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An Economic Analysis of the Allocation of Research Funding at the National Institutes of Health.

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AN ECONOMIC ANALYSIS OF THE ALLOCATION OF RESEARCH FUNDING AT THE NATIONAL INSTITUTES OF HEALTH

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ABSTRACT

Our model examines the allocation of medical research funds at the National Institutes of Health using public interest theory, incremental budgeting theory, and special interest group theory. We use the allocation of research funds among various diseases and measures of the burden of disease on the population to test the hypothesis that the N.I.H. is allocating funds on a pure public interest basis, to test for incremental budgeting effects, and to test for the influence of lobbying and other political variables representing special interest groups. We use pooled cross-sectional, time-series data in a one-way fixed effects model, and also use separate cross-sectional data in a standard multiple regression model. We also evaluate the effect of political variables on the distribution of research funds among the states.

We find evidence to support the public interest, incremental budgeting, and special interest group theories of regulation in the operation of the N.I.H. Using the pooled data sets, we find that the N.I.H. does not respond to changes in death patterns over time, but does consider death patterns in the initial allocation of funding across diseases. Funding increases primarily as a result of incremental budgeting. However, using the more recent and more inclusive cross-sectional disease data, we find that the burden of disease, whether measured by deaths, years of life lost, or hospital stays, does matter in the allocation of funding among diseases, which is evidence that the N.I.H. does consider the public interest when making funding decisions. We also find, however, that the allocation among diseases is impacted by lobbying dollars, and that the allocation across states is influenced by political factors, both of which provide support for the special interest group theory of regulation.

CHAPTER 1

INTRODUCTION AND THEORY

1.1 Background

The National Institutes of Health (N.I.H.) is a politically popular agency which receives budget increases even in years when agency budgets in general are being cut.[1] Even though the N.I.H. has received a real increase in its budget every year since 1982, it is still not possible for the agency to fund all or even most of the proposals it receives. In fact, the N.I.H. rejects three out of every four research proposals it receives.[2] How does the National Institutes of Health determine which diseases should receive research funding, and in what amounts?

The N.I.H. is the largest biomedical research institution in the world. The decisions made by the N.I.H. potentially affect the future health of every American. Choosing to fund research for malaria rather than pancreatic cancer, for example, may benefit some Americans and penalize others. Consequently, Americans have a very personal interest in understanding the decision-making process of the N.I.H. This dissertation attempts to explain, at least in part, the decisions reached by the N.I.H..

The National Institutes of Health is part of the Public Health Service in the Department of Health and Human Services. The N.I.H. has grown into a complex agency employing over 19,000 people with a budget of $20.3 billion.[3]

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[1]Aaron Wildavsky, *The Politics of the Budgetary Process, 4th ed.* (Boston: Little, Brown and Company, 1984), 33.

[2]National Institutes of Health, "Setting Research Priorities at the National Institutes of Health," prepared by the Working Group on Priority Setting (Bethesda, Md.: National Institutes of Health, 1997), Internet. Available from http://www.N.I.H..gov/news/Res_Priority/priority.htm (accessed 9 October 1998).

[3]Setting Research Priorities, p. 9-10.

The N.I.H. is headquartered on a 300-acre campus in Bethesda, Maryland. The N.I.H. is a collection of twenty-six individual institutes and divisions, which are listed in Table 1.1. In addition to the institutes, the N.I.H. also operates on-site a 350-bed research hospital, a clinical center with extensive outpatient programs, a research center for medical students, the Fogarty Center for international cooperation in science, and the National Library of Medicine. The latter is the largest medical library in the world.

The N.I.H. also has numerous facilities away from Bethesda. These include the National Institute of Environmental Health Sciences in North Carolina, the N.I.H. Animal Center in Poolesville, Maryland, a gerontology Research Center and an Addiction Center in Baltimore, and the Rocky Mountain Laboratory in Montana.

The N.I.H. funds research by its employees at its own facilities, which is intramural funding, and accounts for only about eleven percent of the current budget. Most of the money received by the N.I.H. goes to fund scientists and researchers working at universities, medical schools, and hospitals around the country. Currently about seventy-five percent of the total money received by the N.I.H. is paid to these scientists working on extramural grants. The remaining funds (less than fifteen percent) go for support costs.[4]

The N.I.H. provides funding for over 50,000 researchers working on over 35,000 extramural Research Project Grants (RPG's). Table 1.2 shows the number of RPG's and the total RPG funding for each of the last ten years. The RPG is the most

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[4] National Institutes of Health, "N.I.H. Almanac 1999," prepared by the Editorial Operations Branch (Bethesda, Md.: National Institutes of Health, Pub. No. 99-5, 1999), 116-158.

