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DO DIFFERENT EXPENDITURE MECHANISMS INVITE DIFFERENT INFLUENCES? EVIDENCE FROM RESEARCH EXPENDITURES OF THE NATIONAL INSTITUTES OF HEALTH

A Dissertation
Presented to
The Academic Faculty

by

Jungbu Kim

In Partial Fulfillment
of the Requirements for the Degree
Doctor of Philosophy in Public Policy

Georgia State University and the Georgia Institute of Technology
August 2007

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DO DIFFERENT EXPENDITURE MECHANISMS INVITE DIFFERENT INFLUENCES? EVIDENCE FROM RESEARCH EXPENDITURES OF THE NATIONAL INSTITUTES OF HEALTH

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With deepest appreciation
To
My wife, Seung-Ah Lee
And
My daughter, Anna Lee Kim

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LIST OF SYMBOLS AND ABBREVIATIONS

ATP	Advanced Technology Program
CJ	Congressional Budget Justification
CSEPP	Committee on Science, Engineering, & Public Policy
CSR	Center for Scientific Review
EAC	External Advisory Committee of the Director's Advisory Committee
EO	Executive Order
FFY	Federal Fiscal Year
GOCO	Government-Owned, Contractor-Operated Laboratories
GOGO	Government-Owned, Government-Operated Laboratories
IOM	Institute of Medicine
HHS	Department of Health and Human Serevices
NCI	National Cancer Institute
NEI	National Eye Institute
NHLBI	National Heart, Lung, and Blood Institute
NHGRI	National Human Genome Research Institute
NIA	National Institute on Aging
NIAAA	National Institute on Alcohol Abuse and Alcoholism
NIAID	National Institute of Allergy and Infectious Disease
NIAMS	National Institute of Arthritis and Musculoskeletal and Skin Disease
NIBIB	National Institute of Biomedical Imaging and Bioengineering
NICHD	National Institute of Child Health and Human Development
NIDCD	National Institute on Deafness and Other Communications Disorders

NIDCR	National Institute of Dental and Craniofacial Research
NIDDK	National Institute of Diabetes and Digestive and Kidney Disease
NIDA	National Institute on Drug Abuse
NIEHS	National Institute of Environmental Health Sciences
NIGMS	National Institute of General Medical Sciences
NIH	National Institutes of Health
NIMH	National Institute of Mental Health
NINDS	National Institute of Neurological Disorders and Stroke
NINR	National Institute of Nursing Research
NLM	National Library of Medicine
NRC	National Research Council
NSF	National Science Foundation
OMB	Office of Management and Budget
OSRD	Office of Scientific Research and Development
R&D	Research and Development
PHSA	Public Health Service Act
PSE	Public Service Experience
PSM	Public Service Motivation
RPG	Research Project Grant

SUMMARY

This study examines 1) whether the different expenditure mechanisms used by the National Institutes of Health (NIH) invite different sources of influences on the budget process and thus on the expenditure outcomes and 2) whether the frequent use of omnibus appropriations bills since 1996 has changed budget levels of the institutes under the NIH. The NIH uses two major expenditure mechanisms with very different beneficiary groups: the principal investigator-initiated Research Project Grants and Intramural Research. Drawing on theories of motivations of public officials and of political clout of agency heads and considering empirical studies of the effect of omnibus legislation, this study reveals the following: 1) directors with more public service experience are more successful in securing a higher budget for their institutes; 2) while the directors are found to be driven by public service motivation, when it comes to expenditure allocation between two different mechanisms, they behave in a self-interested manner, representing the interests of the institutional sectors where they have developed close relationships; 3) with ever-increasing budgets between 1983 and 2005, the institute directors have chosen to seek higher budgets rather than merely avoid the risk of budget cuts; 4) although the advisory boards are purportedly used to seek private input for the priority setting, they tend to increase intramural more than external research project grant expenditures; 5) the practice of omnibus appropriations bills significantly benefits the institutes under the NIH such that with omnibus legislation the institutes' total expenditures have more than doubled controlling the other factors; and 6) there are significant differences in the effects of the director's public experience and the number of advisory boards and their membership both (i) between disease-focused institutes and nondisease institutes and (ii) with and without omnibus legislation. The effects of the director's public service experience and the advisory boards have more budgetary impact

in the general science-focused institutes than in their disease-focused counterparts. The influence of the advisory board and of the institute director's public service experience on the individual institute's expenditure level is significantly diminished by the frequent use of omnibus appropriations bills.

The findings of this study provide a link between the literature of decision-making for distributive policy and studies of research and development policy.

CHAPTER 1

INTRODUCTION

> "It would be appropriate for the new Administration and the leading professional groups to reconsider … the basis of the division of NIH-supported research among government laboratories, universities, other research institutions, and the for-profit sector." – Alan N. Schechter (1993)

Research Questions

Public budgeting is political since it is ridden with incremental bargaining, interest group influence, and decision-making (Rubin, 2006; Wildavsky & Caiden, 1997; Meyers, 1995). However, the political nature of public budgeting of Research and Development (R&D) expenditures has not been seriously examined, especially when an agency uses multiple expenditure mechanisms to support research performed by scientists in different institutional settings. The prime question this study tries to answer is: *do different mechanisms of R&D expenditures invite different influences from the leadership of an agency, congressional members, and the targeted beneficiary groups?*

This study provides a link between the literature of R&D policy and that of public expenditure of distributive programs by focusing on the characteristics of R&D expenditure decision-making at the agency level with the case of the expenditure mechanisms of the National Institutes of Health (NIH). While the literature of decision-making of distributive programs deals largely with their efficiency issues, R&D policy studies are concerned primarily with innovative potentials of R&D as it relates to the economy. As such, the theoretical treatment of R&D programs pays little attention to the issues of their distributive political characteristics.

The NIH, as the nation's prime engine of medical research, supports a variety of research and training activities performed by universities, intramural laboratories, and nonprofit institutions. Research supported by the NIH is recognized as being "at the

pinnacle of success" (IOM, 2004), and the discovery and innovation powered by the NIH have improved health in America and around the world. To fund medical research, the NIH uses multiple expenditure mechanisms, including competing or noncompeting grants, research centers, cooperative agreements, and contracts. Depending on various funding mechanisms, the NIH classifies its expenditures into Research Project Grants (RPGs), Research Centers, Other Research, Training, R&D Contracts, Intramural Research, Research Management and Support, Cancer Control, and Construction.[1]

Aware of NIH's success, Congress has been persistently vigilant of the relative vitality of NIH research activities that are supported by different mechanisms (IOM, 1988, 1998, 2004; EAC, 1994; Klausner, 1992; NRC & IOM, 2003). Congressional interests in NIH funding and its priority settings are apparently motivated by efficiency considerations, as in the Senate amendment to the Muscular Dystrophy Community Assistance, Research and Education Amendments of 2001.[2] One of the amendment's specific charges upon the Institute of Medicine was to consider "the current areas of research incorporating Centers for Excellence and the relationship of this form of funding mechanism to other forms of funding for research grants, including investigator-initiated research, contracts, and other types of research support awards." The report by NRC and IOM (2003) was also initiated by the congressional mandate to examine "whether the structure and organization of NIH are *optimally* configured for the scientific needs of the twenty-first century" (p. 2, emphasis added).

An assumption of these evaluation reports is that the process and structure of the NIH support mechanisms and their respective expenditure amounts should be determined in the most efficient manner by their relevant participants, whose interests may not be in

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[1] A more detailed description of these expenditure mechanisms is provided in Chapter 2.
[2] The amendment required the Secretary of Health and Human Services to organize a study "on the impact of, need for, and other issues associated with Centers of Excellence at the National Institutes of Health" (IOM, 2004, p. 21).

line with each other's. Each of the NIH funding mechanisms represents a specific type of government policy tool that in turn involves a different group of participants (Salamon, 2002). There are at least seven types of interested constituents in the process of research priority setting and funding decisions: extramural research scientists, clinicians, organized voluntary groups and individuals with regard to specific diseases, organizations and individuals representing population groups, members of Congress, the media (IOM, 1998), and intramural scientists. Given these diverse constituent groups and the consideration that R&D programs are also an example of distributive policy (Lowi, 1964; Meier, 1993), it would be naïve to expect these different constituent groups to cooperate with each other to find the most efficient allocation of R&D funds through different expenditure mechanisms.

In addition to the efficiency question, an alternative empirical question about the funding mechanisms of the NIH would concern how each of its constituent groups influences the processes of budgeting and expenditure decisions. How do different incentives and institutional practices influence expenditure decisions on the multiple mechanisms of the NIH research funding? With a unique set of expenditure beneficiaries, each of the expenditure mechanisms represents the different interests of the different groups. An understanding of R&D budgeting and expenditures would be furthered by an analysis of institutional and actor dimensions—such is the purpose of this research.

The first research question this study examines is *what and how much impact do the different participants in the budgeting process of the NIH research funds have on the expenditure structures of the different funding mechanisms?* Specifically, how are funding decisions made between intramural and private principal investigator-initiated research? The main argument to be made and tested regarding this question is that NIH funding decisions are a function of political factors among directors of the component institutes, interested parties including advisory boards, and members of relevant congressional committees.

The second question to be investigated in this study is *does a change in appropriations practice affect R&D expenditure outcomes by changing the incentives of relevant actors?* The possible effect to be examined is that of the frequent use of omnibus appropriations bills on the dynamics of R&D budget appropriations and thus on R&D funds expenditures of the institutes under the NIH. While omnibus continuing budget resolutions were frequently used in the 1980s, the utilization of omnibus "appropriations" bills is relatively new, first used in Federal Fiscal Year (FFY) 1996. If the impacts are substantial, the NIH may lead to higher levels of uncertainty in the funding streams because of tougher competition from non-R&D programs, which impose an additional burden on researchers in both public and private institutions. The findings are expected to shed new light on current dynamics of federal R&D funding and provide a contribution to the legislative decision-making literature.

These two questions aim to uncover political dynamics of R&D expenditure decision-making at the congressional as well as at the agency level. The decentralized system of R&D budgeting[3] does not mean that appropriations and expenditure decisions on R&D programs have no unique features distinct from other distributive programs. To the contrary, the decentralization in R&D budgeting provides all relevant actors opportunities to be engaged with the process. This research shows that the dynamics of R&D budgeting is closely intertwined with the unique nature of R&D activities as well as the institutional practices of Congress and executive agencies.

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[3] The decentralized system of R&D budgeting refers to the following factors: first, there is no central body to deal with science and technology policy issues, and second, budgets for R&D are handled by a variety of committees in Congress.

New Focus on the R&D Programs as a Distributive Policy

Confronted with increasingly tough competition from abroad and multiple warnings from indicators of R&D activities (CSEPP, 2006; Bonvillian, 2004), U.S. R&D investment draws increasing attention from policymakers as well as R&D insiders. While organizational and procedural reforms (Carnegie Commission, 1994) in R&D budgeting processes are as much of an issue as more spending and priority adjustments, the political nature of the decision characteristics of R&D budgeting and expenditures have gotten short-shrifted in the literature of R&D policy except when consideration is given to tracking annual trends of R&D budgets for federal agencies. On the other hand, some studies of legislative behavior that focus on congressional committees and subcommittees (Sheplse & Weingast, 1987; Weingast & Marshall, 1988), amendment rules (Baron & Ferejohn, 1989; Fréchette et al., 2003; Primo, 2003) and distributive politics (Weingast et al., 1981; Denzau & Munger, 1986; Baron, 1991; DelRossi & Inman, 1999), and relationships between budget processes and levels of spending (Ferejohn & Krehbiel, 1987; Dharmapala, 2006) examine the implications of the distributive program as "a political decision that concentrates benefits in a specific geographic constituency and finances expenditures through generalized taxation" (Weingast et al., 1981, p. 644). The main argument from the legislative decision-making studies with respect to levels of spending on distributive programs is that, regardless of the specified nature of congressional decision-making in terms of universalism[4] and reciprocity (Mayhew, 1974; Weingast, 1979; Weingast et al., 1981), majoritarian minimal winning coalitions (Riker, 1962; Baron, 1991, 1993), or log-rolled super-majorities (Groseclose & Snyder, 1996),

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[4] According to the universalism norm, benefits are distributed to most, if not all, of the geographic districts, as opposed to only the districts of the winning coalitions.

the members of Congress demand more distributive projects to be financed by general taxation, causing too much spending and inefficiency (DelRossi & Inman, 1999).

However, a specific focus on R&D budgets is missing, with the notable exception of Gist (1981), who tackled the impact of changes in budget authorizations on military R&D appropriations. As a result of this deficit, things get complicated when applying these arguments from legislative decision-making studies, especially those with implications of spending on distributive programs, to the analysis of public R&D expenditures. Categorized as a distributive policy (Lowi, 1964; Meier, 1993)[5], public R&D programs are distinct from and much more subtle than other locally beneficial projects.[6] Knowledge from pure sciences has the nature of non-excludability and nonrivalry (Nelson, 1959). The most prominent characteristic of R&D outputs is spillovers benefiting those other than conductors and supporters of R&D. Accordingly, R&D expenditures benefit not only the direct recipient of public money, who may be either special interests or a district, but also the economy as a whole (Boskin & Lau, 1992, 1996; CBO, 2005; Griliches, 1988, 1994; Jorgenson & Griliches, 1967; Mansfield, 1980; Scherer, 1983; Solow, 1957; Terleckyi, 1974). These characteristics of R&D programs are not captured by formal models of geography-based representative legislature. For example, in building a politicians' objective function of a distributive program, Weingast et al. (1981) and Shepsle and Weingast (1984) treated benefits and

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[5] While citing Lowi (1964) in a discussion of policy typology, Weingast et al. (1981) did not mention defense R&D as an example of a distributive policy, implying that classification of R&D programs into a specific policy type could be tricky.

[6] According to scholars such as Becker (1983), McKean (1965), Wintrobe (1987), and Wittman (1989, 1995), this does not represent a problem at all because, it is argued, the political market clears itself, with both pork-barrel projects and R&D programs being funded at the socially optimal level. On the other hand, Coates and Morris (1995) argue that under the conditions of imperfect information on the part of voters about both public projects and politicians, politicians may want to use inefficient public projects over cash transfer to benefit special interests for fear of reputational penalty.

costs flowing to other districts as politically irrelevant, with the conclusion that a distributive policy intervention is not necessarily a Pareto-improvement.

Into this junction comes the need for an independent focus on budgeting and expenditure decisions of R&D programs, which is justified by both the need for theoretical treatment of the implications of the nature of R&D activities in the distributive policy process and the practical need for more informed decisions. This new theoretical interest will direct our attention to the characteristics of R&D expenditure decisions at the various levels of government, with special focus on the political incentives of the participating actors and the institutional structure of the decision-making processes.

Given that various units of the government are engaged in R&D funding decisions in the U.S., this study focuses on two distinct but interrelated dimensions. The first dimension is the characteristics of the institutional framework of R&D budgeting and expenditure decisions where the most political factors are commingled. Especially in the U.S., the R&D budgeting process is a decentralized one in which a wide range of R&D-related agencies and congressional actors are involved without a centralized coordinating body. There are multiple sources of influences in effect, including bureaucrats from executive branches, presidential staff, and members of Congress, especially those of the Appropriations Committees and committees with jurisdictions over science and technology. The second dimension is the decisions made by the individual agencies. At the agency level, funding decisions regarding specific research projects involve multiple parties from the government and private industries.

The theoretical as well as practical implications of the dimension of institutional characteristics are of critical importance to the understanding of the actor incentives dimension. The level of public involvement in R&D is dependent on the institutional arrangements through which public demand for R&D is aggregated and incentives for public and private actors are provided. Institutional settings condition how politicians and bureaucrats act with respect to public demand for R&D. The behaviors at the agency

level are also structurally constrained and/or encouraged by incentive structures under specific institutional settings (North, 1990). Thus, institutions and actors jointly explain the level of public involvement in R&D.

Funding decisions at the NIH exemplify how much the decisions could be complicated among multiple actors: the NIH not only commands intramural laboratories but also extensively funds private research. To support research at private settings, the NIH uses multiple mechanisms as described in Chapter 2, including principal investigator-initiated RPGs, Research Centers, and R&D Contracts. Each of these different funding mechanisms invites unique profiles of participant groups with their own interests and incentives, providing a test bed to examine hypotheses about relationships between specific factors of institutional arrangements and participants and expenditures through the mechanisms. The test bed aspect of these public R&D expenditures is why this study analyzes factors involving expenditure decisions of research funding by this agency.

Scope of Research

This study analyzes expenditures by 18 institutes of the NIH between FFY1983 and FFY2005. The main explanatory variables are proxies for influences of various sources including politically appointed institute directors, private beneficiaries in the medical research community, and congressional actors in the appropriations subcommittees that deal with NIH budgets.

The NIH uses specific labels to refer to its grant programs, such as P01 (Program Projects), R01 (RPGs), R15 (Academic Research Enhancement Award), R21 (Exploratory/Developmental Grants), U01 (Research Project Cooperative Agreements), etc. This study is limited to expenditure data that are grouped into the aforementioned expenditure mechanisms and is not concerned with the specific grant programs.

This study likewise is not concerned with the types of research funded by the institutes. The NIH supports both basic and applied research, about 55% and 40% of its total expenditures, respectively, as of FFY 2006. The NIH tracks its expenditures on research by specific diseases or areas, including aging, AIDS, and Alzheimer's disease. For example, expenditures on aging issues are largely undertaken by the National Institute on Aging (NIA). This study does not address these different classifications of the NIH expenditures, in part because of data availability and in part because they are dependent on specific institutes.

The study is organized as follows. The second chapter provides an overview of the NIH and its expenditure mechanisms using a framework based on the R&D policy tools approach. Chapter 3 focuses on theoretical issues in government R&D expenditures and provides testable hypotheses followed by a discussion of the methods used to test the hypotheses. Chapter 5 reports and discusses the analytical findings. Chapter 6 concludes with discussions of this study's contributions, the limitations of the study, and further research agendas.

CHAPTER 2

R&D TOOLS AND NIH EXPENDITURE MECHANISMS

Tools of R&D Policy

Lowi (1964, 1972) discusses how policies affect political results. The choice of a policy is inevitably inseparable from the choice of a policy tool. Therefore, characteristics of the tools selected make a difference in the political process regarding the policy. Despite its theoretical importance, only RAND (2001)[7] has studied tool choice in the R&D policy area at the agency level. In the R&D policy area, a wide range of tools are utilized to promote R&D activities in the economy. Accordingly, the literature has paid substantial attention to how each of the tools for R&D encouragement affects the behaviors of individuals and the economy. However, the empirical studies on how a R&D policy tool contributes to the innovative capacity of an economy begs the question of how the tool is selected to begin with. What is missing from the perspective of policy process is an empirical analysis of politics through which R&D policy tools are selected and implemented.

The U.S. government uses multiple tools to promote R&D activities: it has directly funded roughly 700 federal laboratories, about 100 of which are large enough to influence the U.S. capacity of innovation and economic competitiveness (Crow & Bozeman, 1998). The government also supports about 14,000 industrial laboratories

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[7] If there is no effective market providing certain types of R&D activities, the federal government may set up R&D labs to do such research. This is true for the cases of National Aeronautics and Space Administration (NASA) and Department of Defense (DOD). For the U.S. Army, the RAND Arroyo Center recommends intramural R&D if, for a certain technology, there is high Army-specific utility. On the other hand, if there are both high Army utility and market potential, it is better to pursue collaborative R&D (RAND, 2001).

through research grants and tax credits. As of FFY 2004, federal obligations to university R&D amounted to $27.3 billion. Considering this profile of federal R&D involvement, the policy tools that can intervene in the nation's R&D efforts could be divided into two types: 1) establishment and management of governmental labs and 2) tools that aim to influence the incentives that private actors may have in R&D investment.[8]

More specifically, four policy tools with budgetary implications are easily identified in the R&D area: 1) direct performing of R&D by federal research agencies such as NASA or NIH, which could be termed government-owned, government-operated laboratories (GOGOs); 2) government-owned, contractor-operated laboratories (GOCOs); 3) government grants to finance private research in universities and firm laboratories; and 4) tax incentives to private firms. Of the $105 billion federal R&D obligations[9] in FFY 2004, $37.7 billion was channeled into industrial laboratories (NSF, 2005). Among the federal R&D obligations to industrial R&D are tax incentives (tax deductions and tax credits): "[T]he research and experiment tax credit represents a small fraction of federal R&D expenditures, about 2.6 percent of total federal R&D funding and about 6.4 percent of federal R&D for industry" (Audretsch et al., 2002). Table 1 illustrates the major policy tools to engage R&D activities in a nation.

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[8] In addition to the tools that have direct budgetary implications, the government can affect scientific and technological activities in a society through various institutional supports, such as intellectual property protection policies including the patent policy, technology transfer, antitrust regulations, etc.

[9] In this case, *obligation* means "binding financial commitment in a congressional budget appropriation" and includes "contracts, staff employment, and purchases of goods and services" (NIAID, 2007).

Table 1. Types of R&D Policy Tools

Direct ←----------→ Indirect			
GOGO	GOCO	Research Grants to Universities, Nonprofits, and Industrial Firms	Tax Incentives to Industrial Firms

These budget-related tools could be assessed in terms of directness of tool dimension (Salamon, 2002). The GOGO labs are the most direct form of policy intervention, while tax incentives to private firms for R&D are the most indirect form of support. This typology need not be based on a rather naïve concept of R&D laboratory systems that "universities are seen as the bastion of fundamental research, industry as home of commercially-related applied and development work, and … governmental labs … as sites for supporting national research missions, especially in weapons, energy, space and agriculture" (Crow & Bozeman, 1998). This typology is irrelevant to what types of research the entities are conducting, focusing instead on how each of the tools works and who controls the money and research topics. However, what types of R&D are to be encouraged is critical when considering which types of tools to choose. For example, if the government wants to promote basic research, GOGO labs or grants to universities can be a better option than tax incentives to firms. This typology provides a sense of main beneficiaries of each type of tools. Budgets for the most *direct* form of GOGO labs support primarily government bureaucracies and public scientists. Private firms are the main beneficiaries of tax expenditures because they seek research issues of their best interests without crippling governmental interventions.

Intramural research (in GOGO labs) is an example of direct government support in the tools approach. The defining feature of direct government support is "the use of bureaucracy to mobilize resources and to carry out decisions" (Salamon, 2002). According to Leman (2002), the following situations may require the use of direct

government involvement: 1) “where the exercise of legitimate force is involved,” 2) “where performance cannot easily be left to chance,” 3) “where equity considerations are especially important,” and 4) “where the maintenance of some government capability is essential” (pp. 61–62). In such cases, direct government involvement may provide more flexibility and responsiveness since it saves transaction costs with private actors and must adjust to changes only internally. From these rationales, intramural research by the NIH may be justified by the fourth reason: through this direct involvement, the agency retains the internal capacity to set priorities and evaluate the results of extramural scientists, which allows them to continue to conduct state-of-the-art research without relying on or being imposed upon by external factors.

The utility and rationale of each tool provide us with an explanation of why the government uses them. However, they do not answer the question of why some tools are utilized more extensively than others. A government agency could exercise the same function both directly and indirectly (Leman, 2002): the NIH both conducts state-of-the-art biomedical research through its in-house laboratories and funds university research more extensively in terms of expenditure amount. Why this arrangement and specific profiles of tool combinations at the NIH’s individual institutes level? This question will be addressed through an analysis of factors involving expenditure decisions by multiple mechanisms of the NIH.

Overview of the National Institutes of Health

The NIH originated from the Laboratory of Hygiene, established at Marine Hospital in Staten Island, New York, in 1887 to conduct research on cholera and other infectious diseases. In 1930, Congress renamed the Laboratory of Hygiene as the National Institute of Health and authorized the creation of the National Cancer Institute (NCI). In 1948, Congress combined the NCI, National Heart Institute, National

Microbiological Institute, Experimental Biology and Medicine Institute, and National Institute of Dental Research to create the National *Institutes* of Health.

The medical research organized by the Office of Scientific Research and Development (OSRD) under Dr. Vannevar Bush during the World War II period was a driving force in the establishment and expansion of the NIH. After the war, Bush drafted a report envisioning a post-war scientific landscape where the government should support research in various settings, including universities, with the purposes of combating disease, of national security, and of public welfare (Bush, 1945). The report specifically emphasized the need for government involvement in medical research given its contribution to reducing the death rate during the war and to increasing life expectancy of the American people.

Since World War II, the NIH has experienced a dramatic expansion in its budgets, organizational units, and number of supported scientists (see Table 2 for the organizational units and their FFY 2005 expenditures). The agency has added new institutes to its profile responding to newly emergent research needs. Currently the NIH houses 19 institutes, six centers, and one library. Various institutes and centers focus on specific diseases (e.g., NCI for cancer, NIDDK for diabetes and kidney disorders, NIMH for mental health, and NIDA for drug and alcohol abuse), specific organs (e.g., NHLBI for heart, lungs, and blood and NIE for eyes), or specific population groups (e.g., NICHD for children and NIA for the elderly) (NRC & IOM, 2003; Morris 1984). Other institutes focus on specific fields of science or professions or technologies: NHGRI for human genome research, NIEHS for environmental health sciences, and NIGMS for general health sciences. In FFY 2004, the agency employed 18,394 persons and had an annual appropriation of $27.9 billion (NIH Almanac, 2005). In FFY 2005, the NIH supported more than 58,000 research grants and 2,000 research contracts. It also funded more than 16,000 training positions in universities, medical schools, and other research institutions.

