda setting by parent agencies are likely to be market-oriented. For this reason, resource privateness will be a less important factor than the dichotomous view would envision. In the government laboratory system, the portion of industrial funds tends to be much smaller as compared to the dichotomous view. In this case, even though there is no direct financial stakes, the missions of government organizations will drive the economic efficiency in the operations of public organizations. As a result, government laboratories under greater resource publicness are more likely to enter cooperative R&D with industry than those under greater resource privateness.

The national differences in the relations between external influences are found in the nature of **inter-sector funding flow**. The JAPANese national R&D system is characterized by a vertical flow of funds, meaning the dominance of government and industry as the source of funding for R&D in the public and private sector, respectively.[44] As shown in Figure 4.8, industry has provided, on average, *4 percent* of the R&D funds spent within the government laboratory system during the 1980s, although industrial funding occupied 5 percent to 8 percent of R&D funds spent in the government laboratories in the second half of the 1980s.[45] In the **UNITED STATES**, the share of industry in the R&D funds spent in government laboratories are comparable to the Japanese case, even though the industrial share may be greater when the FFRDCs are included.

Figure 4.8. The Composition of Funding Sources of Japanese Government Laboratories



Note: The abbreviations, GOV, IND, and OTH, represent government, industry, and other entities (higher education, private non-profit, and entities abroad), respectively.
Source: Calculated by the author from OECD, 1991,1993, 1995, *Basic Science and Technology Statistics*, OECD, Paris, France (Current value of research funds).[46]

[44] While there has been a low level of R&D fund transfer between government and industry, there has been a high degree of intersector personnel flow in Japan (OECD, 1967). However, the main pattern of intersector personnel flow has been in the direction from industry to government laboratories.

[45] According to Tatsuno (1990: 234), it was not until 1984 that corporate firms were allowed to donate equipment to the MITI laboratories because of concern over undue influence in the setting of research priorities.

[46] The composition of funding sources based on the OECD statistics for the Japanese government sector are compatible with the statistics based on the *Statistical Yearbook of Japan* published by the Management

The national contrast is more obvious in case of government support for R&D collaboration. In Japan, interfirm collaboration is heavily funded by government (Aldrich and Sasaki, 1995; Ouchi and Bolton, 1988; Hane, 1993-1994), whereas in the United States interfirm collaboration is financed mainly by membership dues of the participating firms.

The second factor is the difference in the **government budgetary process and subsequent research funding** for government laboratories. A divergence in the government budgetary process is that **JAPAN** is close to a "*managerial budget*" system, whereas the **UNITED STATES** is close to a "*political budget*" system (Bingman, 1989: 39-46).[47] In Japan, R&D budget for government laboratories is drafted and allocated by their parent agencies out of the total budget allocated by the Ministry of Finance. Iinstitutional funding from the parent agencies is stable and has fewer strings, and special and project funding is obtained by a separate request of individual government laboratories to the Ministry of Finance and involves less operational discretion (Nagasu, 1984; National Research Council, 1989). The institutional funding, called 'ordinary funding,' does not need budget request and is allocated on the basis of the number of full-time researchers (Nagasu, 1984).

In the United States, Congress increasingly intervenes in the specifics of the laboratories' activities through direct appropriations. Congressional appropriations are prone to political patronage concerns other than the technical merit of projects (National

and Coordination Agency. The weaknesses of these two statistical reports are that the former includes the NRIs, special corporations, and local government laboratories, whereas the latter differentiates the funds allocated to natural science and technology from those allocated to humanistics and social sciences.

[47] For an excellent rebuttal to the managerial budget perspective, see McCubbins and Noble (1995).

Academy of Sciences, 1995) and involves congressional micro-management of government laboratories and their parent agencies (Wilson, 1989: 241-244). Due to this funding trend, Bingman (1989: 40) argues, the budget has deteriorated as a stable basis for program planning, because "management plans simply lose all reality until the political maneuvering, negotiation, and compromise are completed".

Thus, we can hypothesize the differential effect of resource publicness and resource privateness on the formation of collaboration in Japan on the basis of the unitary view, and in the United States on the basis on the dichotomous view.

4. Red Tape

Hypothesis 5: In Japan (Hypothesis 4_{JAP}) and the United States (Hypothesis 4_{USA}), government laboratories with more red tape will be less likely to form cooperative R&D with industry in both countries.

Government red tape will lower government laboratories' propensity to enter cooperative R&D with industry by delaying the process of cooperative R&D negotiation. From the internal perspective, organic organizations are apt to enter interorganizational relationships (Aiken and Hage, 1968; Bozeman and McGowan, 1982; Levy, 1969). As Burns and Stalker (1961) put it, organic organizations are less rule-bound and have less hierarchy of authority and control. Organic organizations are capable of adapting continually to changes in the external environment. Contrarily, bureaucratic organizations will increase communication costs with other organizations. These organizations will have difficulty sustaining a viable interorganizational communication network due to their low level of internal communication and tolerance (Rogers and Whetten, 1982; Guetzkow, 1966; Schermerhorn, 1975). From the political perspective, government-industry cooperative R&D confronts a number of legal issues. These issues include intellectual property rights, product liability and indemnification, fair access, future pricing, and, particularly in the United States, domestic manufacturing preference. Due to these and other issues, the negotiation process of cooperative R&D agreements takes two to eighteen months, depending on the complexity of issues involved (Berman, 1994).

In both cases, government red tape poses serious problems in forming (and implementing) cooperative R&D. Government red tape creates the "systems in which people are accountable for following rules" and it thus takes the basic operations of government away from "meeting customers' needs" (Gore, 1993). In a period of shortened technology life cycle, the criticality of "temporal sensitivity" is increasing in technology development and global competitiveness (Eisenhardt, 1989; Link and Tassey, 1987; Pearson, 1990; Wood and EerNisse, 1992). As Freeman (1982) put it, a firm's failure to keep up with technological innovations and to speed products to market becomes the firm's failure to compete in the domestic and global market place.

There is a handful of empirical studies on the effect of red tape on the performance of S&T organizations (Andrews, 1979; Bozeman and Crow, 1991a; Bozeman and Loveless, 1987). Among these studies, a very few documented it in the context of interorganizational relations of government laboratories (Bozeman and McGowan, 1982; Larsen and Wigand, 1987). There is no empirical comparative study on government red tape in the United States and Japan. The most frequently cited difference between the United States and Japan is that the UNITED STATES *innovation system suffers from more red tape* than the Japanese counterpart (MacDowell, 1984). Tatsuno (1990: 234) alleges that *red tape prevails as much in* JAPAN as in other countries, and that delay and ignorance occur when research grant proposals are in the mainstream of research or when they can not promise immediately useful applications. In this sense, the *ringi* system, a procedure of circulating proposals to the concerned persons or agencies, can be a source of red tape. The system leads to a "decision by the elimination methods" through which "alternatives with no authorized evidence of certainty are eliminated and the rest with authorized evidence is chosen" (Eto, 1984: 197). Another difference is that government red tape in the United States is more *political* in nature, and it originates primarily with politically imposed laws and regulations (Bozeman, 1993; Gillespie, 1988; Wilson, 1989). In Japan, where policy making occurs in isolation from the public debate (Morris-Suzuki, 1994; Boyd, 1987) and the administrative procedure act is not implemented (Ogawa, 1982), government red tape is more likely to be *internal* to government agencies or laboratories (Tsuji, 1982).

Thus, we hypothesizes the negative effect of red tape on the formation of collaboration in terms of 'internal' red tape in Japan, and 'political' red tape in the United States.

Table 4.2. Similarities and Dissimilarities in Task and Institutional Properties in the United States and Japan

Factor	Japan	United States
GOVERNMENT PARENTHOOD		
Impact on Formation Propensity	**High**	**No effect**
Major Organizational Forms	Special Public Corp.	FFRDCs
Research Orientation	Government Missions	Administrative Orientation
National R&D Share	30%	6%
Funding	Mostly Government. Government-Industry Mix	Mostly Government. Government-Contractor Mix
INDIVIDUAL RESEARCH MISSIONS		
Impact on Formation Propensity	**Commercial Proximity**	**Inappropriability**
Posture toward market failures	Preventive	Ameliorative
Formative Motifs	Economic Development	War or Crisis
Historical mission strengths	Applied/Development	Basic/Applied
Context Dependence of Research	Less	Greater
EXTERNAL FUNDING		
Impact on Formation Propensity	**Publicness>Privateness**	**Publicness<Privateness**
Publicness-Privateness Relations	Unitary	Dichotomous
Intersector Flow of Funds	Rare but Lower	Rare but Higher
Support for Collaboration	High	Low
Nature of Budget Process	Managerial	Political
RED TAPE		
Impact on Formation Propensity	**Negative**	**Negative**
Degree	Fewer or Same	Same or More
Main Source	Administrative (Internal)	Political (External)

4.3. Relationships Between GICR&D Contingencies and Cooperative R&D

1. Research Mission Diversity and Cooperative R&D Propensity

Hypothesis 6: Mission diversity will have a greater positive effect on the formation of collaboration in Japan than in the United States.

As Mark and Levine (1984) suggested, the possession of diverse research missions does not only constitute technical competence for government laboratories, but also the existence of a technical competence within a government laboratory can have an effect of triggering a government policy based on that competence (Mark and Levine, 1984: xi). R&D collaboration is characterized largely as a high-technology endeavor between government laboratories and industrial firms (Berman, 1994) as well as between industrial firms (Dodgson, 1993; Fong, 1990; Harrigan, 1986). A characteristic of high-technology is technological uncertainties. One key characteristic of such an uncertain R&D environment is the existence of different views about a technological problem, in that technological and market uncertainties unfold various possibilities and constraints. Thus, technological innovation involves a degree of pluralism of ideas as its important aspect (Nelson, 1984: 8). Another related characteristic of high-technology is inter-connectedness of technological advances (Link and Tassey, 1987; Nelson, 1984). According to Nelson (1984: 7-10), technological innovations in high technology areas usually are connected not only to prior developments in the same technology, but also to complementary or facilitating advances in related technologies. Since a high technology forms the integrated *systems*, high-technology ventures need to be "plugged in" (Nelson, 1984: 10) to a wide range of technologies. Because of the uncertainty and connectedness nature of high-technology innovations, government laboratories with greater mission diversity can be a precious reservoir of S&T knowledge that attracts industry for R&D cooperation. Thus, these laboratories with diverse missions are more likely to enter cooperative R&D with industry.

Empirical evidence has shown that interorganizational cooperation is more likely to occur when organizations have a broad conception of their target (Akinbode and Clark, 1976), when an organization is providing a wide range of supportive services to its clients in addition to its core services (Whetten and Aldrich, 1979; Wheaten and Leung, 1979), when there is increased occupational diversity in organizations (Aiken and Hage, 1968), or when government laboratories' research missions are diverse (Rahm, Bozeman and Crow, 1988; Bozeman and Coker, 1992).

Both government laboratory systems seem to be similar in mission complexity or diversity. According to Papadakis et al. (1993-94: 25), more than half of all laboratories in their sample of the two countries were responsible for seven or more missions out of their nine laboratory missions, and less than 10 percent were responsible for three or fewer missions. [48] One of the conspicuous institutional differences in mission diversity is the *existence of multi-purpose, multi-mission government laboratories in the* **UNITED STATES**, mostly ones of the United States Department of Energy. These multi-mission government laboratories resembles industrial practice in project selection, with emphasis on scientific innovation, technical feasibility, utility, impact on users and sponsors (Betz, Blankenship, Kruytbosch and Mason, 1980: 244). In **JAPAN**, there is no government laboratories equivalent to the United States multi-purpose laboratories. Rather the diversification of research mission in Japan is closely related to the methods of *research funding*. Based upon the number of full-time researchers, ordinary funding is primarily

[48] For a passing indication of mission diversity in the Japanese government laboratories, also see The Commission on the History of Science and Technology Policy (1991), MacDowell (1984: 168), and National Research Council (1989).

oriented toward basic research, and special and project funding is mainly oriented toward applied research and development (Nagasu, 1984). In this way, mission diversity appears to be more deeply embedded in the government laboratory system in Japan than in the United States.

Thus, this study hypothesizes that mission diversity will have positive impact on the formation of collaboration in both countries and the impact will be greater in Japan than in the United States.

2. The Relative Commercial Project Orientation

Hypothesis 7: Given the government orientation of project selection, the commercial orientation of project selection will have a greater positive effect on the formation of collaboration in the United States than in Japan.

Because of the nature of research projects as the focal point of external influences, the demands of funding organizations tend to be concentrated on the process of selecting research projects in government laboratories. Government orientation and commercial orientation coexist in the process of selecting research projects within government laboratories. The primary responsibility of government laboratories lies in the performance of government-oriented projects. In responding to the demands of industry, government laboratories tend to direct project selection toward commercial outputs in relation to government-oriented outputs. As a result, government laboratories are likely to produce commercial outputs when they have a greater commercial orientation in project selection relative to government orientation. Given the mix of governmental and commercial orientation of project selection, an increase in the commercial orientation of project selection will increase the probability that government laboratories will form cooperative R&D with industry.

In **JAPAN**, project selection is affected by *consensus building mechanisms at the national, ministerial and laboratory levels.* At the national level, national science and technology policies are formulated through an emerging consensus judgment by the supreme advisory bodies such as the Council for Science and Technology (CST). Advisory bodies or committees are also extensively utilized at the ministerial level. At this level, these advisory bodies may be statutory or created by individual ministries. The extensive use of advisory bodies by government ministries ensures the consonance of government-conducted and government-supported research with the S&T needs of the private sector (Lederman, 1994: 283).[49] At the government laboratory level, this ringi system serves the consensus building mechanism. Through the circulation of ideas, this ringi procedure secures the "institutionalized participation of middle level personnel in decision-making" on the one hand, and eliminates what does not suit the government or a whole ministry on the other hand (Eto, 1984: 197). Nationally important decision agendas are negotiated at the top level of ministries, and then they are circulated through the ringi system (Jun and Muto, 1995). In Japan, given the commercial nature of government project orientation, commercial orientation in project selection will be have less impact on the formation of cooperative R&D with industry.

[49] For the view of ministerial advisory bodies as a tool for imposing or propagandizing government policy, see OECD (1967).

The United States lacks such a higher-level coordination of federal R&D. There are actual or potential organizations at the national level that are appropriate to the coordination function. Some appropriate coordination organizations such as the Office of Management and Budget do not perform the coordination function. Organizations in action such as a science adviser and the Office of Science and Technology Policy do not have an independent authority in funding and policy making (CSIS, 1993: 22-25). New missions and projects tend to be organized into the R&D budget in an incremental and ad hoc fashion (CSIS, 1993: 23). Thus R&D agenda is set largely by individual agencies, but government agency decisions about R&D allocations to institutions and projects are increasingly specified in detail by congressional appropriations committees (National Academy of Sciences, 1995). These allocations frequently reflect the public domain research activities or political interests of individual members of Congress. As a result, given the political nature of government project orientation, commercial orientation in project section will have greater impact on the behaviors and performance of government laboratories toward commercial purposes. Thus, increase in commercial project orientation vis-à-vis government project orientation will have a greater positive impact on the formation of cooperative R&D with industry.

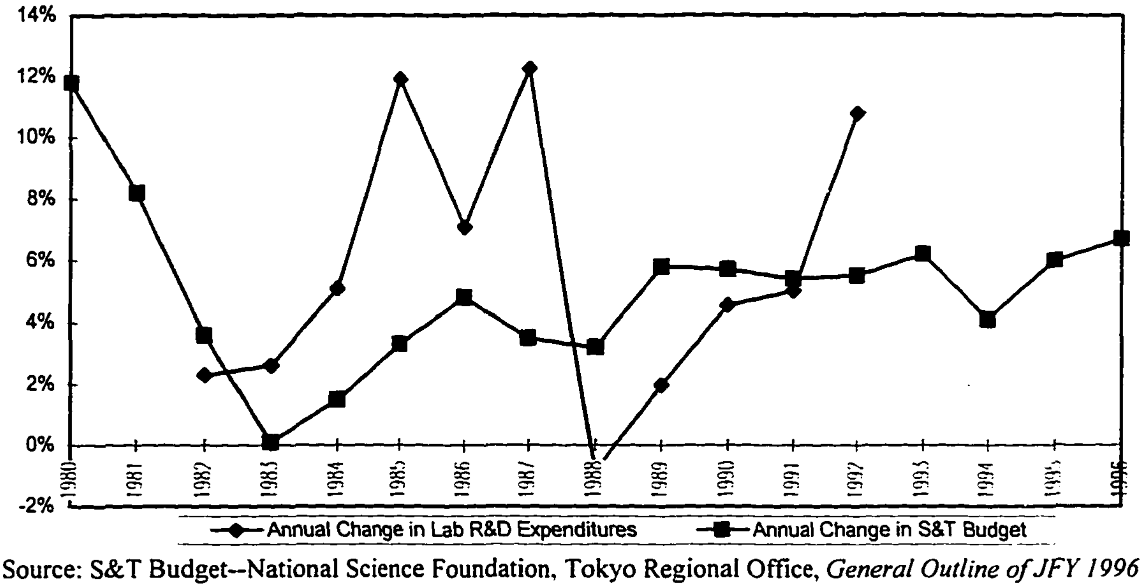
3. The Importance of Resource Acquisition

Hypothesis 8: The organizational importance of resource acquisition will have a greater positive effect on the formation of collaboration in the United States than in Japan.