Table 1.1
N.I.H. Institutes And Centers

Year	Acronym	Name of Institute or Center
1930	0D	Office of the Director
1937	NCI	National Cancer Institute
1944	NLM	National Library of Medicine
1946	CSR	Center for Scientific Review
1948	NHLBI	National Heart, Lung, and Blood Institute
1948	NIDCR	National Institute of Dental and Craniofacial Research
1948	CC	Warren Grant Magnuson Clinical Center
1949	NIMH	National Institute of Mental Health
1950	NIAMS	National Institute of Arthritis and Musculoskeletal and Skin Diseases
1950	NINDS	National Institute of Neurological Disorders and Stroke
1958	NIGMS	National Institute of General Medical Sciences
1962	NICHD	National Institute of Child Health and Human Development
1965	NIEHS	National Institute of Environmental Health Sciences
1968	NEI	National Eye Institute
1968	FIC	Fogarty International Center
1974	NIA	National Institute of Aging
1974	NIAAA	National Institute of Alcohol Abuse and Alcoholism
1974	NIAID	National Institute of Allergy and Infectious Diseases
1974	NIDA	National Institute of Drug Abuse
1986	NIDDK	National Institute of Diabetes and Digestive and Kidney Disease
1986	NINR	National Institute of Nursing Research
1988	NIDCD	National Institute of Deafness and Other Communication Disorders
1990	NHGRI	National Human Genome Research Institute
1990	NCRR	National Center for Research Resources
1992	NCCAM	National Center for Complementary and Alternative Medicine
1998	CIT	Center for Information Technology

Source: Office of Communications and Public Liaison, N.I.H. Almanac 1999.

Table 1.2
N.I.H. Extramural Awards By Activity
Fiscal Years 1988-2000
(Dollars In Thousands)

YEARS	RESEARCH GRANT NUMBER	RESEARCH GRANT AMOUNT	CENTER GRANT NUMBER	CENTER GRANT AMOUNT	CONTRACT NUMBER	CONTRACT AMOUNT
1988	22,107	$ 4,021,486	714	$ 627,297	1,252	$ 600,594
1989	22,752	4,396,635	725	673,670	1,311	697,489
1990	22,504	4,638,602	728	715,638	1,332	777,432
1991	23,352	5,057,591	795	797,673	1,362	793,189
1992	24,033	5,494,152	865	893,798	1,232	866,874
1993	23,952	5,659,458	899	910,562	1,328	861,925
1994	24,964	5,964,779	985	985,549	1,126	1,001,809
1995	24,899	6,151,615	933	1,020,703	1,091	1,016,911
1996	25,519	6,538,580	928	1,049,893	1,296	994,259
1997	26,936	9,046,500	940	1,088,546	1,167	939,700
1998	28,439	9,801,900	915	1,195,763	1,169	894,800
1999	31,150	11,228,700	989	1,424,083	1,191	1,045,200
2000	38,303	13,002,461	1,026	1,605,613	1,133	1,123,000

Source: Office of Extramural Research, N.I.H. Awards by N.I.H. Component and funding Mechanism.

common method of funding extramural research. RPG's are initiated by the researcher. The N.I.H. has several types of RPG's designed to give the institutes flexibility in the awards process. Generally, all awards are classified as competing awards in their first year of support; if support is continued for longer than twelve months, the award is then reclassified as non-competing. Each year, about seventy-five percent of the total RPG's are non-competing. Of the new unsolicited proposals submitted each year, the N.I.H. funds only about one-fourth.[5]

The N.I.H. does not rely exclusively on investigator-initiated proposals to determine the direction of medical research. The N.I.H. actively seeks proposals in areas it designates "high priority or special concern." Program Announcements and Requests for Applications are the two methods used by the N.I.H. to stimulate research interest in areas it would like to fund.

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[5]Ibid.

Research Project Grant proposals are subject to a multi-level peer review process. Initially, applications are reviewed by groups of non-government scientists (called study sections) and are ranked using a loose criteria structure of significance, approach, innovation, investigator, and institutional environment. Generally, the peer-review process occurs in the Center for Scientific Review, but N.I.H.-solicited grant applications are usually reviewed by the institute which solicited them. Each application, regardless of where it is reviewed, is assigned a numerical ranking from 100 to 500, with 100 being the best. Applications with a rank of 300-500 are not routinely forwarded to institutes for further consideration.

The proposals with the lowest (best) scores are then passed on for further review by the individual institutes or centers. Each institute and center has its own National Advisory Council, which makes funding recommendations. The Councils do not have to follow the peer review ranking, and are free to consider other factors in the award process. The Council is composed not only of scientists from the institute, but also of members of the public with an interest in the research of the institute.

Although RPG's constitute the bulk of N.I.H. extramural funding, the N.I.H. also spends substantial amounts of money funding research center grants. These grants are generally larger than RPG's, employ several people, and are made to a research center to do medical research in a clinical application setting. In addition to center grants, the N.I.H. also establishes a number of research and development contracts each year, designed to expand research into areas promoted by the N.I.H.. R&D contracts are overseen by an N.I.H. staff member, but the research is done by an

outside organization. Funding for center grants and research and development contracts is also shown in Table 1.2.