Table 2. Organizational Profile of the National Institutes of Health (source: Office of Budget, National Institutes of Health)

Institutes/Centers		Establishment	FFY 2005 Expenditures (in $ million)		
			Total	RPGs (%)	Intramural Research (%)
NCI	National Cancer Institute	1937	4,798	2,192 (45.7)	711 (14.8)
NEI	National Eye Institute	1968	665	423 (63.6)	67 (10.1)
NHLBI	National Heart, Lung, and Blood Institute	1948	2,923	2,042 (69.9)	166 (5.7)
NHGRI	National Human Genome Research Institute	1989	486	125 (25.7)	98 (20.2)
NIA	National Institute on Aging	1974	1,045	704 (67.4)	103 (9.9)
NIAAA	National Institute on Alcohol Abuse and Alcoholism	1970	436	265 (60.8)	45 (10.3)
NIAID	National Institute of Allergy and Infectious Disease	1948	4,276	2,201 (51.5)	528 (12.3)
NIAMS	National Institute of Arthritis and Musculoskeletal and Skin Diseases	1986	508	338 (66.5)	51 (10.0)
NIBIB	National Institute of Biomedical Imaging and Bioengineering	2000	296	234 (79.1)	4 (1.4)
NICHD	National Institute of Child Health and Human Development	1962	1,262	700 (55.5)	159 (12.6)
NIDCD	National Institute on Deafness and Other Communication Disorders	1988	392	282 (71.9)	34 (8.7)
NIDCR	National Institute of Dental and Craniofacial Research	1948	389	243 (62.5)	58 (14.9)
NIDDK	National Institute of Diabetes and Digestive and Kidney Diseases	1948	1,703	1,165 (68.4)	165 (9.7)
NIDA	National Institute on Drug Abuse	1973	1,000	592 (59.2)	79 (7.9)
NIEHS	National Institute of Environmental Health Sciences	1969	720	279 (38.8)	165 (22.9)
NIGMS	National Institute of General Medical Sciences	1962	1,932	1,379 (71.4)	2 (0.1)
NIMH	National Institute of Mental Health	1949	1,403	813 (57.9)	158 (11.3)
NINDS	National Institute of Neurological Disorders and Stroke	1950	1,530	1,108 (72.4)	135 (8.8)
NINR	National Institute of Nursing Research	1986	137	102 (74.4)	2 (1.5)
NLM	National Library of Medicine	1956	n/a	n/a	n/a
CIT	Center for Information Technology	1964	n/a	n/a	n/a
CSR	Center for Scientific Review	1946	n/a	n/a	n/a
FIC	John E. Fogarty International Center	1968	66	16 (24.2)	0 (0.0)
NCCAM	National Center for Complementary and Alternative Medicine	1999	121	72 (59.5)	7 (5.8)
NCMHD	National Center on Minority Health and Health Disparities	1993	195	6 (3.1)	0 (0.0)
NCRR	National Center for Research Resources	1962	1,108	73 (3.1)	0 (0.0)
CC	NIH Clinical Center	1953	n/a	n/a	n/a

NIH Budget Process and Key Actors

The statutory authority of the NIH budget comes from the Public Health Service Act (PHSA) of 1944, as amended thereafter. While its budget is subject to annual time and dollar authorization, the most recent budget authorization was the NIH Revitalization Act of 1993 (IOM, 2003). The NIH budget process is particularly complex. It begins when investigators and institutions submit their grant applications to be reviewed by the Center for Scientific Review (CSR). Institutes and centers working with NIH directors use their peer reviews to prepare budget requests under guidance from the Office of Management and Budget and the Department of Health and Human Services (HHS). Then, the Secretary of the HHS submits the NIH budget to the President. The NIH budget is primarily appropriated through a mechanism budget (IOM, 2003). Budgets for individual institutes and centers are appropriated according to specific expenditure mechanisms. Therefore, "there is a natural focus on the allocation of funding among institutes and centers because each receives its own appropriation from Congress" (IOM, 1998, p. 16).

The nature of the budget process of the NIH allows three distinctive actors to play critical roles. First, institute directors can exert considerable discretion in seeking a higher budget for specific expenditure mechanisms in spite of their division directors' own budget priorities. Second, members of congressional appropriation subcommittees can influence the NIH budget obligations due to the relative absence of significant role of authorization committees and the President. Third, the NIH maintains considerable mechanisms of inputs from medical research communities through its advisory boards.

Institute Directors

The duties and authorities of institute directors come from Title 42 of the PHSA. The institute directors are appointed by either the President (NCI) or the Secretary of the HHS and report directly to the director of the NIH. Their duty is to "encourage and support research, investigations, experiments, demonstrations, and

studies in the health sciences" (PHSA, §284). Although the division directors in the institute develop the details of the institute's budget, the responsibility of the institute director as related to the institute's appropriations is considerable across different expenditure mechanisms.

First, each institute has separate divisions for intramural and extramural research programs. For example, the NCI has five divisions for supporting extramural research and four comparable units for intramural research purposes.[10] The institute director coordinates the programs and activities initiated by divisions and centers under his/her command in various ways. The institute director appoints division/center directors consistent with his/her own research agenda and preferences. There might be a tug of war among division directors seeking higher budgets for the divisions during which division directors would try to gain support from the institute director and the constituent groups. Having said that, the director may have her/his own agenda that differs from the division directors or have preferences for programs offered by specific divisions.

Second, the external medical research communities at the institute level direct their inputs mainly to the institute directors. The scientific advisory boards appointed by the Secretary of the HHS make their recommendations to the institute director. They can establish their own technical and scientific peer review groups and appoint members. The directors have a good deal of discretion in seeking and implementing advice from external groups selectively.

Third, the institute directors coordinate their institutes' programs and activities with those in other institutes, federal agencies, and private entities. An institute director also has legal authority to "cooperate with the directors of the other national

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[10] Extramural research support divisions are Division of Cancer Biology, Division of Cancer Control and Population Sciences, Division of Cancer Prevention, Division of Cancer Treatment and Diagnosis, and Division of Extramural Activities. Intramural research divisions/centers are Center for Cancer Research, Branch, Lab, and Program Index: Center for Cancer Research, Division of Cancer Epidemiology and Genetics (DCEG), and DCEG Research Interests.

research institutes in the development and support of multidisciplinary research and research that involves more than one institute" (PHSA, §284).

Fourth, the institute directors represent their institute before Congress, especially in the appropriations subcommittees. Each institute prepares a congressional budget justification (CJ) detailing accomplishments of the preceding year, current initiatives, and plans (IOM, 2003). The director presents the CJ to the appropriations subcommittees. Although Congress allows the NIH to exert considerable discretion in its budget, it is interested in NIH fund allocations both across expenditure mechanisms and across different diseases, as is evidenced by congressionally mandated studies of NIH research fund mechanisms (IOM, 1988, 1998, 2004). The institute directors emphasize some funding mechanisms over others in congressional testimonies. They also provide testimony to other related committees such as the Senate Committee on Governmental Affairs and the House Committee on Science and Technology.

All of these factors point to the critical role of institute directors in the budget process, as appropriate to the purposes of this study. These possibilities create an arena of discretion and strategic action on the part of the institute directors. Thus, allocation of research funds across different *mechanisms*, not programs, could not be the realm of bureaucrats at the division level, but of the leadership of the institute and its relationship with Congress and extramural constituent groups.

Medical Research Communities and Patients/Advocacy Groups

The NIH commands a broad base of constituents its research funds support, including research scientists in medical schools and universities, clinicians who apply knowledge from research to disease treatment, patient and advocacy groups, and the general public. Each constituency has its own interest in securing research funds regardless of whether it is for their own research or for addressing specific diseases. For example, the scientific community in universities and medical schools has played an important role in increasing NIH budgets through the Ad Hoc Group for Medical

Research Funding.[11] There are two distinct channels through which the NIH priority-setting process incorporates these interests.

First, specific-disease patients and advocacy groups tend to exert their clout via congressional actors. They argue that NIH funding for research into the diseases of their interest is not sufficient compared to the costs and burdens of the diseases inflicted upon the population. For example, AIDS advocacy groups lobby members of Congress to earmark funding for HIV/AIDS-related research or mandate special programs for their purpose. Members of Congress try to comply with such requests by intervening in the priority-setting process in the NIH, which may lead to distortions in exploiting opportunities for scientific progress.[12]

Second, the NIH maintains input channels from the outside scientific community. Since a great majority of research funds are for extramural purposes, the NIH seeks advice from the medical scientific community in reviewing grant applications, especially through Integrated/Initial Review Groups and Special Emphasis Panels. These groups are housed either in the CSR or in each of the institutes and centers under the discretion of their directors. External advisory groups can provide recommendations to the institute directors with regard to program development and implementation, evaluations, and other issues important to achieving institute missions and goals (IOM, 2003). This is the role of National Advisory Councils and Boards, whose members are appointed by either the President or the Secretary of the HHS. By channeling inputs from the scientific community and the general public, the advisory committees and boards enable the NIH to be more aware of and responsive to medical research communities, research opportunities, and health needs.

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[11] The Ad Hoc Group has affected the NIH funding of biomedical research since 1982. Currently, the Ad Hoc Group is comprises about 350 organizations of the American Association of Medical College's medical schools, research universities, professional societies, and other advocacy groups.

[12] According to the IOM (1998), these disease-specific advocacy groups have avoided open competition for higher budgets for diseases of their own interest but have sought a higher total NIH budget. Through such a strategy, all of the organizations could benefit.

Members of Congressional Appropriations Subcommittees

Three types of congressional committees are important: the Authorizations, Appropriations, and Budget Committees in each house. While budgets for NCI, NHLBI, NIA, and NIMH are subject to annual "time-and-dollar limits" set by the Authorization Committees, nearly half of the NIH funds are unauthorized since 1996. Congress has not reauthorized the NIH budget since 1993. Under these circumstances, the role played by the Authorization Committees for the NIH budget is not as conspicuous as for other discretionary budgets. The guidance about NIH funding is provided by the Appropriations Committees in their legislation and report language (IOM, 2003). As such, the most critical role is played by the Appropriations Committees, especially the Labor, HHS, and Education Subcommittees.

The extent to which Congress is specific about NIH priority setting and funding has been a key issue in the budget process between Appropriations committee members and NIH leadership. Members of Congress tend to think about NIH research funding in terms of "a correlation between the research funding by disease and the distribution of disease burdens and costs in the population" (IOM, 1998, p. 24). Disease-specific interest groups lobby Congress to obtain higher research funds targeting the diseases of their interest. Accordingly, members of Congress seek higher links between NIH funding and social costs by disease by mandating new programs and/or the use of particular funding mechanisms and by earmarking funds for specific purposes. The mechanisms most vulnerable to congressional influence are Other Research, R&D Contract, and Research Centers.[13] In response, the NIH director and institute directors have tried to persuade congressional members that congressional effort to micromanage NIH programs distorts NIH priority setting with the result of lost opportunities for scientific progress (IMO, 1998).

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[13] A description of these expenditure mechanisms is provided in the next section.

Congress has consistently increased NIH funding, from $6.7 billion in FFY 1983 to $37.7 billion in FFY 2005, with an annual rate of 8.7%, doubling the NIH budget between 1998 and 2003. The NIH is said to be an agency "captured by Congress," a "special charge of the legislative branch" (Greenberg, 2001, p. 196) since the U.S. President plays only a minor role in increasing NIH budgets. The White House usually requests a small increase in the NIH budget, but Congress increases it much more.

Key congressional members strongly support more NIH funding out of personal beliefs about benefits from biomedical research as well as because of political advantages. Some of the notable supporters of higher NIH research funding are Senators Mark O. Hatfield, Arlen Spector, Connie Mack, and Orrin Hatch and Representatives John Porter, Robert Walker, and Henry Waxman. Senators Mack and Hatch have been enthusiastic about the NIH because of their personal experiences or their family members' experiences with diseases. Senator Spector supported NIH funding mainly because universities in his district in Pennsylvania have been a big beneficiary of NIH research grants. These congresspersons have played a critical role in times of budgetary uncertainty: for example, Greenberg (2001) argued that Senator Hatfield, as chair of the Senate Appropriations Committee, and Representative Porter, as chair of the House Appropriations Subcommittee, jointly thwarted the balanced budget amendment by Newt Gingrich, which would have reduced the NIH budget (pp. 437–441).

Major Expenditure Mechanisms of the NIH[14]

The NIH uses multiple fund mechanisms such as RPGs and Intramural Research, among others, to support extramural and intramural research. For most extramural research grants, individual investigators in universities, medical and dental and nursing schools, and nonprofit organizations initiate the process by submitting grant applications. Review panels (or *study sections*)[15] in the CSR composed of nongovernmental scientists with relevant knowledge in a research area provide the first round of peer review (NIH, 2005). The review is based on "the importance of the problem or question; the innovation employed in approaching the problem; the adequacy of the methodology proposed; the qualifications and experience of the investigator; and the scientific environment in which the work will be done" (NIH, 2005). The national advisory council/board provides the second-level reviews of the extramural research applications.

RPGs

To fund all types of medical research from basic life mechanism at the molecular level to application of basic knowledge to treatments of human diseases, the NIH uses two kinds of grant awards: the most commonly used R01 supports "a single project with a principal investigator." The program project (P01) aims to support interdisciplinary projects with many investigators working on "various aspects of a specific major research objective or theme" (NIH, 2006a, p. 4). Under the RPGs mechanism, the NIH utilizes some specific awards for certain purposes such as Method to Extend Research in Time (MERIT) Awards (R37), Academic Research Enhancement Award (AREA) (R15), Exploratory/Developmental Grants (R21), and Small Grants (R03). RPGs are awarded for an average of four years. In FFY 2005,

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[14] This section is largely informed by the descriptions of the mechanisms by NIH (2006a).
[15] Currently there are about 125 study sections.

about 30% of extramural RPGs were to support new projects; the remaining 70% was for continuing projects. In FFY 2005, RPGs take up about 46.5% of the total NIH budgets.

Intramural Research

Through intramural research, the NIH can focus on "specific health problems of special concern to a particular institute and basic research that may not target a specific disease, but relates to the overall mission of the institute" (NIH, 2005). The intramural programs undergo peer review by a Board of Scientific Counselors, which provides advice to the institute director. The intramural programs are also subject to review by the national advisory councils and sometimes by additional panels of nongovernmental experts. Though the research is intramural, the provision of research funds is not entirely determined internally. Besides the communication between members of Congress and the directors, patient advocacy groups and other interested parties can be engaged in the decision-making process through the national advisory councils and other NIH advisory committees. As of FFY 2005, 5.4% of total NIH expenditures were spent by intramural laboratories.

Other Expenditure Mechanisms

In addition to RPGs and Intramural Research, the NIH uses many other fund mechanisms, such as Research Centers, Other Research, Research Training, and Research and Development Contracts to support research. *Research Centers* focus on "long-term, multidisciplinary programs of medical research." Through the Research Centers mechanism, the NIH supports "the development of research resources, aimed to integrate basic research with applied research and transfer activities, and promote research in the areas of clinical applications with an emphasis on intervention" (NIH, 2006a, p. 5). Characterized by multi-investigators, research centers have been increasingly used to encourage collaboration among scientists on a broad-based research program of common interests (IOM, 2004). As of FFY 2005, 1,333 Research

Centers grants had been awarded; the share of expenditure through this mechanism is about 7% of total NIH expenditures.

Other Research takes care of issues such as provision of career opportunities to scientists with potential, clinical research collaboration among researchers from multiple institutions, pilot studies, support of minority biomedical research scientists, and the like. As of FFY 2005, more than 13,000 grants had been awarded through this mechanism, which consumes about 12.4% of total NIH expenditures.

Research Training awards grants to individuals and institutions of medical schools and universities to support students at the predoctoral or postdoctoral levels. As of FFY 2005, the NIH spent about 2.7% of its total expenditures through the research training mechanism, supporting more than 16,000 trainees. *R&D Contracts* are used to utilize "advances in knowledge and technology to search for solutions to specific questions" and are usually awarded to nonprofit and commercial organizations (NIH, 2006a, p. 8). To solve specific questions, the NIH issues a Request for Proposals or an Invitation for Bids stating the work to be done or the problem to be solved. In FFY 2005, more than 2,000 contracts were awarded with expenditures at about 7.6% of total NIH budgets.

The mechanisms of Research Centers, Other Research, and R&D Contracts support more directed research and reflect the supporting institute's mission (IOM, 1998). Applications for support through these mechanisms are usually solicited by the institutes and are reviewed by peer-review committees in the institutes, not in the CSR. As such, institute staff can have more influence on the nature of the supported research. At the same time, the directness of the supported research often encourages Congress to specify its supporting mechanisms in legislation or report language (IOM, 1998).

Composition of Expenditure Mechanisms

Why do some institutes utilize RPGs more intensively than others? Why do some institutes get less dependent on RPGs through time, expending more budgets through R&D Contracts? The "tools approach" literature (Peters, 2000; Salamon, 2002) asserts that the selection of a tool from the repertoire of a wide range of government tools represents a unique profile of politics. In terms of the tool dimension of directness,[16] which measures "the extent to which the entity authorizing, financing, or inaugurating a collective activity is involved in carrying it out" (Salamon, 2002, p. 27), intramural research represents a highly direct government charge, while support of extramural research invites private researchers to play the main role of conducting research. Different in the degree of directness, each tool involves its own stakeholders.

The many different mechanisms of research support may focus on different types of research, and the influences exerted in the decision-making process are also different. For the absolute size of an institute's budget, the private interests, including the medical scientific communities and the institute leadership, may have a common interest: they want bigger research expenditures. However, while trying to increase R&D appropriations, they have to make a decision on the relative distribution of the research funds between the intramural and extramural research. For intramural research, the interests of the institute directors, whose utility is argued to depend on budget size and organizational control, might loom large, as implied by budget-maximizing (Niskanen, 1971) and bureau-shaping bureaucrats (Dunleavy, 1986, 1991). On the other hand, private interests and their lobbying activities to the institute leadership and bureaucrats and members of Congress would be important in the

[16] Salamon (2002) discusses four dimensions of policy tools: degree of coerciveness, directness, automaticity, and visibility. Along the changing role of government in society, the directness dimension draws attention from policy students more than the other dimensions do.

provision of extramural research funding. If the leadership of an institute prefer budgets for their own laboratories to budgets they can ultimately control but that are distributed to university researchers, it would be the case that the director of an institute would want increased funding for intramural rather than for extramural research. The opposite will apply to the private medical research communities. However, according to public service and mission motivation perspective (Perry & Wise, 1990; Perry, 1996, 2000; Rainey & Steinbauer, 1999; Wilson, 1989), this may not be the truth. If the directors are driven by public service or mission motivation, they may not necessarily pursue higher intramural budgets for themselves but higher total research funds regardless of intramural or extramural designation. With such motivations, the issue of who performs the research would be irrelevant to public-service–motivated directors as long as the research contributes to public values.

The combination of different support mechanisms could be understood as a determination of relative political influences between the leadership of an institute and private grant beneficiaries. Theoretically, both the leadership at the institute and the private (potential) beneficiaries are assumed to prefer a higher level of total research expenditure. On the other hand, whether to spend a specific portion of the budget on intramural research or on extramural research is an issue that involves the relative resources of the two types of actors. Each may seek influence through relevant congressional committees: public officials may have informational advantages over the committees, and private beneficiaries can muster or withdraw support of members of Congress. Therefore, how the tripartite politics are waged will determine the relative allocation of research funds across different expenditure mechanisms. Here comes the competition. The intramural labs in principle have to compete with nonpublic researchers. Faced with competition from government researchers, private researchers and their interest groups may provide exact cost information of research to the members of Congress. However, since the leadership of an institute and private parties have a common interest in increasing overall NIH funding, the incentives for private parties to provide complete cost information to

members of Congress would be limited. The influence function from these various resource bases could be expressed as:

f = f [*Experience of Directors, Number of Advisory Boards and their Memberships Representing Private Interests, Experience of Members of Congress and their Interest Group Affiliations, Institutional Arrangement for Budget Process, Controls*]

The following chapter provides a theoretical consideration of how these diverse factors are churning into the process of budgeting for the NIH expenditures and the determination of expenditures through specific mechanisms.

CHAPTER 3

THEORETICAL CONSIDERATIONS AND HYPOTHESES

Public R&D and Its Economic Impact

According to market failure theorists, the government intervenes in the economy to correct market failures arising from such factors as imperfect competition, public goods problems, externalities, incomplete markets, and information failures (Stiglitz, 2000). The market failure rationale "centers on questions of externalities or 'spillover' effects" (Bozeman, 2000, p.146). As early as the end of World War II, Vannevar Bush (1945) recognized the importance of R&D in economic welfare and argued for organized public support for R&D activities from the experience of the OSRD. Nelson (1959) theoretically addressed the nature of pure science as "likely to generate substantial external economies" and argued that for-profit firms are not likely to perform basic research to a socially desirable level (p. 302).[17] Externalities make it difficult to establish property rights on outputs of basic research, causing a typical systematic market failure problem (Dasgupta & David, 1984).

That public R&D activities is a way of correcting market failure in private R&D is one thing, and how and at what level the government should engage in R&D activities are another. The utility of the traditional benefit-cost analysis is severely undermined in the determination of public R&D support because of the very nature of R&D activities themselves and their problematic relationship to economic impacts. Causal relationship between R&D investment and its output and impacts is unclear, in part because the process of knowledge production is influenced by factors that are not

[17] On this point, see also Griliches (1960) and Arrow (1962).

directly controllable by the government, such as the dynamic interactions of various actors (Gibbons et al., 1994; Rogers & Bozeman, 2001; Bozeman & Rogers, 2002; Nelson & Nelson, 2002). Moreover, the collective nature of knowledge production is so integrated in the utilization of such knowledge that the government cannot *a priori* designate a causal path from research to productivity increase. The process from R&D to impacts depends on various factors, such as institutional arrangements for technology transfer, entrepreneurship, and market demands. One line of effort to explain the role of institutional factors is a diverse array of innovation systems approaches. The concepts of innovation systems are trying to capture whatever institutional arrangements that would be relevant facilitators of, or obstacles to, innovative activities at the regional (Acs, 2000), sectoral (Malerba, 2004), or national level (Nelson, 1993; Lundvall, 1992). Lastly, externalities (spillovers) in R&D benefits are prevalent,[18] and thus the social rate of return diverges from the private rate of return. Because of these factors, it takes considerable time for R&D investment to yield economic effects: about 7 years between academic publication and citations by industrial patents (Gellman, 1976; Mansfield, 1991, 1998), 8 years of time lag between scientific publication and citation of the publication by industry patents (Branstetter, 2005), and 20 years between publication of research output and its effect on industry productivity (Adams, 1990).[19]

In spite of these complicating characteristics on the road from R&D to economic benefits, a considerable number of economists have tried to examine private R&D effects on productivity at the firm (Griliches, 1980, 1986; Cuneo & Mairesse, 1984; Jaffe, 1988; Mansfield, 1988; Griliches & Mairesse, 1990; Hall & Mairesse, 1995), industrial (Telecky, 1974, 1980; Griliches & Lichtenberg, 1984; Griliches, 1994; Jones & Williams, 1998), and national (Nadiri, 1980; Lichtenberg, 1992; Coe &

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[18] For a summary of literature on R&D spillover effects, see Audretsch et al. (2002, p. 171).
[19] The time lag appears to have narrowed recently (NSF, 2002, p. 5–44).

Helpman, 1995) levels.[20] The estimated R&D elasticity of productivity growth ranges from 0 to as high as 0.82 (Patel & Soete, 1988). At the same time, a considerable number of studies examine the effects of public R&D expenditures on private R&D investment. Some intensive empirical efforts have been made to test whether public R&D spending crowds out private R&D investment (Lichtenberg, 1987; Robson, 1993; David et al., 2001).[21] Another area of scholarly interest is the effects of R&D tax credits, the empirical evidence generated being mixed. Some researchers report failures in finding statistically significant evidence that tax credits increase private R&D expenditures (Mansfield, 1986; GAO, 1995), but others provide substantial positive evidence (Czarnitzski et al., 2005; Russo, 2004; Hall & Reenan, 2000). Recently, Wilson (2005) questioned the assumptions of the cost differentials between in-state and out-of-state firms from state R&D tax credits and found that "the external-cost elasticity is positive and significant, raising concerns as to whether having state-level R&D tax credits on top of federal credits is socially desirable" (p. 1).

On top of these studies, a substantial portion of studies of government R&D policies has centered on institutional arrangements other than levels of R&D expenditures; national (Nelson, 1993; Lundvall, 1992) and other innovation systems (Acs, 2000; Malerba, 2004), patent laws (Jaffe, 2000; Coriat & Orsi, 2002), institutional settings for particular industries (Giesecke, 2000; Lehrer & Asakawa, 2004), specific program-level activities (Dohse, 2000), and technology transfer from government and university labs to industries (Mowery et al., 2001; Di Gregorio & Shane, 2003; Siegel et al., 2003; Chapple et al., 2005).

What is largely missing from this previously mentioned literature is how specific actors in the process of the R&D budgeting process impact the expenditure

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[20] CBO (2005) summarizes this literature succinctly, focusing on econometric issues.
[21] Findings of these studies are not definitive, as they utilized different models and provide mixed results.

amount of public R&D programs. What are the relative roles of public officials, congressional members, private scientific communities, and interest groups in the determination of specific levels and performers of government R&D? If a research agency maintains a variety of R&D programs of differing natures, as in the case of the NIH, do these different participants in the process care about different types of R&D programs? These questions are to be answered in the next section, which discusses theoretical discussions of incentives of participating actors and the institutional arrangement of the R&D budgeting process.

Framework for Understanding R&D Expenditures in a Democracy

This section provides a theoretical basis for understanding the research expenditure mechanisms of a government agency that supports R&D performed by researchers in different institutional settings. There are largely two types of factors, as illustrated in Figure 1: internal and external. Internal factors include leadership styles, input mechanisms from external scientific communities and research advocacy groups, and organizational characteristics. External factors refer to the political environment of the agency, such as political control of the presidency and Congress, the ideological orientation of the appropriations committee members, and competition from the other agencies.

Of these diverse sources of influence on the R&D expenditures of an agency, this section focuses on mainly three factors. First, the motivations and incentives of the leadership of the institutes are critical in determining how much R&D and which performers are to be supported. Second, the mechanisms of input into Congress from the public and interest groups are important in determining levels of public R&D activities. Third, the institutions for the budget process provide incentives to the participants and structure the way they interact. These are the foci in the subsequent subsections.