As indicated in Chapter Three, resource acquisition is an important organizational goal, since it is critical to the ultimate goal of organizations which is survival and maintenance. The birth and death of government laboratories depend largely on government or their parent agencies, although some laboratories may outlive their parent agencies. In most countries including the United States and Japan, the general public service personnel regulations apply to the personnel management of researchers and other employees in government laboratories, leaving little discretion to the government laboratory directors. As a result, the crucial role of resource acquisition in government laboratories is associated with its positive effect on obtaining and maintaining quality researchers and quality research facilities. Secured research capacities are critical to achieve research reputation and a more favorable negotiation position of laboratories vis-à-vis external funders. The achievement of quality research and facilities is critical to meet demands of external resource providers and to acquire or maintain recourses so that it will be effective and will survive. Government laboratories that have a strong reputation and heterogeneous sources of resources will be more resilient regarding threats to financial, personnel, and other organizational resources. Resources are a medium of interdependency between organizations. Since the main sources of resources for organizations are other organizations, resource acquisition entails a search for opportunities in their external environments that will augment resources. One of the ways of generating such opportunities is the formation of cooperative R&D with industry.

Whether and to what extent resource acquisition will drive the formation of cooperative R&D with industry is dependent upon the importance of industrial funds as an alternative funding source, budgetary requirements, and availability of alternative sources. The **importance of industry as an alternative source** is affected by the stability of government funding and the significance of organizations within the government sectors. **Fluctuation in R&D funding** or related policy change facilitates a search for alternative sources and therefore the formation of interorganizational linkages (Oliver, 1990). Figures 4.9 and 4.10 show the annual change rates in government S&T budget appropriations and government laboratory R&D expenditures during the past decade in Japan and the United States. As shown in Figures 4.9 and 4.10, the government S&T budget appropriations and laboratory expenditures have annually

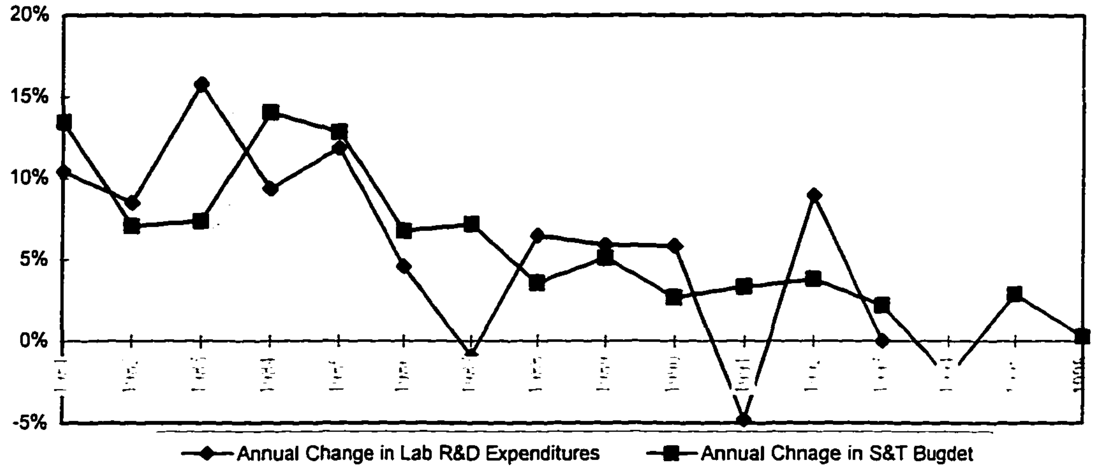
Figure 4.9. Change in S&T Budget and Government Lab R&D Expenditures: Japan



Source: S&T Budget--National Science Foundation, Tokyo Regional Office, *General Outline of JFY 1996 Budget Proposed for Science and Technology*, Report Memorandum #96-5.
Lab R&D Expenditures (1981-1989)--OECD, 1991,1993, 1995, *Basic Science and Technology Statistics*, OECD, Paris, France. (Current Value).
Lab R&D Expenditures (1990-1992)--Management and Coordination Agency, *Statistical Yearbook of Japan*, 1991-1995.

fluctuated in both countries. Differences lie in the *downward* trends in S&T budget and laboratory expenditures in the UNITED STATES, and in the steadily *upward* trends in S&T budget and the abrupt but upward trends in laboratory expenditures in JAPAN.

Figure 4.10. Change in S&T Budget and Government Lab R&D Expenditures: United States



Source: S&T budget--National Science Foundation, Science and Engineering Indicators, 1996. Lab R&D expenditures: OECD, 1991,1993, 1995, *Basic Science and Technology Statistics*, OECD, Paris, France. (Current Value).

The significance of **other government agencies as alternative sources** appears to be low in Japan as compared to the United States. A recent report concerning the American and Japanese government laboratory systems (Papadakis et al., 1993-94) shows that the dominant pattern of technical interactions (i.e., technical assistance and transfer) of laboratories with other government organizations in JAPAN was in the form of technical assistance to their *parent agency*. In the UNITED STATES, laboratories' technical interactions with *government agencies other than their parent agency* was strong.[50]

The government **budgetary processes or accounting regulations** are an important factor affecting government laboratories' decision to enter cooperative R&D with industry in order to raise organizational resources. In both countries, in principle, government accounting regulations do not allow government organizations to have their own discretionary funds. In JAPAN, *special public corporations* are allowed to keep a part of incomes obtained from their operations as *reserve funds*, but when incomes are excessive, the government orders them to reduce the price of services (Bingman, 1989; Shibata, 1993). In the UNITED STATES, government laboratories were allowed to keep up to 25 percent of royalty incomes from licensing technologies to cover the rewards for related researchers, training personnel in technology transfer, and licensing-related fees (see the National Technology Transfer Act of 1986). The countries differ with the way they deal with licensing issues: The UNITED STATES establishes separate offices or designated personnel for technology transfer, whereas JAPAN has established separate corporations specializing in licensing and marketing government-developed technologies, such as the Research and Development Corporation of Japan mentioned earlier.

[50] This pattern in the United States government laboratories was also implied in other studies (e.g., Choi, 1992). Choi's study was based on the GAO database.

Table 4.3. Similarities and Dissimilarities in GICR&D Contingencies in the United States and Japan

Factor	Japan	United States
MISSION DIVERSITY		
Impact on the Collaboration Formation	**Positive, Greater**	**Positive, Lower**
Extent of Diversity	Diverse (Same)	Diverse (Same)
Major Diversity Roots	Funding Methods	Multipurpose Labs
Embeddedness of Diversity	Greater	Lower
RELATIVE COMMERCIAL PROJECT ORIENTATION		
Impact on the Collaboration Formation	**Positive, Lower**	**Positive, Greater**
IMPORTANCE OF RESOURCE ACQUISITION		
Impact on the Collaboration Formation	**Positive, Lower**	**Positive, Greater**
Importance of Industry as Alternative Sources	Low, Medium	Medium, High
Government Funding Stability	Unstable, Upward	Unstable, Downward
Other Agencies as Alternative Sources	Lower	Higher
Government Accounting Regulations	More or Less Strict Depending on Parenthood	Less Strict

Control Variable: Laboratory Size

Larger government laboratories will be more likely form cooperative R&D with industry in both countries. Larger government laboratories will possess organizational slacks, personnel or financial, and technical resources so that they can cater to industry.

V. DATA AND METHODOLOGY

5.1. Unit of Analysis

The unit of analysis in this study is government laboratories. Three criteria were employed to select government laboratories in the United States and Japan. The first criterion is the designation of government laboratories[51] as all types of laboratories which are under government control as "producers of government service" (OECD, 1989). This definition allows one to include in his sample the government-owned, contractor-operated (GOCO) national laboratories in the United States and the semi-government and public corporation laboratories in Japan. The second criterion concerns the research fields of government laboratories: This study included only those laboratories that are engaged in actual R&D activities in the area of physical science, life science, bio-medical science, or engineering research. Laboratories in the social and behavioral sciences or clinical medicine as well as administrative units or funding agencies which are not involved in R&D activities were excluded by this criterion. The third criterion is the organizational size of government laboratories: This study confined itself to those laboratories with a minimum twenty-five full-time personnel. This size limitation was expected to prevent research units from being sampled as research laboratories.

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[51] The use of term "government laboratories" needs an additional explanation. In the United States, the term "national laboratories" usually refers to the Department of Energy's large-scale, multi-purpose government-owned, contractor-operated (GOCO) laboratories, while other U.S. government laboratories are usually called "federal laboratories." In Japan, the term "national laboratories" refers to the national research institutes (NRIs) which are attached to government ministries and agencies. Such a definition excludes semi-government research institutes (*tokushu-hojin*) and non-profit R&D organizations as national research institutes which are strongly connected to the government in Japan. In order to have a more representative sample of the government laboratories in both countries, this study uses the term

5.2. Data and Sample Description

1. Data Description

The data for this study were obtained from the master dataset of the National Comparative Research and Development Project (NCRDP). The NCRDP has been undertaken by a research team at the Technology and Information Policy Program of Syracuse University since 1984. The overarching objective of the NCRDP was to develop a better understanding, and a useful evaluative framework, of the behaviors and performance of the "national R&D laboratory system" in industrialized nations (Crow and Bozeman, 1991). The research focus and scope of the NCRDP varied over a number of phases. The specific foci and scope of the NCRDP were:

Phase I: Development of an environmental taxonomy of R&D laboratories;
Energy-related government R&D laboratories of the United States.

Phase II: Test of the R&D laboratory taxonomy;
Government, university, and industrial laboratories of the United States.

Phase III: Assessment of the performance of technology transfer and commercialization policies with focus on the cooperative R&D;
Government, university, and industrial laboratories of the United States.

The Japanese National Laboratory Study (JNLS): Application of the evaluative model to the Japanese government laboratory system. [52]

"government laboratories" to cover all types of government laboratories including the U.S. GOCOs and Japanese semi- or nonprofit laboratories.

[52] Many empirical studies have been conducted using the NCRDP data over the phases. The Phase I data were analyzed in the work of Bozeman and Crow (1987a; 1987b) and Bozeman (1987). The Phase II provided the data for the work of Bozeman and Crow (1990), Crow and Bozeman (1991), and Rahm, Bozeman and Crow (1988). The Phase III data were utilized in the work of Bozeman (1994), Bozeman and Coker (1992), Bozeman and Crow (1991a; 1991b), Bozeman and Pandey (1994), and Coursey and Bozeman (1992). Research using the Japanese laboratory data can be found in the work of Bozeman and Pandey (1994) and Papadakis, Coker, Wang, Bozeman, Endo, Hirano and Shimoda (1993-94).

This study employs the government laboratory subset data of the NCRDP Phase III survey for the United States, and the JNLS survey data for Japan.

The data for the United States and Japan have four broad categories of question items in common (see Appendix A). These categories include the items concerning laboratory background information, the items concerning technical, institutional, and organizational characteristics, the items concerning technology transfer activities, and the items concerning cooperative R&D activities.[53]

2. Survey Procedures

The research subjects of this study were directors of government laboratories of the United States and Japan. The sampling frames for the survey of the United States government laboratories (Phase III) were *Government Research Centers Directory* (Detroit: Gale Research Company, 1990) and the government laboratories which were identified in the Phase II survey.[54] In the process, 198 government laboratories were added to the United States sample of government laboratories which were not included in the Phase II survey. The total sample size for the Phase III was 1,137 laboratories in various sectors. Of the total sample size, 356 (31.3%) were government laboratories.

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53 In addition to these four categories of items, the JNLS questionnaire included a set of items which address the personnel management in the Japanese government laboratory system. In a process of survey planning, these items were considered to be laboratory issues that are relevant particularly to the Japanese laboratory system.

54 The Phase II survey was an extension of the Phase I (1984), the prototype phase of the NCRDP. The Phase I conducted 30 in-depth case studies in tandem with mailed questionnaire survey over 250 U.S. Department of Energy laboratories. Using a mailing survey, the Phase II (1987) extended its coverage into a representative sample (n=935) of the entire U.S. national R&D laboratory system. The main sampling frames for the Phase II government laboratory survey were *Government Research Centers Directory* (Detroit: Gale Research Company, 1987) and *Research Centers Directory* (Detroit: Gale Research Company, 1987).

The sample for the JNLS was all 97 major Japanese National Research Institutes (NRIs), research laboratories of public corporations (*tokushu-hojin*) , and research laboratories of nonprofit organizations, all of which constitute three categories of public R&D laboratories in Japan.[55] Among the 102 NRIs and *tokushu-hojin*, 94 laboratories were surveyed which met the sampling criteria. Additionally, three nonprofit laboratories were included in the JNLS survey, simply because of their strong current or past connection with the Japanese government.

The data collecting methods used for the United States Phase III and the JNLS were a mailing survey. For the government subset of the Phase III, 356 questionnaires were mailed to directors of the government laboratories, in June and July, 1990. A total of 189 responses were received from government laboratory directors and the response rates were 53.1%.

The JNLS survey was conducted in 1991. The survey questionnaires were mailed to Japan's National Institute for Science and Technology Policy (NISTEP). The NISTEP sent the questionnaires to the directors-general of the 97 government laboratories, with an accompanying letter from the U.S. project director. A total of 88 completed questionnaires were received from government laboratory directors and the response rates were 90.7%.

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[55] The NRIs are the research arms attached to government ministries and agencies. The NRIs are dominant in the public sector laboratory system of Japan. Semi-government research organizations, *tokushu-hojin*, are legally a distinct class of organizations established under separate public laws, but nominally affiliated with individual ministries and agencies through budget allocations and appointment of directors. There are also more than a dozen of non-profit laboratories.

Three attempts were made to ensure the cross-cultural equivalence of question items between the United States and Japan surveys. The format of the questionnaires used for both national groups was identical, except for an addition of personnel management items in the JNLS questionnaire. Translation and reverse-translation were made for the questionnaire used for the JNLS survey in order to obtain cross-cultural literal accuracy (Elder, 1976: 222). The English version of the questionnaire was translated into Japanese by the NISTEP, and was reverse-translated into English by an independent translation firm. Furthermore, a standard description of certain question items, (particularly laboratories' research missions; technology transfer and its effectiveness) was provided in order to achieve the "cross-national conceptual equivalence" (Przeworski and Teune, 1970) of the questions asked (see Section 5.3).

Table 5.1 summarizes the nature of the survey population and research subjects, the survey response rates, the sample size used in the following analysis.

Table 5.1. Response Rates of United States and Japan Government Laboratory Surveys

	United States	Japan
Population	All Government Laboratories	
Research Subjects	Laboratory Directors	
# Questionnaires Mailed	356	97
# Questionnaires Returned (Response Rates)	189 (53.1%)	88 (90.7%)
Effective Response Rates	48.6%	88.8%

3. Sample Description

Tables 5.2, 5.3, and 5.4 summarize the characteristics of research subjects included in the analysis for both countries. As shown in Table 5.2, most responding laboratories in both countries had non-defense parent agencies and were government-owned. The Japanese government laboratory sample includes a much smaller portion (3.5%) of laboratories whose parent agencu is the defense department, compared to the United States (17.3%). At the time of the survey, the Japanese National Defense Agency, the Japanese counterpart of the United States Department of Defense, had just four research institutes under its umbrella, three of which were respondents to the JNLS survey. Compared to the United States government laboratories (78.6%), a lower percentage of the Japanese counterparts (62.8%) were engaged in technology transfer activities (Table 5.3). The rates of collaboration participation, both in general and with industry, were very similar between the samples fo both countries. The participation rates for cooperative R&D with industry are only 47 percent for Japan, and 43 percent for the United States. The mean percentage of cooperative R&D agreements with industry to the totality of cooperative R&D is 24 percent for the United States, and 27 percent for Japan. As shown in Table 5.4, the United States government laboratory samples were larger than the Japanese counterparts in both terms of personnel size and budget size. 93.0 percent of the Japanese government laboratories reported that they had fewer than 500 research and non-research full-time staff, whereas 24.8 percent of the United States laboratories reported that they had more than 500 staff, 9.2 percent of which had more than 3,000 full-time employees. In research budget size, 94.0 percent of Japanese respondents had a research budget of less than 50 million dollars. 17.9 percent of United States government laboratories had a research budget of larger than 50 million dollars.

Table 5.2. Institutional Characteristics of United States and Japan Samples

	The United States* (N=173)	Japan (N=86)
Civilian	82.7%	96.5%
Government-Owned	84.4%	89.0%

The United States sample has 27 unclassifiable labs in government parenthood and ownership. These labs were assigned to the *Civilian* category, and were the non-*Government-Owned* category.