The funding process for research proposals, research centers, and research and development contracts is only part of the complex N.I.H. budget and research funding allocation process. The N.I.H. does not receive a block of funding which it may allocate among the various divisions or even among various research projects. The N.I.H. prepares and presents to Congress each year a proposed budget, for the N.I.H. as a whole and for each individual institute, center and division. Congress and the Administration both tinker with the figures, often altering spending for specific diseases or projects, as well as those for centers or institutes. Indeed, Congress is closely involved in the very structure of the N.I.H., as well as in its funding. Congress authorizes the creation of a new institute or center whenever it feels a disease or group of diseases needs a higher priority in the funding process. For example, Congress last December authorized the creation of a new institute, the National Institute of Biomedical Imaging and Bioengineering, even though the (then) Secretary of the Department of Health and Human Services objected, citing duplication of effort and increased administrative costs in such a move.

There is not a grand plan for medical research at the N.I.H. There is no board or body to oversee the entirety of research funding allocation. Each institute prepares its own budget based on guidelines from the federal Office of Management and Budget. Budget proposals to Congress are based on initial expectations of which projects will be funded, and for how much; Congress then adjusts the budget according to its own goals. Congress frequently holds hearings on funding levels for

particular diseases or centers and invites public participation. The N.I.H. also encourages patient advocacy groups and other members of the public to have input into the budget process.

Once a budget has been agreed upon, the Director of the N.I.H. still has some leeway in altering the budget. The Director can move up to one percent of the N.I.H. total funding among the institutes as he sees fit. In addition, the Director also has a discretionary fund, which he can use to fund projects outside the regular RPG process.

In this study, I will examine the allocation of research funds among the various diseases by the N.I.H. I seek to answer the following questions: Does the N.I.H. allocate funding according to the burden of disease on society? How much influence does politics have in allocation decisions? Does the lobbying of special interest groups affect the allocation of research funds among the various diseases? Does the distribution of research funds among research institutions across the country depend on political influence, or can it be explained by objective criteria?

1.2 Theory

Biomedical research is a service demanded by the public because of the benefits of improved health and longer life that result from such research. The N.I.H. is the largest single supplier of biomedical research in the world. Thus the allocation of the N.I.H. budget among various research projects (i.e., various diseases) can be analyzed in the context of a demand and supply framework. The N.I.H. is a federal agency, part of the Department of Health and Human Services (DHHS), which is a Cabinet department under the nominal control of the Administration. However, the N.I.H. is dependent upon Congress for all its funding; therefore, the agency must

respond to pressures from the Congress, which in turn must respond to the wishes of voters and special interest groups. It is reasonable to assume that both the Congress and the N.I.H. itself have some discretionary power in determining budget levels and the allocation of funds among the various institutes and various diseases.

1.2.1 Simple Public Interest Theory of Biomedical Research Funding

The simplest theory which could explain the allocation of N.I.H. research funds among various diseases would be a pure public interest theory. Public interest theory hypothesizes an altruistic motivation for the behavior of bureaucrats and politicians; that is, they run the government (or the federal agency) in such a way as to obtain the greatest good for the greatest number. Under such a system, the public would demand research on those diseases which impose the greatest burden on society. In this idealistic world, the decision-makers at the N.I.H allocate research funds on the basis of some burden of disease measure, such as deaths, hospital stays, or cost of treatment.

The theoretical framework of the analysis of N.I.H. research funding allocation under a pure public interest theory model would be that of a constrained optimization problem, such as the model developed by Lichtenberg (1995). Lichetnberg's model makes no allowance for the influence of Congressional politics or special interest groups. His model, then, would explain only the relationship between research funding allocation and some burden of disease measure representing the voters' interest. In Lichtenberg's model, policymakers want to maximize the total number of people cured of disease subject to the research budget constraint. The objective function is:

$$J^* = N_1P_1 + N_2P_2$$

$$= N_1X_1^{\alpha} + N_2X_2^{\alpha}$$

where:

J^* = Number of people cured

N_i = Number of people with disease *i*

$X = X_1 + X_2$ = Total research budget

$P_i = f(X_i)$ = Probability of finding a cure, which depends only on research funding.

The assumption that the probability of finding a cure is the same for all diseases does not reflect the realities which exist in scientific research. However, allowing the probability of success in research to vary by disease demands a method of estimating these probabilities, which is not currently available. Also, the United States has no reliable sources for either the incidence or prevalence of many diseases. Neither the Centers for Disease Control, the National Center for Health Statistics, nor any other federal agency collects such data. Estimates of the number of people who suffer from a disease (the disease population) are, except in rare cases, only guesses. Thus, measures of the burden of disease must be restricted to forms such as total deaths or hospital discharges, for which data are available. Because of the lack of data on both disease populations and the probabilities of successful research, Lichtenberg's model is approximated by estimating the relationship between research funding for a disease and some obtainable measure of the burden of disease. We have done this in Chapter 3.