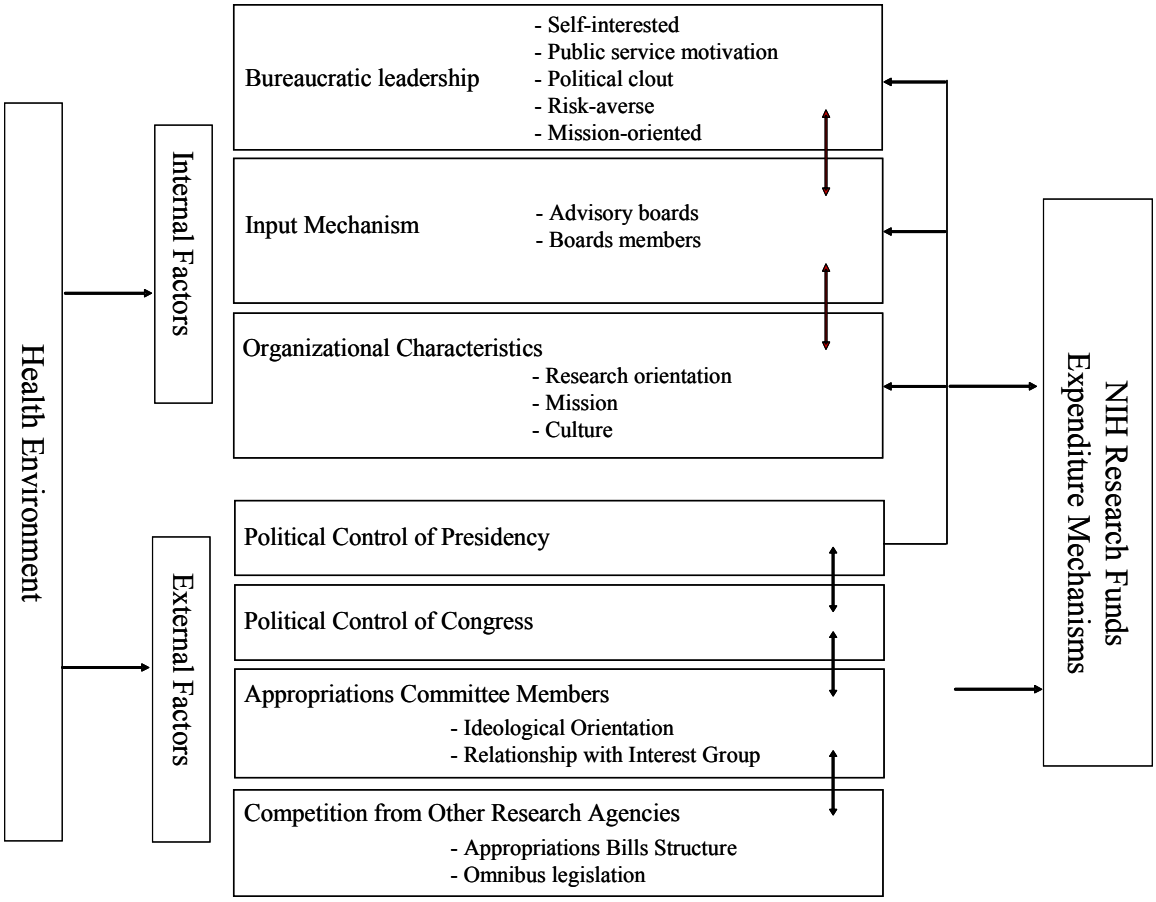

Figure 1. Framework of Determination of NIH Research Expenditures

Public Officials and R&D Expenditures

Self-Interested Bureaucrats

With critical views of the public bureaucracy by Parkinson (1958), Tullock (1965), and Downs (1967), public choice theorists have tried to understand public officials as bureaucrats who are primarily self-interested. Bureaucratic self-interests may be either in the form of bigger total budgets, of bigger discretionary budgets (Migué & Bélanger, 1974), or of shaping organizations (Dunleavy, 1986, 1991). The idea of the bureaucrat as a "self-interest maximizer" is an assumption about the incentive structures of public sector employees enjoying the monopoly status of public service provision. The most powerful and frequently cited work in this line of

thinking is Niskanen's (1971) *Bureaucracy and Representative Government*.[22] With an assumption of budget-maximizing bureaucrats, Niskanen argued that bureaus over-supply public service.

A critical assumption of the Niskanen model is that the interaction between Congress and the bureaus is such that "A bureau offers a promised set of activities and the expected output(s) of these activities for a budget" (Niskanen, 1971, p. 25). The relationship between the two entities is a "bilateral monopoly," and the offer by the bureau imposes "take-it-or-nothing" choice upon Congress. Bendor (1988) characterized this assumption as "authority-based agenda control" rather than information-based control (p. 356). However, Niskanen (1971) made it clear that bureaucratic power of negotiation comes from the fact that "a bureaucrat will know a great deal more about the factor costs and production process for the bureau's services than will the officers of the sponsor organization" (p. 29). Under this asymmetrical advantage over politicians, bureaucrats will try to maximize their utility functions, of which salary, perquisites of the office, public reputation, power, patronage, and output of the bureau are integral parts (p. 38). Niskanen assumes that all of these factors are modeled as a monotonic function of positive total budget of the bureau. Therefore, bureaucrats, Niskanen argued, are maximizers of their bureau budget.

With the criticism by Migué & Bélanger (1974), the argument was modified such that bureaucrats maximize discretionary budget rather than total budget (Niskanen, 1975), but the basic thrust of budget-maximizing bureaucrats has not changed. However, there have been substantial challenges from empirical testing. Some studies have addressed the assumption of budget-maximizing bureaucrats—with mixed results. Lewis (1990), using nationwide survey data of the general population, showed that bureaucrats are "no more likely than the general public to

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[22] A cited reference search on the Web of Science data base resulted in about 1,700 citations. Between 1994 and 2006, Niskanen (1971) was cited 534 times in journals in English, with an annual average of 44 excluding 2006.

favor raising government spending" (p. 221). Dolan (2002) found that the spending preferences of the members of Senior Executive Service are below the general public on most spending categories. Jacobsen (2006) , using data on 30 Norwegian municipalities, compared relative importance between bureaucrats and politicians in government growth and found that government growth is attributable more to politicians than to bureaucrats. On the other hand, Garand et al. (1991) found that government employees are more supportive of increased government spending than private employees. Sigelman (1986), elaborating on the job characteristics of bureaucrats, reported that there are differences in the preferences for budget expansion between bureaucrats with high professional commitment and those with managerial or policy development interests: professionally committed bureaucrats are likely to seek budget expansion, while those with managerial or policy development interests do not necessarily prefer higher budgets.

While these studies provide mixed results of the budget preferences of bureaucrats, other studies have focused on the bureaucrats' political power to explain ever-increasing size of the public sector. Building upon Niskanen (1971), Tullock (1974) and Buchanan & Tullock (1977) attributed the rapid rise in the salaries of public employees to their self-interested political power since "the votes of bureaucrats would be partially directed toward expanding the size of their agencies and partially toward raising their own salaries" (p. 148). Bureaucratic power as modeled by Niskanen has been argued to increase the size of government (Borcherding et al., 1977; Legrenzi & Milas, 2002). Berry & Lowery (1984) refuted this hypothesis, showing that relatively slow productivity growth in the public sector (Baumol, 1967) better explains the increase of the public sector than bureaucratic power does. Responding to Berry & Lowery's (1984) argument that price effects dominate the effects of bureaucratic power, Ferris and West (1999) furthered the theory of bureaucratic power, stating that *informational advantage* enables bureaucrats to capture "government rents" that are newly generated through lower welfare costs of tax collection (Kau & Rubin, 1981). Another source of bureaucratic

power is *unionization*, through which bureaucrats play the role of demander as well as supplier of public goods/services (Marlow & Orzechowski, 1996).

The implication of these studies is that public services are over-supplied or supplied inefficiently. Mueller (2003) summarized 71 empirical studies that compared public and private sectors in the provision of similar goods and services. In only 5 of the 71 studies, public provision was more efficient than private provision.[23] But, there is also empirical evidence that tells a very different story. Ruttan (1980, 1982), reviewing three dozen empirical studies on the effects of agricultural R&D programs, found that the annual rate of return on R&D investment ranged between 30% and 60%, which is, he interpreted, very high compared to the private rate of return. Even after factoring in deadweight loss in rising taxes for R&D programs, Yee (1995) reported a 43% rate of return on public agricultural R&D investment. The evaluation studies on the Advanced Technology Program[24] also reported as high as an 80% social rate of return (Bingham et al., 1998; Austin & Macauley, 2000; White & Gallaher, 2002). These findings could be regarded as indicating an undersupply of public R&D programs, which is squarely at odds with Niskanen's implication. Ruttan (1980, 1982) and Yee (1995) made a strong case that Niskanen's work essentially ignores the rich differences across different agencies that provide different services.

Public Service Motivation and R&D Expenditures

The collection by Blais & Dion (1991) revealed that the picture of budget-maximizing bureaucrats is empirically much richer than it appears at a first glimpse. Since bureaucrats may or may not seek a budget-maximizing strategy under the circumstances of different benefits and costs, it is difficult to *a priori* specify such

[23] Wintrobe (1987) pointed out that these empirical studies take no account of institutional differences between private markets and political markets. While firms in the private markets are themselves entities on their own, bureaus in political markets are "merely parts of a larger organization and responsive to demands originating from the whole organization" (p. 446).

[24] The Advanced Technology Program was established by the Omnibus Trade and Competitiveness Act of 1988 to "support R&D on high-risk, cutting edge technologies with broad commercial and societal potential" and provided more than $14.7 billion to more than 6,900 proposals between 1990 and 2004.

circumstances (Lynn, 1991), rendering this an empirical question. Moreover, benefits to bureaucrats from a larger budget seem to be small (Young, 1991). However, as Kiewiet (1991) argues, budget-maximizing bureaucrats are as much an approximation as profit-maximizing firms (p. 144), and "there is ample evidence that bureaucrats systematically request larger budgets" (Blais and Dion, 1991, p. 355). That said, public employees' motives are not limited to mere self-interests but encompass other factors (Wise, 2004; Rainey & Steinbauer, 1999; Hill, 1991; Kelman, 1987). Hill (1991) argued that the public choice approach to bureaucracy, assuming self-interested bureaucrats, fails to recognize "the richness of the interaction and the diversity of the values pursued" (p. 290) by public officials.

However, the extant literature on the behavior of public officials lacks a coherent theory of behavioral motivations comparable to the budget-maximizing bureaucrats in the public choice school, although there have been some recent efforts to build such a theory (Bowling et al., 2004; Wise, 2004; Hill, 1991). Among these efforts, Bowling et al. (2004) and Wise (2004) clearly utilized two typologies of public employees: Pitkin (1967) and Downs (1967). According to Pitkin (1967)[25] and Eulau (1962), bureaucrats as well as legislators, representing the public, could be viewed as either delegates, trustees, or politicos. A delegate represents constituents, pursuing policies that are preferred by those whom he or she identifies in terms of social origins or group affiliations. Dolan (2002) contrasts this type of bureaucrats[26] with the self-interested ones assumed by Niskanen (1971) and Downs (1967). On the other hand, a trustee, as a free agent, seeks the best interests of the public, and a politico combines the role of delegate and trustee depending on the issue being addressed. The politico is more flexible and sensitive to conflicting alternatives and less dogmatic (Eulau, 1962). Wise (2004) matched these types of bureaucrats to her four postures of bureaucracy: Weberian/responsible (delegate), representative (trustee

[25] The current discussion of Pitkin (1967) is largely dependent on Wise (2004).
[26] For empirical studies in this view of bureaucrats, see Dolan (2002, p. 43).

or delegate), public service motivation (trustee or politico), and public choice (politico). Tracing expansion preferences of state agency heads between 1964 and 1998, Bowling et al. (2004) developed a typology of expansion preferences[27] and related them to Downs's (1967) typology of bureaucrats,[28] treating administrative preferences (motivations) as antecedents to behaviors in budgetary requests. A climber, one of Downs's purely self-interested officials, is matched with an aggrandizer (budget maximizer), and the conserver, another purely self-interested type, with an abider.

An implication that could be drawn from these empirical as well as theoretical studies is that the picture of bureaucratic behavior in budget requests cannot be painted by a single brush of self-interested budget maximization (Niskanen, 1971, 1975). While cited as a prime example of taking the self-interest assumption, Downs (1967) actually presented a variety of factors by which bureaucrats might be motivated, such as security, personal loyalty, pride in high performance, public interests, and commitment to specific programs as well as power, monetary income, prestige, and convenience. Although Downs (1967) emphasized the pressures from personal goals or from bureaus much more than the pressure of being a representative, it might still be the case that commitments to factors other than self-interest have a positive association with budget size. This may explain why public officials systematically request larger budgets even though they receive no or only minor benefits from increased budgets (Blais & Dion, 1991, p. 357).

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[27] Depending on their attitudes toward the expansion of their own agencies in terms of programs, activities, expenditures and overall state, the agency heads are classified as abiders (minimizers), altruists, advocates, and aggrandizers (maximizers) (Bowling et al., 2004).

[28] As purely self-interested officials, climbers regard power, income, and prestige very highly, and conservers regard convenience and security highly. There are also mixed-motive officials—"zealots are loyal to relatively narrow policies or concepts," "advocates are loyal to a broader set of functions or to a broader organization than zealots," and "statesmen are loyal to society as a whole, and they desire to obtain the power necessary to have a significant influence upon national policies and actions" (Downs, 1967, p. 88).

Some dimensions of behavioral motivation other than self-interest could be public service motivation (Perry & Wise, 1990; Rainey & Steinbauer, 1999). Pubic service motivation (PSM) is defined as "an individual's predisposition to respond to motives grounded primarily or uniquely in public institutions" (Perry, 1996, p. 6) and involves affective, normative, and rational dimensions of human needs (Wise, 2004; Perry & Wise, 1990). Perry (1996) constructed six dimensions of PSM including commitment to the public interest, self-sacrifice, compassion, and attraction to policy-making .[29] Depending on concepts of PSM, individuals could be Samaritans (helping others), Communitarians (committed to civic duty and public service), Patriots (caring about the good of the public), or Humanitarians (concerned with social justice and public service) (Brewer et al., 2000). People with high PSM are more likely to work in the public sector (Houston, 2000; Wise, 2000; Crewson, 1997; Perry & Wise, 1990) since government service provides "the unique vantage point … for making the world a better place" (Kelman, 1987, p. 92). Even though empirical evidence on the relationship between PSM and organizational performance and productivity is not conclusive yet (Alonso & Lewis, 2001; Gabris & Simo, 1995; Naff & Crum, 1999), it has been found that PSM is positively related to civic involvement (Brewer, 2003), whistle-blowing (Brewer & Selden, 1998), and charitable contributions (Houston, 2006).

The question then becomes how could PSM be incorporated into the objective function of bureaucrats or public officials for that matter? In this regard, the attempt made by Mueller (1987) to incorporate ethical considerations of voters in their voting behavior is useful, where the objective function (O_i) of the voter *i* is defined as follows:

$$O_i = U_i + \theta_i \Sigma U_j,$$

[29] Through a confirmatory factor analysis, the dimensions of social justice and civic duty were found to be collapsed into commitment to the public interest.

where $i \neq j$ and U_i and U_j refer to the utility functions of the voters i and j, respectively. If $\theta_i = 0$, the voter i is purely self-interested; if $\theta_i = 1$, the voter i is as much self-sacrificing as self-interested. As such, rational voters maximize a weighted sum of their own utility and that of others (Mueller, 2004).[30] This type of objective function could be utilized in incorporating the diverse dimensions of the behavioral motivation of public officials. In such an application, U_i will be the bureaucratic utility function of self-interests and U_j the utility function of individuals of the general public or the group the agency serves. U_j may be a positive monotonic function of benefits that they get from government expenditures and a negative function of tax burden they have to bear to finance public programs. The value of θ_i may be different according to both individual officials and agencies. U_i and U_j now include as a vector the budget size of the individuals' agency. From the literature discussed previously, it is reasonable to assume that U_i is a positive monotonic function of budget size, while the total and marginal effect of budget size on U_i may not be as great as assumed by Niskanen (1968, 1971, 1975). On the other hand, U_j may or may not be a positive monotonic function of budget size. If a larger budget is negatively related with the total utility of the public, the program may benefit well-organized small groups at the expense of disorganized consumers or the public.

This formulation provides an interesting insight into the R&D expenditures of different support mechanisms of the NIH. First, even though the causal path from R&D investment to economic productivity increase is not clearly explained yet, it is widely accepted that the path exists. On top of the competitiveness rationale, a high degree of the public nature of R&D, with its non-excludability and spillovers, may motivate an institute's leadership with high PSM to aggressively pursue a higher level of R&D programs, activities, and expenditures. In such a case, this will not lead automatically to an oversupply of R&D activities as shown by Ruttan (1980, 1982)

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[30] Mueller (2004) discussed the objective function operationalized in this way in a more general context, labeling it *behavioral economics* as an alternative to neoclassical economics.

and Yee (1995). If coupled with problems of political expression of public demand of R&D activities, the institute directors seeking a higher R&D budget may be a case of Pareto-improvement. Second, the formulation above indicates that self-interested motivation could co-exist with PSM. In such a case, if public officials seek a higher budget, it might be because of self-interests, not PSM. The case of the NIH provides an opportunity to test the hypothesis of the budgetary effect of PSM in a way that controls the effects from self-interestedness because it extensively funds private research in addition to conducting R&D with its own in-house laboratories. While both the intramural and extramural funding represent a contribution to the public interest, public officials with high PSM at the institutes may not discriminate between intramural research funds and extramural research funds.

Risk-Averse and/or Mission-Oriented Bureaucrats and R&D Expenditures

Mueller (1989) points out that along with X-inefficiency (Leibenstein, 1966; Vanagunas, 1989),[31] risk aversion seems to be "the most plausible addition to the list of possible bureaucratic goals" (p. 257). Bureaucrats, being risk-averse, may value security as highly as larger budgets, leading them to try to boost rather than maximize their budgets (Blais & Dion, 1990). If bureaucrats are risk-averse, the marginal utility from increasing budgets would be lowered, in which case the oversupply of public service may not be as serious as modeled by Niskanen (1971). Risk-averse bureaucrats care more about avoiding budget cuts than about getting ample budget increases (Blais & Dion, 1991). Moreover, risk aversion may encourage bureaucrats to avoid risky and less visible/measurable projects (Gist & Hill, 1981; Lindsay, 1976; Mueller, 1989). Leyden and Link (1993) also found that risk-averse bureaucrats prefer

[31] X-inefficiency refers to factors internal to the organization such as quality of workers and management that cause suboptimality in production (Vanagunas, 1989). It is argued that inefficiencies result from behavioral characteristics in addition to the external market structure, such as a monopoly.

cost-plus contracts with private sector firms when they outsource services if the firms are also risk-averse.

Risk-averse bureaucrats at an institute under the NIH may want to prevent budget cuts in tight budget situations. One strategy to avoid large budget cuts would be to diversify research support through multiple mechanisms. If expenditures are concentrated on one or two mechanisms, the expenditures would be more vulnerable to reductions. This implies that bureaucrats at an institute may want to increase expenditures outside of the major RPGs mechanism.

The nature of research supported through other expenditure mechanisms provides another theoretical reason that may prompt bureaucrats to seek higher expenditures through Intramural Research, Research Centers, Other Research, and R&D Contracts: they address research areas that are closely related to the missions of the institutes. The mission of an agency is defined as a single culture "broadly shared and warmly endorsed" (Wilson, 1989, p. 109). *Mission motivation* refers to the development/inculcation of missions within an agency. The leader of an agency could develop "a sense of mission" among its members through goal setting and other symbolic actions (Rainey & Steinbauer, 1999, pp. 25–26). While PSM is externally oriented vis-à-vis the public agency, mission motivation is in relation to the missions of the agency. The identification of the mission by the agency members enhances the sense of importance of their jobs (Wright, 2007), encouraging them to pursue accomplishing their organizational mission. In examining the self-interest assumption, Lynn (1991) and Campbell and Naulls (1991) found that bureaucrats may be motivated by missions. If bureaucrats are motivated by missions, they would act in line with what the leadership of the agency wants them to do. Thus, institutes at the NIH may have incentives to seek R&D activities that are specifically targeted toward achieving organizational goals out of mission motivation rather than more broadly defined research issues that could be addressed by investigator-initiated research.

Political Clout of Institute Directors

Although public officials prefer larger budgets, they do not request as much as they want because of strategic reasons (Wildavsky, 1964). Most of all, the relationship between agency heads and congressional members of appropriations subcommittees in the budget process forms "reciprocal expectations that lead to self-fulfilling prophecies" (Wildavsky & Caiden, 1997, p.50). For example, if the agency requests too much and gets a relatively small portion of what it requested, it will lose credibility among the appropriations committee members. This is a simple indication that the agencies use budget strategies to seek higher budgets. These strategies are "the links between the intentions and perceptions of budget officials, and the political system that both imposes restraints and creates opportunities for them" (Wildavsky & Caiden, 1997, p. 57). Public officials develop budget strategies based on their expansion preferences (Bowling et al., 2004) and, as such, different agencies adopt different strategies to achieve their respective goals in the budget process (Sharkansky, 1968).

Wildavsky and Caiden (1997) illustrated basic strategies for agency officials in the budget process, some of which are "Be a Good Politician" and "Building Confidence" (pp. 52–67). Being a good politician requires active clientele groups, development of confidence among other government officials, and skills in following budget strategies. Agency heads may want to use budget structure[32] tactics, and it is critical to find "tactical opportunities" for budget increase. Identifying tactical opportunities is complicated, requiring special skills and technical expertise (Meyers, 1994).

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[32] The budget structure for an individual program has four components: method of accounting, decision procedure, policy design, and perceived effects (Meyers, 1994). Expectations for the budget process lead to a specific form of budget structure under which agency heads and the Office of Management and Budget (OMB) develop strategies for achieving their relevant goals.

How strongly the agencies seek strategies for budget increase could be understood as agency assertiveness. Agency assertiveness might be manifested in various aspects of the budget process, including the formulation of annual requests (Ryu et al., 2006). The agencies may use innovative promotional devices and techniques and be more skillful in seeking greater discretion in spending (LeLoup & Moreland, 1978). LeLoup and Moreland (1978) argued that agency assertiveness is a function of the agency head's values, attitudes, and orientation as well as its external support and environmental constraints.

All of this leads up to the importance of the political clout the agency heads[33] have accumulated as well as the political clout the agency enjoys because of its organizational characteristics.[34] The political clout of the agency heads comes from two sources: confidence from government officials, clientele groups, and members of appropriations committees and technical skills and knowledge. Their role in the budget process is especially important in terms of their relationships with the OMB and the appropriations subcommittees. For example, in the initial process of executive budget formulation, the OMB issues guidelines (OMB Circular A-11) to the agency in the spring, setting ceilings for the dollar amount and full-time equivalent employees of the agency. During the summer, these ceilings are negotiated between the agency head and the OMB, which is a testament to the test of the agency head's political clout. Internally, the agency head invents and operates the budget strategies, as has been pointed out by Meyers (1994) and Wildavsky and Caiden (1997). For example, while serving and expanding the agency's clientele groups, the agency head can promote feedback from these groups and leverage their influence in the budget process.

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[33] Agency heads are the heads of either departments or agencies, but for the purposes of this study, institute directors of the NIH could be treated as such.
[34] Slaughter (1986) uses an agency's size and age and the campaign contributions of the agency's clientele group to measure its political clout.

However, it requires time, energy, and intuition to develop political clout among government officials and appropriations subcommittees since the political clout is to be exerted through relationships with other participants in the budget process. The interactions in the budget process are typically repeated ones, and the best strategy in such circumstances is to gain confidence (Axelrod, 1984). Therefore, to push its budget request, the agency first needs to develop trust among the OMB and the appropriations subcommittee members. Additionally, to effectively put the budget strategies into effect, the agency heads need to acquire technical knowledge and skills of the budgetary process and budget structures. These skills include accounting rules, government decision procedures, and policy analysis and implementation (Meyers, 1994). As time goes on, the agency heads develop more political clout and are likely to have learned which budgetary strategies are more effective for realizing their spending preferences. From these considerations, it is expected that agency heads with more political clout will be more successful in obtaining higher budgets than those with less political clout.

Based on the behavioral motivations and political clout of public officials, this study presents its first set of hypotheses as follows:

- *Hypothesis 1: As an institute director's public service experience (PSE) as measured in years increases, the institute's total expenditures increase.*
- *Hypothesis 2.1: If the Niskanen model of self-interested bureaucrats is correct, as an institute director's PSE as measured in years increases, intramural research expenditures increase more than RPG expenditures do in percentage terms.*
- *Hypothesis 2.2: If the model of PSM is correct, as an institute director's PSE as measured in years increases, RPG expenditures increase as much as intramural research expenditures do in percentage terms.*

- *Hypothesis 3: As an institute director's PSE as measured in years increases, the institute's propensity to diversify its expenditures through various expenditure mechanisms as measured by a Herfindahl Index increases as well.*

Benefits and Costs of Public R&D Expenditures

Downs (1957, 1960) predicted that "the government budget is too small in a democracy" (p. 541) because of 1) the cost of getting information on what benefits and costs government activities involve and of 2) the difference between private and public transactions. In private transactions, the *quid pro quo* relationship provides accurate estimation of both costs and benefits, which is not available with public transactions. Because information is not costless, a certain level of ignorance is inevitable, and there are differences in the levels of information gained on benefits and costs of public transactions. While benefits from government actions tend to be more remote in terms of either time, space, or comprehensibility, costs involved in such benefits may not be equally remote (Downs, 1960). Having said that, party competition where political parties try to gain votes by promising more visible and immediate benefits would lead to too-small budgets for programs whose potential benefits voters are less aware of. Therefore, "a tendency toward elimination from the budget of all expenditures that produce hidden benefits" (p. 553) is probable. Downs also noticed that if voters see costs more clearly than benefits, the actual budget size would be smaller than the "correct" budget. Moreover, benefits from government programs are more likely to be uncertain than those from private transactions. Thus, the returns from public expenditures are to be discounted more heavily than private investments. Uncertainty involved in the calculation of the expected values of the benefits makes programs of high uncertainty not attractive to vote-seeking politicians, which means that a democracy would have a tendency not to spend a lot of money on uncertain programs.

Downsian discussion of "too-small budgets" fits nicely with the nature of governmental R&D expenditures. It typically takes several years or decades for government expenditures on basic research to be used in practical applications. The

results of basic research utilizations are very difficult to note, which was evidenced by the experience of Project Hindsight[35] (Sherwin & Isenson, 1967; Greenberg, 1968). It has been found that even for private R&D investments to yield visible economic outcomes it takes on average seven years (Mansfield, 1991). Furthermore, the uncertainty problem is prevalent such that the utilization of research results depends on a great number of contingencies: while the production of knowledge is increasingly dependent on dynamic interactions of various actors such as the knowledge value collectives (Rogers & Bozeman, 2001; Bozeman & Rogers, 2002), factors other than the knowledge itself are critical in the utilization and evolution of such knowledge (Nelson & Nelson, 2002). In a nutshell, what and how much the public will get from R&D programs are highly uncertain. The benefits from public R&D expenditures exemplify the characteristics of public transactions discussed by Downs. As such, public R&D budgets might be too small compared to their socially efficient level.

Another argument of "too-small budgets" for R&D comes from theories of majority voting and log-rolling (Buchanan & Tullock, 1962; Tullock, 1959, 1970). Under the system of majority voting, log-rolling is justified at least in part by the consideration that the intensities of preferences would be taken into account. For example, a minority voter who opposes a government program very strongly would benefit from a transaction with a majority voter who slightly favors the program, where the former provides the latter compensation for changing his/her position (Tullock, 1959). This transaction would make both voters better off depending on the relative intensities of their preferences. Regardless of being positive or negative, vote-trading involves externalities to the nontraders, and if they are negative and large, trading would result in an efficiency loss (Mueller, 1976). If the benefits from a

[35] Project Hindsight was a Department of Defense evaluation study of contributions of scientific research to 20 weapon systems, conducted mainly by engineers in 1963. Of the 556 discrete, identified contributions to weapon systems, 92% were under the technology category and the remaining 8% were for applied research (Greenberg, 1968). Only 0.03% were for basic research.

program are highly concentrated on a small group but the costs are borne by the general taxpayers, log-rolling would make it possible for the program to be supported. This may lead to "overinvestment of resources" (Tullock, 1959, p. 573). Since interest groups have every incentive to propagate the merits of a program,[36] the costs of getting information on such programs of highly concentrated benefits would be much lower than those of widely diffused benefits. This problem would look more serious, with a higher probability for voters to vote for candidates who support programs of narrowly concentrated benefits being than for candidates with more general interests (Olson, 1965; Mueller, 1976). This has implications on the level of government expenditure (Mueller, 1976): there are over-expenditures on special interest programs and under-expenditures on general interests.[37, 38] Because of the high externality of R&D outputs, politicians may turn away from R&D expenditures, favoring special interest programs instead.