Table 5.3. Participation Rates of Technology Transfer and Collaboration in the United States and Japan

Activity Type	The United States*	Japan
Technology Transfer	136 (78.6%)	54 (62.8%)
All Types of Cooperative R&D(A)	112 (64.7%)	56 (65.1%)
Cooperative R&D with Industry(B)	76 (43.9%)	41 (47.7%)
% (B)/(A)	23.8%	27.4%

Table 5.4. The United States and Japanese Sample Description By Personnel and Budget

	The United States*	Japan
Total Personnel (Unit: persons)		
Fewer than 100	49 (28.3%)	32 (37.2%)
100 to 500	81 (46.8%)	48 (55.8%)
500 to 1,000	14 (8.1%)	5 (5.8%)
1,000 to 3,000	13 (7.5%)	1 (1.2%)
More than 3,000	16 (9.2%)	0 (0.0%)

(Continued)

	The United States*	Japan
Total Research Budget (Unit: million dollars)		
Less than 1	0 (0.0%)	9 (11.0%)
1 to 10	74 (43.8%)	44 (53.7%)
10 to 50	58 (34.3%)	24 (29.3%)
50 to 100	11 (6.5%)	1 (1.2%)
100 to 500	21 (12.4%)	2 (2.4%)
More than 500	5 (3.0%)	2 (2.4%)
(Frequency Missing)	4	4

Note: The U.S. dollar value of Japanese Yens was calculated using the purchasing power parity (196 yens per U.S. dollar in 1990).

5.3. Measurement

Technology Transfer Effectiveness In Chapter Three, technology transfer was defined as the transfer of physical devices, processes, 'know-how', or proprietary information about devices or processes from one organization to another. Due to the diversity of the meanings of technology transfer, technology transfer effectiveness was measured using multiple criteria, as mentioned in Chapter Three (Bozeman, 1994; Bozeman and Coker, 1992; Bozeman and Crow, 1991b; Bozeman and Fellows, 1988; Carr, 1992; Papadakis, 1995; Roessner, 1993b). Three types of the effectiveness of technology transfer used in the analysis are defined:

Out-The-Door (TSUCCESS): The extent to which government laboratories were effective in getting organizations interested in using their technology.

Licenses (TECHLIC): The number of licenses of patented technologies developed at and with government laboratories.

Market Impact (TIMPACT): The extent to which technologies transferred were commercially viable and profitable on the part of adopters.

Two measures, Out-the-Door and the Market Impact, were based on the responding laboratory directors' self-assessment of the effectiveness of technology transfer activities of their laboratories. Directors of government laboratories in both countries were asked to indicate their laboratories' success of technology transfer efforts in accordance with each measure. They were given an ordered category of responses to the two criteria, ranging 0 to 10 (0 for "poor", 10 for "excellent") respectively. Licenses were measured by the count of the number of the licenses of patented technologies developed at and with government laboratories.

Government-Industry Cooperative R&D (INDAGREE) Government-industry cooperative R&D is measured by the count of the number of cooperative R&D agreements which responding government laboratories have entered with industrial firms. Directors of government laboratories in both nations were asked to indicate the total number of cooperative R&D agreements which their own laboratories have formed during a given fiscal year (FY 1989 for the United States, FY 1990 for Japan). They were also asked to break down the total number of cooperative R&D agreements by the sector of cooperating partners--other government agencies and laboratories, industry, universities, nonprofit organizations, and other organizations--on 0% to 100% scale. The number of cooperative R&D agreements that government laboratories formed with industry was computed by multiplying the total number of cooperative R&D agreements by the percentage of cooperative R&D agreements with industry.

The question items concerning cooperative R&D in both countries have been initially designed as branched questions. The use of branching methods dissuaded those government laboratories that did not have any formal cooperative R&D agreements by the time of each corresponding survey from answering any questions concerning cooperative R&D. These government laboratories without a cooperative R&D agreement were assigned 0 as "sampling zeros" (Lindsey, 1995), instead of being treated as a special case of missing observations. The reason is that although government laboratories had no cooperative R&D agreements in the period when each survey was conducted, they might form cooperative R&D agreements in another period.

Individual Research Mission Research missions of government laboratories were operationalized by the percentage of research budget allocated to individual research missions on a 0 to 100 percent basis. Directors of government laboratories in both countries were asked to indicate the percentage of research budget allocations for basic research, applied research, and development missions. To ensure the reliability of cross-cultural measures of the research missions, the research subjects for this study were given a uniform set of definitions of research missions in the questionnaire. The laboratory missions were defined in this study as follows:

> *Basic Research Mission* (BASBUD): Research budget allocated to research activities for knowledge for its own sake without any particular application in mind.
>
> *Applied Research Mission* (APPBUD): Research budget allocated to research activities focused on bringing new products and processes into being, but not directed at a specific design (precommercial applied research), and research activities focused on product or process with specific design in mind (commercial applied research).

Development Mission (DEVBUD): Research budget allocated to development activities of existing prototypes, modifying existing products/processes or applications engineering.

Resource Publicness (RDAPPR) Resource publicness was operationalized as the percentage of a laboratory's R&D budget received directly from government appropriations or parent organizations. Directors of government laboratories in both countries were asked to indicate the percentage of a laboratory's R&D budget received from government appropriations, on a 0 to 100 percent basis.

Resource Privateness (RDIND) Resource privateness was operationalized as the percentage of R&D funds received from industrial sources, including industrial grants or contracts, on 0 to 100 percent basis. Directors of government laboratories in both countries were asked to indicate the percentage of R&D funding received in the form of industrial grants and contracts.

Research Mission Diversity (MISDIV) Research mission diversity was measured by collapsing the research mission budget allocations into 2 point binary scales. Government laboratories were assigned score 1 if these laboratories allocated at least 10% of research budget to individual research missions, and score 0 otherwise. The scores for the three research missions were summed up together. The composite index of research mission diversity ranges from 3 for those laboratories that would put emphasis on a variety of research missions to 0 for those laboratories that would not put emphasis on research missions.

Relative Commercial Orientation of Project Selection (PROJECT) The relative commercial orientation of project selection was operationalized as the commercial orientation of project selection conditional upon the government orientation of project selection. It was measured by dividing the scores on the commercial orientation of project selection by the scores on the government orientation of project selection. In the survey, the items for both orientation of project selection were measured by four-point Likert scales (1 for 'strongly disagree' to 4 for 'strongly agree'). Directors were asked to indicate the extent to which they agree or disagree with the question of whether changes in policies of other governmental organizations often have a significant effect on their laboratory's selection of research projects (the government orientation), and the extent to which they agree or disagree with the statement that the assessments of the commercial benefits of their unit's R&D output often have a significant effect on the selection of research projects (the commercial orientation).

Importance of Resource Acquisition (EFFRES) The importance of resource acquisition was operationalized as the perceived importance of resource acquisition as a laboratory's effectiveness criterion. Directors were asked to indicate its importance for their laboratory as an effectiveness criterion, on a 0-4 scale (0 for 'not important' to 4 for 'single most important').

Red Tape (BBUREAU) Red tape was operationalized as the directors' self-assessment about the procedural slowness in individual government laboratories. They were asked to indicate the extent to which they agree or disagree with the statement "I think there is more bureaucracy slowing things down in this lab than in other labs I know about." The measure was a 5-point Likert scale (0 for 'strongly disagree' to 4 for 'strongly agree').

Laboratory's Parenthood (GOVPAREN) Whether or not individual government laboratories have government agencies as their parent organization is a dummy variable (1 for 'those laboratories whose parent organizations are government agencies' to 0 for 'otherwise').

Laboratory Size (LABSIZE) Laboratory size was operationalized as the total number of full-time professional staff (researchers and technicians) employed by individual government laboratories. Its logarithmic form was used in the present statistical analyses.

The conceptual relationships between the variables used in the analysis can be expressed into two models of functional equations that assume simultaneity.

Transfer Effectiveness Models

Effectiveness $_{i,j} = f$(Number of government-industry cooperative R&D agreements),

where i denotes each of three types of effectiveness measures--the out-the-door, licenses, and market impact--, and j denotes either the United States or Japan.

Collaboration Propensity Model

PROPENSITY$_j = f_j$ (Parenthood, Task and Institutional Properties, GICR&D Contingencies, and Control variable),

where "PROPENSITY" denotes the expected number of government-industry cooperative R&D agreements which is expressed in the logarithmic form of the observed number of cooperative R&D agreements.

VI. STATISTICAL ANALYSIS

As formulated in the previous chapter, there are two foci in the analysis. each requiring its own analytical procedure. The first focus is whether technology transfer effectiveness varies as a function of the number of cooperative R&D agreements with industry. This question was estimated using least squares regression models. The second focus is on the question of whether the propensity of government laboratories to form cooperative R&D agreements with industry varies as a function of their organizational properties. This question was analyzed using Poisson-related regression methods.

Since the Poisson regression employs the ordinary least squares (OLS) estimates as its base information for estimation, general regression diagnostics are applicable for both Poisson and OLS regression models. Section 6.1 examines the quality or potential issues of the data used in this analysis. Section 6.2 discusses two methods adopted in this study to estimate the models using the sample data. The LIMDEP PC Version 7.0 was employed for the purpose of estimation.

6.1. Regression Diagnostics

1. Test for Multicollinearity

Multicollinearity refers to an exact or approximate linear relationship between explanatory variables in the sample data used for the analysis. It is "a data weakness that can manifest itself as a statistical problem" (Belsley, Kuh and Welsch, 1980: 191).

The presence of strong correlations between explanatory variables in an estimation model leaves little variation which could otherwise be explained uniquely by each explanatory variable. The estimation procedure using the multicollinear data has little information to use in estimating its coefficients. Higher correlations between explanatory variables result in a more severe or harmful multicollinearity, which in turn leads to a higher variance of estimates of the coefficients. A high variance of coefficient estimates degrades reliability in estimating the parameters, and lowers the power of a hypothesis testing (Kennedy, 1992).

In this analysis, the detection of multicollinearity was performed through the use of the condition index of the data (Belsley, Kuh and Welsch, 1980). As the square root of the ratio of the largest to the smallest characteristic root of the data matrix, a condition index provides information about the extent to which explanatory variables are dependent on one another. A condition index being around 5 or 10 indicates a weak linear dependency, whereas moderate or strong dependencies are associated with condition indices of 30 to 100 (Belsley, Kuh and Welsch, 1980: Section 3.3). As a rule of thumb, a condition index greater than 30 indicates a harmful collinearity. Results show that there is no strong collinearity in the sample data sets for the United States and Japan (Appendix B). The condition index of one variable in the propensity model for Japan exceeded 30, indicating a possible strong collinearity. This result was verified by relying on the variance inflation factor (VIF) method. For the standardized data, VIF with values greater than 10 for the regressors indicates the existence of harmful multicollinearity (Kennedy, 1992). All VIF values for the regressors in both country samples were less than 2.1 (See Appendix B). Thus, this study used all the variables as operationalized in the previous chapter.

2. Test for Heteroskedasticity

The OLS estimation is also based upon the homoskedasticity assumption that the disturbances have uniform variance and are not correlated with one another. When this assumption is violated, or when heteroskedasticity exists, 1) the OLS estimator is still unbiased, but not efficient (meaning that it no longer has minimum variance among all linear unbiased estimators), and 2) a hypothesis testing is not valid because variances for parameter estimates are inconsistently estimated (Kennedy, 1990; Pindyck and Rubenfeld, 1991).

The White test (1980) was performed to see that the assumption of homoskedasticity holds for the estimation models used in this analysis. It tests specifically for whether or not any heteroskedasticity present causes the variance-covariance matrix of the OLS estimator to differ from its usual formula (Kennedy, 1990: 118). White's test statistic is distributed asymptotically as a chi-square with degrees of freedom equal to the number of the regressors (excluding the constant). In his test, the assumption of homoskedasticity can not be held when the test statistic is greater than the chi-square value with the corresponding degrees of freedom at the five percent level of error. Test results show that the assumption of homoskedasticity held in the estimation models for the United States and Japan, except for one case where Variable TIMPACT was regressed on Variable INDAGREE in the United States sample (see Appendix C).

6.2. Statistical Methods

1. Two-Stage Least Squares Estimation

The two-stage least squares (2SLS) estimation method was used to provide an indication of the direction and significance of observed differences between the United States and Japan in the relationships between the number of cooperative R&D agreements and transfer effectiveness. As indicated in the functional forms, the general form of the transfer effectiveness models has one endogenous variable, INDAGREE, as an independent variable. This leads to a violation of one underlying assumption of the OLS estimation that the observations on the independent variable are fixed in repeated samples (Kennedy, 1992). In this situation, the dependent variable will be determined by the simultaneous interaction of other relationships. When simultaneity exists, the OLS estimator becomes biased or inconsistent. The 2SLS was used to obtain the value of structural parameter in each of the simultaneous equations as expressed in Section 6.4. In the first-stage estimation, the endogenous variable, INDAGREE, acting as a regressor in each of the Transfer Effectiveness Models, was estimated on all the exogenous variables. The fitted values of the dependent variable, INDAGREE, were determined, using ordinary least squares. In the second-stage estimation, the first-stage fitted variable, i.e., the fitted values of the variable INDAGREE, was used as a regressor in each Transfer Effectiveness Model.

2. Poisson Estimation

Properties of the Poisson Estimation The Poisson regression in the analysis was used to provide an indication of the direction and significance of observed differences between the United States and Japan in determinants of the propensity of government laboratories to form cooperative R&D with industry. One of the reasons that this study has adopted the Poisson regression is that as part of the analysis, this study focused on the potentiality or propensity of government laboratories to work with industry rather than the observed magnitude of numerical change in cooperative R&D agreements. Another reason is that the propensity was measured as the count of the number of cooperative R&D agreements that government laboratories have formed with industrial partners. The Poisson regression technique is considered to be a regression model appropriate for the count data.

The count data consist of the observations that are naturally measured as non-negative integers like 0, 1, 2, 3, ... and, thus, are ordered but not categorical (Maddala, 1983). In the Poisson regression, zero observations are given a theoretical meaning as sampling zeros--responses that were zero in the survey period but might be some positive values in another period--rather than structural zeros--zeros that were imposed for the purpose of statistical modeling (Lindsey, 1995).[56]

[56] As mentioned in Section 5.3, the count data of Variable INDAGREE were obtained through the use of bracket question method that dissuades respondents to respond those collaborative R&D questions when they are not engaged in the activity in question. This procedure often produces a large portion of zero responses as indicated in Sections 6.3 and 6.4, thereby inflating unduly the theoretical value of zero responses in the Poisson estimation. The zero inflation can be tested and corrected in at least two ways. One way to deal with the zero responses is to test the influence by zero responses and estimate the splitted, Poisson-applicable model--the zero altered ZIP (Zero Inflated Poisson) model. The Vuong test (Vuong, 1989) is appropriate for this purpose (Green, 1994; Lambert, 1992). The Vuong test favored the zero altered ZIP (Zero Inflated Poisson) model in the data for Japan and the United States, and suggested the

The Poisson regression model has two distinctive statistical properties (Greene, 1990; Grogger and Carson, 1991; Maddala, 1983). The first property is that the mean of the Poisson distribution is log-linearly dependent on the explanatory variables used in the estimation. In the estimation process, an exponential regression function is used to constrain the conditional mean to be positive. This positive measurable function becomes a *rate* or *intensity* function. The coefficients can be interpreted as average proportionate changes in the mean of the count dependent variable for a unit change in the individual explanatory variables.

Another property, and also a weakness, of the Poisson estimation is the restriction of mean-variance equality. This Poisson imposition of mean-variance equality may be inappropriate for the the real data which frequently exhibit the problem of overdispersion, i.e., conditional variation being greater than the mean. Violations of this restriction , i.e., overdispersion, have consequences similar to those of heteroskedasticity in the OLS regression model of typically a cross-sectional data (Cameron and Trivedi, 1990). When the overdispersed data are used for the estimation, the conditional mean of the Poisson regression is consistently estimated, but with downward biased standard errors of coefficients in the Poisson regression model (Grogger and Carson, 1991). This downward bias is prone to the Type II error in testing a hypothesis.

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need to split the zero responses. Another method is the use of truncated Poisson and negative binomial estimation. Grogger and Carson (1991) demonstrated that the use of truncated negative binomial regression will best fit the estimation of overdispersed data with many zero responses. Since the use of the ZIP function induces overdispersion independently of overdispersion observed in the data, this study deals with the zero observations in line with the work of Grogger and Carson (1991).

Test for Overdispersion, and Corrections The test for overdispersion in this study was performed by a regression-based test proposed by Cameron and Trivedi (1990). Their regression-based test for overdispersion in the Poisson model is a test of whether å is zero in the alternative hypothesis [H_1: $var(y_i)=\mu_i+å\cdot g(\mu_i)$], while H_0: $var(y_i)=\mu_i$. Cameron and Trivedi's test static is computed as the t-test from the OLS regressions expressed in the form of the alternative hypothesis. The test results for overdispersion indicate evidence of overdispersion in the data used in standard and truncated Poisson regressions for the United States and Japan (See Appendices F and G). The negative binomial regression is used as an appropriate estimation technique for the overdispersed count data (Hausman, Hall and Grilliches, 1984). The data for the United States and Japan were estimated through the negative binomial regression model. Since both Poisson and negative binomial regressions are in the family of linear exponential probability estimation (Grogger and Carson, 1991), the direction and magnitude of coefficients of each regression are directly comparable. Table 6.1 summarizes the statistical methods used in this analysis.