1.2.2 Expanded Theory of Biomedical Research Funding

In reality, the N.I.H. does not operate in a ivory tower, devoted to serving the public interest, removed from the influence of politicians, scientists, or patient advocacy groups. Lichtenberg's model must be modified to reflect the political reality of the world in which the N.I.H. operates. We expand Lichtenberg's model to include not only variables which measure the burden of disease, but also those representing the forces of politics and special interest groups. The following system of equations can be used to identify and isolate determinants of the allocation of N.I.H. funds:

$$\text{Demand N.I.H. Research Funds}_{it} = D(VI_{it}, SIG_{it}, S_t) \quad (1.1)$$

$$\text{Supply N.I.H. Research Funds}_{it} = S(CONGPOL_t, NIHSUB_{it}, NIHPOL_t, PA_t) \quad (1.2)$$

$$\text{N.I.H. Research Funds}_{it} = \text{Demand N.I.H. Funds}_{it} = \text{Supply N.I.H. Funds}_{it} \quad (1.3)$$

$$\text{N.I.H. Research Funds}_{it} = f(VI_{it}, SIG_{it}, CONGPOL_t) \quad (1.4)$$

where

VI_{it} = Voters' (public) interest in research on disease i in year t

SIG_{it} = Special Interest Group pressure for research on disease i in year t

S_t = Relative political power of voters and special interest groups in year t

$CONGPOL_t$ = Congressional politics in year t

$NIHSUB_{it}$ = N.I.H. grant submissions for research on disease i in year t

$NIHPOL_t$ = Internal politics at N.I.H. in year t

PA_t = Principal-Agent relationship with Congress in year t

1.2.2.1 The Demand Equation

According to Equation 1.1, the demand for N.I.H. research funding for disease i in year t depends on voters' interest (VI_{it}), the pressures of special interest groups

(SIG_{it}), and the structure of the political system with respect to the relative political power of voters and interest groups (S_t). Let us consider the measurement of each of these variables and their relationships to the allocation of N.I.H. grants.

The inclusion of a public or voters' interest variable in Equation 1.1 is based on the assumption that, at least in part, the allocation of public funds to biomedical research is done to maximize the public welfare. It is also reasonable to assume that communicable diseases will draw more public support than diseases which affect only an isolated population. Members of the public make their demands known through their votes, as well as expressions of concern to both Congress and the N.I.H. directly. To serve the public's or voters' interest, the N.I.H. will be forced to allocate additional funds to those diseases which have the greatest impact on the public.

The N.I.H. is a federal agency whose budget is determined each year by Congress. The N.I.H., in fact, does not have a global budget which is divided up by scientists working only for the good of the public. The N.I.H. submits a separate budget request for each center and institute (twenty-six in all). Both the Office of Management and Budget (OMB) and Congress can adjust the total amount for each institute, as well as the allocation of each institute's budget to various diseases. In addition, Congress can and does dictate specific amount of money to be dedicated to specific research topics. These are called Congressional directives.

Thus, the theory must be adjusted to allow for the goals and objectives of individual member of Congress, as well as politicians in the Executive Branch. The input of politicians must be considered, and their goal may in fact be to get re-elected, not to improve the public welfare. Consequently, the influence of voters and special

interest groups will determine the amount of interference by Congress or Executive Branch appointees in the research allocation process. These groups or individuals have goals which may or may not be compatible with the public interest. People who suffer from a disease, say, diabetes, will have an incentive to urge Congress to allocate additional funds for diabetes research. The benefit to them will be large, while the cost of research will be spread over the entire tax base. As a result patient advocacy groups will each be motivated to act to increase research funding for their disease. The allocation that results from their activities may not be the welfare-maximizing allocation.

The literature on the theory of regulation and special interest groups, as developed by Becker (1983), Olson (1965), Peltzman (1976), Stigler (1971), and Wilson (1974) fits well with a cursory examination of the funding process for the N.I.H.. Wilson noted that the funding of kidney dialysis under the Medicare program was a triumph of an interest group and reflected the truth of the concentrated benefits and diverse costs philosophy.[6]

Mancur Olson in *The Logic of Collective Action* (1965) analyzed the motivation behind the process of groups, noting that political power is vested in a number of powerful special interest groups, none of which represent the majority of the voters or citizens of the United States. The potential gain to any individual from lobbying efforts is quite large; on the other hand, there is a substantial free rider problem in large groups. Consequently, small groups will win benefits at the expense

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[6] James Wilson, "The Politics of Regulation," in *Social Responsibility and the Business Predicament* (Washington, D.C.: the Brookings Institution, 1974), 135-136.

of large, unorganized groups. Olson explained the political power of small business groups, unions, and professional associations using this model.

George Stigler developed a model of special interest group theory in "The Theory of Economic Regulation" (1971). Stigler argues that the public interest view of regulation does not explain most economic regulation and ignores political reality. The special interest group has much greater motivation to seek beneficial regulation than the general public does to oppose it: the benefits for the interest group members will be substantial, while the cost to any individual member of society will be quite small. Therefore, the incentive of any individual to work to prevent special group regulation is negligible.