Yet, does public R&D expenditure not serve special interests? The answer is not a straightforward one. Lowi (1964) and Meier (1993) designated R&D programs as distributive policies along with "most contemporary public land and resource policies; rivers and harbors ('pork-barrel') programs" (Lowi, 1964, p. 690). Moore (1997) accused the R&D expenditures through the Advanced Technology Program (ATP) under the National Institute of Standards and Technology (NIST) of being concerned with "corporate welfare" because its primary beneficiaries are large

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[36] Political competitors of the incumbents may have incentives to provide voters with information on the influence of special interests on the incumbents (Wittman, 1989, 1995). However, it may not necessarily be the case that the competitors are affected by the special interests, as in the case of campaign contributions from the American Rifle Associations to both Republican and Democratic Parties.

[37] While the implications of the theories of majority voting (and log-rolling) apply to both special interest programs and programs of general interest, public choice theorists tend to focus only on legislative voting with regard to special interests, ignoring cases of voting based on public interests (Orchard & Stretton, 1997).

[38] Applying Downs's economic theory of democracy, Mayhew (1974), assuming politicians' prime objective is reelection, argued that incentives for "credit-claiming" and "position-taking" force them to pursue particularized benefits (programs) and turn away from programs bereft of such benefits.

companies.[39] The same is true of the federal R&D tax credits, where the main beneficiaries are high-tech companies and large manufacturing firms (OTA, 1995), since they undertake most of the private research activities. As for federal support of university research, during FFY1971–2000, "the research, doctorate-granting, and medical institutions" received more than 90% of federal R&D funds for university research (NSF, 2003, p. 15), with the funds concentrated in the top prestigious universities. These considerations indicate R&D expenditures do serve special interests, revealing that R&D expenditures are themselves an area of politics among interested parties, members of Congress, and the bureaucrats.

It seems that government spending on R&D has generated a number of interested groups among the beneficiaries. While outputs from NIH-funded research have the nature of spillovers, it is also true that the NIH commands quite well-developed interest parties in medical schools, universities, and patient groups. These groups have every incentive to push for increasing NIH budgets. The biomedical research community and health and disease-related advocacy groups are an ever-growing presence in the NIH budget process (Strickland, 1972; IOM, 1998). One of the most prominent examples is the Ad Hoc Group for Medical Research Funding. The Ad Hoc Group has developed a close working relationship with members of Congress and NIH bureaucrats. If the presidential request of an NIH budget is not satisfactory to the Group, it initiates an intensive lobbying campaign for higher medical research funding, even directly criticizing the President (Greenberg, 2001). Moreover, each institute is required to establish and maintain a national advisory council/board to seek inputs from those interested groups. In addition, each institute has the discretion to establish multiple types of committees, boards, groups, and panels to get advice from the biomedical research communities and from the general

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[39] *Corporate welfare* is defined by Moore (1997) as "the use of government authority to confer privileged or targeted benefits to specific firms or specific industries" with an obvious adjudication that in this case the ATP is a special interest program.

public who are attentive to health issues. Some of them are to advise the institute directors, while others provide inputs for specific research programs.

Drawing upon the discussion above, the following set of hypotheses aims to take into account that the influences of private interested parties may be different across different types of institutes and between RPGs and intramural expenditures.

- *Hypothesis 4: Research expenditures of specific disease-focused institutes are greater than those of their general science-focused counterparts.*

- *Hypothesis 5: As the participation of private interested parties in the priority setting process increases as measured by either an institute's number of advisory boards or board members, the institute's total expenditures increase as well.*

- *Hypothesis 5.1: As the participation of private interested parties in the priority-setting process increases as measured by either an institute's number of advisory boards or board members, RPG expenditures increase more than intramural research expenditures in percentage terms.*

- *Hypothesis 5.2: As the participation of private interested parties in the priority-setting process as measured by either an institute's number of advisory boards or board members increases, research expenditures of specific disease-focused institutes increase more than their general science-focused counterparts in percentage terms.*

- *Hypothesis 6: If the congressional members of the appropriations subcommittees with jurisdiction over the NIH are ideologically more favorable to special interest groups as measured by either the median vote ratings of the Chamber of Commerce and the National Taxpayers Union or their median years of congressional service, an institute's RPG*

expenditures increase more than intramural research expenditures in percentage terms.

- *Hypothesis 6.1: If the congressional members of the appropriations subcommittees with jurisdiction over the NIH are ideologically more favorable to special interest groups as measured by either the median vote ratings of the Chamber of Commerce and the National Taxpayers Union or their median years of congressional service, research expenditures of specific disease-focused institutes increase more than their general science-focused counterparts in percentage terms.*

Appropriations Bills Structure and NIH Research Expenditures

The U.S. budgeting process for R&D activities is characterized as decentralized and complex. Without a centralized body for the coordination of authorization and appropriation of R&D programs, disjointed interactions among relevant congressional committees and executive departments/agencies are prevalent in the R&D budgeting process. In the House, jurisdiction over R&D-related legislation is dispersed across several committees, with no matching alignment in the Senate. While funds for government programs are appropriated currently by 12 appropriations bills, funding for R&D faces a double-edged competition: it is addressed in each of the appropriations bills, and R&D programs compete with other R&D programs as well as non-R&D programs. There could be two types of competition under the current appropriations bills structure with the possibility of omnibus legislation. At the agency (department) level, R&D budgets have to compete with non-R&D budgets. This affects all of the agencies in one way or another. Additionally, there is interagency competition. R&D programs of civilian purposes have to compete with R&D programs in the other departments/agencies as well as defense R&D. In addition to these competitive factors, there is a further complicating factor of the R&D appropriations process: while the Senate and House Appropriations Bills for Defense and Energy departments usually pass the Congress free-standing, the other appropriations bills are frequently grouped together into one or more omnibus appropriations bills. Therefore, R&D funds that are appropriated by appropriations bills other than the bills of Defense and Energy and Water Development are more vulnerable to competition among research-supporting agencies under the same appropriations bill. The current structure of the appropriations bills requires the NIH research funding to compete with research activities by the Departments of Labor and Education and by the Center for Disease Control and Prevention of the HHS as well as non-research activities by these Departments.

Against this background, this study considers the effect of the institutional arrangements of the appropriations process on NIH expenditures. The institutional arrangements include the frequent use of omnibus appropriations and the jurisdictional structure of the appropriations committees. An omnibus bill is "legislation that is hundreds or thousands of pages in length and which encompasses disparate policy topics" (Davidson & Oleszek, 2004, p. 190). In the same vein, Sinclair (1997) defined omnibus legislation as "legislation that addresses numerous and not necessarily related subjects, issues, and programs, and therefore is usually highly complex and long" (p. 64). Krutz (2000) uses a more operational definition: "any piece of major legislation that: (1) spans three or more major topic policy areas OR ten or more subtopic policy areas, AND (2) is greater than the mean plus one standard deviation of major bills in size" (p. 539). Omnibus bills have been a conspicuous phenomenon since the 1980s, during which fiscal deficits posed to Congress the difficult challenges of approving budgets within time constraints (Oleszek, 2001). The telltale example would be the experience of FFY 1986 and FFY 1987, when all of the appropriations bills could not pass Congress and thus appropriations were put together into continuing resolutions. Given the theoretical interest this study has in the budgeting process, these omnibus continuing resolutions are not regarded as omnibus appropriations bills. It was not until 1996 that the appropriations bills for the new fiscal year were packaged into omnibus bills.[40] Appropriations bills covering the NIH have been put together with other bills eight times between 1996 and 2005. With the advent of bundling together several new

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[40] There is one exception: the Omnibus Appropriations Act of 1950, which was a one-time experiment. At that time, proponents argued that the Omnibus Appropriation Act would provide an opportunity to evaluate appropriations "by relative merits, importance, or cost in view of the whole fiscal situation" and allow for "greater care and attention in the appropriations process, discovery of conflicts and duplication, prevention of riders and logrolling, discouragement of deficit spending, completion of regular appropriations before the end of the fiscal year, and achievement of substantial economics as a result of these factors" (Nelson, 1953, pp. 276–77). There were objections, including fears that there would be a delay in appropriations, haste approval of a bill without adequate consideration, logrolling and weakening of congressional control over appropriations, and undermining presidential veto power.

appropriations bills since 1996, there may now be the expectation that each of the appropriations bills would be rolled into a mega-bill. This could pose a change in the incentive structures of members of Congress.

While understood as "an agenda-control and coalition-building tool" (Krutz, 2000, p. 533), the omnibus bill has many reasons for its ascendancy in the latter half of the twentieth century. Simply incorporating several bills into one mega-bill can improve the chances of all of the bills being enacted into law. According to Krutz (2001), omnibus legislation changes the traditional legislative process, fast-tracking the mega-bill "through committees with less consideration than typical bills" (p. 210). These mega-bills also provide an alternative for policy entrepreneurs who push legislation, and omnibus bills may be strategically pursued to get through the labyrinth legislative process. Members of Congress may find political shelters in the omnibus bills since omnibus bills can relieve them of the burden of casting difficult votes (Davidson & Oleszek, 2004). By highlighting one part of the omnibus bill, political leaders can divert the attention of constituents from another part of the bill (Krutz, 2000).

Empirical research on omnibus bills has centered on the productivity of law-making and on who benefits from such omnibus bills (Baumgartner et al., 1997; Krutz, 2000, 2001). Krutz (2000) examined the relationship between omnibus legislation and productivity of legislation, reporting a positive influence on legislative productivity. Krutz (2001) tried to answer the question of why leaders attach some bills but not others to an omnibus bill in terms of the relationships both between leaders and members and between Congress and the President. The finding was that "party leader and member incentives[41] for omnibus use also significantly increase the chances that a bill will be attached to an omnibus package" (p. 218).

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[41] The incentives are party-agenda items and distributive measures.

Krutz's argument is compelling, but it lacks attention to the possibility that the content of each of the bills packaged into an omnibus bill could be changed from what was originally intended by the bill' sponsors. Theoretical interest in such a possibility is due to the consideration that the practice of omnibus legislation poses a change in the operation of the congressional standing committee system. According to the institutional formal theorists of rational choice, the standing committees monopolize jurisdictions through a system of property rights[42] (Jenkins, 1998). Shepsle (1986) posits that the choice set X is "partitioned into what may be called jurisdictions over which property rights are assigned to organizational subunits" (p. 55). As such, a committee is a provider of proposals with monopoly power over its jurisdiction. In exchange for the monopoly on the legislative proposals of the areas that are most important to them, the committee members trade off influences in many other policy areas (Weingast, 1979; Shepsle, 1986). Decentralization and monitoring of the behavior of the committees comes with this arrangement.[43]

The practice of rolling several appropriations bills into one mega-bill could change the incentive structure of members of Congress with the effect that, depending on their respective preferences over the combination of R&D and non-R&D funding, they have higher incentives to seek funding for their preferred programs. This would move the budget outcomes to the ones that are most preferred by only the dominating coalitions among legislators. If the members of the House Subcommittee on Labor, HHS, and Education, whose jurisdiction covers the NIH and the CDC, expect that the appropriations bills are to be packaged into an omnibus appropriations bill and if they are committed to increasing appropriations for these agencies, they may pursue more aggressively a higher level of funding for these agencies. However, in such a case,

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[42] For a political theory of the origin of property rights, see Riker & Sened (1991).
[43] Based on the understanding of the committee system as a property rights system, Jenkins (1998) examined the change in the House of Representatives from a system of channeling a majority of legislation through select committees to a system of standing committees in terms of establishment of property rights.

members of the subcommittees are more likely to pursue further funding of more preferred programs at the expense of less preferred ones. This is because if the bill is not able to pass Congress free-standing they expect it will pass packaged into an omnibus bill. On the other hand, if the subcommittee members care more about non-R&D programs, the practice of omnibus legislation would militate against funding for these agencies. This reasoning is in line with Krutz (2001), who argued that ordinary members of Congress benefit from omnibus legislation in terms of distributive programs.

Considering that the NIH has enjoyed support from a wide range of congresspersons, including key members such as Senators Hatfield, Spector, Mack, and Hatch and Representatives Porter, Walker, and Waxman, this study hypothesizes that due to omnibus legislation, the institutes under the NIH have succeeded in securing higher budgets. Furthermore, it is expected that specific patient and advocacy groups seek even higher budgets by lobbying congressional leaders and key actors in the appropriations subcommittees. Thus, the expenditures of disease-focused institutes may have increased more than their non-disease counterparts. On the other hand, omnibus legislation may provide different incentives to institute directors: they may find an opportunity to increase their institute budget more than without omnibus legislation. In such a case, there might be a change in the effect of the director's PSE on the institute's total expenditures in a way that strengthens the importance of the institute directors in the budget process.

- *Hypothesis 7: With the practice of omnibus legislation, an institute's total expenditures are greater after 1997 than before 1997.*

- *Hypothesis 8: With the practice of omnibus legislation, disease-focused institutes' total expenditures have increased more than those of other institutes.*

- *Hypothesis 9: With the practice of omnibus legislation, as an institute director's public service experience as measured in years increases, the institute's total expenditures increase more rapidly than without omnibus legislation.*

All of the hypotheses developed above have different foci. Some of them address the relationships between specific characteristics of actors and total institute expenditures, and others examine the actors' relative influence on different fund mechanisms. Some hypotheses are concerned with institutional procedures and their budgetary impacts. The diversity of the hypotheses indicates the diverse influences at work in the complex process of budgeting for the institutes. As such, the testing of these hypotheses requires a sophisticated research design, which is the topic of the next chapter.

CHAPTER 4

METHODOLOGY

Measures of Key Variables

Dependent Variables

This study uses two types of dependent variables, as describe in Table 3. The first type is log of total expenditures and those through the mechanisms of RPGs and Intramural Research. Because the expenditure amount can be as much as $4.8 billion for an institute, it is better to see the effects of independent variables not in dollars but in percentage terms. The second type of dependent variable is calculated from expenditure amounts through different sources. To examine the hypothesized differential effects of the independent variables between RPGs and Intramural Research, the percentage of Intramural Research in the sum of the expenditures on these two funding mechanisms is used. This study focuses only on the RPG and Intramural Research expenditure mechanisms. As described in Chapter 2, there are other expenditure mechanisms such as Research Centers, Other Research, Research Training, and R&D Contracts, on which both the institute leadership and the scientific communities have significant influence. Therefore, these are not good candidates to test different motivations of the institute leadership.

To examine the bureaucratic risk aversion and mission motivation hypotheses, a Herfindahl index[44] of concentration of expenditures through different mechanisms[45]

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[44] The Herfindahl index is a measure of market competition, calculated as the sum of squares of the market shares of each component firms in a market defined by substitutability. Thus, it ranges between 0 and 1. Being closer to 0 indicates that there are numerous small firms without pricing power. The Herfindahl index has achieved an unusual popularity because of its usability in a wide range of contexts (Rhoades, 1993) other than market concentration, such as party fragmentation and political strength (Borge & RattsØ, 2002), interest system diversity (Gray & Lowery, 1993, 2001; Lowery & Gray, 1998), congressional committee jurisdiction concentration (Hardin, 1998), concentration of a

was created. In calculating the Herfindahl index, all of the NIH expenditure mechanisms are utilized. If the index is closer to 0, it means that the institute diversifies its expenditures through multiple support mechanisms.

Table 3. Dependent Variable Descriptions and Data Sources

Variable	Description	Source
lninstitotal	Log of an institute's total expenditures in year *i*	Office of Budget, NIH
lnpiinitiated	Log of expenditures through private PI-initiated RPGs in year *i*	
lnintramural	Log of expenditures on research by intramural laboratories in year *i*	
intraprop	The percent of Intramural Research in the sum of intramural and RPG expenditures in year *i*	
herfindahl	Herfindahl index of these different mechanisms in year *i*	

Key Independent Variables

The *institute director's PSE measured in years* is used as a proxy of how much the director has absorbed the prevalent values of the institute and of how much political clout the institute director has developed. There are two components to this variable: PSE before being appointed as an institute director and PSE experience thereafter. The rationale of using this indicator comes from the theories of organizational socialization. While socialization is a process of one's assimilation with the norms and values of a society, organizational socialization involves the process of acquiring the knowledge, skills, and values that are necessary to assume a role in the organization (Van Maanen & Schein, 1979), through which a newcomer adapts to be an integrated and effective insider (Cooper-Thomas & Anderson, 2006).

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firm's patenting across nations (Ahuja, 2000), and concentration of health-care bond issuers (Gershberg et al., 2000).

[45] To calculate the Herfindahl index of expenditures, this study uses the expenditure mechanisms of RPGs, Intramural Research, Research Center, Research and Development Contracts, Other Research, Research Training, Research Management and Support, Cancer Control, and Construction.

The domains of organizational socialization (performance proficiency, politics, language, people, organizational goals/values, and organizational history) (Chao et al., 1994) indicate that through organizational socialization, the values, norms, and goals of the organization are transmitted to the newcomer (Fogarty & Dirsmith, 2001).

If the prevalent value of the institute is self-interest maximization via seeking bigger budgets (Niskanen, 1971), the longer the director works in the public sector the more likely he/she identifies his/herself with the values, norms, and politics of budget maximization. On the other hand, if the institute is brimming with PSM, the long-served directors are likely committed to public values and public interests. Either way, as time goes on, the directors are expected to absorb practical knowledge for leading the institutes and steering through the complex and treacherous budget process. Such knowledge should help them get whatever they seek as institute directors. To allow for the possibility of a nonlinear relationship with years of the institute director's PSE and the expenditure levels of specific mechanisms, a squared term was created. The possibility is such that the effect of the director's PSE on expenditure levels is increasingly stronger or weaker.

Numbers of advisory boards and their memberships are used as proxies of the influence of the private biomedical research community and advocacy groups.[46] Each institute has four distinct types of advisory committees: integrated/initial review groups and special emphasis panels, which provide preliminary peer review of research grant applications; national advisory councils and boards, which conduct the second-level peer review as well as oversee intramural research; boards of scientific advisors, which review and evaluate research and programs of intramural laboratories; and program advisory committees for specific advice for research programs (IOM, 2003). The influence of each type of committee on funding outcomes should not be

[46] There may be an alternative proxy of interest group influence on the priority-setting process. In the initial stage of data collection for this study, information about organizations of health advocacy and medical research was collected. But it is truly difficult, if not impossible, to relate each organization to a specific institute.

equal, but without any consistent weighting scheme, each of the advisory committees is treated as equally affecting the decisions of research fund allocations; so is the number of their members. As in the director's PSE, a squared term of the number of advisory boards was created. This squared term allows for the possibility that with more advisory boards the budgetary decision-making process may undergo either a type of nondecision-making or X-inefficiency (Leibenstein, 1966). That is, as the number of advisory boards increases, it could be more difficult to decide on specific issues because of increased opinions and veto points. Alternatively, the marginal effect of increasing the number of advisory boards might be a function of a positive slope, indicating that the effect of one additional board may be bigger when the advisory boards are many than when there are only a few.

There was a break in the number of advisory boards both at the institute and the agency level, as indicated by Figures 2–5. figures 2 and 3 describe the ups and downs of advisory boards at the NCI and the NHLBI, both of which indicate a drastic change during the first half of the 1990s. After the change, the number of advisory boards remained stable through to 2005. Figures 4 and 5 show the trends of the advisory boards and their members at the agency level. Before 1994, both the numbers of advisory boards and their members rapidly increased. However, during 1993 and 1994 there was a drastic reorganization of advisory boards and their membership. Since 1994, the numbers of both advisory boards and their membership have remained flat.

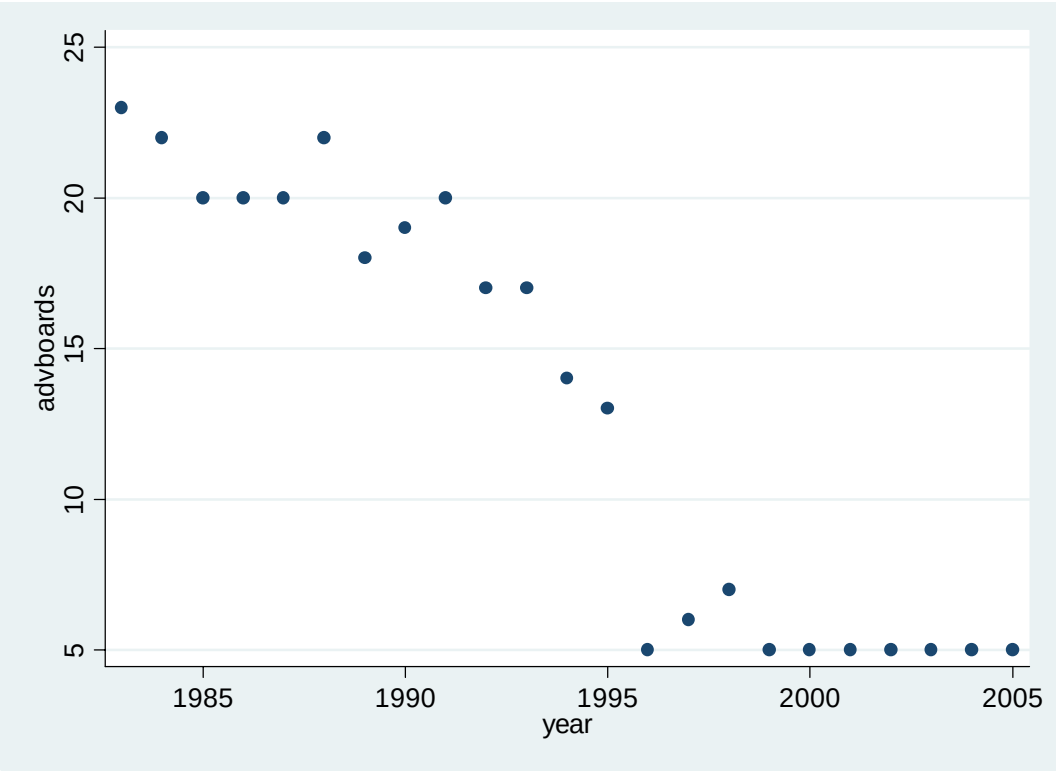

Figure 2. Number of Advisory Boards for the Leadership of NCI

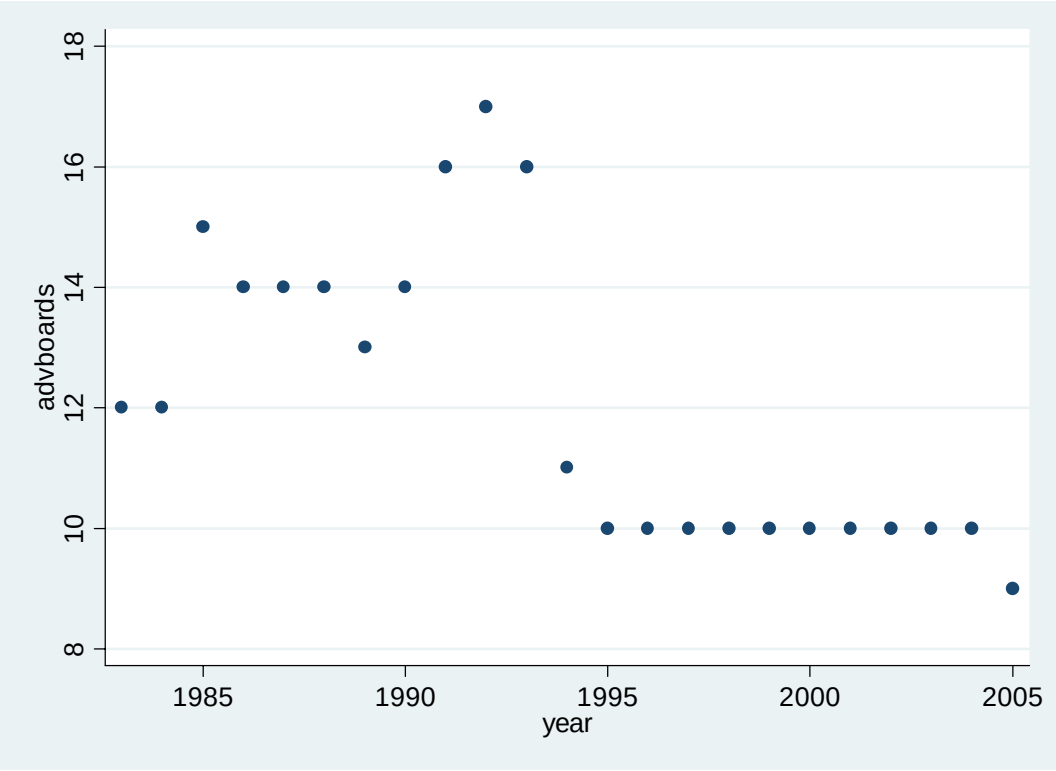

Figure 3. Number of Advisory Boards for the Leadership of NHLBI

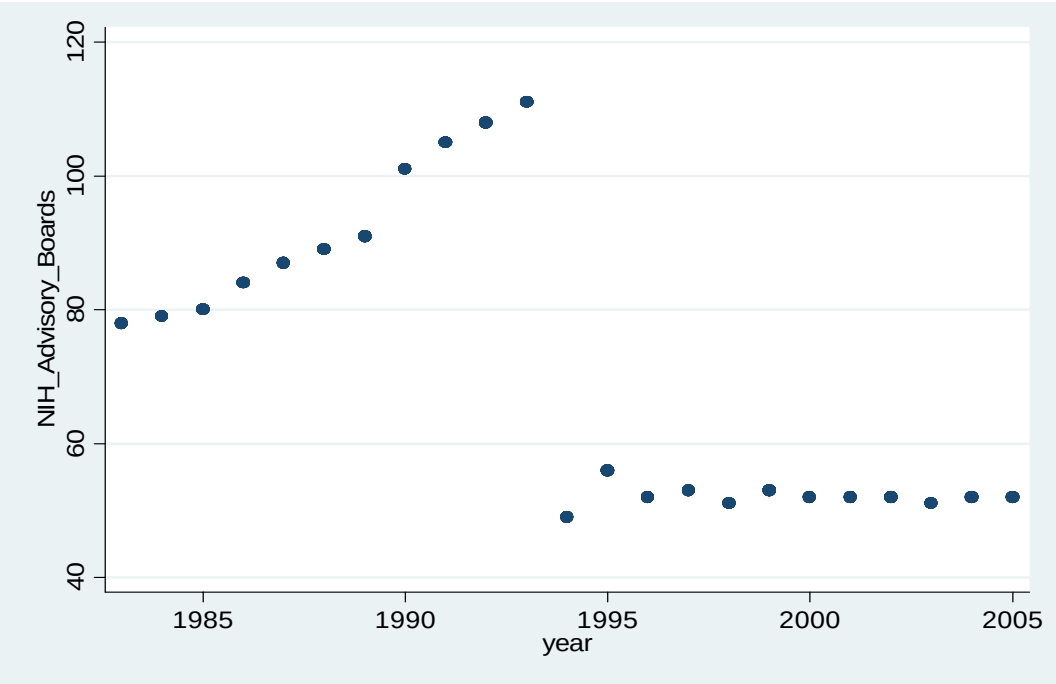

Figure 4. Number of Advisory Boards for NIH Agency Leadership

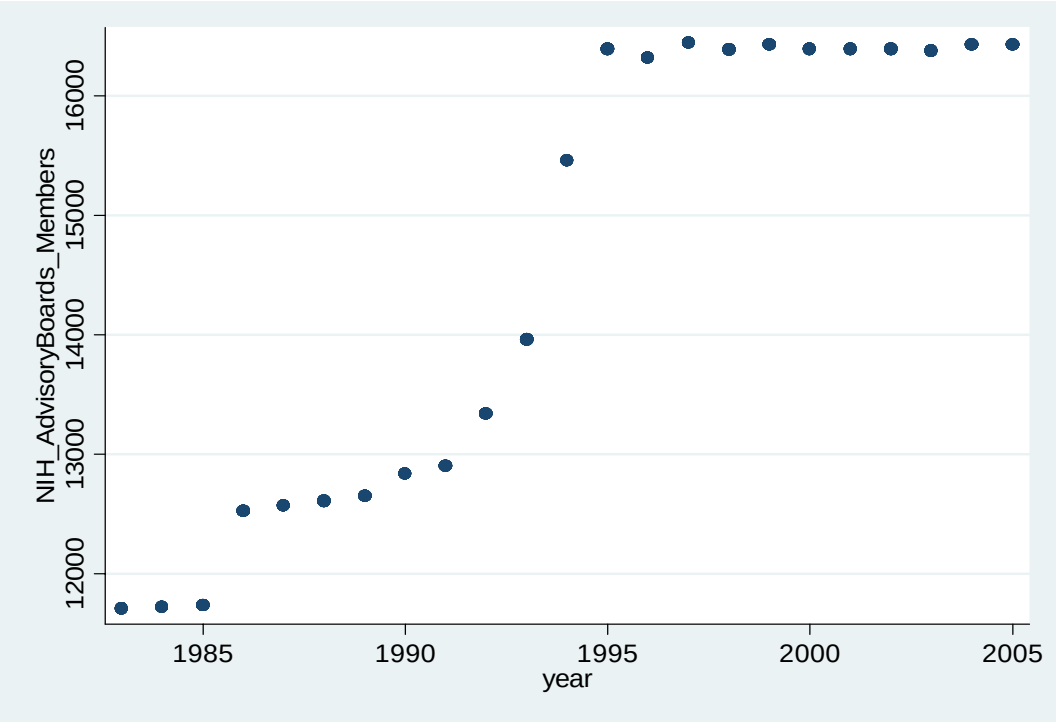

Figure 5. Members of Advisory Boards for NIH Agency Leadership

The single most important reason driving such a drastic termination of advisory boards was Executive Order 12838 of February 10, 1999. In EO 12838,