Table 6.1. A Summary of the Statistical Methods Used for Analysis

Regression Models	Estimation Methods
Transfer Effectiveness Models	
Out-the-Door	OLS and 2SLS
Licenses	OLS, 2SLS and Poisson
Market Impact	OLS and 2SLS
Collaboration Propensity Model	
	Standard and Truncated Poisson and Negative Binomial

6.3. Japan

1. Basic Statistics

As shown in Table 6.2, responses to perception variables are somewhat normally distributed around corresponding means, but responses to objectively measurable variables show a high degree of skewness. For the count data (TECHLIC and INDAGREE), such a skewness appears to be attributable largely to the inclusion of "sampling zeros," theoretical meanings of which are estimated in the Poisson estimation. There were 45 zero responses on Variable INDAGREE (52.3% of the total observations). There were two types of zero observations in the data. One type of the zero responses stemmed from government laboratories that were engaged in cooperative R&D activities, but not in cooperative R&D with industrial firms, during the fiscal year of 1990. Eleven zeros (24.4% of the zero responses) belonged to this type of zeros. The rest of the zero responses (75.6%) came from those laboratories that did not form cooperative R&D agreements with any organization during the period, whether or not it may be industry. There were 52 zero observations on Variable TECHLIC, meaning that licensing did not occur in 60.5 percent of the responding government laboratories in Japan during the fiscal year. Among the government laboratories under study, only 20.7 percent had one percent or more of industrial funds (RDIND) in their research budget, and the rest had zero or near-zero percentage of industrial funds. 78.0 percent of the respondents to Variable RDAPPR had at least 80 percent of government funds, direct appropriations or budget allocations from parent agencies, in their total research budget. 60%, 62%, and

64.6% of the responding laboratories allocated less than corresponding means to research missions, BASBUD, APPBUD, and DEVBUD, respectively.

Table 6.2. Descriptive Statistics of Variables Used for Analysis: Japan

Variable	N	Mean	Std. Dev.	Minimum	Maximum
TSUCCESS	58	6.5172	1.4896	3.0000	10.0000
TIMPACT	56	5.9286	1.7041	2.0000	9.0000
TECHLIC	86	12.6977	45.7890	0	300.0000
INDAGREE	86	5.0930	11.8417	0	83.0000
GOVPAREN	86	0.8953	0.3079	0	1.0000
BASBUD	79	36.7975	27.6412	0	100.0000
APPBUD	79	15.8316	21.5488	0	97.6000
DEVBUD	79	21.5848	22.8740	0	93.0000
RDAPPR	82	84.7366	20.2805	0	100.0000
RDIND	82	1.3207	3.6066	0	26.0000
BBUREAU	86	2.0930	0.5867	1.0000	3.0000
MISDIV	86	1.5930	0.8592	0	3.0000
PROJECT	79	0.8650	0.3730	0.2500	2.0000
EFFRES	79	2.3291	0.9703	0	4.0000
LABSIZE	86	4.7403	0.9080	2.5649	7.7732

As shown in Table 6.3, the low degree of association existed between the dependent variables and individual explanatory variables in each estimation model. Associations among three transfer effectiveness variables were statistically significant in the bivariate relations between two perception variables only (rho=0.43 at p<.01). These effectiveness variables except for Variable TECHLIC were not statistically associated with other independent variables at any conventional error level. Among three transfer effectiveness variables, only variable TIMPACT had a significant association with the cooperative R&D variable, INDAGREE, but at a marginal level (p<.10). The cooperative R&D propensity variable had a statistically significant association only with two explanatory variables and one control variable. Associations between independent variables were moderate (rho=0.20 to rho=0.45 at significance levels of p<.10 to p<.0001). These associations are characterized by a low degree of association within variable groups and a higher degree of association between variable groups. Within variable groups, higher associations existed between research mission variables. Basic research mission was negatively associated with other mission variables (rho=0.37 to rho=0.39 at p<.001). Variables regarding the task and institutional properties were moderately (rho=0.20 to rho=0.45) associated with GICR&D contingency variables at significance levels of p<.10 to p<.01).

Table 6. 3. Correlation Coefficients of the Variables Used for Analysis: Japan

Variable	TSUCCESS	TIMPACT	TECHLIC	INDAGREE	BASBUD	APPBUD
TIMPACT	0.42815**					
	56					
TECHLIC	0.05285	0.03191				
	58	56				
INDAGREE	-0.02120	-0.25707†	0.11038			
	58	56	86			
BASBUD	-0.15963	-0.22181	0.12105	0.19402†		
	54	53	79	79		
APPBUD	0.10532	0.19391	-0.03565	0.04136	-0.36651***	
	54	53	79	79	79	
DEVBUD	0.12875	-0.03010	-0.01708	-0.09721	-0.38638***	-0.15326
	54	53	79	77	79	79
RDAPPR	0.18587	0.08950	-0.26928*	0.11842	-0.06979	0.10978
	56	54	82	82	78	78
RDIND	-0.10364	-0.12436	0.07404	-0.00656	0.24337*	-0.11251
	56	54	82	82	78	78
MISDIV	0.01850	-0.01347	-0.15148	-0.00780	-0.12990	0.36177**
	58	56	86	86	79	79
PROJECT	0.04463	0.06949	0.14027	0.03731	-0.21988†	0.45432****
	55	54	79	79	73	73
EFFRES	-0.11185	-0.11725	0.15575	-0.08488	0.08068	-0.24903*
	56	54	79	79	73	73
BBUREAU	0.00731	0.06880	-0.00595	-0.01311	0.04819	0.10425
	58	56	86	86	79	79
LABSIZE	0.03472	-0.01215	0.13143	0.31697**	-0.18476	0.01807
	58	56	86	86	79	79
GOVPAREN	0.21460	0.21182	-0.28182**	-0.20381†	-0.06169	0.07574
	58	56	86	86	79	79

(Continued)

Variable	DEVBUD	RDAPPR	RDIND	MISDIV	PROJECT	EFFRES	BBUREAU	LABSIZE
RDAPPR	-0.00225 78							
RDIND	-0.11508 78	-0.20923† 82						
MISDIV	0.33241** 78	-0.00392 82	-0.05060 82					
PROJECT	-0.11855 73	0.11718 75	-0.03011 75	0.01991 79				
EFFRES	0.12418 73	-0.22404† 77	0.20070† 77	-0.19468† 79	-0.07533 73			
BBUREAU	0.08899 79	-0.11769 82	0.09104 82	0.21601* 86	-0.06646 79	0.0613 79		
LABSIZE	0.26112* 79	0.19656† 82	-0.24125* 82	0.03967 86	0.00344 79	0.00251 79	-0.14623 86	
GOVPAREN	-0.25904* 79	0.38312*** 82	-0.15059 82	0.01500 86	0.01270 79	-0.3206** 79	-0.0106 86	-0.259* 86

* Significance: † p<.10, * p <.05, ** p<.01, *** p<.001, **** p<.0001.
* The integers indicates the number of observations used in computing pairwise Pearson's product moment correlation coefficients.

2. Linking Cooperative R&D To Transfer Effectiveness

Tables 6.4, 6.5, and 6.6 show the results from the OLS, 2SLS, and Poisson regression analyses. Three models of technology transfer effectiveness were consistent in coefficient signs across the estimation forms, but did not behave well in terms of model tests (F-value) and goodness of fit (R-squared or pseudo-R-squared). The statistical significance of the effectiveness models existed only in the OLS form of the MARKET IMPACT model and in the Poisson regression form of LICENSES model. The OLS regression form of MARKET IMPACT model explained about 7 percent (Adjusted R-squared=0.05) of the variation in the effectiveness of technology transfer (at Prob.>F=0.06). In its 2SLS regression model, the sign of the coefficient estimate was in the same direction as in the OLS regression, but the model was not statistically significant. A statistically significant relationship was found only in the Poisson regression of the LICENSES model of technology transfer effectiveness.

Table 6.4. 2SLS Regression Coefficients for Japan: Dependent Variable--Out-the-Door

Variable	Parameter Estimates	
	OLS	2SLS
INTERCEPT	6.533****	6.702****
INDAGREE	-0.002	-0.045
N	58	50
R-squared	0.00	0.03
Adjusted R-squared	-0.02	0.01
F	0.03	1.68
Prob.>F	0.87	0.20

Significance:† p<.10, * p<.05, ** p<.01, *** p<.001, **** p<.0001

Table 6.5. 2SLS Regression Coefficients for Japan: Dependent Variable--Market Impact

Variable	Parameter Estimates	
	OLS	2SLS
INTERCEPT	6.144****	6.149****
INDAGREE	-0.031†	-0.051
N	56	49
R-squared	0.07	0.04
Adjusted R-squared	0.05	0.02
F	3.82	1.85
Prob.>F	0.06	0.18

Significance:† p<.10, * p<.05, ** p<.01, *** p<.001, **** p<.0001

Table 6.6. Poisson Regression Coefficients for Japan: Dependent Variable--Licenses

Variable	Parameter Estimates		
	OLS	2SLS	Standard Poisson
INTERCEPT	10.542†	8.634	2.407****
INDAGREE	0.427	0.445	0.019****
N	86	68	86
F (Chi-Sqr)	1.04	0.30	114.38
Significance level	0.31	0.59	0.0000000
R-Squared	0.01	0.005	Chi-Sqr 13242.69
Adjusted R-Squared	0.00	-0.01	Pseudo-R^2 0.06

* Significance:† p<.10,* p<.05, ** p<.01, *** p<.001,**** p<.0001

The coefficient of OUT-THE-DOOR model was not only statistically insignificant, but its sign was opposite to our expectations in the OLS and 2SLS regression forms as well. In the MARKET IMPACT model, the cooperative R&D variable was only marginally significant in the OLS regression form, and it had the opposite sign to our expectations in both estimation forms. As a result, **Hypothesis 1AJAP, a more positive perception of transfer effectiveness in terms of market impact than of out-the-door in Japan, was not supported by these statistical results.** In the LICENSES model, cooperative R&D was significantly positive as expected, although its explanatory power was very low (Pseudo R^2=0.06). Compared to results from the United States survey (see Table 6.13), **Hypothesis 1B, Japanese cooperative R&D producing more licenses, does not seem to be supported**. The magnitude of coefficient estimate for the collaboration variable was a little bigger in Japan (0.019) than in the United States (0.004), but the gap is negligible.

3. Linking Organizational Properties To Cooperative R&D

Table 6.7 presents parameter estimates from standard and truncated forms of the Poisson and negative binomial regressions for the Japan data. Given the small number of observations used to estimate the models, the truncated models and particularly the truncated negative binomial model should be considered to be referential. Based on the log-likelihood static, the truncated Poisson model fitted best (-131.0), followed by the standard negative binomial model (-212.5) and the standard Poisson regression model (-316.1). Evaluated in terms of goodness of fit (pseudo-R^2),[57] the standard Poisson and the truncated Poisson models explained 61 percent and 78 percent of the variances of the dependent variable, respectively. In spite of this data limitation, the four regression analyses have produced relatively consistent results. The parameter values did not vary greatly across the estimation forms. Across the models, most variables were consistent in the signs of association and significance levels for the parameter estimates. Two variables concerning industrial funds and resource acquisition fluctuated in signs and significance levels.

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[57] For the strengths and weaknesses of a chi-square test for the goodness of fit, see (Aldrich and Nelson. 1984) in the linear probability, logit and probit models, and Haight (1967) in the Poisson models.

Table 6.7. Poisson and Negative Binomial Regression Coefficients for Japan: Dependent Variable--The Cooperative R&D Propensity [58]

Variable	Parameter Estimates: Standard Poisson	Negative Binomial	Truncated Poisson	Truncated Negative Binomial
Constant	-4.8783****	-5.7193****	-2.3319*	-3.0251†
GOVPAREN	-0.6530**	0.0186	-1.8144****	-1.4500*
BASBUD	0.0221****	0.0246****	0.0276****	0.0290****
APPBUD	-0.0122†	-0.0097†	-0.0355****	-0.0227**
DEVBUD	-0.0157***	-0.0148**	-0.0150***	-0.0100
RDAPPR	0.0137**	0.0173***	0.0283***	0.0290*
RDIND	0.0920**	0.1008****	0.0015	-0.0193
BBUREAU	0.3469**	0.4344****	0.7127****	0.7097**
MISDIV	0.6625****	0.5786****	0.5550**	0.3015
PROJECT	0.3764†	0.1787	0.9077***	0.9302†
EFFRES	-0.1555*	-0.0039	0.1282	0.2059
LABSIZE	0.6556***	0.5726****	-0.0551	-0.0040
N	68	68	68 (34)	68 (34)
Log-L	-316.1	-212.5	-131.0	-101.3
Restricted Log-L	-513.5	-316.1	-278.5	-131.0
Chi-squared	394.8	207.1	295.0	59.5
Significance	0.000000	0.0000000	0.0000000	0.0000000
Chi-sqr.(Rý_p)	727.5 (0.61)		163.8 (0.78)	
G-sqr. (Rý_d)	511.0 (0.44)		150.4 (0.66)	

* For Negative Binomial Regressions, Fixed Value (alpha=0.2).
* For Truncated Regressions, Left Truncation at Y=0.
The numbers in the parentheses indicate the number of observations used to obtain the OLS starting values in the truncated Poisson and negative binomial estimation procedures.
* Significance: † <.10, * p<.05, ** p<.01,*** p<.001,**** p<.0001

Hypothesis 2JAP, the negative relationship between government parenthood and the formation of collaboration, is supported. Variable concerning government parenthood (GOVPAREN) was statistically significant (p<0.5 to p<0.0001) and, as

[58] For OLS estimates for standard and truncated Poisson regressions, see Appendix D.

expected, had negative signs across the regression forms but in the negative binomial form. In the negative binomial estimation form, the variable was insignificant in the opposite direction. Even though the truncated Poisson and truncated negative binomial forms may be questionable due to the small sample size, consistent results except for the negative binomial form appear to support the hypothesized negative relationship. It should be also noted that the variable concerning government parenthood shows quite a large effect on the collaboration formation, particularly in the truncated regression forms (also see Appendix F).

Variables concerning individual research missions showed consistent and strong associations with the dependent variable. Basic research mission (BASBUD) was positively associated with the dependent variable at the significance level of $p<.0001$ across the regression models. Applied research mission (APPBUD) also had consistently a negative relationship with the dependent variable, but at varying significance level ($p<.10$ to $p<.0001$). Development mission (DEVBUD) was significantly but negatively related to the dependent variable ($p<.01$ to $p<.001$) in the regression models except for the truncated negative binomial model. **These results are opposite to our expectations that Japanese laboratories will show an ordering of development>applied research>basic research in the effect of research missions on the collaboration formation. Thus, the Hypothesis 3_{JAP} is not supported.**

Government funding (RDAPPR) was associated positively with the cooperative R&D propensity, as expected, in all the models ($p<.05$ to $p<.001$). The association between industrial funding (RDIND) and the cooperative R&D propensity was positive and significant ($p<.01$ to $p<.0001$) in the standard Poisson and negative binomial regression models, but the relationship was insignificant in the truncated regression forms. Despite this inconsistency, it seems that **results do not support the hypothesis 4_{JAP} that government laboratories under greater resource publicness will be more likely to enter cooperative R&D than will those under greater resource privateness in Japan.**

Red tape (BBUREAU) was positively related to the cooperative R&D propensity at the significance levels of $p<.01$ to $p<.0001$ across the four models. **This result is opposite to our expectations that government red tape will have a discouraging effect on the formation of cooperative R&D.** Thus, Hypothesis 5_{JAP} is not supported by the present analysis.

Mission diversity (MISDIV) was positively related to the cooperative R&D propensity in three regression forms except for the truncated negative binomial regression ($p<.001$ to $p<.0001$). In the truncated negative binomial regression form, the coefficient estimate of the variable was positive but insignificant. **Hypothesis 6 that mission diversity will have a greater effect in Japan seems to be supported by the present analysis.** The magnitude of coefficient estimates for Japan was greater in each regression form than for the United States. As shown in Table 6.13, in the United States, mission diversity was statistically significant and positive in all regression forms except for the truncated negative binomial form. As shown in Appendix F, marginal effects of the mission diversity variable were twice as much in Japan as in the United States, across the regression forms.

Relative commercial project orientation (PROJECT) was positively related to the cooperative R&D propensity in the regression models ($p<.10$ or $p<.001$) except for the standard negative binomial regression. In the negative binomial form, the variable had a positive sign but was not insignificant. The statistical significance of coefficient estimates for the variable was marginal ($p<.10$), except for the truncated Poisson regression form. In both terms of coefficient estimates (Table 6.7) and marginal effects (Appendix F), the effect of relative commercial project orientation was much greater in the United States than in Japan. Since we hypothesized the positive effect of the variable on the collaboration formation in favor of the United States, **results largely support the Hypothesis 7.**

Resource acquisition importance (EFFRES) was significantly related to the cooperative R&D propensity in the standard Poisson regression only ($p<.05$), but with a sign opposite to the hypothesis. This variable was not statistically significant in the other regression models with varying signs on its coefficients. In the United States, the variable was statistically significant in three regression forms with the positive sign as expected (Table 6.13). The marginal effects of the variable were also larger in the United States than in Japan (see Appendix F). **Results only partially support Hypothesis 8**, because we have hypothesized the positive effect of the variable in favor of the United States.