Becker (1983) further developed Stigler's theory. He concurred with Stigler that politically successful groups tend to be small relative to the size of the groups taxed to pay their subsidies. Only groups that are efficient at eliminating free riding become politically powerful, which parallels the concentrated benefits, diverse costs philosophy. Special interest groups purchase votes in legislatures through lobbying and other political activities. Peltzman (1984) used a simple principal-agent model to explain voting behavior by members of Congress. Congressmen respond to the interests of those who contribute to the election effort, through donations or political activity. Peltzman concludes that legislators are not shirking; they are representing the interests of the groups which got them elected. Special interest group theory is rational.

Special Interest Groups (SIG) can be expected to lobby the Congress (and the N.I.H.) and to provide campaign contributions and votes to members of Congress in

pursuit of increased funding for particular diseases. In this study, we proxy the influence of advocacy groups by a simple registered lobbyist dummy variable and additional dummy variables indicating the level of lobbying expenditures.

The structure of the political system (S) reflects the relative political power of voters and special interest groups. This balance of power may be altered over time. It is widely believed that the legalization of political action committees (PACs) in 1973, which were subsequently confirmed by the courts, may have enhanced the relative power of interest groups. Similarly, recent proposed changes in campaign finance laws may alter the relative power of interest groups in the future. For our observation period, no major changes were enacted in campaign finance law, so this variable is excluded from our final reduced-form Equation 1.4.

1.2.2.2 The Supply Equation

According to Equation 1.2, the supply of N.I.H. research funds to disease *i* in year *t* depends on Congressional politics (CONG-POL_t), N.I.H. grant submissions (NIH-SUB_{it}), N.I.H. politics (NIH-POL_t), and the principal-agency relationship (PA_t) between Congress and the N.I.H. The congressional political factors which may influence the allocation of N.I.H. research grants across diseases from year to year include: (1) which political parties control the House, Senate, and Presidency; (2) who chairs particular committees in the Congress; (3) the member composition of the committees and their geographic constituency of voters and special interest groups. Data on congressional political factors is available and is included in our model. A final aspect of congressional politics which influences N.I.H. grant expenditures is the concept of "incremental budgeting."

When examining the budgeting process by agencies of the federal government, the starting point is the incremental budgeting model developed by Aaron Wildavsky in his 1964 book *The Politics of the Budgetary Process*. Wildavsky demonstrated that government bureaus do not use zero base budgeting; that is, beginning with a budget of zero dollars and evaluating each program expenditure each year in comparison with all other possible programs. Furthermore, he suggested that doing so is not efficient, given the size and complexity of the federal budgeting process. Instead, agencies modify the previous year's budget in relatively inconspicuous ways, gradually expanding existing programs or requesting small amounts for new programs. This process generally results in slowly expanding budgets; the incremental change may be either large or small, but it is still an incremental increase in last year's funding. We analyze the incrementalism present in the N.I.H. budget by comparing trends of institute budgets.

Wildavsky also incorporated some special interest theory into his work, discussing the importance of building relationships with key Congressmen, those who sit on the committees overseeing an agency, or on the powerful appropriations committees. He noted that committee recommendations on agency budgets are almost always accepted by the entire chamber.[7] In addition, Wildavsky emphasized the importance of building an identifiable clientele for agency services, and making sure the agency clientele provides positive feedback to Congress on the agency's behalf. In particular, Wildavsky noted that the N.I.H. would sometimes cut requested funding for popular research programs, such as cancer research funding, when asking for increases in administrative expenses or less popular items such as dental research; their

expectation was that Congress would restore the politically popular cancer funding. They were correct.

In theory, the N.I.H. is responsible to Congress, which approves the N.I.H. budget, monitors its decisions, and helps to set its policies. The N.I.H. is therefore an agent which represents its principals' (i.e., the Congress) interests. The nature of this principal/agent relationship may change over time in response to perceived crises and changes in public opinion; Congress may become more or less active in its supervision of the N.I.H. from period to period. In our observation period, Congress exercised a high level of control over the budgeting process of the various N.I.H. Institutes and Centers. In addition, Congress maintained the power to specifically order research on a partial disease or spending in a certain area, which they exercised from time to time. They did not pass any legislation altering their degree of control over the N.I.H., or charging the administrative status of the N.I.H. Therefore, because no significant changes occurred in the nature of the N.I.H./Congress relationship, we can drop the CONGPOL variable in our final reduced-form Equation 1.4.

Most of the N.I.H.'s funding for research is allocated through external Research Project Grants (RPG's). RPG's are initiated by research proposal submitted by non-N.I.H. researchers. Thus, the allocation of N.I.H. research funds to disease categories is in part dependent on the research proposals submitted to the N.I.H. (NIHSUB). However, there is no data available to the public on the proposals submitted but not approved for funding (about seventy-five percent of proposals submitted). Consequently, we make no attempt to model such submissions, so that NIHSUB is not included in our final reduced-form Equation 1.4.

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[7] Wildavsky, 51.

N.I.H. politics (NIHPOL) also plays a role in the allocation of research dollars. The N.I.H. does not rely exclusively on investigator-initiated proposals to determine the direction of medical research. The N.I.H. actively seeks proposals in areas it designates "high priority or special concern." Program Announcements (PA) and Requests for Applications (RFA) are the two methods used by the N.I.H. to stimulate research interest in areas it would like to fund. However, the process underlying the decision to issue a PA or RFA is not made known to the public; consequently, this variable is not included in our final model.