President Clinton ordered each executive department and agency to "terminate not less than one-third of the advisory committees subject to Federal Advisory Committee Act (and not required by statute) that are sponsored by the department or agency by no later than the end of fiscal year 1993" (p. 1). This order also prohibits creation of an advisory committee unless the agency head finds it necessary to establish such a committee and receives approval from the Office of Management and Budget. Because of to this order, nonstatutory advisory committees such as peer review groups and program advisory boards were terminated between 1993 and 1994. This point was confirmed by personal communication with a NIH historian:

> The NIH response to Executive Order 93-10, Termination of Federal Advisory Committees, primarily involved peer review groups and program advisory bodies, with the single exception of the Advisory Committee to the NIH Director. I scanned the minutes and agendas of this body and found a disposition to press for expanded authority for NIH in 1992 to appoint public sector representatives to all 31 NIH advisory committees, but this was not adopted in the subsequent annual meetings.

The *medians of the U.S. Chamber of Commerce (CC) and the National Taxpayer Union (NTU) voting scores of the NIH-related appropriations subcommittees members* are used to measure how the subcommittee members' policy preferences represent the extent of subcommittee members' affiliation to special interest groups. In the literature, these measures are essentially measures of political ideology in the liberal/conservative continuum (Poole, 1981). The measures are used in this way because the CC and NTU ratings measure how much the members of Congress vote either in a pro-business way (CC) or in a manner that saves tax dollars. The difference between these ratings is that the CC vote ratings focus on economic matters whereas the NTU ratings track votes on bills with high price tags. However, a high CC voting score may indicate that a voter is more connected to well-organized private interests. On the other hand, the NTU rating refers to the spending preferences of the lawmakers, which may in turn indicate how they care about the general interest of taxpayers. These two ratings are not necessarily negatively associated: a pro-

business congressman could also vote in favor of taxpayers. For example, the median CC rating of the House Appropriations Subcommittee with jurisdiction over the NIH is strongly correlated with the median NTU ratings (r=.833) in the dataset used in this study, as shown in Table 4.

These ratings are used in various contexts, as surrogate measures for partisan and ideological effects (CC) (Bailey & Brady, 1998) and as spending preferences or preferences for deficit reduction (NTU) (Binder et al., 1999; Payne, 1991). In spite of their high acceptance as a proxy of ideology (Fowler, 1982; Poole, 1981), the interest group ratings have also been criticized as being biased (Fowler, 1982), shifting, and stretching. This is because these groups have to use different sets of votes to construct their ratings every year and because the underlying rating scales are different across chambers and time (Groseclose et al., 1999, p. 33).

Table 4. Correlation among Vote Ratings and Years of Congressional Service

	Senate		House		Senate	House
	CC	NTU	CC	NTU	Years	Years
Senate CC	1.0000					
Senate NTU	0.2462	1.0000				
House CC	0.8496	0.2445	1.0000			
House NTU	0.7240	0.4362	0.8330	1.0000		
Senate Years	0.4270	0.1793	0.4179	0.4003	1.0000	
House Years	-0.6370	-0.3323	-0.7755	-0.7289	-0.0337	1.0000

The *median of years of congressional service of the NIH-related appropriations subcommittees members* is also used as a proxy of how much the members represent special interests with regards to NIH-funded medical research. One pivotal argument for using years of congressional experience as a proxy of special interest affiliation is that as time goes on, members of Congress will nurture closer relationships with interest groups in their jurisdiction. It is a well-established

argument that the policy process of the U.S. federal government is dominated by relationships among congressional committee members, administrators (bureaucrats), and interested parties (Griffith, 1939; Hamm, 1983), regardless of how they are termed: iron triangle, issue network (Heclo, 1978), or advocacy coalition (Sabatier & Jenkins-Smith, 1999). Under the subsystems of these three main actors, the influence of a congressional committee member vis-à-vis bureaucrats or other committee members tends to increase when he or she gets support from the interest groups or the public involved in the process (Freeman, 1955; Schattschneider, 1960). Moreover, with reelection in mind (Mayhew, 1974), congresspersons have more reasons to develop close relationships with interest groups within their jurisdictions. Because of their shorter election cycle, this tendency is expected to be greater for the Representatives than the Senators. Therefore, the more experienced congresspersons tend to develop more stable relationships with interest groups in the policy subsystem.

Correlation coefficients between the CC and NTU ratings in and median years of congressional experience in Table 4 show that congressional service experience of the House Appropriations Subcommittee members is consistently negatively associated with CC and NTU ratings. On the other hand, years in Congress of the Senate Appropriations Subcommittee members is positively associated with CC and NTU ratings. As an indicator of special interest affiliation, years of senatorial service of the Senate Appropriations Subcommittee members does not work well with the concept. Rather, as congressional service years increase, Senators appear to care more about public interest. This may be because their election cycle is longer than their House counterparts. These points will be considered in the interpretation of the results.

Omnibus is a dummy variable capturing new appropriations practice. It is coded as 1 for years between 1997 and 2005. While each of the institutes under the NIH focuses on particular medical research areas, about half of them are organized in the line of a specific disease around which patient and advocacy groups are well-developed. To examine the differences between these two types of institutes, this

study incorporates a dummy variable, *diseaseinst*, coded as 1 for the institutes of NCI, NIA, NIAAA, NIAID, NIAMS, NIDCD, NIDDK, NIDA, NIMH, and NINDS. To examine whether these two dummy variables make a difference in the effect of the other independent variables, a series of interaction terms were created. A list of independent variables, control variables and their sources, and descriptive summaries are provided in the tables 5-7.

Table 5. Independent Variables and Data Sources

Variable	Description	Data Source
director directsq	Institute director's PSE measured in years–Squared term of *director*	NIH Almanac 1983–2005
advboards advboardsq advmember	Number of advisory boards/councils/committees of an institute Squared term of *advboards* Number of members of advisory boards/councils/committees of an institute	Encyclopedia of Government Advisory Organizations 1983-2005
nihdirector nihdirectsq	NIH director's PSE measured in years Squared term of *nihdirector*	NIH Almanac 1983–2005
nihadvboards nihadvboardsq nihadvmember	Number of advisory boards/councils/committees at the agency level Squared term of *nihadvboards* Number of members of advisory boards/councils/committees at the agency level	Encyclopedia of Government Advisory Organizations 1983–2005
ssubccus hsubccus	Median voting scores by the CC of the Senate Appropriations Subcommittee members with jurisdiction of NIH Median voting scores by the CC of the House Appropriations Subcommittee members with jurisdiction of NIH	Sharp (2006)
ssubntu hsubntu	Median voting scores by the NTU of the Senate Appropriations Subcommittee members with jurisdiction of NIH Median voting scores by the NTU of the House Appropriations Subcommittee members with jurisdiction of NIH	
ssubyos hsubyos	Median years of congressional experience of the Senate Appropriations Subcommittee members with jurisdiction of NIH Median years of congressional experience of the House Appropriations Subcommittee members with jurisdiction of NIH	
president republican divided democrat omnibus diseaseinst dis*** ***omni	Republic control of the Presidency coded as 1 and Democratic control as 0 Political control of the Congress: Republican control of both houses of Congress Mixed control of Congress between Democrats and Republicans Democratic control of both houses of Congress Dummy variable capturing a change in appropriations legislation: years between 1997 and 2005 coded as 1 and the others as 0 Institutions focusing on specific diseases: NCI, NIA, NIAAA, NIAID, NIAMS, NIDCD, NIDDK, NIDA, NIMH, and NINDS coded as 1 and others as 0 Interaction between *diseaseinst* and other variables Interaction between *omnibus* and other variables	

Table 6. Control Variables and Their Descriptions

Variable	Description
lninstitotal_1	One year lagged variable of *lninstitotal*
lnpiinitiated_1	One year lagged variable of *lnpiinitiated*
lnintramural_1	One year lagged variable of *lnintramural*
intraprop_1	One year lagged variable of *intraprop*
lnpiinitiated*net*	Total institute expenditures net of expenditures on PI-initiated RPGs
lnintramural*net*	Total institute expenditures net of expenditures on Intramural Research

Table 7. Descriptive Statistics of Independent Variables

Variable	Mean	Std. Dev.	Min	Max
Director's PSE	17.07817	11.28461	1	51
Number of Advisory Boards	5.669192	3.948294	1	25
Number of Advisory Board Members	417.553	444.1179	12	1758
NIH Director's PSE	5.826087	3.034698	1	11
Number of NIH Advisory Boards	71.21739	21.58481	49	111
Number of NIH Advisory Board Members	14537.57	1927.104	11710	16439
CC Rating of Senate Appr. Subcomm.	55.8913	14.44641	33	84
NTU Rating of Senate Appr. Subcomm.	38.91304	10.77492	20	65
Experience of Senate Appr. Subcomm.	19.73913	2.153788	14	24
CC Rating of House Appr. Subcomm.	55.36957	27.22434	13	94
NTU Rating of House Appr. Subcomm.	37.93478	17.14196	17	80.5
Experience of House Appr. Subcomm.	12.82609	4.233922	7	20

Data and Sources

The datasets used for the dependent variables are from the Office of Budget of the NIH and are available on its website. The dataset breaks down an institute's expenditures between FFY 1983 and FFY 2005 into multiple mechanisms of RPGs, Intramural Research, Research Centers, Other Research, Research Training, and R&D Contracts, as enumerated in Chapter 2. Since some institutes were established in this study period,[47] the dataset is an unbalanced time-series cross-sectional (TSCS) dataset. The data-set does not provide any information on what type of research is supported in terms of specific disease types or basic versus applied research. On the other hand, it does give an idea of who are the main beneficiaries of the support and how the expenditure mechanisms are managed. For example, R&D Contracts are used to seek research agendas specific to an institute, with the initiative of the institute's leadership to seek applications from commercial firms and nonprofit institutions. Thus, they are the main beneficiaries of this mechanism. The opposite is applied to the principal investigator-initiated RPGs, whose main recipients are scientists in medical schools and universities.

Data on the independent variables were obtained from various sources, including the NIH Almanac 1983–2005 for the institute directors, the Encyclopedia of Government Advisory Organizations 1983–2005, and the Directory of Congressional Voting Scores and Interest Group Ratings (4th edition, 2006). Information on appropriation subcommittee members was obtained from the Congressional Directory.

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[47] Four institutes were established in this study period: National Human Genome Research Institute (NHGRI, 1989), National Institute of Arthritis and Musculoskeletal and Skin Disease (NIAMS, 1986), National Institute on Deafness and Other Communication Disorders (NIDCD, 1988), and National Institute of Biomedical Imaging and Bioengineering (NIBIB, 2000).

Model Specifications

This study uses a TSCS dataset with observations of the 18 institutes established prior to 2000.[48] Observations per institute are between 11 and 18, and the total number of observations is between 359 and 366, depending on the specification of models. Relying on Ordinary Least Square (OLS) regression would be problematic because of its temporal and spatial properties (Beck & Katz, 1995): the typically observed phenomena of panel heteroskedasticity, contemporaneous correlation, and serial correlation. In such a case, even if the estimates of the coefficients of the independent variables are consistent, the hypothesis tests might be misleading because of heteroskedasticity and serial correlation problems. To solve these issues, Beck & Katz (1996) advise using OLS with panel-corrected standard errors (PCSEs) while controlling temporal dynamics of serial correlation. While using OLS with PCSEs with panel-common first-order autocorrelation structure, the models specified in this study will include lagged dependent variables, which is a typical method of removing serial correlation in OLS with PCSEs.

However, including a lagged dependent variable in the model may pose a problem if either unobserved observation-specific effects or time-invariant explanatory variables are omitted in the specification of the model (Kristensen & Wawro, 2003). All of the four different models specified in this study do not include year or institute dummies since the independent variables explain about 94% of the residuals of the regression on total institute expenditures with only year and institute dummies. The last, but not the least, problem with the model specification is a potential endogeneity: the more successful directors may keep the position longer. Under tough competition among federal agencies for higher budgets, securing more budgets is one of the defining factors of success of an institute director. Additionally,

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[48] Since it was established in 2000, the NIBIB is not included in the analysis.

the institutes with more discretionary budgets can fund additional advisory boards. That is, there may be two-way flows of influence between the dependent and these two variables. Without a plausible instrumental variable for two-stage regression and limitations of the dataset, this study could not effectively resolve the endogeneity issue. This point will be discussed in the section of the study limitations in Chapter 6.

The basic model includes the independent variables described in the previous section without interaction terms. This basic model (model I) assumes that the effects of the major independent variables—director, advisory boards and their members, and congressional vote ratings and experience—are not different between 1) with and without omnibus legislation and 2) between disease-focused institutes and their non-disease counterparts. To test whether the practice of omnibus legislation impacts how the other independent variables affect the dependent variable, interaction terms between *omnibus* and the other variables are included in the second model (model II). Since the main focus is on the leadership and input channels of the individual institutes and ideological orientation and interest group affiliation of members of the appropriations subcommittees, interaction terms are selectively used for only the variables measuring these factors. Model II, with interaction terms with only *omnibus*, eliminates the first assumption in model I such that the effects of the independent variables are different with and without omnibus legislation, whereas they are not different between disease-focused institutes and their non-disease counterparts. To examine differential effects between disease-focused institutes and other institutes in the independent variables, the interaction terms between *diseaseinst* and the other independent variables are included in the extended model (model III). Model III, with interactions with *omnibus* and *diseaseinst*, assumes that *omnibus* and *diseaseinst* independently make differences in the effects of the independent variables. Lastly, to consider a possibility that *omnibus* and *diseaseinst* jointly influence how the other independent variables affect the dependent variables, interaction terms among *omnibus*, *diseaseinst*, and the other independent variables are included (model IV).

Model IV considers an additional possibility that these two dummies interact with each other and jointly influence the effects of the other independent variables.

These basic and extended models are specified for the dependent variables of total institute expenditures, investigator-initiated RPGs, Intramural Research, percent of Intramural Research in the sum of Intramural and RPG expenditures, and Herfindahl index of different expenditure mechanisms. For the mechanisms of investigator-initiated RPGs and Intramural Research, the expenditure amount net of the designated mechanism is controlled.

CHAPTER 5

ANALYTICAL FINDINGS AND DISCUSSIONS

This chapter reports findings from the empirical tests of the hypotheses developed in Chapter 3. Determinants of an institute's total expenditures are discussed first.

Total Institute Expenditures

Institute-Level Factors

Effect of Institute Director's Public Service Experience (PSE)

Since every institute has its own mission, history, leadership, size, organizational structure, and constituency groups, the priority-setting process involving the budget process varies across the institutes (IOM, 1998). The process of allocations for specific research activities is also unique to every institute. However, the primary participants in the process are the leaders of the institutes and the interested scientific communities.

The institute director's PSE is the sum of the years the director has been in charge of the institute and his/her years in public service previous to the appointment of the institute. During those periods of public service, the researchers would absorb bureaucratic incentive structures, as posited by Downs (1967) and Niskanen (1971). Arguably, they might behave in a way to maximize their own private interests, including vying for larger budgets, more staff members, and bigger offices. Alternatively, they might insulate themselves based on their cherished values of serving the public. The organizational mission of the NIH is "science in pursuit of fundamental knowledge about the nature and behavior of living systems and the application of that knowledge to extend healthy life and reduce the burdens of illness and disability" (NIH, 2006b). A high interest in health issues may have helped NIH

officials identify themselves with their organizational mission. As a consequence, in the perspective of both bureaucratic maximization and PSM, as the director's experience increases he/she is expected to seek higher budgets for his/her institute (*Hypothesis 1*).

The results of OLS regression with PCSEs on total institute expenditures are provided in Table 8. The coefficients on *director* and its squared term in all four models indicate that more years of PSE lead to higher institute budgets. The size of the coefficients appears small: for example, the coefficients on *director* and its squared term indicate that if the director's experience increases from 1 to 2 years, total institute expenditures increase by 1.4%. However, it is misleading to regard this increase as minor, considering the size of the institute's budget. Let us take the NCI as an example. In FFY 2004, its total expenditure was about $1,382 million. An additional year of experience from 1 to 2 years for the NCI director leads to an increase of $19.3 million in NCI expenditures. If the director has led the NCI for 10 years and had 5 years of previous public service, the cumulative effects amount to $275 million, which is not negligible.

Table 8. Determinants of Total Institute Expenditures

Variable	Model I: Basic	Model II: Interaction with Omnibus	Model III: Interaction with Omnibus & Disease Inst	Model IV: Interaction with Omnibus & Disease Inst.
Director's PSE	.01475***	.02505***	.02808***	.03074***
(Director's PSE)^2	-.00032***	-.00048***	-.00051***	-.00056***
Number of Advisory Boards	.07326***	.07055***	.06146***	.06819***
(Number of Advisory Boards)^2	-.00253***	-.00230***	-.00112***	-.00144***
Number of Advisory Board Members	.00020***	.00005*	.00010**	.00002
NIH Director's PSE	.15476***	.25860***	.24974***	.23904***
(NIH Director's PSE)^2	-.03254***	-.02496***	-.02418***	-.02315***
Number of NIH Advisory Boards	-.03254***	-.02727***	-.02650***	-.02568***
Number of NIH Board Members	.00006	-.00018***	-.00017***	-.00016**
CC Rating of Senate Appr. Subcomm.	-.00699**	.00375	.00275	.00356
NTU Rating of Senate Appr. Subcomm.	.00271	-.01069*	-.01032*	-.01098**
Experience of Senate Appr. Subcomm.	-.02434	.21950***	.22488***	.24184***
CC Rating of House Appr. Subcomm.	.00166	.00188	.00126	-.00014
NTU Rating of House Appr. Subcomm.	.01324***	.00280	.00275	.00319
Experience of House Appr. Subcomm.	.23736***	.10754**	.10833**	.10166**
Republican Control of Presidency	.24193***	.07806	.07591	.08049
Republican Control of Congress	.36349***	-.09161	-.09759	-.08683
Mixed Control of Congress	.16952	-.13944	-.13709	-.12497
Omnibus Legislation (omnibus)	.05037	3.07364***	2.92510***	3.51396***
Disease-focused Institutes (diseaseinst)	.09925***	.08147***	.89189***	1.82718***
Lagged Dependent Variable	.74183***	.75760***	.74340***	.73593***
(Director's PSE) *Omnibus		-.00950***	-.00816***	-.01160***
(# of Adv. Boards) * omnibus		-.01098*	-.01063*	-.01692**
(# of Adv. Board Members)*omnibus		.00024***	.00022***	.00048***
(CC Senate Rating)*omnibus		.01049	.00991	.00818
(NTU Senate Rating)*omnibus		.01353**	.01315**	.01397**
(Senate Exp.)*omnibus		-.26547***	-.25337***	-.28543***
(CC House Rating)*omnibus		-.01247**	-.01198**	-.00862
(NTU House Rating)*omnibus		.01363*	.01334**	.01145*
(House Exp.)*omnibus		.15882	.15581	.14938
(Director's PSE)*diseaseinst			-.00676***	-.00810***
(# of Adv. Boards)*diseaseinst			-.02455***	-.02465***

Table Continued.

Variable	Model I: Basic	Model II: Interaction with Omnibus	Model III: Interaction with Omnibus & Disease Inst	Model IV: Interaction with Omnibus & Disease Inst.
(# of Adv. Board Members)*diseaseinst			.00001	.00012**
(CC Senate Rating)*diseaseinst			.00233	-.00044
(NTU Senate Rating)*diseaseinst			.00044	.00418**
(Senate Exp.)*diseaseinst			.03168***	-.09484***
(CC House Rating)*diseaseinst			.00176	.00547***
(NTU House Rating)*diseaseinst			-.00087	-.00244
(House Exp.)*diseaseinst			-.00763	.00371
omnibus*diseaseinst			-.14373**	-1.72012
(Director's PSE) *OD[a]				.00392
(# of Adv. Boards) *OD				-.00172
(# of Adv. Board Members)*OD				-.00030***
(CC Senate Rating)*OD				.00338
(NTU Senate Rating)*OD				-.00406*
(Senate Exp.)*OD				.09272***
(CC House Rating)*OD				-.00663**
(NTU House Rating)*OD				.00393
(House Exp.)*OD				.00700
R-squared	.936	.948	.953	.956
Rho	.249	.27	.286	.300

- *** p<.01, ** p<05, * p<.10
- *a* : omnibus*diseaseinst

The coefficients on *director* and *directsq* jointly indicate that as an institute director's PSE increases up to about 23 years, its positive effect on total institute expenditures decreases. Of the 49 directors whose previous PSE records were obtained, 19 directors served the government on a full-time basis for more than 23 years. This means that there is a negative relationship between the director's years of PSE and the institute's expenditures if the PSE exceeds 23 years. Above 23 years of experience, the length of government service adversely affects institute budgets. There could be multiple explanations for this effect. First, after working as institute directors, a majority of directors return to the academic institutions where they originally worked. If the directors expect themselves to work at an academic setting in the foreseeable future, they may want to distance themselves from the organizational norms, values, and cultures of the institutes. Second, if anticipating retirement, directors may find important or meaningful things other than running the institute or securing higher budgets.

The coefficients on the interaction terms between *omnibus* and the director's PSE in the extended models indicate that the effect of the director's PSE is different with and without the practice of omnibus legislation. In model II, without omnibus legislation, the director's PSE increases the institute's total expenditures up to 26 years; with omnibus legislation, the effect reaches its peak at 16 years of PSE. The coefficient on the interaction between omnibus legislation and the director's PSE shows that the effect of an additional year of experience is smaller with omnibus legislation than without (*Hypothesis 9*). Models III and IV show that for the nondisease-focused institutes, their directors' PSE increases the institutes' total expenditures up until 27 years without omnibus legislation. With omnibus legislation, total expenditures of the nondisease-specific institutes increase as their directors' PSE increases up to 17 (model IV) to 19 years (model III).

The coefficients on the interaction terms between disease-focused institutes and the director's PSE in models III and IV reveals that with omnibus legislation, the director's PSE increases disease-focused institutes' total expenditures only when it is

less than 13 years. Before 1997, when the omnibus appropriations bills were not used, the director's PSE under 20 years tended to increase total expenditures of the disease-focused institutes. This is summarized in Table 9.

Table 9. Years of Positive Relationship between Director's PSE and Institute Total Expenditure in Model III

	Disease Institutes	Non-Disease Institutes
With Omnibus Legislation	13 (17.3)	19 (17.6)
Without Omnibus Legislation	20 (17.5)	27 (16.2)

- ( ): Mean years of the director's PSE.

Table 9 indicates that with omnibus legislation the importance of the director's PSE in the budget process is exhausted more rapidly than without omnibus legislation, and its marginal effect is smaller with omnibus legislation. This finding may be explained by the consideration that omnibus legislation allows congressional committee chairs and key players in the appropriations subcommittees to play a bigger role. Alternatively, with omnibus legislation, organized interest groups such as the Ad Hoc Group may be encouraged to push their requests of higher budgets toward appropriations committee members. Another case made by Table 9 is that the positive effect of the directors' PSE of the nondisease institutes lasts longer than that of the disease-focused institutes.This result indicates that, ceteris paribus, without much support from well-developed patients and advocacy groups, the leadership of the institute takes more responsibility to pursue research agendas. This finding may imply that the directors of these non-disease institutes are driven by PSM rather than self-interests. This point will be discussed further in the subsequent sections.