6.4. The United States

1. Basic Statistics

As shown in Table 6.8, the pattern of sample distribution in the United States data is very similar to that in the Japan data. Responses to perception variables are relatively normally distributed around corresponding means. Responses to objectively measurable variables, particularly the count data variable and the budget-related variables, are skewed. For the count data (TECHLIC and INDAGREE), such a skewness stemmed primarily from the inclusion of "sampling zeros". There were 93 zero responses on Variable INDAGREE (55.7% of the total observations). Of the zero responses, 32.3 percent came from government laboratories that were engaged in cooperative R&D activities, but not in cooperative R&D with industrial firms, during the fiscal year of 1989. The rest of the zero responses came from those laboratories that did not form cooperative R&D agreements with any organizations or sectors during the same period. There were 118 zero observations on Variable TECHLIC, meaning that licensing did occur in 31.8 percent of the responding government laboratories in the United States during the same fiscal year. Of the responses to Variable RDIND, 78.4 percent came from those government laboratories with no industrial funds (50.9%) or those with less than 10 percent of their research budget (27.5%). In terms of the portion of government appropriations in the laboratory research budget, RDAPPR, over half of the sample (56.1%) depended on government appropriations for more than 80 percent of their research budget. 64.1%, 58.3%, and 66.5% of the responding laboratories allocated research funds less than corresponding means to individual research missions, BASBUD, APPBUD, and DEVBUD, respectively.

Table 6.8. Descriptive Statistics of Variables Used for Analysis: The United States

Variable	N	Mean	Std. Dev.	Minimum	Maximum
TSUCCESS	135	6.0370	2.2640	1.0000	10.0000
TIMPACT	134	5.1194	2.6273	0	10.0000
TECHLIC	173	1.1358	2.5416	0	20.0000
INDAGREE	167	12.4431	48.3217	0	368.0000
BASBUD	170	32.4882	32.9973	0	100.0000
APPBUD	168	24.6012	26.2149	0	90.0000
DEVBUD	170	16.7294	22.6365	0	100.0000
RDAPPR	171	67.1170	34.8777	0	100.0000
RDIND	171	5.1637	8.8247	0	48.0000
MISDIV	173	1.4971	0.7442	0	3.0000
PROJECT	170	0.8495	0.4865	0.2500	4.0000
EFFRES	168	2.0119	0.7737	1.0000	4.0000
BBUREAU	172	2.0756	0.7724	1.0000	4.0000
LABSIZE	172	4.9548	1.3936	2.5649	8.5942
GOVPAREN	173	0.8439	0.3640	0	1.0000

As shown in Table 6.9, two of the transfer effectiveness variables, TSUCCESS, TIMPACT, and TECHLIC, were significantly related to explanatory variables (rho=0.17 to rho=0.36 at $p<.10$ to $p<.0001$). Three transfer effectiveness variables were all significantly related to the cooperative R&D propensity variable INDAGREE at the levels of $p<.10$ or $p<.05$. The propensity variable was significantly related to a few explanatory variables at the marginal level of $p<.10$. More significant associations among explanatory variables were found within variable groups rather than between variable groups. Associations among three transfer effectiveness variables were statistically significant between Variables TSUCCESS and TIMPACT (rho=0.62 at

Table 6.9. Correlation Coefficients of the Variables Used for Analysis: The United States

Variable	TSUCCESS	TIMPACT	TECHLIC	INDAGREE	BASBUD	APPBUD
TIMPACT	0.61161****					
	134					
TECHLIC	0.08055	0.20400*				
	135	134				
INDAGREE	0.14952†	0.19645*	0.15791*			
	129	128	167			
BASBUD	-0.02613	0.02772	-0.09199	-0.01199		
	132	131	170	164		
APPBUD	0.09056	0.14662†	0.10710	0.09090	-0.38029****	
	131	130	168	162	168	
DEVBUD	-0.17252*	-0.19213*	-0.08031	-0.00834	-0.41921****	-0.24425**
	132	131	170	164	170	168
RDAPPR	0.05565	-0.03001	-0.05340	0.03507	0.02511	0.01189
	134	133	171	165	169	167
RDIND	0.09836	0.25261**	0.09145	0.08113	-0.01117	0.18836*
	134	133	171	165	169	167
MISDIV	0.00493	0.10713	0.11318	0.14172†	-0.04970	0.30385****
	135	134	173	167	170	168
PROJECT	0.21416*	0.27397**	0.11839	0.13757†	-0.14400†	0.20126**
	132	131	170	164	168	166
EFFRES	0.01175	0.06551	-0.02811	0.03078	-0.05415	-0.01085
	131	130	168	162	165	163
BBUREAU	-0.35624****	-0.00829	0.11799	0.00039	-0.17993*	0.01608
	134	133	172	166	169	167
LABSIZE	-0.07428	-0.01239	0.31918****	0.30756	-0.21522**	0.04153
	134	133	172	166	169	167
GOVPAREN	-0.15031†	-0.23692**	-0.12779†	-0.09623	-0.12583	-0.08020
	135	134	173	167	170	168

Variable	DEVBUD	RDAPPR	RDIND	MISDIV	PROJECT	EFFRES	BBUREAU	LABSIZE
RDAPPR	0.00768							
	169							
RDIND	-0.07358	-0.53711****						
	169	171						
MISDIV	0.12038	-0.06920	0.20343**					
	170	171	171					
PROJECT	-0.04895	0.14153†	0.02580	0.16593*				
	168	168	168	170				
EFFRES	-0.03004	-0.14166†	0.08666	0.13543†	-0.01074			
	165	166	166	168	165			
BBUREAU	0.09591	0.17556*	-0.11313	0.05587	0.04519	0.10022		
	169	170	170	172	169	167		
LABSIZE	0.15135*	-0.03599	0.02162	0.02240	0.00879	0.09426	0.21378**	
	169	170	170	172	169	167	171	
GOVPAREN	0.13611†	0.20483**	-0.47313****	-0.16266*	-0.07398	-0.05628	0.06249	-0.029
	170	171	171	173	170	168	172	172

* Significance:† p<.10,* p <.05,** p<.01,*** p<.001,**** p<.0001.
* The integers indicates the number of observations used in computing pairwise Pearson's product moment correlations coefficients.

p<.0001), and between Variable TIMPACT and Variable TECHLIC (rho=0.20 at p<.05). Strong and significant relationships were also found between research mission variables and between these and other independent variables. Three research mission variables were negatively associated with each other (rho=0.24 to rho=0.42 at p<.01 or p<.0001).

2. Linking Cooperative R&D To Transfer Effectiveness

Tables 6.10, 6.11, and 6.12 show the results of the OLS, 2SLS, and Poisson regression analyses. The OLS regression forms performed better in the three effectiveness models than the 2SLS regressions, with the exception of the LICENSES model. The OLS regression forms were significant at the conventional significance levels (at the marginal level of significance in the OUT-THE-DOOR model). The OUT-THE-DOOR model explained 2 percent of the variances in the OLS regression (Prob.>F=0.09), but it was not significant in the 2SLS regression. The MARKET IMPACT model explained 4 percent of the variances in the OLS regression (Prob.>F=0.03), but it was only marginally significant in the 2SLS regression. The LICENSES model had a greater explanatory power in the 2SLS regression than in the OLS regression. The model explained 10 percent of the variances in the 2SLS regression (Prob.>F=0.0000), as compared to 2 percent in the OLS regression (Prob.>F=0.04). Its negative binomial regression form was statistically highly significant, but its goodness of fit was still low (Pseudo-R^2=0.03 for the standard Poisson regression).

Table 6.10. 2SLS Regression Coefficients for The United States: Dependent Variable--TSUCCESS

Variable	Parameter Estimates OLS	2SLS
INTERCEPT	5.996****	6.062****
INDAGREE	0.006†	0.009
N	129	117
R-squared	0.02	0.01
Adjusted R-squared	0.01	-0.002
F	2.90	0.82
Prob.>F	0.09	0.37

* Significance: † <.10, * p<.05, ** p<.01,*** p<.001,**** p<.0001

Table 6.11. 2SLS Regression Coefficients for the United States: Dependent Variable--TIMPACT

Variable	Parameter Estimates OLS	2SLS
INTERCEPT	4.975****	4.909****
INDAGREE	0.009*	0.019†
N	128	116
R-squared	0.04	0.02
Adjusted R-squared	0.03	0.01
F	5.06	2.66
Prob.>F	0.03	0.10

* Significance: † <.10, * p<.05, ** p<.01,*** p<.001,**** p<.0001

Table 6.12. Poisson Regression Coefficients for the United States: Dependent Variable--LICENSES

Variable	Parameter Estimates		
	OLS	2SLS	Negative Binomial
INTERCEPT	1.021****	0.602*	0.039
INDAGREE	0.008*	0.041****	0.004****
N	167	152	167
Log likelihood	-392.0	-354.8	-296.2
Restricted log-L	-394.1	-362.7	-345.9
F (Chi-sqr)	4.22	16.38	(99.4)
Significance level	0.04	0.00008	0.0000000
R^2 [Chi-sqr.(Rŷ_p)]	0.02	0.10	[949.3 (0.03)]
Adj-R^2 [G-sqr.(Rŷ_d)]	0.02	0.09	[538.5 (0.03)]

* Significance: † <.10, * p<.05, ** p<.01,*** p<.001,**** p<.0001

In the previous chapter, we set up two hypotheses concerning the impact of cooperative R&D and technology transfer effectiveness in the United States. **The hypothesis that government laboratory directors will perceive the impact of collaboration in terms of delivery rather than of market impact (Hypothesis 1USA) is not supported.** In the 2SLS forms, the OUT-THE-DOOR model was positive but not statistically significant. Not only was the MARKET IMPACT model positive and statistically significant (p<.10), but the coefficient estimate of the collaboration variable (0.019) was also bigger in magnitude than that in the OUT-THE-DOOR model (0.009). **This is opposite to the expectations of this study.**

On the other hand, in the LICENSES model, the collaboration variable was significant in all regression forms. In the Poisson-related estimation form, the collaboration variable was positive and highly significant. As in the Japanese case (pseudo-R^2=0.06), the explanatory power of the model was very low (pseudo-R^2=0.03). The collaboration variable for the United Sates was much smaller in magnitude (0.004) as compared to that of Japan (0.019). Due to the reasons discussed in the Japanese case, **Hypothesis 1B is not supported.**

3. Linking Organizational Properties To Cooperative R&D

Table 6.13 presents the parameter estimates from standard and truncated forms of the Poisson and negative binomial regression models for the United States data. Based on the log-likelihood static, the truncated negative binomial model fit best (-677.0), followed by the negative binomial model (-358.7). The truncated Poisson and the standard Poisson model were a poor third (-1305.9) and fourth (-2281.4), respectively. In terms of a goodness of fit (pseudo-R squared), the standard Poisson model and the truncated Poisson regression models explained 57 percent and 49 percent of the variances in the cooperative R&D propensity, respectively. The signs, significance levels, and values of the parameter estimates did not vary greatly across the four estimation forms. Almost all the variables have turned out to be statistically significant in explaining the variances in the government laboratories' propensity of collaboration formation. Those statistical associations were significant at $p<.0001$. Variables concerning resource acquisition (EFFRES), red tape (BBUREAU), and laboratories' parenthood (GOVPAREN) fluctuated in signs and significance.

Table 6.13. Poisson and Negative Binomial Regression Coefficients for the United States: Dependent Variable--The Cooperative R&D Propensity [59]

	Parameter Estimates			
Variable	Standard Poisson	Negative Binomial	Truncated Poisson	Truncated Negative Binomial
Constant	-7.6086****	-7.3198****	-7.3772****	-5.4888****
GOVPAREN	-0.2197**	0.5181****	-0.0358	0.0085
BASBUD	0.0319****	0.0248****	0.0377****	0.0301****
APPBUD	0.0211****	0.0353****	0.0066****	0.0202****
DEVBUD	0.0266****	0.0147****	0.0343****	0.0241****
RDAPPR	0.0175****	0.0089****	0.0244****	0.0170****
RDIND	0.0512****	0.0504****	0.0819****	0.0552****
BBUREAU	-0.6328****	-0.1725****	-0.1566***	0.2244****
MISDIV	0.2343****	0.3619****	0.1065**	-0.0330
PROJECT	1.1622****	0.9150****	1.3813****	1.1239****
EFFRES	0.2244****	-0.0058	0.3429****	0.1431**
LABSIZE	1.0459****	0.9140****	0.7908****	0.5947****
N	152	152	152 (69)	152 (69)
Log-L	-2281.4	-677.0	-1305.9	-358.7
Restricted Log-L	-4618.6	-2281.4	-2990.9	-1305.9
Chi-squared	4674.4	3408.8	3370.0	1894.4
Significance	0.000000	0.0000000	0.0000000	0.0000000
Chi-sqr.(Rý_p)	12221.8 (0.57)		6017.5 (0.49)	
G-sqr. (Rý_d)	4305.4 (0.52)		2386.1 (0.58)	

* For Negative Binomial Regressions, Fixed Value (alpha=0.2).
* For Truncated Regressions, Left Truncation at Y=0. The numbers in the parentheses indicate the number of observations used to obtain the OLS starting values in the truncated Poisson and negative binomial estimation procedures.
* Significance: † <.10, * p<.05, ** p<.01,*** p<.001,**** p<.0001

The impact of government parenthood (GOVPAREN) varied in sign between pre- and post-overdispersion test results, and between the negative binomial and truncated negative binomial regressions. Since the data have an overdispersion problem (see

[59] For OLS estimates for standard and truncated Poisson regressions, see Appendix D.

Appendix E), it is safer to rely on the results obtained from the negative binomial regressions. The variable concerning government parenthood was statistically significant (p<.0001) but negative in the negative binomial form, and it was positive but statistically insignificant in the truncated negative binomial form. Although a goodness of fit for the regression forms is better in the truncated form out of two negative binomial regressions, **such a inconsistency makes unreliable a test for Hypothesis 2USA that government parenthood will have no effect on the collaboration formation in the United States.**

Variables concerning individual research missions showed consistent and strong relationships with the dependent variable (INDAGREE) across the regression forms. Basic research mission (BASBUD), applied research mission (APPBUD), and development mission (DEVBUD) were all positively related to the cooperative R&D propensity at p<.0001. The magnitude of coefficient estimates for each mission type showed an ordering of basic research, development, and applied research in descending order. Although there are some variations between applied research mission and development mission, the pattern was consistent across the regression forms. We expected that government laboratories' formation of collaboration with industry will be governed by the appropriability proposition. According to this proposition, the propensity will be highest in basic research laboratories and lowest (and possibly in the negative direction) development laboratories, applied research laboratories being in between. **Results do not support Hypothesis 3USA: the hypothesized ordering implied in the appropriability proposition.**

The funding variables had positive and significant relationships with the cooperative R&D propensity at p<.0001 in the regression forms. The variable concerning industrial funding (RDIND) was consistently greater (three to four times) in magnitude of coefficient estimate across the regression forms than the variable concerning government funding (RDAPPR) (also see Appendix F). Since we hypothesized the positive effect of the two variables on the collaboration formation in favor of industrial funding, **this result support Hypothesis 4USA**.

Hypothesis 5 that red tape will have a negative effect on collaboration is largely supported in the United States sample. Variable concerning red tape (BBUREAU) was negatively related to the cooperative R&D propensity in three regression models as expected (p<.001 or p<.0001). As opposed to the hypothesized relationship, the relationship was significant but positive in the truncated negative binomial regression.

Research mission diversity (MISDIV) was positively related to the cooperative R&D propensity at p<.0001 in three regression forms. The relationship was insignificant and negative in the truncated negative binomial regression. As tested in the Japanese sample (see Table 6.7 and Appendix F), **Hypothesis 6 that mission diversity will have a more positive effect on the collaboration formation in Japan than in the United States seems to be supported by the present analysis**.

As already tested in the Japanese case, **Hypothesis 7 is largely supported.** Relative commercial orientation of research projects (PROJECT) was positively related to cooperative R&D propensity (p<.0001). Since we hypothesized a positive relationships between these two variables, Hypothesis 5: USA is supported by the present analysis. In both terms of coefficient estimates and marginal effects, the effect of relative commercial project orientation was much greater in the United States than in Japan (also see Table 6.7 and Appendix F).