1.2.2.3 Equilibrium Determination

According to Equation 1.3 of our model, the allocation of N.I.H. research funding among diseases will be determined by an equilibrium between the demand for and supply of such funding. Like previous researchers, we do not attempt to estimate the structural Equations 1.1 and 1.2 because of difficulty in obtaining the relevant data. Many of the theoretical structural variables are omitted from the reduced-form equations either because they did not change over the observation period or no empirical proxy variable was available to capture their effects. Therefore, we are forced to estimate variations of the reduced-form Equation 1.4 using different data sets. Nevertheless, the estimated reduced-form equations are far more sophisticated and theoretically complete than previous models that have been estimated to explain the allocation of N.I.H. research funds.

CHAPTER 2

REVIEW OF THE LITERATURE

2.1 Introduction

The allocation of government medical research funding is not a topic which has been extensively studied, primarily because of the lack of useable data. Most analyses of the National Institutes of Health which have been undertaken have focused on areas other than the social welfare economics of research funding. Analyses of the special interest and political factors impacting the National Institutes of Health are more plentiful, but the lack of hard data has been a problem for them, also.

2.2 General Medical Research Funding

Some of the earliest work on the social welfare economics of medical research was done by Weisbrod (1961). He theorized that medical research funding should be allocated according to some definable mechanism based on a goal of improving the public welfare. Weisbrod did groundbreaking work in the area of quantifying the cost of disease: the lost production from premature death and from sickness and the direct costs of treatment. His approach was unique in that he noted that "in addition to the loss of a producer, a death also involves the loss of a consumer."[1] Consequently, Weisbrod used the value of future earning net of consumption when calculating the cost of premature death. He also justified the concept that research expenditures should be allocated proportionally to diseases based on the death rates from those diseases, as the best approximation of equating the marginal benefits and marginal costs of research on various diseases. His was a pure public interest theory

[1] Burton A. Weisbrod, *Economics of Public Health* (Philadelphia: University of Pennsylvania Press, 1961), 35.

application. The flaws in Weisbrod's work stem from his scanty data. He examines only three diseases: cancer, poliomyelitis and tuberculosis; and he uses data only for 1954. While he finds that the allocation of research to each disease does not correspond proportionally to the deaths from those diseases, his limited data makes it very difficult to reject the public interest theory as a motive for public medical research spending.

Eshelman (1971) examined the allocation of medical research funds using a different approach, which was a variation of the public interest method used by Weisbrod. He criticized Weisbrod's ideas of deducting consumption from earnings to measure the cost of premature death and of using death rates as an allocation mechanism. Ehselman used gross earnings and advocated developing marginal rates of return for research on individual disease categories. He tried to estimate directly the rates of return for medical research on infectious and parasitic diseases and cancer, in order to compare the marginal benefits and the marginal costs of research on those diseases. He argued that the greatest benefit to society would be achieved not by allocating research funds based on deaths, but by allocating the most funds to those diseases with the most productive research. In doing so, he made some restrictive assumptions: he excluded environmental factors such as sanitation and hygiene from the benefits of medical research, as well as lifestyle factors such as diet, exercise or tobacco use. These omissions certainly understated the value of medical research, as medical research led to many of the changes in sanitation, hygiene, and lifestyle. Also, his data set has serious problems: when estimating the equation for the rate of return to cancer research, he used only data from the state of Connecticut on five-year

survival rates, and only data from California for six to fifteen-year survival rates. Because of his restrictive assumptions and spotty data, his research is of limited usefulness. However, even with these problems, he still found that the marginal benefits from medical research far exceeded the marginal costs.

Selma Mushkin's extensive work on Biomedical research funding (1979) highlights many of the problems associated with developing a resource allocation model for biomedical research expenditures. She operates under a standard public-interest, welfare-maximizing model. Mushkin's analysis is limited by her data set; she had access only to expenditures by institute level. The overlapping nature of the research done by the institutes – research on leukemia and lung cancer is carried out by both the National Cancer Institute and the National Heart, Lung, and Blood Institute, for example – makes institute-level data unreliable. Using this data, however, Mushkin found only a basic correlation between institute funding and death rates. No other measure of illness impact provided any explanation of funding levels. In addition, Mushkin did not attempt to incorporate any other explanatory variables into her equations. The fact that death rates for various diseases remained essentially stable for long periods of time also tainted her results. Mushkin does sketch an interesting experimental resource allocation model for use by the N.I.H. in allocating funding among diseases. She suggests that special interest groups, such as the March of Dimes or the American Cancer Society, should be allowed to bid for increases in research funding for various diseases by making contributions to the N.I.H.. Mushkin's main contribution is in her detailed effort to examine the N.I.H. and

government medical research as a unified program. She also highlighted the real shortcomings of the government's collection of information on research funding.