Advisory Boards and Their Members

There are largely four types of advisory boards/committees/councils at the institute level. Some of them advise the institute director in the priority-setting

process, while others provide peer reviews. Some deal with issues of specific research programs, not with priority setting. As such, their engagement of the process of research fund allocation is inevitably unequal both across types of boards and across institutes. With this caveat, the resulting Table 10, with total institute expenditures as the dependent variable, shows that the number of advisory boards has a significant positive impact on total institute expenditures. For example, in the model I without interactions, a change in the number of advisory boards from 4 to 6 has about a 9.6% budgetary impact, holding all other factors constant. However, its impact is curvilinear so that as the number of advisory boards exceeds 14, an additional advisory board has a negative impact on the institute's expenditures.

The outputs from the extended models indicate that there is variation in the relationship between advisory boards and an institute's total expenditures depending on omnibus legislation and institute types (Table 10). First, with omnibus legislation, the effect of advisory boards reaches its peak with a smaller number of boards. If there are more than 12 advisory boards at a disease-focused institute, an additional board tends to decrease total expenditures. The maximum number of advisory boards at the non-disease institutes that is beneficial to its total expenditures is 23. Without the omnibus practice, the budgetary effect of advisory boards increases at a decreasing rate up to 16 (disease institutes) and to 27 (non-disease institutes). Second, as the number of advisory boards increases, the effect of advisory boards at the disease institutes is exhausted more rapidly than that of the non-disease institutes, which is shown in Table 10. Its marginal effect is smaller for the disease-focused institutes than for their general science-focused counterparts. Given that the mean value of advisory boards is 5.7 and the maximum is 27, it seems that advisory boards all have positive impacts on the institute's total expenditures. However, the effect is stronger when there is no omnibus legislation and for nondisease institutes.

Table 10. Number of Advisory Boards with Positive Relationship with Institute Total Expenditure in Model III

	Disease Institutes	Non-Disease Institutes
With Omnibus Legislation	12 (4.6)	23 (5.0)
Without Omnibus Legislation	16 (7.3)	27 (5.2)

- ( ): Mean number of advisory boards

It is found that in three of the four models the number of advisory board members has a positive effect on the institute's total expenditures, as hypothesized. With omnibus legislation, the effect of advisory board members increases: in model III, one additional board member is associated with a 0.032% increase in total institute expenditures. On the other hand, in model IV, *omnibus* and *diseaseinst* interact with each other and jointly influence the institute's total expenditures. While omnibus legislation in itself increases the effect of advisory board members, it increases the total expenditures of the nondisease institutes more than those of the disease institutes, as indicated by the coefficient on the interaction term among the number of advisory boards, omnibus legislation, and disease institutes, which is positive.

These findings indicate that the advisory boards themselves may align the interests of institute directors' expenditure preferences as well as those of well-organized patients and advocacy groups. If the advisory boards serve the interests of patients and advocacy groups, their effect should remain positive as the number of advisory boards increases, and it does. However, it is not clear whose interests the advisory boards serve. There are good reasons that advisory boards may support the institute director's budget preferences. The institute directors can exert a considerable amount of discretion in establishing advisory boards and appointing their members. Moreover, it might be the case that organized disease-related advocacy groups are not well represented in an institute's input system. In most of the cases, the advisory

board members are from scientific communities in medical schools and research universities. The chances that representatives from disease-related advocacy groups join advisory boards are small.

NIH Agency-Level Factors

NIH Director's PSE

The important finding for the NIH director's PSE is that the magnitude of effects by agency-level factors is much greater than by the institute-level factors. In model I, as the NIH director's PSE increases from 1 to 2 years, an institute's total expenditures increase by 5.7%, compared with 1.4% of its institute-level counterparts. However, the positive effect of the NIH director's PSE is exhausted in 2.4 years. As the NIH director's PSE increases to more than 3 years, its impact becomes negative. In the extended models with interaction terms, total expenditures of an institute increase as the NIH director's PSE increases up to 5 years. Beyond 5 years of tenure as the NIH director, his/her budgetary impact on total expenditures is negative.

There may be several explanations for this outcome. First, as mentioned by NIH (2006a), the role of the NIH director involves the whole of the NIH and is to provide leadership to all component institutes and centers. One step removed from the individual institute level detail, the NIH director pays more attention to shaping the agency and responding to emerging needs and opportunities. As such, the NIH director may "have much less to gain from increments and confront substantial advocacy costs in seeking to push through increases in the agency's base budget" (Dunleavy, 1991, p. 208). Second, there are only two NIH directors who led the agency more than four years. One of these two agency directors is Harold Varmus, who led the agency between 1993 and 1999. During his tenure, Congress decided to double the NIH budgets. Varmus's influence on the individual institute-level expenditures might be absorbed by the omnibus variable.

Advisory Boards and Their Members at the NIH Level

At the agency level, the NIH maintains more than 50 advisory boards to seek advice from the medical research community, patient advocacy groups, and the public. To explore new research issues that are not suitable for individual institutes, the NIH director also establishes advisory bodies.

The model I shows that one additional advisory board's budgetary impact at the agency level is negative: one additional advisory board is associated with about 3.25% of budget decrease, and its relationship is linear. The effect seems to get smaller when including interaction terms in the model. The figures in Chapter 4 indicate that the number of advisory boards negatively affected individual institute expenditures between 1986 and 1993. Too many advisory boards may invite negative consequences in multiple dimensions in terms of decision veto points (nondecisions) and managerial inefficiencies. This negative effect might be one of the reasons driving the reorganization of the advisory boards. Another consideration about this negative relationship is that the advisory boards are intended to provide advice to the NIH director, who may not get substantial benefits from budget increases at the individual institute level. The NIH director may benefit more from establishing more advisory boards and securing discretionary funds than securing more budgets for component institutes.[49]

With regard to the effect of advisory board membership, the basic model reports that the number of advisory board members at the agency level does not have a significant effect on the individual institute's total expenditures. In the extended models with interaction terms, the relationship is found to be negative: one additional board member at the agency level leads to as much as a 0.016% decrease in the individual institute's total expenditures.

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[49] As early as 1988, the need for increasing the NIH director's discretionary funds was raised, and in FFY 2004 Congress allotted $44 million for the purpose of the NIH director's discretionary use.

These findings are noteworthy when compared to the relationship between advisory boards and their membership and the institute's total expenditures. While at the institute level the number of advisory boards and their members has a positive relationship with the institute's total expenditure, at the agency level the direction of the relationship is reversed.

Factors with Respect to Appropriations Subcommittees with Jurisdiction of NIH

The basic model shows (1) that the median CC ratings of the Senate Appropriations Subcommittee has a negative effect on an institute's total expenditures and (2) that the median NTU rating of the members of the House Appropriations Subcommittee is positively associated with an institute's total expenditures. According to these results, pro-business Senate Subcommittee members prefer lower institute expenditures, while their pro-taxpayer counterparts in the House Subcommittee want the opposite. While years of congressional service of the Senate Appropriations Subcommittee members does not seem to have a definitive impact on an institute's total expenditures, years of House experience increase the institute's total expenditures.

However, the extended models provide richer relationships between characteristics of the subcommittee members and an institute's total expenditures. If introducing interactions with omnibus and disease-focused institutes, it is found that CC ratings of Senate subcommittee members do not have a significant relationship with an institute's total expenditures. The interaction terms also show that omnibus legislation makes no difference in the relationship between CC Senate ratings and the total expenditures of an institute. The interaction terms with disease-focused institutes indicate that the effect of CC ratings is not significantly different between disease and non-disease institutes. The coefficients on House NTU ratings report no significant relationship between the ratings and an institute's total expenditures.

The findings in the four models about the relationship between CC ratings and an institute's total expenditures indicate 1) that the relationship, if any, is a weak and

minor one and 2) that the relationship is not significantly different (i) between disease-focused institutes and non-disease institutes and (ii) before and after 1997. Together with the findings about House NTU ratings, it is shown that the CC ratings of the Appropriations Subcommittee members with jurisdiction over the NIH are largely irrelevant on the levels of the institute's total expenditures. This may be explained by the consideration that CC ratings primarily focus on firms in the business sector whereas the NIH research support involves institutions in the academies or in the nonprofit sector.

Although Senate NTU ratings are not related to the dependent variable, their House counterparts indicate a considerable relationship. In the extended models, without the omnibus appropriations practice, Senate NTU ratings lower an institute's total expenditures such that as the median NTU rating of the Senate Appropriations Subcommittee members increases by 10 points, an institute's total expenditures decrease by 10%. This relationship turns to positive with omnibus legislation. A 10-point increase in Senate NTU ratings is associated with a 2.2% increase in total expenditures. On the other hand, there is no difference in the effect of Senate NTU ratings between disease-focused and non-disease institutes. House NTU ratings are found to increase an institute's total expenditures in model I. However, the extended models indicate that this relationship is mainly from the practice of rolling appropriations bills since 1997. These results indicate that while the Senate Appropriations Subcommittee members do not care much about NIH expenditures, their House counterparts do, and that with the omnibus practice, subcommittee members from both houses increase NIH's individual institutes' expenditures. That is, the more committed to the public interests and taxpayers' money the members of the subcommittees are, the more likely they are to seek higher budgets for the NIH. It does make sense in that research activities supported by the NIH benefit the general public as well as the supported scientists and institutions.

The coefficients on experience of the subcommittee members indicate that the NIH research supports still serve well-organized groups in the medical research

community. First, years of House experience does influence an institute's total expenditure in the basic model, but Senate experience does not. However, the interaction terms reveal an interesting story: without omnibus appropriations, an additional increase in the Senate median years of experience leads to a 22% increase in total institute expenditure, and with omnibus legislation, a comparable increase in experience decreases the institute's budget by 4.6%. While Senate experience seems to lead to higher expenditures for disease-focused institutes, it turns out that the omnibus legislation cancels out this effect such that interacting with *omnibus* and *diseaseinst* jointly, one additional year of median Senate experience increases an institute's total expenditures by 9.3%, but it decreases a disease-focused institute's expenditures by 9.5%. On the other hand, in the extended models, the effect of years of House experience does not change between disease-focused and non-disease-focused institutes. There is no significant difference in the effect of House experience with and without omnibus legislation.

The findings about the relationship between years of congressional experience and an institute's total expenditures indicate that the representatives become more in favor of NIH spending as their experience as congresspersons accumulates than do their Senate colleagues. This indicates that NIH expenditures may be regarded as serving special interests. While a step removed from reelection considerations with longer tenures, Senators may care about programs of public interest that may not be sought by special interest groups. This point is comparable to the finding that the relationship between NTU rating and total expenditure is not as strong as the relationship between congressional experience and an institute's total expenditures. In the budget process for NIH funding, consideration of the medical research communities and health advocacy groups may be taken more seriously than concerns for the improvement of the general public health.

Effect of Omnibus Legislation and Disease-Oriented Research

This study hypothesizes that depending on the Appropriations Subcommittee members' policy preferences, the practice of omnibus legislation will make a difference in the expenditure amount of NIH institutes and that such a difference would be positive. The simple model without interaction terms reveals that a frequent use of omnibus legislation does not directly affect an institute's budget. However, this basic model assumes that the practice of bundling appropriations bills into a couple of omnibus bills does not affect actors other than the congressmen. If such a possibility is allowed by introducing interaction terms, the result changes dramatically: the regression coefficient on omnibus legislation is as much as 2.9. Since the coefficient refers to the difference the omnibus practice makes when we set the values of the other independent variables at 0, its practical meaning is limited. However, it is clearly indicated that the omnibus appropriations bills have made huge budgetary changes. It is not a surprise given that the NIH budget has doubled between FFY1998 and FFY2003. This indicates that the NIH actually has won the battle for higher budgets against non-R&D programs in the Departments of Labor, Education, and HHS in the congressional appropriations process with strong supporters of NIH research.

The frequent use of omnibus legislation is found to mediate the effects of the other determinant factors of institute expenditures. The extended models show that with the omnibus appropriations bills, the effect of an institute director has been weaker and shorter on an institute's total expenditures and that the effect of the median NTU ratings of the members of the Senate Appropriations Subcommittee has increased since 1997. The omnibus legislation has also produced big winners among the institutes as indicated by the coefficients on interaction terms with *diseaseinst*: the non-disease-focused institutes' total expenditures have increased more than their disease counterparts by 14.5%.

As hypothesized, the expenditures of disease-focused institutes are greater than that of their non-disease-focused counterparts. In model I, the disease-specific institute's budget is about 10% larger than the non-disease institute's budget. This indicates that the well-developed patients and advocacy groups along with the public's keen awareness of disease issues put their agenda through the priority-setting process of the institutes and Congress, overcoming the problems in collective action in a democracy as discussed by Downs (1957, 1960), Buchanan & Tullock (1962), and Tullock (1969, 1970).

Interaction terms indicate that there are differences in effects on an institute's total expenditure between the disease-focused institutes and the non-disease-focused ones. Clearly, the effect of the institute director's PSE is stronger for the disease-focused institutes, as is the number of advisory boards. However, those effects are exhausted more rapidly for the disease-specific institutes, as shown by the negative signs of the interaction terms in Table 10.

For the hypotheses regarding an institute's total expenditures, the findings are summarized in Table 11. Most of the hypotheses are confirmed, but their relationships are much richer than hypothesized.

Table 11. Analytical Findings about an Institute's Total Expenditures

Hypothesis	Findings
Director's PSE (H1)	The director's PSE increases an institute's total expenditure. The relationship is curvilinear. Hypothesis confirmed.
Disease-focused Institutes (H4)	The disease institute's expenditures are greater than its nondisease-focused counterparts by about 10%. With omnibus legislation, the non-disease institutes benefit more and the difference is reduced. Hypothesis confirmed.
Advisory Boards (H5)	Advisory boards increase an institute's total expenditure. The relationship is curvilinear. Hypothesis confirmed.
Disease Institutes and Advisory Boards (H5.2)	Effect of advisory boards is greater for general science-focused institutes. Hypothesis not confirmed.
Omnibus Legislation (H7)	Without interaction terms, the omnibus practice has no impact on an institute's total expenditures. However, with interaction terms with the other independent variables, omnibus legislation more than doubles an institute's total expenditures. Hypothesis confirmed.
Omnibus Legislation and Disease Institutes (H8)	With omnibus legislation, non-disease institutes' total expenditures have increased more than those of their disease counterparts. Hypothesis not confirmed.
Omnibus Legislation and Director's PSE (H9)	Omnibus legislation makes the effect of the director's PSE weaker and shorter. Hypothesis not confirmed.

Principle Investigator-Initiated RPG Expenditures[50]

The RPG mechanism is different from the other mechanisms in that the process is initiated by private scientists and grant applications are reviewed by their peers. Therefore, institute leadership may not care about RPG expenditures as much as it does about that of the other mechanisms, through which it can exert influence on types of research and diseases targeted.

The main findings described in the previous section apply here with the expenditures through the investigator-initiated RPG mechanism (Table 12). However, there are also some differences. First, an institute director's PSE increases the institute's RPG expenditures at a decreasing rate as experience increases up to 21 years. Unlike the total expenditures, omnibus legislation does not make a significant difference in the effect of the director's PSE, shown by the interaction terms in the extended models. The effect of the director's PSE at disease-focused institutes is weaker than at their non-disease counterparts. This may be explained by the fact that the disease institutes command well-developed advocacy and patient groups. They push their agendas toward key congressional actors and appropriations subcommittee members. In such a circumstance, the role played by directors of disease-focused institutes may not be as great as the one played by directors of non-disease institutes.

Second, the number of advisory boards increases the institute's PI-initiated project grant expenditures at a decreasing rate up to 9. However, with omnibus legislation, the effect turns negative: in model III, the coefficients on the number of advisory boards and the interaction term with omnibus indicate that after 1997 the number of advisory boards is adversely related to the institute's RPG expenditures. At the disease-focused institutes, as the number of advisory boards increases, the institute's RPG expenditures decrease. That is, the number of advisory boards

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[50] From this section on, the interpretation of the results will focus on the difference between those in the models with institute total expenditures as the dependent variable.

increased the RPG expenditures of the non-disease institutes before 1997. This finding may be explained by the nature of the research supported by the non-disease institutes and the discretion enjoyed by the director. The research supported by these institutes is focused on the general sciences, workings of human organs, and health needs of specific population groups. For this reason, interest groups in such research areas are not developed as well as in disease-combating research areas. In such cases, the institute directors may want to increase RPG expenditures by boosting participation from the research communities. This point is supported by the finding that the PSE of the non-disease institutes' directors has a stronger effect on RPG expenditures than that of the disease-focused institutes' directors.

On the congressional appropriations subcommittee side, the effects from CC and NTU ratings and congressional experience do not seem as strong as they are with total expenditures as the dependent variable. In the basic model, a 10-point increase in CC ratings is associated with a 5% decrease in RPG spending, compared to 7% with total expenditures. The median of Senate NTU ratings is not associated with RPG spending levels in all four models. Senate experience increases RPG expenditures of non-disease institutes more than their disease-focused counterparts. Without the omnibus legislation, an additional year of Senate experience increases RPG spending by 17%, but this effect disappears with the omnibus practice. The House NTU ratings and the years of House experience significantly increase RPG spending while omnibus legislation and types of institutes do not mediate this effect.

As in the models of total institute expenditures, the effect of omnibus legislation is not definitive in the basic model, but in the extended models with interaction terms the omnibus practice is found to increase an institute's RPG expenditures by about two and half times. Given that its effect is more than a 200% increase in the models with total expenditures, it is likely that with omnibus legislation an institute's expenditures through other mechanisms would increase more than RPG expenditures. As for the interaction terms, the practice of omnibus legislation is found to play a role of mediating the effects of the other independent

variables. There are also big winners with omnibus appropriations bills: non-disease institutes' RPG expenditures increased about 270%, much bigger than their disease-focused counterparts' 77%.

Overall, it appears that the determinant factors of an institute's expenditures through RPG are not very different from those of its total expenditures. This may be due to the finding that the RPG expenditure mechanism uses about 46.5% of the institute's total expenditures.

Table 12. Determinants of Private Principal Investigator-Initiated RPG Expenditures

Variable	Model I: Basic	Model II: Interaction with Omnibus	Model III: Interaction with Omnibus & Disease Inst	Model IV: Interaction with Omnibus & Disease Inst.
Director's PSE	.03131***	.03441***	.03741***	.04207***
(Director's PSE)^2	-.00072***	-.00078***	-.00081***	-.00092***
Number of Advisory Boards	.02001**	.01816*	.00997**	.01690**
(Number of Advisory Boards)^2	-.00112***	-.00086**		
Number of Advisory Board Members	.00003	-.00009**	.00003	-.00009
NIH Director's PSE	.11427***	.19202***	.18999***	.17129***
(NIH Institute Director's PSE)^2	-.00856**	-.01811***	-.01972***	-.01618***
Number of NIH Advisory Boards	-.02120***	-.01924***	-.01924***	-.01747***
Number of NIH Advisory Board Members	.00004	-.00014**	-.00014**	-.00012*
CC Rating of Senate Appr. Subcomm.	-.00528**	.00146	.00130	.00054
NTU Rating of Senate Appr. Subcomm.	.00237	-.00834	-.00807	-.0075
Experience of Senate Appr. Subcomm.	-.01359	.16000***	.16817***	.16876***
CC Rating of House Appr. Subcomm.	.00017	-.00030	-.00080	-.00219
NTU Rating of House Appr. Subcomm.	.00898***	.00386	.00362	.00478
Experience of House Appr. Subcomm.	.15725***	.07847	.08270*	.07698*
Republican Control of Presidency	.15212**	.01188	.02090	.02501
Republican Control of Congress	.25612***	-.02893	-.03381	-.03251
Mixed Control of Congress	.12038	-.07964	-.08355	-.05453
Omnibus Legislation (omnibus)	.01686	2.6650***	2.56160***	2.76793***
Disease-Focused Institutes (diseaseinst)	.09510***	.08345***	.88438***	1.36307***
Lagged Dependent Variable	.57206***	.58792***	.58659***	.56541***
Log of Expenditures net of RPGs	.31076***	.30603***	.29006***	,30334***
(Director's PSE)*omnibus		-.00120	-.00153	-.00482
(# of Adv. Boards)*omnibus		-.00931*	-.01354**	-.07168***
(# of Adv. Board Members)*omnibus		.00020***	.00024***	.00086***
(CC Senate Rating)*omnibus		.00999	.00953	.01003
(NTU Senate Rating)*omnibus		.00875	.00869	.00809
(Senate Exp.)*omnibus		-.17155***	-.16534**	-.17171***
(CC House Rating)*omnibus		-.00751	-.00756	-.00334
(NTU House Rating)*omnibus		.00356	.00377	.00026
(House Exp.)*omnibus		.01970	.02168	.00510

Table Continued.

Variable	Model I: Basic	Model II: Interaction with Omnibus	Model III: Interaction with Omnibus & Disease Inst	Model IV: Interaction with Omnibus & Disease Inst.
(Director's PSE)*diseaseinst			-.00589**	-.00539**
(# of Adv. Boards)*diseaseinst			-.01118*	-.02621**
(# of Adv. Board Members)*diseaseinst			-.00014**	.00007
(CC Senate Rating)*diseaseinst			.00085	.00107
(NTU Senate Rating)*diseaseinst			-.00003	.00167
(Senate Exp.)*diseaseinst			-.02888***	-.06125***
(CC House Rating)*diseaseinst			.00189	.00523***
(NTU House Rating)*diseaseinst			-.00031	-.00375***
(House Exp.)*diseaseinst			-.01009*	-.00624*
omnibus*diseaseinst			-.07296	-1.70923***
(Director's PSE)*OD[a]				-.00145
(# of Adv. Boards)*OD				.11979***
(# of Adv. Board Members)*OD				-.00079***
(CC Senate Rating)*OD				-.00239
(NTU Senate Rating)*OD				.00009
(Senate Exp.)*OD				.03436**
(CC House Rating)*OD				-.00635***
(NTU House Rating)*OD				.00957***
(House Exp.)*OD				.09876***
R-squared	.936	.946	.949	.952
Rho	.304	.335	.335	.342

- *** p<.01, ** p<05, * p<.10
- *a* : omnibus*diseaseinst

Intramural Laboratory Research Expenditures

Since intramural research is conducted by government scientists who are governed by personnel management regulations and the bureaucratic reporting system, expenditures through intramural laboratories represent an agency budget in the Niskanen (1971) sense. These expenditures could be understood as an expression of bureaucratic production such that organizational slack may be included. Since intramural laboratories undertake research topics of high risk and uncertainty, in which private scientists are encouraged not to engage, intramural research may be truly of pubic interest. Therefore, regardless of whether bureaucrats at an institute are driven by self-interest or PSM, they are expected to increase intramural research. The issue at point is whether they prefer intramural research to extramural grant programs.

The regression outputs on intramural laboratory expenditures are provided in Table 13. The basic model without interaction terms reports that the PSE of the institute directors decreases their expenditures for intramural laboratories, and the relationship is curvilinear: as the director's PSE increases up to 25 years, the institute's Intramural Research expenditures decrease at a decreasing rate. Given that the mean value of the director's full-time public experience is 17 years, it indicates that throughout their public careers directors care less about intramural research programs than about research expenditures through other mechanisms such as extramural grant programs. However, this needs elaboration. If an institute director is a senior scientist of the institute, it is likely that upon appointment as director, he or she will decrease intramural research programs unless his or her previous experience is greater than 25 years. Out of the 49 directors whose previous PSE was recorded, only 6 had served the government for 25 years or more. If the director is recruited from within, he or she leads the institute for about 8.2 years with 16.3 years of previous experience on average. Given the curvilinear relationship, the directors promoted from the institutes tend to try to protect, if not expand, the intramural research program.

This does not apply to institute directors who are recruited from institutions in academic settings. Directors recruited from outside the institutes lead the institutes about 7.8 years on average. This means that if the director is new to the institute as an employee, he or she is likely to reduce intramural expenditures. There could be two reasons for this occurrence. One is directing resources from intramural laboratories to extramural programs. The other is increasing extramural grant expenditures more rapidly while keeping intramural programs relatively unchanged. However, the magnitude of this effect appears to weaken as time goes on. As mentioned in the previous chapter, the director who is new to the government organization may be undergoing organizational socialization, absorbing the values and norms of the bureaucratic organization and realizing the importance of maintaining significant capacity in intramural research.

The interaction term with omnibus legislation shows that the practice of bundling appropriations bills does not significantly change the effect of the director's PSE. On the other hand, interaction with *diseaseinst* indicates that the turning point of the effect comes earlier, at about 17 years of experience for disease-focused institutes. If the director is recruited from within the institutes with 16 years of previous experience, he or she tends to increase Intramural Research funds.

One interesting finding is that the number of advisory boards is positively associated with expenditures through intramural laboratories. Given a curvilinear relationship in the basic model, advisory boards increase intramural spending until the number of boards reaches about 18. Given that the mean number of boards is 5.7, this tendency applies to almost all institutes. Moreover, advisory board membership consistently increases intramural expenditures. This unexpected finding decreases the significance of the role played by the advisory boards. Originally—and expectedly—the advisory boards are regarded as a channel of input from scientific communities, interest groups, and the public. However, the boards themselves are found to serve Intramural Research activities. If they are representing the interests of private parties, their presence may run counter to intramural programs in favor of extramural grants.

This point will be picked up in the discussion of the proportion of Intramural Research in the next section.

As for the ratings of appropriations subcommittee members, it seems that a higher median score of NTU rating is positively associated with intramural expenditures at $\alpha = .01$ in the basic model. Just as in the previous sections, the more experience the subcommittee members have, the more they support intramural programs. While in the basic model Senate experience does not increase intramural expenditures, the extended models with interaction terms report it clearly boosts intramural program spending. However, the CC ratings for subcommittees in both houses are found to be largely irrelevant in the levels of intramural expenditures. This is due to the fact that higher CC rating scores indicate the members' support of business activities of private firms.

It appears that the major findings with regards to *diseaseinst* and *omnibus* in the previous sections apply to intramural expenditures. The Intramural Research expenditure of a disease-targeting institute is about 30% larger than that of more generally focused institutes in the basic model. The effect of the director's PSE is significantly different between these two types of institutes. In the disease-specific institutes, the effect reaches its bottom at 17 years rather than at the 27 years of the non-disease institutes. The marginal effect of decreasing intramural expenditures is greater in the non-disease than the disease-focused institutes. Like the findings reported in the previous sections of this chapter, the findings of this section reveal that advisory boards at disease-focused institutes are less strongly associated with intramural research programs. Together with the finding that advisory boards in general increase total intramural expenditures, one consistent finding is that the advisory boards at the non-disease institutes increase expenditures more than at the disease-focused institutes. This is an indication that advisory boards themselves may not be representing external inputs from interest groups but the interests of the leadership of an institute. Since the directors have considerable discretion in establishing and manning advisory boards, this finding implies that they are driven

more by PSM than by self-interests. If they are mainly interested in expenditures, the advisory board effect should be greater in the disease-focused institutes.