Importance attached to resource acquisition (EFFRES) showed the expected, significant and positive, associations with the dependent variable in three regression models ($p<.001$ to $p<.0001$). The relationship was insignificant and negative in the standard negative binomial regression. As mentioned, the variable was not statistically significant in most regression forms in Japan and its marginal effects were larger in the United States (see Table 6.7 and Appendix F). **Thus results partially support the Hypothesis 8, the positive effect of resource acquisition importance on the collaboration formation in favor of the United States.**

Table 6.14 summarizes the test results of hypothesized relationships between laboratory properties and cooperative R&D propensity, and between cooperative R&D and technology transfer effectiveness.

Table 6.14. A Summary of Hypothesis Tests

Hypothesis	Japan	U.S.
Collaboration and Effectiveness		
Hypothesis 1A (Market Impact vs. Out-the-Door)	NS	EO
Hypothesis 1B (Licenses: Japan>United States)	NOT SUPPORT	
Organizational Properties and Propensity		
Hypothesis 2 (Government Parenthood)	ES	OT
Hypothesis 3 (Research Missions)	EO	PS.PO
Hypothesis 4 (External Funding)	PO	ES
Hypothesis 5 (Red Tape)	EO	ES
Hypothesis 6 (Mission Diversity: Japan>US)	SUPPORT	
Hypothesis 7 (Project Orientation: Japan<US)	SUPPORT	
Hypothesis 8 (Resource Acquisition: Japan<US)	PARTIALLY SUPPORT	

(Continued)

* ES: Statistically significant with the expected sign.
* EO: Statistically significant with the opposite sign.
* NS: Statistically insignificant at error levels of 10% or less.
* PS: Statistically significant with expected sign with minor deviations in sign and significance.
* PO: Statistically significant with opposite sign with variations in sign and significance.
* OT: Impossible to test hypotheses due to inconsistencies.

VII. FINDINGS AND DISCUSSION

7.1. Findings: Similarities and Dissimilarities

Similarities center around the transfer effect of collaboration and mainly around the formation effect of GICR&D contingencies. First, there was little or no discernible difference in the effects of collaboration on transfer effectiveness between Japan and the United States. Second, resource privateness was perhaps a more influential determinant than resource publicness. Third, GICR&D contingencies worked similarly, and national differences were a matter of degree. Mission diversity was more facilitative in Japan than in the United States, and the relative commercial project orientation was more facilitative in the United States than in Japan.

National differences are concentrated on the task and institutional properties of government laboratories in each country. In **JAPAN**: First, the transfer effectiveness of collaboration was negatively perceived (even though statistically insignificant). Second, government laboratories with non-government agencies as their parent organization were more likely to enter collaboration, and the government parenthood of laboratories was the most influential factor. Third, only basic research mission had a positive effect, the other research missions being negative on the formation of collaboration. Fourth, government red tape had an recognizable positive effect on the formation of collaboration between government laboraotries and industry.

The formation of cooperative R&D with industry by **UNITED STATES** government laboratories is characterized as follows: First, the market impact of collaboration was more positively perceived than the delivery effect. Second, the commercial project selection relative to governmental project selection was the most influential factor. Third, government laboratories were likely to enter cooperative R&D with industry irrespective of research mission. Fourth, government red tape had a discouraging effect on the formation of collaboration. Fifth, resource acquisition as a criterion of organizational effectiveness was an important factor.

7.2. Discussion

1. Linking Cooperative R&D To Technology Transfer Effectiveness

Findings of this study are different from the observational findings by Cutler (1988) that cooperative R&D based on personal links is the most effective mechanism for technology transfer in Japan (as well as in the United States). The weak explanatory power of licenses in Japan may question Hane's (1993-1994) allegation that licenses have been an important policy tool for normalizing S&T capabilities across industrial firms. Results concerning the United States appear to support the findings by Bozeman and Crow (1991b) that collaboration -- as measured by the number of inter-laboratory cooperative R&D agreements among government, industry and universities-- is just a marginally significant predictor of technology transfer to either government or industry.

Findings suggest that cooperative R&D is just a one, but not very effective, mechanism for transferring technology, and that it should be thus utilized along with other mechanisms. Findings may also suggest that the results of cooperative R&D are not necessarily relevant to economic impact. Even though the United States government laboratory directors perceived the transfer effectiveness positively in economic terms, findings casts doubt to the adequacy and effectiveness of the United States government laboratory policy that has been pushed under the banner of "cooperative R&D as a competitiveness weapon." Particularly interesting are findings concerning the perceived measures of transfer effectiveness. This study suggests that in Japan, cooperative R&D may serve other purposes than the transfer of technology from government laboratories to industry (even though the relationships were not statistically significant).

There can be various alternative accounts for a poor economic performance of cooperative R&D. A number of researchers find the main benefits of collaboration in the formation, or dynamics, of links or networks among researchers (Bruce, Leverick, Littler and Wilson, 1995; Magnaval, Massimo and Removille, 1992; Larsen and Wigand, 1987; Van Dierdonk, Debackere and Rappa, 1990; Wigand, 1990). However, we can not judge from this study whether cooperative R&D has facilitated the formation and dynamics of research communication networks between researchers or between government laboratories and industry.

Another attractive account is associated with Macdonald's warnings against the uncritical adoption of Japanese collaboration that without prior informal network relations, formal cooperative R&D can hamper the interactiveness and intimacy advantages of informal relationships. If it is the case, the argument that formal collaboration will facilitate informal interactions within the context of collaboration (Breman, 1994) should be limited. However, Macdonald's proposition seems to be untenable in the face of the findings of this study that Japanese government laboratory directors perceive the transfer effectiveness of collaboration in a negative way (if not statistically significant). It is unclear that government-industry collaboration differs from interfirm collaboration upon which Macdonald bases his argument. Nevertheless, findings concerning Japanese laboratories suggest that the government-industry collaboration might be more informal. In this sense, Eagar's (1985) observations of technical-meeting-type cooperative R&D in Japan may shed light on the importance of informal and information-exchange type of cooperative R&D in Japan.

Finally, the poor performance of the cooperative R&D variable may be also related to the "long-term and systemic" nature of the benefits of collaboration. If it is the case, benefits of collaboration can only be "assessed through an analysis of the processes occurring within participating firms" as Quintas and Guy (1995) argued.

2. Linking Task and Institutional Contexts To Collaboration

Findings concerning government parenthood suggest that the important policy tools for technology transfer are perhaps special public corporations or government-affiliated nonprofit organizations rather than national research institutes. This may address cautions against the adoption of Japanese government-industry collaboration in the United States where there is no equivalent organization.

Findings concerning research mission re-affirm the findings from piecemeal observations of the government-industry cooperative R&D ventures in the United States and particularly in Japan (Hane, 1993-1994; Mowery and Rosenberg, 1989; Ray and Buisseret, 1995; Levy and Samuels, 1991: 121). Thus, findings of the current study present for the first time empirical evidence that Japan is shifting from applied research oriented cooperative R&D toward basic research collaboration. Findings concerning the United States in this study are different from the work by Bozeman and Pandey (1994), in which no significant association was found between research missions and cooperative R&D with industry in the Japanese sample, and positive relationships were found only on precommercial applied research mission and commercial applied research mission in the

United States sample.[60] Findings suggest that United States government laboratories are pressured to contribute to the enhancement of competitiveness through collaboration irrespective of their research missions, whereas government-industry cooperative R&D in Japan may be shifting its focus to basic research. This perhaps means that political demands for enhanced social relevance of government research have been delivered to government laboratories. Meanwhile, the potential shift of government-industry collaboration in Japan may be qualified, because there is no agreement about what constitutes basic research in Japan and the United States.[61]

Results concerning red tape suggest that government red tape in the United States tends to be perceived as the *bureaucratic pathology* externally imposed to government laboratories by the political process, as Bozeman (1993) argued, whereas government red tape in Japan may be perceived in terms of organizational structure or *bureaucratic physiology*. This implies that if there is any differential effect of red tape across nations, it may be the character of red tape, not simply the degree of red tape, that is important in determining the formation of cooperative R&D between government laboratories and industry. Findings concerning the effect of red tape on collaboration formation should be interpreted with caution. Red tape can be both cause and effect of collaboration. Government red tape tended to serve as a good rationale for privatizing or contracting-out

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60 It seems that such a disparity stems from some methodological differences between their study and the current study. Methodological differences between the two studies are that Bozeman and Pandey included only government laboratories with at least one linkage formation in their study, regardless of sectors. Second, their study was not thus intended to deal with the government laboratories' propensity to form cooperative R&D. The third and related is that they relied for statistical analysis upon Kendall's tau correlations analysis.

61 In Japan, basic research in the government laboratory system is considered to be application-oriented by many Japanese and Western observers (Goto and Wagasuki, 1988: 197; Lederman, 1994: 283; Nagasu, 1984; National Research Council, 1989; Press, 1987: 20).

government laboratories (e.g., Samios and Crease, 1981), and privatization may cause red tape (e.g., Meyer, 1979). Findings also raise the measurement issue of red tape within-culture and cross-cultural analysis. In contrast with these findings of the present study, Bozeman and Coker (1992) found the positive effect of red tape (measured by the time lag between request and approval) on technology transfer effectiveness in the United States, suggesting that red tape may be closely related to the organizational size.

Findings concerning external funding suggest that resource publicness and privateness work in a very similar way. Greater impact of resource publicness may imply that Japanese government is increasingly facing limits in driving firms toward publicly-designed commercial purpose projects. This account seems to be tenable in that the organizational importance of resource acquisition does not count in explaining Japanese government laboratories' propensity to enter collaboration with industry. Thus, contrary to the United States, government budgetary austerity is not a reason for collaboration in Japan. This is contrasted with the finding of Bozeman and Pandey (1994) that resource acquisition is a more influential motivation in Japanese government laboratories than in United States counterparts. Meanwhile, coupled with other findings concerning the United States, findings about the commercial project orientation suggest that government laboratories in the United States are under great political pressures toward the implantation of commercial orientation in the system under the budgetary austerity.

In short, findings in Japan and the United States suggest that two government laboratory systems behave similarly in terms of the GICR&D contingencies that could have arisen from somewhat different task and institutional environments.

VIII. CONCLUSIONS

This dissertation has aimed at identifying similarities and differences in cooperative R&D between government laboratories and industry in the United States and Japan in terms of its determinants and transfer outcomes. The author's adoption of the present subject matter has been motivated by a surprising dearth of scholastic interest in the government research *system* in general, and in the government laboratory side of the government-industry cooperative R&D in particular, amid two contradictory movements in the United States-- "Learning Japan" and "Bashing Japan." This dissertation has approached the subject matter from a government laboratory perspective in which the effectiveness of technology transfer is determined by the formation of cooperative R&D, which is in turn dependent upon the GICR&D contingencies affected by the task and institutional properties of government laboratories.

This dissertation has found that the two government laboratory systems are moving toward each other's previous strength point away from their own strengths that functioned effectively, as Mowery and Rosenberg (1989) observed. This study has suggested that the government laboratory system in the United States is moving toward a better commercialization under political pressures toward the socio-economic relevance of government research. It seems that this effort has paid off to a degree in the United States. This study has suggested that the Japanese system is moving toward basic research ventures but with policy tools other than the American ones, that is, public corporations rather than national government laboratories.

Since the author began writing this dissertation, there have been changes in government cooperative research policies. The Republican Congress has been trying to cut cooperative projects that they believe would smack of a "corporate welfare." Under these circumstances, this study may provide us with some important policy implications as well as theoretical implications.

8.1. Implications

1. Theoretical Implications

The performance of the conceptual model used in the analysis was mixed. The simultaneous construct of the relationships between the number of cooperative R&D agreements and three forms of technology transfer effectiveness has poorly worked. Two accounts are in order. The first account for the poor performance is simply that cooperative R&D as measured by the frequency of formal agreements is not itself an influential factor affecting the effectiveness of technology transfer. The poor performance of its 2SLS estimation form, compared to the OLS estimation form, questions the adequacy of the simultaneous conceptual relationship between the simple frequency of cooperative R&D and the effectiveness measures used in the present analysis.

By contrast, the propensity model of the relationships between the expected number of cooperative R&D and laboratory variables has performed well in terms of goodness of fit. Findings concerning these relationships suggest that we need to differentiate between, and integrate, the more remote institutional environments of government laboratories and the more direct collaboration formation contingencies in the comparative analyses of the United States and Japan. In this sense, this study reaffirms an agreed-upon axiom that cross-cultural inter-organizational or sector analyses should integrate a multiplicity of theoretical perspectives. The performance gap between the two regression models calls upon a researcher to take other major intervening factors into account in the research design. These factors may include the management of relationships per se, the partnering firms' characteristics, and the flow of technology into the participating government laboratories.

2. Policy Implications for United States Government Laboratories

Responding to a competitiveness challenge and pooling public and private resources have been the main reasons for government-industry cooperative R&D in both countries. This study has suggested that the Untied States and Japan are moving toward the "fit" between the government R&D system and its surrounding techno-economic environments. Returning to the questions we have raised, this study presents important clues to one of the questions: Is (or Was) the United States a different cooperative R&D regime from Japan? Did the United States look at a wrong model for learning a lesson? Our answer to these questions is close to the positive one. As Hane (1993-1994) observed, "the United States was right to look to Japan for a model, but they did not look closely enough." The Japanese practice of government-industry cooperative R&D is not only shifting toward basic research, but also the major instruments are special public corporations that were designed to fulfill the special national missions of Japan. This study suggests that such a government-industry collaboration in Japan may serve purposes other than technology transfer.

The issue of collaboration is not a question of "Collaborate or Die" (Bruce, Leverick, Littler and Wilson, 1995: 33), but a question of how to optimize the combination of the various existing mechanisms for transferring technologies. Thus, the number of cooperative R&D agreements should not be used as a criterion in assessing the performance of government laboratories. Creating more partnerships is not by itself a strategy for meeting national needs and improving industrial competitiveness. The government policy toward government laboratories should be more based on the missions of government laboratories. R&D collaboration with industry should be closely aligned with core mission areas of the government laboratories. In line with a renewed uniqueness of clusters of government laboratories, government policies toward the government laboratories should be systematized based upon the relative strengths among government laboratories, universities, and industry.

8.2. The Limitations of This Study

The findings of this study should be treated with some caution. There are some sources of potential threats to validity. The most serious threat to validity could be posed by the failure of this study to take into account an industry side of collaboration in the research design. Construct validity could be threatened by the use of the frequency measure of cooperative R&D. The adoption of the formation frequency measure could be warranted for policy reasons mentioned at the beginning of this study, but it left intact other important dimensions of collaboration, i.e., the technical or economic importance (or quality) of collaboration, the management of collaboration, or the utilization of research results within firms. The perception measures of technology transfer effectiveness used in this study appear to be too broad to come to grips with the divergent opinions among government laboratories, political entities or parent agencies, and industrial firms. Those perception measures are perhaps useful in telling a *story*, but they are of limited use in addressing policy-relevant issues. Another possible threat to validity is associated with the failure of the present study to differentiate international cooperative R&D from domestic ones.[62] This threat might be less serious in the Japanese sample than in the United States sample (see footnote 59). A more serious threat may be related to the failure of the present study to differentiate developed countries from developing countries as the partners of international collaboration. Difference in the level of economic development could affect the antecedents and transfer outcomes of international R&D collaboration differently. The preceding discussion of government red tape raises a potential specification problem of the estimation model used

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62 In the data used, very high degrees of correlations existed between collaboration with industry and other types of collaboration such as international collaboration (rho=0.44 at p<.0001, rho=0.76 at p<.0001) and domestic collaboration (rho=0.91 at p<.0001, rho=0.71 at p<.0001) in Japan and the United States, respectively.

in the analysis, because red tape is perhaps an effect as well as a cause of cooperative R&D.

There are some possible threats to validity that are relevant to cross-cultural analyses. The first is a threat that could be caused by a selection bias in the Japanese data. The wide national gap in survey response rates might have been caused by the involvement of a government agency, NISTEP, in the process of the JNLS survey. Because of the functional and positional significance of NISTEP in the S&T policy process, Japanese government laboratory directors have felt more forced to respond to the survey than they would otherwise have. For this reason, the United States government laboratories were under-represented relative to the Japanese government laboratories in this study. Second, there is a possible threat to validity with respect to cross-cultural equivalence of research mission variables, particularly basic research. Although there is a greater cross-cultural comparability in government laboratory R&D between two countries as compared to industrial R&D (Papadakis and Jankowski, 1991), this study suggests that the issue at stake is not just conceptual, but also may be associated to a greater extent with the way basic research activity are funded. Coupled with the political economy of R&D taxonomy within national boundaries (see Averch, 1991), this cross-cultural inequivalence might have complicated the effect of basic research on the collaboration formation. Third, the age of the data used in this study would be a threat to temporal generalizability of the present research results within national boundaries. Since the United States data are based on government laboratories' earlier experience, the use of such data for the U.S. sample might have underestimated a 'collaboration fever' since the present survey. There is a related but distinct threat to validity, which is a history-maturation interaction effect. A one year gap between the two different surveys could reflect the maturation of the Japanese laboratories which were pressured toward basic research, leaving the United States laboratory system still in the infancy period of collaboration.