Garber and Romer (1993) examined the costs and benefits of medial research to American society as a whole in "Evaluating the Federal Role in Financing Health-Related Research". They assume that a public interest paradigm dominates the decision-making process in government medical research funding. The two methods available for financing the costs of research are expanded property rights (monopoly power) and tax-financed subsidies. Policy makers must address two questions: Is the total level of support research adequate? Is the balance between subsidies and monopoly power appropriate? In order to do this, they must have quantitative information about the costs and benefits of medical research. This is difficult to obtain. If profits (of pharmaceutical firms, for example) are used as a measure of benefits, they underestimate benefits because they omit the consumer surplus. The over-consumption of medical goods and services caused by insurance also creates a distortion in estimating the true benefits to society.

Garber and Romer theorize that the highest payoff to government spending on medical research may come from funding research in areas where it is prohibitively expensive to establish the system of property rights that makes private profits possible. They use as an example the discovery by government researchers that aspirin can prevent heart attacks. Because of the large number of firms producing aspirin, no one firm would underwrite this research, because the profit increase from additional aspirin consumption was shared among all the aspirin firms. In this case, government research clearly increased consumer surplus. In another example, however, N.I.H.

sponsored research led to the development of the drug alglucerase for the treatment of Gaucher disease. Subsequently the N.I.H. gave the monopoly rights for this drug to a private firm, under the provisions of the Orphan Drug Act, in order to get the drug produced. However, the price of drug therapy is over $300,000 per year, and victims must take the drug for life. Because there is no substitute for the drug, the monopoly producer can charge any price and insurers will pay. Here, profits clearly exceed the benefit to society. Garber and Romer assert that the present paucity of information on measurable benefits and costs of research makes it extremely difficult to answer the critical policy questions facing the federal government and American society. They call for extensive collection of new types of data and limited social experiments to facilitate informed decision making. They do not attempt to provide evidence that the federal government is actually operating under a public interest model, or any other model, for that matter.

In a departure from the prevailing public interest approaches to modeling research funding, Ince (1985) undertakes an examination of medical research policy in Australia in an effort to determine if special interest groups played a role in the awarding of research grants by the Australian National Health and Medical Research Council. Her database consists of approved applications received between 1966-1981, and rejected applications by people who had at least one other application approved during that period. Consequently, her data on non-funded applications is skewed and contains an unknown portion of the total pool of non-funded applications. Thus it is impossible, for example, to tell which areas of research are being discouraged, or to make any judgments about geographic discrimination.

Ince recognizes the importance of classifying research by disease category if useful conclusions are to be drawn from the analysis, so she assigns each application to a particular disease based on which journals the publications resulting from the research were published in. In this way she gets an admittedly crude estimate of the dollars being spent on research on each disease, because the journals are classified under one disease only, but often contain articles on several diseases. Of course, the articles being published may not be in the journal which best corresponds to the disease classification of the research. Ince does a basic analysis of the data to see which, if any, of several organizational and process models drive the allocation of research funding and the awarding of grants. Her results are mixed. Only a weak correlation between peer-review scientific merit scores and the dollar amount of a funded grant is revealed. She tests an interest group model, but does not find any evidence to support it. Finally, she does not find any correlation between disease funding levels and any burden of illness measure (death, hospital stays, office visits, etc.). Ince's efforts represent the first attempt to actually measure the impact of special interest groups on research allocation. Her lack of concrete results, supporting either special interest group or public interest theory most likely stem from her limited data and methodological problems.

2.3 N.I.H. Funding

Lichtenberg, in "The Allocation of Publicly-Funded Biomedical Research" (1995) undertook one of the few studies which is an examination of the allocation of research at the N.I.H. His is a classic social-welfare model of resource allocation. He developed a theoretical model for efficient allocation of research funds, in which

research for all diseases is assumed to produce equal returns, the probability of finding a cure depends directly on research funding, and the budget for research is fixed. This becomes a constrained optimization problem, in which the goal is to cure the most people (maximize the public welfare). Research funding should increase with the incidence of the disease. He estimates a simple model using data on government funding of research taken from the CRISP (Computerized Retrieval of Information on Scientific Projects) database. This database contains information on research grants awarded by the federal government, primarily the N.I.H.. Many grants are not disease-specific, and are not included. Using data on grants made in 1995 and classified as research on a particular disease, he constructs an estimate of the 1995 spending by the government in individual disease research.

Lichtenberg first estimates a regression using the potential years of life lost to various disease categories in 1980 as an explanatory variable for government research funding on each category in 1982. The source of this data is not clear. With a sample size of 14, it is difficult to make accurate judgments. Also, the estimation method he uses to isolate the impact of life years lost to whites and non-whites on federal research spending creates a collinearity problem which is not addressed. In addition, he uses statistically insignificant coefficients to draw conclusions.