In the basic model, the frequent use of omnibus appropriations bills does not make a difference in an institute's intramural expenditures. When controlling the effects that omnibus legislation may have on the effects of the other variables, the omnibus practice increases intramural lab expenditures almost three times. The interaction terms between *omnibus* and the other variables reveal some interesting points. First, the effects of a director's PSE, the number of advisory boards, and the advisory board membership do not change with the frequent use of omnibus appropriations bills. On the other hand, since 1997 the Senate CC ratings have adversely affected intramural spending, but the opposite relationship applies to its House counterpart.

One of the key findings of this section is that the director's PSE decreases intramural expenditures. However, if the director is from within the institute with significant previous experience, he or she increases intramural lab spending. Another key finding is that advisory boards at non-disease institutes increase intramural budgets more than their disease-focused counterparts. This implies that the institute's leadership may be driven more by PSM than by self-interests. These points will be further developed in the following sections.

Table 13. Determinants of Intramural Research Expenditures

Variable	Model I: Basic	Model II: Interaction with Omnibus	Model III: Interaction with Omnibus & Disease Inst	Model IV: Interaction with Omnibus & Disease Inst.
Director's PSE	-.04123***	-.04570***	-.08189***	-.09180***
(Director's PSE)^2	.00083***	.00088***	.00149***	.00165***
Number of Advisory Boards	.06181**	.01328**	.06483***	.06354***
(Number of Advisory Boards)^2	-.00173*			
Number of Advisory Board Members	.00055***	.00056***	.00106***	.00108***
NIH Director's PSE	.13656***	.17429**	.14072**	.13832**
(NIH Director's PSE)^2	-.01198***	-.02079***	-.01792***	-.01753***
Number of NIH Advisory Boards	-.03776***	-.02756***	-.02289***	-.02201***
Number of NIH Board Members	.00003	-.00025**	-.00025**	-.00025***
CC Rating of Senate Appr. Subcomm.	-.00394	.00941	.00834	.00951
NTU Rating of Senate Appr. Subcomm.	.00364*	-.01320	-.01226	-.01006
Experience of Senate Appr. Subcomm.	-.03119	.23508***	.24109***	.27989***
CC Rating of House Appr. Subcomm.	.00254	.00193	-.00063	-.00307
NTU Rating of House Appr. Subcomm.	.01371***	.00219	.00270	.00163
Experience of House Appr. Subcomm.	.25961***	.10004	.0781	.06224
Republican Control of Presidency	.15066	-.06079	-.05579	-.05452
Republican Control of Congress	.14040	-.39596*	-.38635*	-.38737***
Mixed Control of Congress	.04172	-.27876	-.28966	-.30955
Omnibus Legislation (omnibus)	.02526	2.59640*	2.91316**	3.10517**
Disease-focused Institutes (diseaseinst)	.29566***	.27981***	.92518*	2.45853***
Lagged Dependent Variable	.58756***	.60714***	.54094***	.54405***
Log of Expenditures net of Intramural Exp.	.07422	.10531*	.10168	.08201
(Director's PSE)*omnibus		.00560	.00429	.01422
(# of Adv. Boards)*omnibus		.05621*	.01098	.06422
(# of Adv. Board Members)*omnibus		-.00014*	-.00003	-.00033
(CC Senate Rating)*omnibus		-.00672	-.01005	-.01213
(NTU Senate Rating)*omnibus		.01922**	.01797*	.01656*
(Senate Exp.)*omnibus		-.29839***	-.28588***	-.36516***
(CC House Rating)*omnibus		-.00343	-.00233	.00396
(NTU House Rating)*omnibus		.01453*	.01439*	.01774*
(House Exp.)*omnibus		.26264**	.25195**	.32865**
(Director's Pub. Exp.)*diseaseinst			.029664***	.04050***

Table Continued.

Variable	Model I: Basic	Model II: Interaction with Omnibus	Model III: Interaction with Omnibus & Disease Inst	Model IV: Interaction with Omnibus & Disease Inst.
(# of Adv. Boards)*diseaseinst			-.06203***	-.05984***
(# of Adv. Board Members)*diseaseinst			-.00053*	-.00053**
(CC Senate Rating)*diseaseinst			.00380	.00170
(NTU Senate Rating)*diseaseinst			-.00154	-.00585**
(Senate Exp.)*diseaseinst			-.03492	-.12791***
(CC House Rating)*diseaseinst			.00592	.01203***
(NTU House Rating)*diseaseinst			-.00433	-.00403
(House Exp.)*diseaseinst			-.00833	-.00054
omnibus*diseaseinst			-.20077	-.31668
(Director's PSE)*OD[a]				-.01883
(# of Adv. Boards)*OD				-.12859*
(# of Adv. Board Members)*OD				.00038
(CC Senate Rating)*OD				.00434
(NTU Senate Rating)*OD				.00139
(Senate Exp.)*OD				.18747***
(CC House Rating)*OD				-.01341
(NTU House Rating)*OD				-.00868
(House Exp.)*OD				-.20905
R-squared	.824	.828	.843	.848
Rho	.378	.369	.424	.415

- *** p<.01, ** p<05, * p<.10
- *a* : omnibus*diseaseinst

Proportion of Intramural to PI-Initiated RPG Expenditures

Up until now, the analysis has focused on determinants of total, RPG, and Intramural Research expenditures without consideration of how each of these determining factors of expenditure affects differently RPGs and Intramural Research. To examine the relative influences from the independent variables, a variable measuring the percentage of Intramural Research has been created. In calculating the percentage, expenditures through mechanisms of Research Centers, Other Research, Research Training, R&D Contracts, and Research Management are excluded since these mechanisms tend to represent both bureaucratic and extramural interests. In the models estimating the relative effects of the determining factors, all of the major independent variables from the previous analyses are used.

Self-Interestedness versus PSM

The first section of this chapter indicated that as an institute director's PSE increases, the institute's total expenditure increases as well. However, it was not clear if the directors' self-interest of budget maximization or commitment to public service was more influential. If motivated by self-interest consideration, the directors will increase Intramural Research expenditures (*Hypothesis 2.1*). Alternatively, if they are primarily driven by PSM, they will not discriminate betwen the expenditure mechanisms (*Hypothesis 2.2*) because both mechanisms equally contribute to the advancement of medical knowledge.[51]

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[51] The directors may feel differently: they could argue that their preferred types of expenditures contribute more to the improvement of health.

Table 14. Determinants of Proportion of Intramural Research Expenditures

Variable	Model I: Basic	Model II: Interaction with Omnibus	Model III: Interaction with Omnibus & Disease Inst	Model IV: Interaction with Omnibus & Disease Inst.
Director's PSE	-.37333***	-.37289***	-.43676***	-.51030***
(Director's PSE)^2	.00955***	.00964***	.01074***	.01252***
Number of Advisory Boards	-.30971***	-.53269***	-.38215***	-.25258**
(Number of Advisory Boards)^2	.01357***	.01964***	.01051*	
Number of Advisory Board Members	.00130***	.00260***	.00152*	.00239*
NIH Director's PSE	.01356	-.09917	-.09596	-.09225
(NIH Director's PSE)^2				
Number of NIH Advisory Boards	-.00878	-.00110	.00113	-.00426
Number of NIH Advisory Board Members	-.00000	-.00027	-.00027	-.00042
CC Rating of Senate Appr. Subcomm.	.02252**	.06774**	.05559	.07566**
NTU Rating of Senate Appr. Subcomm.	-.01063	-.01752	-.01137	-.00656
Experience of Senate Appr. Subcomm.	-.00332	.19048	.25077	.40690
CC Rating of House Appr. Subcomm.	-.00709	.01531	.00722	.00840
NTU Rating of House Appr. Subcomm.	-.00880	.05886*	-.05848*	-.07781**
Experience of House Appr. Subcomm.	-.08528	-.25671	-.37267	-.41628
Republican Control of Presidency	-.30256	.49822	.48173	.49054
Republican Control of Congress	-.65295	-1.24053	-1.21797	-.98769
Mixed Control of Congress	-.92524*	-1.79189**	-1.79366**	-1.89071**
Omnibus Legislation (omnibus)	-.44840	4.14482	4.67605	6.11217
Disease-Focused Institutes (diseaseinst)	-.34020	-.25312	-4.36875*	2.72514
Lagged Dependent Variable	.81225***	.81634***	.79444***	.76049***
(Director's PSE)*omnibus		-.01894	-.013118	-02182
(# of Adv. Boards)*omnibus		.43283***	.45240***	1.12268***
(# of Adv. Board Members)*omnibus		-.00250***	-.00279***	-.00892**
(CC Senate Rating)*omnibus		-.12120***	-.12165**	-.15435***
(NTU Senate Rating)*omnibus		,01028	.01128	.01555
(Senate Exp.)*omnibus		-.32995	-.35292	-.78623*
(CC House Rating)*omnibus		.00190	.00021	-.01236
(NTU House Rating)*omnibus		.07153**	.07503**	.14107***
(House Exp.)*omnibus		.49954	.55806	1.23088*
(Director's PSE)*diseaseinst			.07847**	.07233**

Table Continued.

Variable	Model I: Basic	Model II: Interaction with Omnibus	Model III: Interaction with Omnibus & Disease Inst	Model IV: Interaction with Omnibus & Disease Inst.
(# of Adv. Boards)*diseaseinst			.06132	.30604**
(# of Adv. Board Members)*diseaseinst			.00155	-.00025
(CC Senate Rating)*diseaseinst			.02421	-.017
(NTU Senate Rating)*diseaseinst			-.01657	-.02876
(Senate Exp.)*diseaseinst			-.10262	-.52532***
(CC House Rating)*diseaseinst			.01465	.01224
(NTU House Rating)*diseaseinst			.00620	.05645***
(House Exp.)*diseaseinst			.191**	.29233***
Omnibus*diseaseinst			-.68448	5.60333
(Director's PSE)*OD[a]				.05066
(# of Adv. Boards)*OD				-1.58765***
(# of Adv. Board Members)*OD				.00824**
(CC Senate Rating)*OD				.06653**
(NTU Senate Rating)*OD				-.02984
(Senate Exp.)*OD				1.10781***
(CC House Rating)*OD				.01437
(NTU House Rating)*OD				-.17687***
(House Exp.)*OD				-2.27587***
R-squared	.791	.802	.797	.788
Rho	.296	.278	.299	.332

- *** p<.01, ** p<05, * p<.10
- *a* : omnibus*diseaseinst

The results table provided (Table 14) reveals a series of important relationships between the institute director's PSE and the percentage of intramural expenditures. First, the relationship is curvilinear in the basic model. The direct interpretation of the coefficients in the model with squared terms is that institute directors increase RPGs more than intramural program expenditures until their public service reaches about 19 years of experience. Their preferential treatment of RPGs gets increasingly tenuous as time goes on. At the same time, they develop an affinity to intramural programs that gets stronger as their PSE increases more than 19 years. While the average director PSE is 17 years, about half of the directors appear to care more about Intramural Research than about RPG expenditures to the end of their public career.

To expand on the relationship, the following conditions are offered. First, the directors' average length of charge at an institute is 7.7 years. If the director is from a non-governmental institution, he or she will prefer RPGs to intramural laboratories throughout his or her tenure at the institute. Before coming to the institute, the director-to-be-scientist has a large investment in science and technical human capital (Bozeman et al., 2001; Bozeman & Corley, 2004) developed through collaboration and communications among his or her fellow scientists in the private sector. It appears that the newly recruited directors are still embedded in their non-governmental communities, serving the interests of private scientific communities more than those of intramural research laboratories.

Second, if the directors are promoted from positions at their respective institutes, they tend to increase intramural expenditures more than RPGs. Out of the 49 directors whose previous PSE information was available, 31 were promoted from previous governmental positions with an average of 16.3 years experience. These directors from within institutes increase intramural research more than extramural research expenditures as their charge of the institutes exceeds 3 years. On average, directors with previous public experience lead the organizations about 8 years. Unlike the case of the directors with nongovernmental backgrounds, it is unlikely that these

from-within directors feel that intramural research is less qualified than research funded through RPGs. This implies that regardless of their PSE, the institute directors are complying with their respective self-interests: they may still be influenced by PSM in increasing research expenditures, but when it comes to resource allocation between two at-odds interests, they follow their respective interests. That is, the directors seem to act in accordance with their self-interests in resource allocation between intramural versus extramural research expenditures. This outcome rejects both *Hypotheses 2.1* and *2.2*.

However, there could be an alternative interpretation: directors coming from medical schools or universities may regard intramural programs as having lower quality than their academic counterparts. It is pointed out that there is more variation in the research quality of intramural programs than of RPGs (Cohen, 1993). While intramural programs have produced research results of extremely high quality,[52] they also have faced persistent criticisms. For example, the Klausner Report (1993) pointed out that intramural programs suffer from bureaucratic top-down management, small PI-dominated lab operations, recruitment difficulties, and inconsistent budget cuts. Given these problems, the institutes are limited in rewarding high-performing labs and penalizing low-performing ones. An awareness of these problems may prompt externally hired directors to hesitate when increasing expenditures on intramural programs. From-within directors may still regard intramural programs as capable of taking care of issues of high risk and uncertainty that many scientists may not want to get involved with. In such cases, it would be practically impossible to

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[52] The NIH intramural programs ranked really high in citation lists or in lists of the organizations with the top scientists in the world. For example, in the list of the Institute of Scientific Information's 100 most cited scientists in the world, 16 NIH intramural scientists were included along with the other 59 U.S. scientists (Cohen, 1993). In addition, five scientists from NIH intramural labs won Nobel Prizes (NIH Almanac): Dr. Marshall W. Nirenberg (1968, NHLBI) for discovering the key to deciphering the genetic code; Julius Axelrod (1970, NIMH) for research into the chemistry of nerve transmission; Christian B. Anfinsen (1972, NIAMDD) for achievement in research of the structure of ribonuclease; D. Carleton Gajdusek (1976, NINDS) for discovering new mechanisms for the origin and dissemination of infectious disease; and Martin Rodbell (1994) for research into signal transmission.

discern between PSM and self-interests in supporting respective research mechanisms. However, if it is reasonable to regard expenditure amounts through specific mechanisms as representing interests of those involved in the process, the persuasiveness of this alternative interpretation is rather limited.

Differential Private Influences on Intramural and RPG Expenditures

Hypothesis 5.1 predicts that the effect of private interested parties will be greater on expenditures through RPGs than on Intramural Research expenditures. Because of the limitations in the process of public service demand revealing and log-rolling in a democracy, programs of hidden or remote/uncertain benefits, among which R&D programs would be included, tend to be undersupplied. However, if interest groups regarding these programs are well developed and allowed to get involved in the agenda-setting process, the obstacles may be overcome. As a result, the more private inputs are channeled to the decision-making process, the more likely government will support programs that benefit these interests. NIH extramural programs might be an example of this scenario.

The result from the analysis delivers an opposite message: the number of advisory boards and their memberships at the institute level increase the proportion of Intramural Research expenditures in the sum of RPGs and intramural expenditures. The regression coefficient on the number of advisory boards in the first model reports that as the independent variables increase up to 11, they increases the proportion of Intramural Research at a decreasing rate. Since on average there are 5.7 advisory boards at an institute, their effect on the proportion of intramural expenditures is very positive. This is clearly the opposite of the expectation. Moreover, at the institute level an increase in advisory board memberships leads to a higher portion of intramural expenditures. At the agency level, both boards and their memberships do not significantly influence the dependent variable. Obviously Hypothesis 5.1 does not secure support from the result.

There could be a potential explanation to this result. First, the operationalization of the private interest representation in the priority-setting process may be flawed. Simply, the number of advisory boards may not be a measure of inputs from outside but of bureaucratic maximization. While some advisory boards, such as the National Advisory Council, are legally mandated in each institute, the institutes' directors have the discretion of establishing advisory boards and appointing their members for advice on specific programs and scientific reviews. More advisory boards invite more administrative staff and budgets for operation: they could be a symbol of organizational power.[53] It is still possible for the institute director to sideline the advisory boards by making them inactive. IOM (1998) reported a considerable number of such inactive advisory boards. This possibly refers to existent problems of NIH input mechanisms.

Differential Congressional Influences on Intramural and RPG Expenditures

Hypothesis 6 predicts that as the appropriations subcommittee members are more favorable to special interest groups, they tend to increase extramural more than intramural research expenditures. The analysis disconfirms this prediction: only the coefficient on the median rating score of the Senate appropriations subcommittee is positively associated with the proportion of intramural research expenditures, which is the opposite of the hypothesis. Given that the median House rating of NTU votes and the median years of congressional service of the House subcommittee members increase an institute's total expenditures, PI-initiated expenditures, and intramural expenditures, it is likely that the subcommittee members do not favor one type of expenditure over the other but want higher expenditures on biomedical research in general.

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[53] This point will be further developed in the discussion section.

Bureaucratic Risk Aversion, Mission Motivation, and the Herfindahl Index

Hypothesis 3 predicts that being risk-averse or mission-oriented, institute directors may seek to diversify expenditures through various mechanisms with the result that expenditures through mechanisms other than the large portion of RPGs increase. In such a case, the proxy measure of concentration, the Herfindahl index of expenditures through multiple mechanisms, will be smaller.[54] Another rationale for increasing expenditures through Intramural Research, Research Centers, Other Research, Research Training, and R&D Contracts is that they target research issues of specific relationships to the institute's mission. If the director of the NIDDK is committed to dealing with diabetes, he or she is more likely to pursue specific diabetes-related research themes rather than to depend on private investigator-initiated research projects. Accordingly, this tendency will also lower the Herfindahl index of expenditure mechanisms.

The correlation coefficient (0.92) between the proportion of RPG expenditures and the Herfindahl index of an institute's total expenditures (Table 15) reveals that the major driver of the index is RPGs, while expenditures through intramural laboratories significantly lower the index. Expenditures through the other mechanisms also drive down the index. Especially, the Other Research mechanism that takes care of education, clinical research collaboration, pilot studies of high risk/uncertainty, and supporting minority scientists is clearly negatively associated with the Herfindahl index.

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[54] If all of an institute's expenditure is through RPGs, its Herfindahl index will be 1; if the expenditures are distributed equally through five mechanisms, the index will amount to 0.2.

Table 15. Correlation Coefficients between Herfindahl Index and Proportion of Expenditure Mechanisms

	Herfindahl Index	Proportion of					
		RPGs	Intramural	Centers	Contracts	Other	Management
Herfindahl Index	1.000						
RPGs	0.921	1.000					
Intramural	-0.803	-0.833	1.000				
Centers	-0.359	-0.550	0.316	1.000			
Contracts	-0.254	-0.131	-0.071	-0.097	1.000		
Other	-0.545	-0.557	0.505	-0.133	-0.092	1.000	
Management	-0.275	-0.156	0.054	0.002	0.031	-0.106	1.000

Table 16. Herfindahl Index of Expenditure Mechanisms: FFY 1983–FFY 2005

Institute	Mean	Std. Dev.	Min	Max
NCI	.26407	.01059	.23529	.28559
NEI	.49870	.05130	.43020	.59414
NHGRI	.35010	.06565	.29665	.51574
NHLBI	.43326	.04272	.36109	.50601
NIA	.42118	.03736	.36419	.47988
NIAAA	.35580	.04939	.23247	.40785
NIAID	.44019	.05014	.30304	.50045
NIAMS	.47733	.01890	.44993	.53410
NICHD	.37050	.03021	.31812	.41749
NIDA	.37299	.05045	.27726	.43998
NIDCD	.53102	.04503	.49078	.64879
NIDCR	.32973	.04848	.27803	.42591
NIDDK	.50406	.01286	.48491	.52950
NIEHS	.24970	.00672	.24143	.26282
NIGMS	.63700	.06433	.51276	.71123
NIMH	.31888	.03154	.25298	.36972
NINDS	.51160	.04038	.41159	.56561
NINR	.56344	.02996	.50969	.60229

Table 16 indicates a considerable variation in the Herfindahl index across time and institutes. For example, the mean value of the index of NCI is 0.264, with the difference between minimum and maximum values being 0.05. Figure 6 also confirms this point. The index increased during the second half of the 1990s but stabilized thereafter. In such institutes as the NHGRI, NIAID, and NIGMS, the variation is more impressive, with its range being almost 0.20.

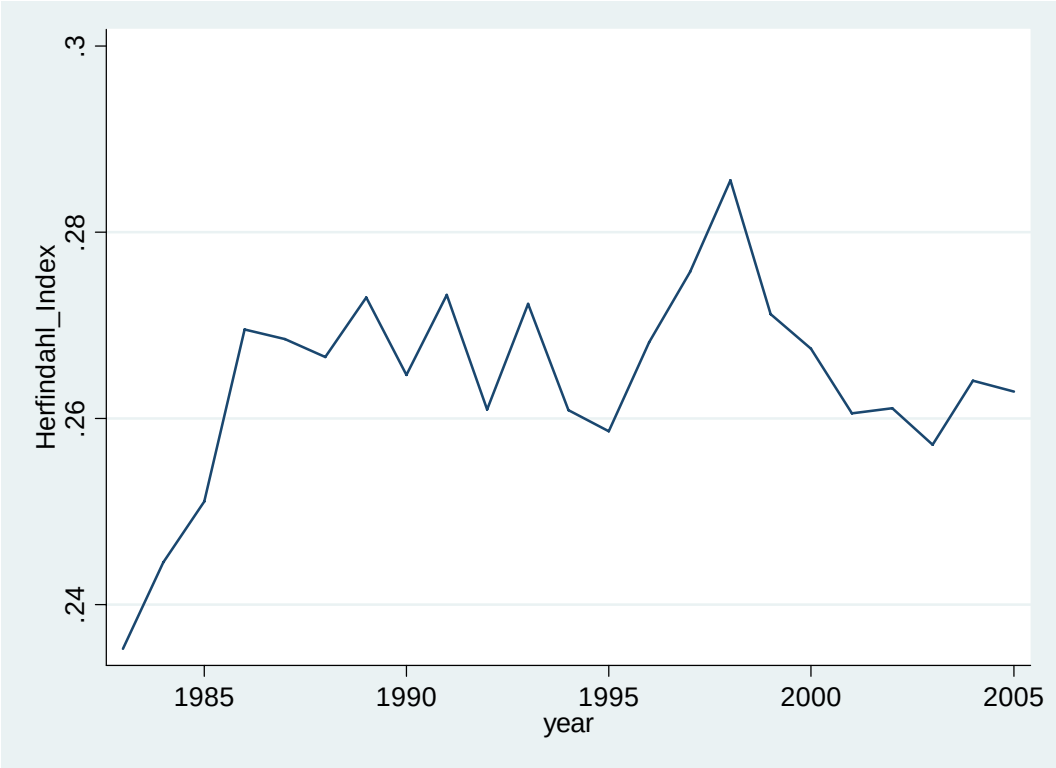

Figure 6. Herfindahl Index of Expenditure Mechanisms: NCI

The regression analysis (Table 17) indicates that the director's PSE does not appear to increase diversity of expenditures through multiple mechanisms. Model I with squared terms reports a curvilinear relationship between the director's PSE and the diversification of expenditure mechanisms, but the relationship is positive: the longer the institute director's PSE, the more the expenditures of his or her institute are concentrated on only a few of the mechanisms. This effect reaches its peak at 21 years

of PSE. If a director is promoted from within the institute with substantial previous PSE, he or she tends to seek higher budgets for other support mechanisms than the RPGs. If a director is from outside institutions, the director's public experience obviously does not increase his or her attitudes of risk aversion.

Making sense of this finding requires an understanding of the relationship between the director's PSE and their preference for RPGs. As analyzed in the previous sections, as a director's PSE increases, RPG expenditures increase but intramural expenditures decrease. This leads to more portions of an institute's research support being expended through the RPGs mechanism. In the previous analysis, it is found that the gap between RPGs and Intramural Research expenditures gets even bigger when the directors are recruited from outside the institutes. Outsourced directors are not necessarily risk-averse in a bureaucratic sense upon their appointment. They may want to seek higher budgets for their cherished research areas or the research activities in their embedded sectors without an anticipation of drastic budget cuts. The directors who are promoted from within tend to be more favorable to increasing intramural expenditures than RPGs, in which case the Herfindahl index would decrease.

Table 17. Effects on the Composition of the Expenditure Mechanisms (Herfindahl Index)

Variable	Model I: Basic	Model II: Interaction with Omnibus	Model III: Interaction with Omnibus & Disease Inst	Model IV: Interaction with Omnibus & Disease Inst.
Director's PSE	.00211***	.00267***	.00324***	.00392***
(Director's PSE)^2	-.00005***	-.00006***	-.00007***	-.00008***
Number of Advisory Boards	.00138	-.00044	-.0005	-.00028
(Number of Advisory Boards)^2	-.00008**			
Number of Advisory Board Members	-.00001***	-.00002***	-.00003***	-.00004***
NIH Director's PSE	0.00023	.00183	-.02748***	-.02967***
(NIH Director's PSE)^2			.00193***	.00209***
Number of NIH Advisory Boards	.00064**	.00046	.01383***	.01473***
(Number of NIH Advisory Boards)^2			-.00007***	-.00008***
Number of NIH Advisory Board Members	.00000	.00001	.00002***	.00003***
CC Rating of Senate Appr. Subcomm.	-.00007	-.00035	-.00118***	-.00141***
NTU Rating of Senate Appr. Subcomm.	.00029**	-.00042	.00035	.0006*
Experience of Senate Appr. Subcomm.	.00000	-.00374	-.00686*	-.0071*
CC Rating of House Appr. Subcomm.	-.00024*	-.0004**	-.00066***	-.00073***
NTU Rating of House Appr. Subcomm.	-.00016	.00042	.00127***	.00144***
Experience of House Appr. Subcomm.	-.00415*	-.00262	-.00102	-.00091
Republican Control of Presidency	-.00177	-.00878	-.0319***	-.03348***
Republican Control of Congress	.00402	.00238	-.00864	-.0107
Mixed Control of Congress	.00938	.01466**	.03985***	.04224***
Omnibus Legislation (omnibus)	.00157	-.19722***	-.13196***	-.11061**
Disease-focused Institutes (diseaseinst)	.003	.0023	.04351*	.06026
Lagged Dependent Variable	.87779***	.87354	.86502***	.85269***
(Director's PSE)*omnibus		-.00042*	-.00034	-.00085**
(# of Adv. Boards)*omnibus		.00127*	.00153*	-.00264*
(# of Adv. Board Members)*omnibus		.00001	.0000	.00006***
(CC Senate Rating)*omnibus		.0006	-.00061*	-.00027
(NTU Senate Rating)*omnibus		.00105**	.00031	.00007
(Senate Exp.)*omnibus		.00418	.00689	.00693*
(CC House Rating)*omnibus		.00017	.00242***	.00245***
(NTU House Rating)*omnibus		-.00049	-.00243***	-.00284***
(House Exp.)*omnibus		.00427	.00021	-.00008

Table Continued.