The data used could be vulnerable to two statistical problems which might have influenced the validity of this study. The normality assumption was difficult to hold in many objectively measured variables and in estimation models. Normality could be more seriously violated in the United States sample than in the Japanese sample. A related issue could be raised by the presence of 'too many' zero responses in the both data. The truncated forms of estimation could have reduced to a great extent potential threats, while there exists a possibility that the excess of zero responses might have caused inconsistencies in coefficient estimation among the regression forms used in this study. The problems could be more serious in the truncated estimation process of the Japanese sample. The small sample size of the Japanese data has raised a trade-off between the number of independent variables required of the explanation of the complicated laboratory systems and the maintenance or enhancement of the degree of freedom.

Methodologically, based upon the one-shot survey data, the present study was static in nature. This study was not appropriate to handle the relationships between the task and institutional properties and government-industry cooperative R&D contingencies, on the one hand, and potential dynamics of the collaboration process, on the other hand. Possible interactions among laboratory properties, collaboration, and technology transfer were not given due attention in this study. Which one is a cause or result of the others is too elusive to detect by the cross-section, one-shot survey research.

8.3. Suggestions for Further Research

The preceding discussion sheds some light on areas deserving further research. This study directs our scholastic concerns toward three new substantive areas of research: 1) the neglected side of technology transfer which is the transfer of technologies from industry to government laboratories, 2) the interaction domain itself, and 3) the development of theoretical approaches appropriate to the relationship analysis. These new concerns will provide important clues for the poor performance of collaboration observed in this study. The explosion of government-industry cooperative R&D agreements in the United States and the *repeated deal argument* of the Japanese collaboration will warrant the theoretical and practical significance of the focus on the relationships or network.

The findings of the present study will be more useful when they are compared to research results concerning collaboration between government lab and university, between government lab and industry, and between government labs. These comparative attempts will contribute to the development of more relevant theoretical approaches to government-industry collaboration.

Methodologically, there is a need for a time-series or, at least a longitudinal study, on the one hand, and case studies, on the other hand, of the determinants and transfer effectiveness of cooperative R&D. Collaboration is a long term process, and its results usually occur over extended periods of time. Technology transfer interacts with cooperative R&D efforts and influences the antecedents of cooperative R&D over time.

These renewed concerns with the research methods of R&D collaboration should enrich the development of more relevant measures of the effectiveness of R&D collaboration and subsequent technology transfer. It should also be noted that there should be a balanced focus on the primary missions of government laboratory and its technology transfer activities.

APPENDIX A

SURVEY QUESTIONNAIRE

* The questions below include only those that was commonly asked in both surveys about U.S. and Japanese government laboratories.

I. Items for Laboratory's Identification

Laboratory Number/ Laboratory Name/ Parent Agency of the Laboratory

II. Items for Understanding Government Laboratories

1. For each of the research technology missions listed below, please indicate the significance of the mission for your laboratory, (on a 0-4 scale where 0 is "not a mission and 4 is "single most important mission"). (Note: no more than one mission may be listed as "single most important.")

a. Basic research.
b. Pre-commercial applied research.
c. Commercial applied research.
d. Development.
e. Technical assistance to government agencies.
f. Technical assistance to this laboratory's parent organization or agency.
g. Technical assistance to private firms and industrial organizations.
h. Technology transfer to government organizations.
i. Transfer technology to private firms or industrial organizations.

2. Please rate each of the following factors in regard to its importance to your R&D laboratory as an effectiveness criteria, (on a 0-4 scale where 0 is "not a mission and 4 is "single most important mission").

a. Contributing to advance of fundamental scientific knowledge.
b. Producing knowledge useful in developing commercial products and processes.
c. Meeting the needs and serving the interests of a constituent group.
d. Increasing the resources.

3. Please indicate the extent to which you agree or disagree with the following statements (on a 1-4 scale where 1 is "strongly disagree" and 4 is "strongly agree").

a. "I think there is more bureaucracy slowing things down in this lab than in other labs I know about."
b. "Scientists and professionals working here have a great deal of autonomy in their work."
c. "Change in policies of other government organizations often have a significant

effect on my laboratory's selection of research projects."

d. "Assessment of the commercial benefits of my unit's R&D output often have a significant effect on selection of research projects."

4. How many administrative levels are there between (but not including) the level of the most senior bench level scientists and engineers and the laboratory director?

5. What is your laboratory's total R&D budget, from all sources, for the current fiscal year? (for U.S., in dollars; for Japan, in million Yen)

6. In the last complete fiscal year, what was the percentage of R&D funding received from each of the sources listed below/ (Note: should total 100%)

a. Direct government appropriations or allocations from parent agency.
b. Contracts and grants from other government agencies (not from our parent agency).
c. Industrial grants and contracts.
d. Other.

7. How many full-time workers of all types are employed at your laboratory?

a. How many researchers?
b. How many technicians?
c. Others?
d. Total ?

8. During the last two weeks, about what percentage of your (not the lab's) business-related telephone calls was with non-government personnel, (e.g., personnel from industry, small business, nonprofit organizations, universities)?

9. During the last two weeks, about what percentage of the mail correspondence initiated by you was sent to non-government agencies or personnel?

10. For each of the missions listed, please indicate the approximate percentage of your laboratory's total budget devoted to each. (Note: should total 100%)

a. Basic research.
b. Applied research (pre-commercial and commercial).
c. Development.
d. Technical assistance to parent agency.
e. Technical assistance to government agencies other than your parent agency.
f. Technical assistance to private industry organizations or individuals.
g. Technology transfer to business organizations.
h. Technology transfer to government agencies.
i. Other.

11. Please indicate, for each activity listed below, how much time (in weeks) is typically required between a request made by a unit within a lab and the actual approval or the request. Check the closest time period. If no approval is necessary, please check "NA". IF requests are never made, check "NR.

a. Hiring full-time personnel.
b. Hiring part-time personnel.
c. Termination
d. Buying low-cost equipment.
e. Buying expensive equipment.
f. Submitting research results for publication.
g. Circulating research results outside the lab.
h. Getting internal funding for an individual researcher's research project.
i. Getting internal funding for intermediate to large-scale team research project.

12, Approximately what percentage of the laboratory director's effort is devoted yearly to the maintenance of relationships with other organizations (not including your parent organization) of any type?

13. How is research conducted in your laboratory, (on a 1-2 scale where 1 is "primary practice" and 2 is "secondary practice")?

a. Based on the initiative of individual researchers.
b. Principal investigator-led research groups.
c. Departments, divisions or branches.
d. More or less ad hoc, based on the needs of the project.
e. Other.

14. Please identify the relative percentage of your lab's R&D output (in terms of persons hours devoted yearly to each) for each category listed below.

a. Published articles.
b. Patents and licenses.
c. Algorithms and software.
d. Technical and scientific reports for internal use only.
e. Technical and scientific reports for use by others outside the parent agency.
f. Prototype devices and materials.
g. Papers for presentation at external conferences.
h. Demonstration of technological devices.
i. Other products.

15. Please indicate the extent to which each factor given below is an important R&D barrier for your laboratory, (on a 0-4 scale where 0 is "not a barrier and 4 is "most important barrier"). (Note: only one item should be listed as "the most important barrier.")

a. Not enough trained scientific and technical personnel.
b. Insufficient government R&D funding.
c. Insufficient support staff.
d. Outmoded scientific and technical equipment.
e. Lack of physical space for R&D operations.
f. Inability to stay abreast of rapidly growing scientific and technical knowledge.

III. Items for Technology Transfer
* The questions in this section were supposed to be answered only if a laboratory was involved in technology transfer to other organizations.

1. Government laboratories engage in technology transfer any of a number of reasons. To what extent is each of the following an important motivation for your laboratory's or parent organization's technology transfer activity (on a basis of 0-3 scale where 0 is "not a factor" and 3 is "very important")?

a. Legislative requirements.
b. To help economic development.
c. Outgrowth of cooperative R&D, consortium members or joint ventures.
d. Exchange of technical information.
e. Hope to increase lab's or parent agency's budget.
f. Scientists' and engineers' personal satisfaction at seeing ideas/technologies developed.
g. Scientists' and engineers' interests in entrepreneurship and personal wealth.

2. From the standpoint of "getting technology out the door" (getting others interested in using your lab's technology", how would you evaluate the lab's success during the past three years? Please rate on a 0-10 scale where 10 is excellent, 5 is average, and 0 is totally ineffective.

3. From the standpoint of commercial impact on the organizations receiving the technology, how would you evaluate the lab's success during the past three years? Please rate on a 0-10 scale where 10 is excellent, 5 is average, and 0 is totally ineffective.

4. Below is a list of possible technology transfer strategies. For those used by your laboratory, evaluate the success of particular strategies from the standpoint of "getting technology out the door," or interesting other organizations in your labs' technology (on a 0-3 scale where 0 is "no success as a strategy and 3 is "very successful strategy).

a. On-site seminars or conferences.
b. Fliers, newsletters or other mailed correspondence.
c. Person-to-person contacts.
d. Present papers or demonstrations at industry meetings.
e. Presentations at scientific meetings sponsored by professional organizations.
f. Presentations at scientific meetings sponsored by government organizations.
g. Memberships in research consortia or associations.

h. A special office or staff with responsibility for technology transfer activities.
i. Encouraging informal, on-site visits.
j. Personal exchanges.
k. Cooperative R&D.
l. Contractual relations for direct R&D funding.
m. Permitting persons from other organizations access to lab's equipment/facilities.
n. Sales of patents or copyrights.
o. Electronic media, such as videotape or computer diskettes.
p. Joint research in your lab.

5. For most labs, technology transfer activities can have both benefits and problems. 1) Please indicate whether your lab has experienced the following benefits (on a 0-3 scale where 0 is "no benefit" and 3 is "single most important benefit). (Note: check only one item as single most important benefit)

a. Profit for the laboratory.
b. Profit for individual scientists and inventors employed by your laboratory.
c. Increased public visibility of the laboratory and its activities.
d. Approval of legislative or executive branch government officials.
e. A more "real world" approach among the lab's scientific/technical personnel.
f. Drawing S&T personnel to collaborate on tech. development /transfer projects.
g. Gained technical knowledge from recipient organizations of technology.
h. Gained clients, users.

2) Please indicate whether your lab has experienced the following problems, (on a 0-3 scale where 0 is "no benefit" and 3 is "single most important benefit). (Note: check only one item as single most important problem)

a. Has taken away time from other research-related activities.
b. Has moved the lab's agenda away from fundamental or precommercial research.
c. Has led to disharmony and discord among scientific/technical personnel.
d. Has led to intellectual property disputes.
e. Too many interruptions from outsiders interested in our technology.

6. During fiscal year 1989 (for Japan, 1990), about how many technologies did your laboratory (or laboratory employees) allow others to use through sales of patents and copyrights?

7. During fiscal year 1989 (for Japan, 1990), about how many technologies, if any, were patented by your lab or lab employees?

IV. Items for Cooperative R&D

* The questions in this section were supposed to be answered only if a laboratory has any formal cooperative R&D agreements with outside organizations.

1. How many formal cooperative R&D agreements does your laboratory currently have? (Note: do not include ties to other labs owned by your parent agency.)

2. How many, if any, of these agreements are with foreign or foreign-owned organizations?

3. Please indicate below the percentage of cooperative R&D agreements with each of the categories of organizations.

a. Government (including government labs).
b. Industry.
c. Universities.
d. Private nonprofit.
e. Other.

4. Please list your most significant (up to three) cooperative R&D agreements (giving the name of the major cooperating organization or laboratory), where "significant" is defined in terms of the quality of the resulting R&D products.

5. Considering only the first cooperative R&D agreements listed above, what is the approximate total R&D budget and about how much does your laboratory contribute to the total R&D budget.

6. Generally speaking, to what degree have all your laboratory's cooperative R&D agreements contributed to your laboratory's overall research effectiveness in each of the following, (on a 0-3 scale where 0 is "not at all or not relevant" and 3 is "a great deal")?

a. Basic research and development of new knowledge.
b. Pre-commercial applied research.
c. Commercial applied research and development.
d. Technology transfer efforts.

7. Generally speaking, to what degree has your laboratory's participation in cooperative R&D agreements been motivated by the following, (on a 0-3 scale where 0 is "not at all or not relevant" and 3 is "a great deal")?

a. Desire for fundamental scientific knowledge.
b. Desire for new technology or applied knowledge.
c. Desire to contribute to other party(ies) involved in the agreement.
d. Incentives provided by other parties to the agreement.
e. Personnel exchange opportunities.
f. Increased profits or resources available to the lab or parent organization.
g. R&D mission of lab.
i. Other.

APPENDIX B

COLLINEARITY DIAGNOSTICS

Dependent Variable: INDAGREE

1. Japanese Data

Belsley, Kuh and Welsch's Condition Index Method

Collinearity Diagnostics

Number	Eigenvalue	Condition Index	Var Prop INTERCEP	Var Prop GOVPAREN	Var Prop BASBUD	Var Prop APPBUD
1	9.09308	1.00000	0.0001	0.0007	0.0018	0.0017
2	0.89805	3.18204	0.0000	0.0011	0.0076	0.0387
3	0.73423	3.51917	0.0000	0.0001	0.0017	0.2284
4	0.58642	3.93779	0.0001	0.0035	0.1509	0.0582
5	0.20889	6.59774	0.0005	0.0120	0.3279	0.0724
6	0.14748	7.85222	0.0001	0.0843	0.0543	0.1893
7	0.11096	9.05269	0.0004	0.1169	0.0995	0.0016
8	0.07563	10.96522	0.0003	0.0013	0.1448	0.2694
9	0.06145	12.16409	0.0013	0.1073	0.1567	0.1011
10	0.05440	12.92923	0.0012	0.3520	0.0227	0.0143
11	0.02215	20.26090	0.0098	0.1179	0.0011	0.0239
12	0.00727	35.35473	0.9862	0.2030	0.0311	0.0012

Number	Var Prop DEVBUD	Var Prop RDAPPR	Var Prop RDIND	Var Prop MISDIV	Var Prop PROJECT	Var Prop EFFRES	Var Prop BBUREAU	Var Prop RESSIZE
1	0.0016	0.0004	0.0014	0.0010	0.0013	0.0012	0.0007	0.0003
2	0.0011	0.0002	0.5793	0.0007	0.0006	0.0022	0.0000	0.0000
3	0.1255	0.0000	0.0623	0.0000	0.0042	0.0025	0.0001	0.0003
4	0.1644	0.0002	0.0781	0.0028	0.0000	0.0001	0.0000	0.0001
5	0.0683	0.0048	0.0009	0.1223	0.0546	0.0732	0.0006	0.0018
6	0.0011	0.0064	0.0881	0.0215	0.0545	0.4199	0.0000	0.0001
7	0.0532	0.0021	0.0159	0.0115	0.7002	0.0082	0.0330	0.0000
8	0.2059	0.0714	0.0503	0.4336	0.0951	0.1058	0.0724	0.0313
9	0.2998	0.0387	0.0038	0.3114	0.0270	0.0068	0.2118	0.1061
10	0.0733	0.0078	0.0023	0.0240	0.0095	0.1954	0.5209	0.0351
11	0.0058	0.8346	0.0003	0.0459	0.0000	0.0564	0.0028	0.4181
12	0.0000	0.0333	0.1172	0.0253	0.0530	0.1285	0.1576	0.4067

Variance Influence Factor Method

Variable	INTERCEP	BASBUD	APPBUD	DEVBUD	RDAPPR	RDIND
VIF Index	0.000000	1.539389	1.9242305	2.0172552	1.43543305	1.29482260

Variable	MISDIV	PROJECT	EFFRES	BBUREAU	LABSIZE	GOVPAREN
VIF Index	1.6623449	1.2146125	1.2802835	1.1145626	1.381359	1.52531444

2. United States Data

Belsley, Kuh and Welsch's Condition Index Method

Number	Eigenvalue	Condition Index	Var Prop INTERCEP	Var Prop GOVPAREN	Var Prop BASBUD	Var Prop APPBUD
1	8.60308	1.00000	0.0002	0.0013	0.0016	0.0019
2	0.93494	3.03343	0.0000	0.0075	0.0016	0.0252
3	0.81260	3.25377	0.0001	0.0004	0.1511	0.0128
4	0.66269	3.60307	0.0000	0.0006	0.0539	0.1851
5	0.22890	6.13062	0.0004	0.0407	0.0003	0.0491
6	0.20785	6.43355	0.0005	0.0505	0.1895	0.1813
7	0.14441	7.71855	0.0005	0.0721	0.0280	0.0621
8	0.13702	7.92395	0.0001	0.3238	0.0493	0.0411
9	0.09775	9.38146	0.0000	0.0109	0.0611	0.0387
10	0.08704	9.94157	0.0006	0.2470	0.1840	0.2877
11	0.06948	11.12771	0.0046	0.0106	0.0350	0.0603
12	0.01424	24.57579	0.9931	0.2345	0.2447	0.0548

Number	Var Prop DEVBUD	Var Prop RDAPPR	Var Prop RDIND	Var Prop MISDIV	Var Prop PROJECT	Var Prop EFFRES	Var Prop BBUREAU	Var Prop RESSIZE
1	0.0018	0.0015	0.0015	0.0016	0.0024	0.0014	0.0013	0.0008
2	0.0635	0.0114	0.2493	0.0013	0.0003	0.0002	0.0009	0.0000
3	0.1673	0.0036	0.0292	0.0010	0.0000	0.0002	0.0000	0.0000
4	0.1074	0.0065	0.0870	0.0001	0.0076	0.0004	0.0000	0.0000
5	0.0024	0.0212	0.0021	0.0001	0.7134	0.0383	0.0062	0.0048
6	0.1655	0.0128	0.0335	0.1608	0.0472	0.0477	0.0298	0.0143
7	0.0376	0.1543	0.2646	0.2764	0.0239	0.2237	0.0036	0.0004
8	0.0289	0.2982	0.0194	0.0001	0.1124	0.0004	0.1445	0.0114
9	0.0068	0.3684	0.0858	0.0023	0.0144	0.2701	0.4311	0.0333
10	0.2992	0.0302	0.1021	0.4967	0.0301	0.2086	0.0341	0.0261
11	0.0526	0.0024	0.0308	0.0556	0.0071	0.0961	0.3278	0.5707
12	0.0670	0.0895	0.0947	0.0042	0.0412	0.1129	0.0207	0.3381

Variance Influence Factor Method

Variable	INTERCEP	BASBUD	APPBUD	DEVBUD	RDAPPR	RDIND
VIF Index	0.0000000	2.0356151	1.9223482	1.8169345	1.5569396	1.8608169
Variable	MISDIV	PROJECT	EFFRES	BBUREAU	LABSIZE	GOVPAREN
VIF Index	1.3762708	1.1214095	1.1078647	1.1335584	1.1264127	1.3645901

APPENDIX C

WHITE TESTS FOR HETEROSKEDASTICITY

The White tests for heteroscedasticity were performed by using ACOV and SPEC options under the SAS program.

1. Japan

Dependent Variable: Technology Tranfer Effectiveness--Out-the-Door

Consistent Covariance of Estimates

ACOV	INTERCEP	INDAGREE
INTERCEP	0.0485036451	-0.001288495
INDAGREE	-0.001288495	0.0001421939

```
     Test of First and Second Moment Specification
DF:  2   Chisq Value:      2.0506   Prob>Chisq:   0.3587
```

Dependent Variable: Technology Tranfer Effectiveness--Licenses

Consistent Covariance of Estimates

ACOV	INTERCEP	INDAGREE
INTERCEP	18.768748063	-0.001792295
INDAGREE	-0.001792295	0.1947627934

```
     Test of First and Second Moment Specification
DF:  2   Chisq Value:      1.1906   Prob>Chisq:   0.5514
```

Dependent Variable: Technology Transfer Effectiveness--Market Impact

Consistent Covariance of Estimates

ACOV	INTERCEP	INDAGREE
INTERCEP	0.0553526412	-0.001611145
INDAGREE	-0.001611145	0.0003042668

```
     Test of First and Second Moment Specification
DF:  2   Chisq Value:      1.0116   Prob>Chisq:   0.6030
```

Dependent Variable: Cooperative R&D Propensity

Consistent Covariance of Estimates

ACOV	INTERCEP	GOVPAREN	BASBUD	APPBUD
INTERCEP	145.8046613	2.8575328875	-0.02759899	0.0217024196
GOVPAREN	2.8575328875	111.46988329	-0.268537284	-0.15836294
BASBUD	-0.02759899	-0.268537284	0.0028836235	0.0010569155
APPBUD	0.0217024196	-0.15836294	0.0010569155	0.0016547888
DEVBUD	0.218511553	0.7241164386	-0.000990861	-0.000262334
RDAPPR	-0.395329541	-0.462242052	0.0012155519	0.0000972021
RDIND	-2.299988554	-0.819154055	-0.002503792	0.0026994088
MISDIV	-4.102743697	-5.972833079	0.0069493378	-0.011244808
PROJECT	-9.170585638	-5.912286702	-0.004432863	-0.021021325
EFFRES	-2.103029937	7.7608967556	-0.022398654	-0.021479897
BBUREAU	-14.36369709	-6.573610903	0.0249665908	0.0226881336
RESSIZE	-14.04913607	-12.9533554	0.0198553547	0.0203628679

ACOV	DEVBUD	RDAPPR	RDIND	MISDIV
INTERCEP	0.218511553	-0.395329541	-2.299988554	-4.102743697
GOVPAREN	0.7241164386	-0.462242052	-0.819154055	-5.972833079
BASBUD	-0.000990861	0.0012155519	-0.002503792	0.0069493378
APPBUD	-0.000262334	0.0000972021	0.0026994088	-0.011244808
DEVBUD	0.0074779856	-0.003630146	-0.00818385	-0.057952174
RDAPPR	-0.003630146	0.005446045	0.012880056	0.0360391271
RDIND	-0.00818385	0.012880056	0.2046705923	0.0572168156
MISDIV	-0.057952174	0.0360391271	0.0572168156	1.7703762186
PROJECT	-0.075392232	0.0184179237	-0.058880245	0.6361816095
EFFRES	0.035670508	-0.021760862	-0.024012132	-0.381556646
BBUREAU	-0.045123603	0.0451859806	0.3396582959	0.3182575716
RESSIZE	-0.11228837	0.0572239095	0.2694734428	0.9860780924

ACOV	PROJECT	EFFRES	BBUREAU	RESSIZE
INTERCEP	-9.170585638	-2.103029937	-14.36369709	-14.04913607
GOVPAREN	-5.912286702	7.7608967556	-6.573610903	-12.9533554
BASBUD	-0.004432863	-0.022398654	0.0249665908	0.0198553547
APPBUD	-0.021021325	-0.021479897	0.0226881336	0.0203628679
DEVBUD	-0.075392232	0.035670508	-0.045123603	-0.11228837
RDAPPR	0.0184179237	-0.021760862	0.0451859806	0.0572239095
RDIND	-0.058880245	-0.024012132	0.3396582959	0.2694734428
MISDIV	0.6361816095	-0.381556646	0.3182575716	0.9860780924
PROJECT	5.3916065625	0.0653603493	0.3925467208	1.7512323682
EFFRES	0.0653603493	1.3273084399	-0.655999522	-0.857795787
BBUREAU	0.3925467208	-0.655999522	4.1544646489	1.7261500403
RESSIZE	1.7512323682	-0.857795787	1.7261500403	3.744911243

Test of First and Second Moment Specification

DF: 67 Chisq Value: 63.3699 Prob>Chisq: 0.6032

2. The United States

Dependent Variable: Technology Tranfer Effectiveness--Out-the-Door

Consistent Covariance of Estimates

ACOV	INTERCEP	INDAGREE
INTERCEP	0.0409666563	-0.000145906
INDAGREE	-0.000145906	8.4748584E-6

Test of First and Second Moment Specification
DF: 2 Chisq Value: 1.8300 Prob>Chisq: 0.4005

Dependent Variable: Technology Tranfer Effectiveness--Licenses

Consistent Covariance of Estimates

ACOV	INTERCEP	INDAGREE
INTERCEP	0.0375576552	-0.000189674
INDAGREE	-0.000189674	0.0000357363

Test of First and Second Moment Specification
DF: 2 Chisq Value: 1.2724 Prob>Chisq: 0.5293

Dependent Variable: Technology Transfer Effectiveness--Market Impact

Consistent Covariance of Estimates

ACOV	INTERCEP	INDAGREE
INTERCEP	0.0583391476	-0.000231485
INDAGREE	-0.000231485	3.9078931E-6

Test of First and Second Moment Specification
DF: 2 Chisq Value: 6.1346 Prob>Chisq: 0.0465

Dependent Variable: Cooperative R&D Propensity

Consistent Covariance of Estimates

ACOV	INTERCEP	GOVPAREN	BASBUD	APPBUD
INTERCEP	1060.7453233	-102.9304561	-3.064771706	0.4034103351
GOVPAREN	-102.9304561	212.56987469	0.5022724872	-0.46979997
BASBUD	-3.064771706	0.5022724872	0.0207266322	0.007402994
APPBUD	0.4034103351	-0.46979997	0.007402994	0.0200753609
DEVBUD	-0.346770746	-0.447285287	0.0068481593	0.0130943904
RDAPPR	-1.760320496	0.1506723394	0.0063891734	0.0000609107
RDIND	-4.908803315	1.89712775	0.0257812302	-0.010793357
MISDIV	-55.36918548	17.399558585	-0.308052362	-0.588135526
PROJECT	-70.97957104	-56.53897485	0.1532207965	0.2399720703
EFFRES	32.930496113	-62.32280483	-0.282663153	0.2312237855
BBUREAU	22.31139028	10.262634652	-0.116512265	-0.138851066
RESSIZE	-163.9207441	5.2289109908	0.5193298334	-0.079394667

ACOV	DEVBUD	RDAPPR	RDIND	MISDIV
INTERCEP	-0.346770746	-1.760320496	-4.908803315	-55.36918548
GOVPAREN	-0.447285287	0.1506723394	1.89712775	17.399558585
BASBUD	0.0068481593	0.0063891734	0.0257812302	-0.308052362
APPBUD	0.0130943904	0.0000609107	-0.010793357	-0.588135526
DEVBUD	0.0243192343	0.0022553493	-0.006686898	-0.380976491
RDAPPR	0.0022553493	0.0066072004	0.01814899	-0.028809229
RDIND	-0.006686898	0.01814899	0.136244423	-0.205702052
MISDIV	-0.380976491	-0.028809229	-0.205702052	35.978188033
PROJECT	0.6508205298	0.1465889083	-0.610727646	-7.234844926
EFFRES	0.2408648141	-0.060430908	-0.969532692	-5.005473613
BBUREAU	-0.291856019	-0.139131513	0.1340423864	5.0960826861
RESSIZE	-0.020532475	0.2773852818	0.7766430464	5.8305905472

ACOV	PROJECT	EFFRES	BBUREAU	RESSIZE
INTERCEP	-70.97957104	32.930496113	22.31139028	-163.9207441
GOVPAREN	-56.53897485	-62.32280483	10.262634652	5.2289109908
BASBUD	0.1532207965	-0.282663153	-0.116512265	0.5193298334
APPBUD	0.2399720703	0.2312237855	-0.138851066	-0.079394667
DEVBUD	0.6508205298	0.2408648141	-0.291856019	-0.020532475
RDAPPR	0.1465889083	-0.060430908	-0.139131513	0.2773852818
RDIND	-0.610727646	-0.969532692	0.1340423864	0.7766430464
MISDIV	-7.234844926	-5.005473613	5.0960826861	5.8305905472
PROJECT	68.62194738	23.73988258	-24.88911586	12.451539788
EFFRES	23.73988258	30.3298896	-7.819480473	-5.92968788
BBUREAU	-24.88911586	-7.819480473	23.30886777	-7.028228261
RESSIZE	12.451539788	-5.92968788	-7.028228261	30.076178187

Test of First and Second Moment Specification

DF: 76 Chisq Value: 33.6138 Prob>Chisq: 1.0000

APPENDIX D

OLS REGRESSION COEFFICIENTS USED AS THE BASES FOR STANDARD AND TRUNCATED POISSON REGRESSION MODELS: DEPENDENT VARIABLE--INDAGREE

Variable	Parameter Estimates: OLS Estimates for Standard Poisson Regression		OLS Estimates for Truncated Poisson Regression	
	United States	*Japan*	*United States*	*Japan*
Constant	-85.235**	-15.513	-180.17*	11.487
BASBUD	0.184	0.099	0.654	0.257*
APPBUD	0.088	0.003	-0.020	-0.165
DEVBUD	0.088	-0.098	0.414	-0.276†
RDAPPR	0.148	0.073	0.420	0.257
RDIND	0.321	0.330	1.331	-0.743
MISDIV	6.691	1.972	6.243	3.786
PROJECT	12.000	1.683	31.916	9.301
EFFRES	1.784	-1.446	3.099	1.474
BBUREAU	-5.648	1.931	0.653	6.986
LABSIZE	13.724****	3.401*	20.100***	-2.346
GOVPAREN	-2.185	-10.659†	0.960	-49.228***
N	152	68	69	34
Mean of Y	13.6	4.99	29.87	9.97
F-value	2.49	1.70	1.77	3.07
Prob. value	0.01	0.09	0.08	0.01
R^2	0.16	0.25	0.25	0.61
Adjusted R^2	0.10	0.10	0.11	0.41

* For Truncated Regressions, Left Truncation at Y=0.
* Significance: † p<.10,* p<.05, ** p<.01,*** p<.001,**** p<.0001

APPENDIX E

TESTS FOR OVERDISPERSION OF THE COUNT DATA

As suggested by Cameron and Trivedi (1990), tests for overdispersion are performed using two regression-based statics, i.e., $g(\mu_i) = \mu_i$, and $g(\mu_i) = \mu_i^2$. Only when the mean-variance equality assumption holds for both statics, we could accept the assumption of no overdispersion in a statistical sense.

1. Japan

Models	Test Statics $g(\mu_i) = \mu_i$	$g(\mu_i) = \mu_i^2$	H0: $(y-E[y])^2=E[y]$
Dependent Variable: INDAGREE			
Standard Poisson	2.43 (0.018)	1.08 (0.286)	Reject
Truncated Poisson	4.26 (0.000)	13.65 (0.000)	Reject
Dependent Variable: Licenses			
Standard Poisson	1.62 (0.110)	1.58 (0.117)	Accept

* Statistics: t-ratio (Prof>T).

2. The United States

Models	Test Statics $g(\mu_i) = \mu_i$	$g(\mu_i) = \mu_i^2$	H0: $(y-E[y])^2=E[y]$
Dependent Variable: INDAGREE			
Standard Poisson	2.03 (0.044)	1.19 (0.242)	Reject
Truncated Poisson	2.50 (0.013)	2.21 (0.029)	Reject
Dependent Variable: Licenses			
Standard Poisson	2.17 (0.032)	2.04 (0.043)	Reject

* Statistics: t-ratio (Prof>T).

APPENDIX F
PARTIAL DERIVATIVES OF POISSON AND NEGATIVE BINOMIAL REGRESSIONS
DEPENDENT VARIABLE--INDAGREE

The tables below present information about partial derivatives of expected valence with respect to the vector of characteristics. They are computed at the means of the independent variables. Observations used for means are all observations.

1. Japan

Variable	Standard Poisson	Negative Binomial	Truncated Poisson	Truncated Negative Binomial
Constant	-14.043****	-17.359****	-15.167*	-19.945†
GOVPAREN	-1.880**	0.057	-11.801****	-9.560*
BASBUD	0.063****	0.075****	0.179****	0.191****
APPBUD	-0.035*	-0.029†	-0.231****	-0.149**
DEVBUD	-0.045***	-0.045***	-0.098**	-0.066
RDAPPR	0.039**	0.053***	0.184***	0.191*
RDIND	0.265**	0.306****	0.010	-0.127
BBUREAU	0.999**	1.318****	4.635****	4.679**
MISDIV	1.907****	1.756****	3.610***	1.988
PROJECT	1.083†	0.542	5.904***	6.133†
EFFRES	-0.448*	-0.012	0.834	1.357
LABSIZE	1.887****	1.738****	-0.358	-0.027
Conditional $\overline{X}$	2.88	3.035	6.565	6.870
Scale Factor	2.88	3.035	6.504	6.593

* For Negative Binomial Regressions, Fixed Value (alpha=0.2).
* For Truncated Regressions, Left Truncation at Y=0.
The numbers in the parentheses indicate the number of observations used to obtain the OLS starting values in the truncated Poisson and negative binomial estimation procedures.
* Significance: † <.10, * p<.05, ** p<.01, *** p<.001, **** p<.0001

2. United States

Variable	Standard Poisson	Negative Binomial	Truncated Poisson	Truncated Negative Binomial
Constant	-26.344****	-27.939****	-73.602****	-75.052****
GOVPAREN	-0.761**	1.978****	-0.358	0.116
BASBUD	0.110****	0.095****	0.376****	0.412****
APPBUD	0.073****	0.135****	0.066****	0.276****
DEVBUD	0.092****	0.056****	0.343****	0.330****
RDAPPR	0.061****	0.034****	0.243****	0.232****
RDIND	0.177****	0.192****	0.817****	0.755****
BBUREAU	-2.191****	-0.659****	-1.562***	3.069****
MISDIV	1.381****	1.063**	-0.452	0.811****
PROJECT	4.024****	3.492****	13.781****	15.368****
EFFRES	0.777****	-0.022	3.421****	1.957**
LABSIZE	3.621****	3.488****	7.889****	8.131****
Conditional $\overline{X}$	3.462	3.817	9.981	13.742
Scale Factor	3.462	3.817	9.977	13.674

* For Negative Binomial Regressions, Fixed Value (alpha=0.2).
* For Truncated Regressions, Left Truncation at Y=0.
  The numbers in the parentheses indicate the number of observations used to obtain the OLS starting values in the truncated Poisson and negative binomial estimation procedures.
* Significance: † <.10, * p<.05, ** p<.01,*** p<.001,**** p<.0001

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