Variable	Model I: Basic	Model II: Interaction with Omnibus	Model III: Interaction with Omnibus & Disease Inst	Model IV: Interaction with Omnibus & Disease Inst.
(Director's PSE)*diseaseinst			-.00055*	-.00074*
(# of Adv. Boards)*diseaseinst			-.0001	-.00106
(# of Adv. Board Members)*diseaseinst			.00001	.00003***
(CC Senate Rating)*diseaseinst			-.00036*	-.00001
(NTU Senate Rating)*diseaseinst			.00022	-.00015
(Senate Exp.)*diseaseinst			-.00121	-.00142
(CC House Rating)*diseaseinst			.00024	.00036*
(NTU House Rating)*diseaseinst			-.00007	-.0004**
(House Exp.)*diseaseinst			-.00054	-.00109*
omnibus*diseaseinst			-.00809	-.11265**
(Director's PSE)*OD[a]				.00037
(# of Adv. Boards)*OD				.00875***
(# of Adv. Board Members)*OD				-.00007***
(CC Senate Rating)*OD				-.00085**
(NTU Senate Rating)*OD				.00049
(Senate Exp.)*OD				-.00049
(CC House Rating)*OD				.00028
(NTU House Rating)*OD				.00089**
(House Exp.)*OD				.00622
R-squared	.863	.862	.858	.855
Rho	.128	.14	.167	.188

- *** p<.01, ** p<05, * p<.10
- *a* : omnibus*diseaseinst

However, this is obviously not the case: the correlation coefficient between adirector's previous PSE (*director2*) and the index is 0.14, significant at 0.01 level. On the other hand, how long a director leads the institute (*director1*) is not significantly associated with the index (r = .036). These correlation coefficients mean that directors promoted from within tend to increase the Herfindahl index of expenditures more than those recruited from external scientific communities, which is the opposite of Hypothesis 3.

Table 18. Correlation Coefficients between Director's PSE and the Herfindahl Index of Expenditures

	direct1	direct2	Herfindahl Index
direct1	1.000		
direct2	0.1248 0.0162	1.000	
Herfindahl Index	0.0361 0.4745	0.1403 0.0069	1.0000

To explicate this puzzle, it is important to understand how much budgetary risk the directors have been confronted with. During the study period, FFY 1983–FFY 2005, the NIH budget increased from $6.1 billion to $37.7 billion, with an average annual rate of increase of 8.7%. Over this period, the NIH was never subject to budget cuts. This is because the NIH enjoys support from key members of Congress as well as from well-developed patient and advocacy groups and scientific communities, including the Ad Hoc Group. Between 1998 and 2003, its budget doubled, thanks to key players in Congress such as Senators Arlen Spector and Connie Mack. Even when the President requesteda NIH budget with only a minor incremental increase, Congress responded with a big increase (Greenberg, 2001). Put simply, NIH leadership has not been vulnerable to budgetary uncertainty or risk of budget cuts.

Under these circumstances, the best strategy for public officials who are motivated by either self-interest or organizational mission would be budget maximization, not risk diversification. In the correlation coefficient table (Table 18), directors' *previous* experience is shown to actually increase the proportion of RPG expenditures in the institutes' total budgets while decreasing its intramural portion. With previous experiences in the institute, the director from within favors a greater budget than mitigating the risk of budget cuts since there is essentially no such risk. Therefore, the finding, opposite to Hypothesis 3, reveals that the directors of the NIH-comprising institutes are faced with a different risk situation than other agencies whose budgetary vicissitudes undergo annual fluctuations. With strong support groups in Congress as well as in the scientific communities, the NIH directors come to expect budget increases. The only strategy to pursue has been to increase the budget irrespective of which expenditure mechanisms are to be used.

However, there could be an alternative explanation to this unexpected finding. The real issue in budget-cut politics may be about types of diseases that are targeted, for example, AIDS and cancer. There has been criticism that the NIH has allocated funds to AIDS-related research more than the disease deserves while simultaneously short-changing cancer research. The rationale of the criticism is that cancer affects more Americans than AIDS does. Under such a circumstance, institute directors may diversify expenditures in terms of targeted disease types, not of expenditure mechanisms. This consideration may not be captured by the model developed here and is beyond the scope of this research. However, this alternative explanation seems to apply better to the agency level than to the individual institute level, since each institute has unique areas of concentration.

A second set of summary of findings about the hypotheses is provided in Table 19.

Table 19. Hypotheses and Findings about Differential Effects between Intramural and RPG Expenditures

Hypothesis	Findings
Self-interest Maximizations vs. PSM (H2.1 and H2.2)	Directors tend to increase expenditures in relation to their relevant backgrounds: if the director is recruited from the outside scientific communities, he or she is more likely to increase extramural RPG expenditures. Hypotheses not confirmed.
Diversification (H3)	A director's PSE tends to increase the concentration of research expenditures to a few expenditure mechanisms. This applies better to internally promoted directors; it is because of consistent budget increase over the study period. The leadership of the institute does not need to consider avoiding budget cuts. Hypothesis not confirmed.
Advisory Board Effects (H5.1)	Advisory boards increase intramural more than extramural RPG expenditures. This raises a question about the role of advisory boards: it seems they represent the spending preferences of the institute leadership rather than those of private scientific communities and advocacy groups. Hypothesis not confirmed.
Interest Group Affiliation of Subcommittee Members (H6 and H6.1)	No significant relationships were found between congressional voting scores (experience) and the proportion of intramural research expenditures. Hypotheses not confirmed.

CHAPTER 6

CONCLUSION

Summary of Key Findings

This study originated from an observation that there is a missing link between studies of distributive policy-making and R&D policy. While the former focus on the political nature of distributive policies and their efficiency implications, the latter deals with annual budgetary trends when it comes to budget and expenditure decision-making. Considering political actors in the decision-making process of medical research supported by the NIH, this study tries to show that each of the NIH expenditure mechanisms invites a unique set of influences from its beneficiaries and legislators. This study also provides evidence that although the benefits from a distributive program may have an externality effect, the relevant actors seek to increase their respective interests.

Given that the process of NIH research expenditure decision-making involves various actors such as the directors of the institutes, bureaucrats, external scientific communities, and patient and advocacy groups, the study measured their influence in the process, such as the director's PSE at the institute and agency levels and the number of advisory boards and their memberships. At the same time, since Congress, especially the appropriations subcommittees with jurisdiction over NIH funding, has been a major actor in the process, this study also measured ideological orientation and interest group affiliation of the members of the appropriations subcommittee members. Moreover, following the literature of congressional decision-making rules (Baron & Ferejohn, 1989; Dharmapala, 2006; Ferejohn & Krehbiel, 1987; Fréchette et al., 2003; Krutz, 2000; Primo, 2003), this study examined the effect of omnibus appropriations bills frequently used since 1996.

Based on the literature of economic theories of bureaucrats (Niskanen, 1968, 1971), recently developed theories of public service motivation (Perry & Wise, 1990; Perry, 1996), and theories of political clout in the budget process (Wildavsky & Caiden, 1997; Meyers, 1994), this study predicted that the PSE of institute directors would increase total institute budgets. With longer years of public experience, directors are expected to absorb prevalent values in the public organizations regardless of whether they are self-interest, PSM, and/or mission orientation. They are also expected to absorb practical information and skill of maneuvering the labyrinth of the budget process. The rationales behind this hypothesis are that if the directors are self-interested they will seek higher budgets for their own benefits, that if they are primarily motivated by PSM they seek higher budgets to improve the quality of health of the American people, and that if they have a knack for the budget process and gain considerable political clout it is easier to secure a higher budget. The analytical findings support this hypothesis, reporting a curvilinear relationship. It was found that the marginal positive effect from the director's PSE decreases at a decreasing rate up to a certain point then it turns into a negative factor.

Drawing on assumptions about the motives of public officials, this study expected that if they were self-interested, they would increase Intramural Research expenditures more than RPGs and that if they were PSM-driven, they would not discriminate in favor of one type of expenditure over another (*Hypotheses 2.1* and *2.2*). The findings reveal a reality much richer than the hypotheses predicted: if directors are recruited from outside the institutes, they tend to increase extramural research more than intramural research expenditures throughout their public career. The findings indicate newly recruited directors tend to decrease intramural laboratory spending. On the other hand, if the directors are recruited from within the institutes with a considerable amount of experience in the governmental setting, they are likely to increase intramural expenditures more than extramural RPGs. These findings reveal that institute directors are driven by their self-interest although they may seek public values. But, in this case, self-interest is not used in the Niskanen sense but in

the sense that the directors want to represent the interests of the institutional sectors from which they come and in which they command substantial networks of collaboration. If the newly recruited director has developed a substantial collaborative and informational network in his or her previous setting and is thus embedded in the interests of that community, he or she tends to seek the interests of this reference community. If the director is from an academic institution, his or her behavioral values and norms will most likely be those of the institution and of the institutional setting in which his or her home institution is embedded. These norms and values might be very different from those prevalent in the institutes. While absorbing the values of the institutes, directors recruited from external entities grow increasingly less favorable to expenditures through extramural RPGs. Directors promoted from within the institutes grow increasingly more favorable to expenditures by intramural laboratories.

Instead of seeking higher budgets, an institute director, it is expected, would diversify the agency's expenditures through multiple mechanisms either to avoid the risk of budget cuts or to seek institute-specific missions. The findings of this study tell a story opposite of this expectation, however: the longer the director's PSE, the more he or she concentrates the institutes' expenditures on only a couple of mechanisms, as indicated by the Herfindahl index of expenditures through different mechanisms. This increasing tendency of the directors toward only a few mechanisms can be explained by the support the institutes have gotten from Congress and their respective constituent groups. During the study period, the NIH budget increased at an annual rate of 8.7%. In a nutshell, the NIH budget has never been subject to budget cuts, which turns the politics of the NIH budget process into that of increasing budgets, not of avoiding the risk of budget cuts. The tendency of concentrating expenditures on a few mechanisms is greater for directors who are promoted from within the institutes than for those who come from the outside. If the directors are more committed to the values and norms of the institutes from the start of their directorship, they tend to increase the Herfindahl index more than those from the outside medical research

communities. This indicates that within-recruited directors more aggressively seek budget increases than their counterparts recruited from without.

The former two points indicate that whether or not the institute directors are recruited from the public setting makes a difference in both the allocation of research funds between intramural and extramural RPGs and how aggressively the directors seek higher budgets. Directors from within tend to seek both higher expenditures for intramural research and higher total institute budgets by increasing extramural RPGs. The most effective way of securing higher budgets for the institutes is to increase support through the biggest expenditure mechanism, RPGs. Just a small, incremental increase of RPGs has a much greater impact on the institute's total budget than a big hike in expenditures through the other minor mechanisms. Because expenditures through RPGs take up almost half of the institutes' budgets, only slightly increasing the RPGs will lead to a higher Herfindahl index, even when the percentage increase rates are greater for expenditures through the other mechanisms. In other words, a budget maximizing strategy used by directors from within is increasing RPG expenditures. Directors from without do not seek this strategy; they tend to increase the proportion of expenditures through R&D Contracts but not those through RPG.

Since disease-specific institutes are expected to be more vulnerable to advocacy and lobbying efforts of patient and advocacy groups, research expenditures of these institutes would be greater than those of the other institutes. The former institutes get support from relatively better-developed patient and advocacy groups than the other institutes do. The analytical result conforms to this prediction: the disease-focused institutes' total expenditures are greater than their nondisease-focused counterparts by as much as 10%. However, there are some variations in the difference between these two groups depending on the expenditure mechanisms. The expenditures through RPGs by the disease-focused institutes are about 9.5% greater than those of the nondisease institutes. The former institutes maintain intramural research laboratories almost three times greater than the latter institutes. It is found, however, that the disease-targeting institutes' proportion of intramural programs to

PI-initiated RPG expenditures is not considerably higher than that of their nondisease counterparts. This is because the total budget size of the former institutes is much greater than the latter institutes'. This study also reports that there is no difference between these two types of institutes when it comes to diversifying their expenditures.

This study also predicted that the participation of private interested parties in the priority-setting process measured by either the number of advisory boards or advisory board members would increase total institute expenditures, that this effect would be greater for extramural RPGs than for Intramural Research, and that the effect would be greater for disease-specific institutes than for the other institutes. For the budgetary influence of the advisory boards and their members, the result is rather mixed: the advisory boards and their memberships clearly increase the institute's total expenditures, but the effect is greater for the nondisease institutes than for their disease counterparts. On the other hand, there is no difference between these two types of institutes in the effect of the advisory board memberships. The number of advisory boards increases intramural expenditures more than extramural RPGs, thus increasing the proportion of intramural expenditures. This finding also indicates that the number of advisory boards may not be a proxy for inputs from outside but instead an indicator of a means by which the institute director enforces his or her expenditure preferences. With more advisory boards, the institutes may seek higher budgets for supporting their administration and operation. The effects of the advisory board memberships are different between different channels of support. For example, the number of advisory board memberships increases intramural lab expenditures but not extramural RPG expenditures. Thus, the advisory board membership increases the proportion of intramural expenditures, indicating that private participants in the budgeting process favor intramural expenditures at the expense of extramural research, which is clearly not what is expected from the advisory boards at face value. This interpretation may be supported by the fact that only a couple of the advisory boards are legally mandatory and the majority of them are established at the discretion of the institute directors. Thus, these boards may serve the interests of the institute's

leadership, not serve to channel input from the scientific community or the general public.

To examine the potential difference in the effects of input from outside between disease-focused institutes and nondisease-focused institutes, this study used interaction terms between the input variables and the variable of disease-focused institutes in models III and IV. The output reports quite a different story than the predicted one. For total institute expenditures, the advisory board effect is greater in the nondisease institutes than in the disease-specific institutes. In addition, advisory memberships decrease private PI-initiated RPG expenditures of disease-specific institutes. While advisory board memberships increase Intramural Research expenditures, they do so more for nondisease-focused institutes than for disease-specific ones. These findings refer to possible problems in the input mechanisms of the NIH. The majority of the advisory memberships are from academic settings such as medical schools and research universities, which are the main beneficiaries of research funds. Only a couple of members from patient and advocacy groups and the general public are on the boards that advise institute directors. Thus, the interests of these groups are not effectively funneled into the budgetary and priority-setting process by the individual institutes. Accordingly, these groups might find it more effective to lobby members of Congress, pushing them to seek legislative mandates for specific programs, expenditure mechanisms, or set-aside funds.

This study hypothesized that if the members of the appropriations subcommittees with jurisdiction over the NIH are ideologically more favorable to special interest groups, an institute's expenditures on RPGs will increase more than its intramural expenditures and that the effect of the appropriations subcommittees members' affinity to special interest groups will be greater for the specific disease-focused institutes. To measure the concept, this study used three indicators: the median of the Chamber of Commerce vote ratings, the median of the National Taxpayers Union vote ratings, and the median years of congressional experience. The results from the regression analysis are mixed, reflecting the mixed nature of NIH

research support: NIH research support is a type of distributive policy but benefits the general public with a high degree of non-excludability and non-rivalry. It serves the interests of scientific interest groups in medical schools and research universities since the NIH grants, through multiple mechanisms, allow scientists in these institutions to maintain their laboratories and train doctoral and post-doctoral students. At the same time, even though the relationship between medical research and benefits from the research in terms of health quality is getting increasing tenuous (Sarewitz, 1997; Bozeman & Sarewitz, 2005), it is not difficult to argue that medical research has hugely contributed to the health of the American people. Regardless of whether they supports special interests, members of Congress have to bear considerable damage if they decide to curtail budgets for medical research. That is why they persistently increase NIH budgets more than presidential requests (Greenberg, 2001). As predicted, longer experience as a representative leads to higher spending at the institutes, which indicates that the NIH support serves organized groups. The House NTU ratings are found to increase NIH spending as well. This means that the more concerned about budget deficit and taxpayer monies the representative is, the more likely he or she is to support higher spending by the NIH. It seems this is because of the nature of funded research as a public good. On the other hand, according to the basic model, the relationship between the measures of affinity of legislators to special interests in the Senate and the levels of institute expenditures is not established as good as the one in the House.

Lastly, this study hypothesized that the frequent use of omnibus appropriations bills since 1996 has made a positive difference in the expenditures of the institutes under the NIH, that the disease-focused institutes' total expenditures have increased more than their nondisease counterparts, and that with the omnibus legislation the effect of the institute director's PSE have increased. The basic model reports that the omnibus appropriations practice does not change the level of an institute's expenditures. However, it is found that the practice has changed the way the other independent variables affect the institute's expenditures. When controlling these

mediating effects, the omnibus legislation has indirectly increased the institute expenditures as much as three times. This should not be a surprise, because the NIH has enjoyed strong support from Congress, who doubled its total budget between 1998 and 2003.

When assuming that the omnibus legislation and the types of institutes do not jointly mediate the effects of the other variables, the nondisease-focused institutes' budgets have increased more than their disease-specific counterparts with omnibus legislation. Unlike the prediction in *Hypothesis 8*, the omnibus legislation benefited the nondisease-oriented institutes more than the disease ones. However, when the possibility is considered that omnibus legislation and the institute types jointly affect the effect of the other independent variables, there is no difference between these two types of institutes. As for its mediating role, the omnibus practice has dampened the marginal effect of the director's PSE. Another interesting finding with the practice of omnibus legislation is that it does not favor extramural research projects expenditures vis-à-vis intramural research.

These findings indicate that when the expenditure mechanisms involve different actors to a varying degree and the budgeting process is decentralized, the specific level of expenditures through a particular mechanism depends on the motivations of the actors involved, the type of agency, and the institutional arrangement for the budget process.

Implications of the Study

Much of the current discussion of the decline of the U.S. scientific advantage has budgetary implications for increasing R&D spending and changing funding priorities (National Academies, 2005; Lemonick, 2006). However, the discussions of public R&D investments beg the question of the institutional and political nature of R&D budgeting and expenditure decision-making. As implied by the literature on R&D policies, the real problem may not be the level of expenditures but the institutional settings for R&D-related incentives and activities. With a focus on NIH

budgets, this study has provided an empirical answer to the question regarding how different actors in the process affect expenditure levels through different support mechanisms.

Thus, one of the major contributions of this research to R&D policy studies and the literature of distributive politics is that it makes clear the political nature of the expenditure decision-making process of medical research. It is found that institute and agency leadership, input channels from the outside communities, ideological orientation, and interest group affinity of members of Congress affect the decision outputs. Along with Gist (1981), this research also reports that congressional rules have an implication in the expenditure levels of a research agency.

To make sense of the role assumed by the directors in the determination of expenditure levels through particular expenditure mechanisms, this research draws upon theories of motivations of public officials and of political clout of agency heads in the budget process. The analysis of this study confirms the utility of the political clout theory in the sense that with more public experience the institute heads develop connections and obtain on-the-job information about the organization and the policy process. They utilize such clout to seek higher budgets. However, the "marginal product" of political clout is diminishing at a decreasing rate, as is shown by the curvilinear relationship between the director's PSE and the institute's expenditure level. On the other hand, the study found the utility of theories of bureaucratic self-interest maximization and PSM is limited. Regarding bureaucratic budget maximization, this study reported that directors with significant amounts of PSE still decrease their institutes' intramural expenditures. If the directors are self-interested, they will increase Intramural Research more than RPGs because the former represents a true example of bureaucratic production function and because the expenditure through this mechanism is mainly controlled by the insiders of the institutes. On the other hand, although the institute leadership are seriously PSM-driven, this can not explain why the directors more strongly support research performed by the private institutions from which they come with connections, networks, and collaborators.

Directors tend to increase intramural research more than extramural research grants if they are promoted from within the institutes with considerable experience. The opposite applies to directors who are outsourced from the academic sector.

This research has policy implications. One of the major findings is that the appointment of institute directors either by the President or the Secretary of the HHS has a profound impact on institute expenditures irrespective of total expenditures or those through specific mechanisms. For example, if a director is from the outside scientific community, he or she tends to increase extramural RPGs and to decrease Intramural Research expenditures. Therefore, it would be important during appointment considerations to consider which research mechanism needs more support than the others. If the government faces higher uncertainty in predicting which research fields the academic medical research community will pursue, if it wants to nurture a swift response to newly arising medical issues, or if it seeks research in highly risky and uncertain fields, it may want to strengthen intramural research capacity by appointing a government scientist with substantial previous public experience. On the other hand, if the government wants to channel more resources into medical research fields in terms of education and personnel, strengthening America's medical research infrastructure, it would be better to invite academic scientists to the directorship.

The second major finding of this study is that the role of advisory boards and their membership might be problematic in channeling input from outside communities. First of all, the advisory boards may in fact serve the interests of the institute leadership and bureaucrats, not the outside scientific communities, due to the fact that institute directors can exert their discretion in establishing advisory boards and appointing members who will seek their interests. It might be a wise decision for the institute leadership to limit the number of advisory boards and to streamline their advisory roles vis-à-vis the leadership of the institutes. In addition, it is likely that when advisory board members do represent input from the outside communities they are more favorable to the research interests of the scientific communities, not

necessarily those of the patient and advocacy groups and the general public. To mitigate this problem, it would be better for directors to seek more advisory board members from advocacy groups and the general public.

The third major finding is that the distinct types of funding mechanisms used by the NIH not only entail different mechanisms of management and levels of government involvement (Salamon, 2002) but also have distinctive channels of spillovers. The knowledge transfer processes from intramural research and extramural research are different. There is a well-established finding that universities are more active in invention disclosures, patent applications, and patent licensing than government research agencies (Heisey et al., 2006). Research findings from both types of research might be reported by publication, but university scientists are more likely to be actively involved in the utilization of their findings for a profit purpose. Biotechnology firms that are prosperous in regions such as California, Texas, and Massachusetts have in large part originated from university scientists' active engagement with business enterprises as consultants, CEOs, etc. The U.S. biotechnology industry is dependent on highly recognized scientists who have been funded by the National Science Foundation and/or the NIH (Zucker et al., 1998; Zucker & Darby, 1999). Such an active interaction between members of the research community and those in the business community is not readily available for NIH intramural research. Therefore, the process of knowledge transfer from internal government labs to the industry may take more time, unwittingly sacrificing those who suffer from the diseases being researched by these internal labs. For these reasons, the decision regarding which types of research to fund is critical to the contribution of NIH funded research to the economy. This study reports that factors at the institute and agency levels, the ideological orientations of members of Congress, and the political control of the Congress and the presidency all affect research support expenditures through different mechanisms.

Limitations of the Study

The findings of this research clearly indicate that R&D expenditure decisions are closely interwoven with actors and institutional arrangements, as discussed by the literature of motivations of public officials and distributive politics. Each constituent group is found to provide specific influences with regard to expenditures through specific mechanisms. However, these findings should be qualified when considering the critical limitations of this research. Of the limitations, the methodological ones are noteworthy.

First, there could be endogeneity problems in the models, as was pointed out in the methodology section. Directors who are better at securing higher budgets may be more likely to enjoy longer years of success as the leadership of their institutes. This might be especially true when securing a stable stream of research funds for academic and medical institutions is the first-order priority. Moreover, institutes with a higher level of total expenditures would have more discretionary resources to establish additional advisory boards. Thus, with the possibility of two-way flows of influence, the dependent variable may also affect the independent variables. In such a case, the t-tests of the models are not as reliable as those without such problems. Realizing them, this study could not effectively resolve them without any plausible instruments.

Second, when summing the numbers of advisory boards and their memberships, for the purpose of simplicity this study does not make a distinction across different types of advisory boards. For example, the National Advisory Council at an institute advises its director, while special emphasis groups focus on initial peer review of grant applications. These two different advisory boards may have very different effects on expenditure decisions. However, this study does not take this into account, assuming that the magnitude of this problem would be constant across different institutes. This may limit the interpretation of the effect of advisory boards and their memberships.

Third, when reporting the significant effects of different constituent groups and institutional arrangements, it is still not clear how different actors interact throughout the process. The interpretation of the coefficients is based on marginal changes, holding the other variables constant. Therefore, they do not allow this researcher to determine how one type of actors reacts to the actions of another type of actors. Institute directors may be able to manipulate the process of advisory board membership to represent their own agendas, not seeking input from outside, or, conversely, they might choose board members who are supportive of intramural research to seek higher expenditures for intramural programs—the data collected and analyzed for this study do not reveal which way the directors or the advisory board members will act.

Lastly, this study might be overemphasizing the role of institute directors in the expenditure decision-making process. The significant role in planning and budgeting at the program level is played by the division directors, which would be comparable to the role assumed by the institute directors. Playing the role of bureau-shaping (Dunleavy 1986, 1991), the institute directors may allow division directors to take care of which expenditure mechanisms to use to support specific programs. While this argument has some validity,[55] the role played by the director is still important in the sense that it is the responsibility of the institute director to choose division directors, that the institute directors defend the institute's budgets in front of congressional committees, and that the institute directors coordinate programs administered by different divisions. A more serious problem may stem from the fact that this study does not explicitly measure the extent to which the directors are driven by self-interests or PSM. The *director* variable measures the amount of political clout the directors have developed and how much the directors identify themselves with the

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[55] This study could not provide in-depth qualitative knowledge about the internal processes of budgeting and expenditures, which could be its major limitation.

values and norms of the institute. Thus, if the bureaucrats at the institute are driven mainly by self-interests, the director is expected to be socialized to seek self-interests. If the degrees of self-interestedness or PSM could be measured, the hypotheses regarding the institute directors' motivations and the budgetary consequences could be more directly tested.

Further Research Agenda

The limitations of this research themselves provide agenda for further research. In the subsequent research, some measures of bureaucratic self-interests and PSM might be devised. Such measures might resolve the endogeneity problem. Moreover, the validity regarding advisory boards and their members may be improved by more specified coding. On top of these, this research topic could be sought further along the lines of the following.

First, a qualitative study of budgeting and expenditure decisions with a special focus on the relationship between institute directors and division directors would complement the current study. It is a very competent argument that the division director's role in the process is not insignificant. It is likely that they are more entrenched in organizational values and missions but less political in their decision-making than the institute director. Second, this study does not examine intensely the effects from political control of the presidency and the Congress. Given that the Secretary of Health and Human Services is responsible for appointing institute directors, the political control of the presidency who appoints department heads may factor in the other independent variables, making differences in their effects. Presumably, there might be differences in the effects of public service experience between directors appointed by a Democratic president and those chosen by Republican one. Third, the findings about the variables measuring political ideology and interest group affiliations of the Senate Appropriations Subcommittee members did not lend significant patterns. This might be because of potential problems in the

measurement. A more clear-cut measure may prove to be more useful in predicting expenditure outcomes.

It is expected that all of these research agendas will enrich the research into the dynamic process of Research and Development expenditure decision-making since they focus on the incentives of the relevant actors in the process. Being based on the political interests of the actors, this line of study will provide a new perspective in examining the political characteristics of public budgeting for distributive R&D programs, which remains largely untouched in the relevant literature.

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