Next Lichtenberg estimates the relationship between persons living with chronic conditions in 1990-1992 (using the National Health Information Survey) and the CRISP data on 1995 research funding. However, he uses the number of grants which mention a disease in the subject as the measure of research funding, not the dollar amount of the funding awarded. Also, grants can be counted toward more than

one disease. Although his sample size is fifty-four chronic conditions, the nature of the classification of condition in the NHIS makes it difficult to precisely correlate them with the disease categories used by the N.I.H. In summary, although Lichtenberg sets up a useful framework for further study of the subject, his data is not substantial enough to support any real conclusions about the allocation of research funding by the N.I.H.

A second economic analysis of the allocation process at the N.I.H. under the public interest theory has been done by Gross, Anderson, and Powe (1999). They used a cross section of twenty-nine diseases, including such items as injuries, alcohol abuse, depression, and dental disorders. They compared funding by the N.I.H. in 1996 for each of these items with various measures of the burden of disease, such as total mortality, hospital days, and years of life lost to each disease. They made extensive use of the Global Burden of Disease Study by the World Health Organization.

This study divided the countries of the world into eight regions, with the United States classified in the Established Market Economies region. Its goal was to develop estimates of the incidence, prevalence, and mortality of various diseases around the globe in 1990 for use in determining policies and programs for the WHO. It also developed a new measure of the burden of disease called Disability Adjusted Life Years (DALYs). A DALY is defined as one year of healthy life lost due to disability or death from each disease. Gross et al used these 1990 incidence and prevalence rates for the EME region as explanatory variables in their study. They had no predictive power. However, they focused on the DALY as an explanatory variable, showing that it was positive and highly significant in explaining N.I.H. funding. Their

conclusion was that it was an excellent measure of the burden of disease, and that the N.I.H. was indeed allocating funds appropriately.

There have been numerous criticisms of the DALY, namely that it explicitly states that life is less valuable for disabled people than healthy people.[2] It includes a rubric which forces respondents to discount the lives of disabled people; weighting the value of a year of life to a deaf person as equal to a year of life for a hearing person is not permitted. In addition, the DALY computation is heavily weighted toward people between the ages of eighteen and forty-eight. Years of life to children and older people are weighted less than those for young-to-middle-aged adults. In addition, future years of life are weighted less than the current year. These computational mechanisms give a result that is not necessarily in accordance with the ideas of equity among the American population. If weights are determined by age, why not sex, income, or race? The fact that DALYs are correlated well with N.I.H. funding across diseases in 1996 is not reassuring to the parents of young children or to senior citizens. Gross et al completed the first truly rigorous analysis of the social welfare implication of research allocation at the National Institutes of Health. Their major problems are the sample size and the reliance on the DALY.

In contrast with Lichtenberg and Gross, several studies analyzing the N.I.H. have tired to determine the role that special interest groups play in the decision-making processes of the N.I.H. Carter (1974) analyzed the awarding of N.I.H. grants to medical schools during the years 1968-1973. She worked on a project undertaken by the Rand Institute for the N.I.H. in response to a critical report by the OMB, raising

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[2] Trude Arnesen and Erik Nord, "The Value of DALY Life: Problems with Ethics and Validity of Disability Adjusted Life Years," *British Medical Journal* 319, no. 7222 (1999): 1425.

allegations of conflict of interest in the peer review process, over-concentration of funds among a few school, and the existence of an "old boys network" at the N.I.H. She found that the applications funded were those with the highest quality, although she did not explain the strong correlation between the probability of funding and previous approval. Carter did not test for the influence of political and special interest groups.

Ginzberg and Dutka (1989) provide substantial evidence of geographic distortion in the awarding of research grants by the N.I.H., but do not provide any real explanation for it. They also note the persistent decline in the percent of eligible projects funded after 1975. Their chapter on the allocation of research funding resources among diseases essentially concludes that this topic is problematic and, therefore, usually not addressed.

Another study in the special interest group framework is that done by Janet M. Cuca. In "Scientific, Social, and Other Factors in the Evaluation of Applications for N.I.H. Research Grants" (1990), she found that non-scientific factors contributed substantially to the probability of receiving grant funds. She also found that study section members are, in fact, "interested parties," and that some applications are likely to be "favored." She also noted the latitude in interpreting such abstract terms used in the scoring criteria as "significance" and "originality." Her data set was the most comprehensive ever used in a study of the N.I.H.: approximately 2,000 applications for research funds for fiscal year 1982. Because she actually had data for both funded and unfunded grants, her data is not subject to the selectivity bias present in other work. Dr. Cuca was an employee of the N.I.H. who used data not available to the

public for her research. Again, her research supports the contention that forces exist which affect the awarding of research grants that have nothing to do with maximizing social welfare.

Kiken (1993) pursues a different approach and investigates the roles of various interest groups in the funding process at the N.I.H.. This is helpful in that political forces are acknowledged to be a powerful determinant on both the levels of funding for various institutes and which diseases are pursued. She identifies several logical special interest groups – the Administration, Congress, the N.I.H. bureaucracy, the media, doctors/the AMA – but is unable to provide any substantive evidence of their effectiveness in shifting research priorities. Her evidence is almost entirely anecdotal. She gets a number of anonymous employees of the N.I.H. to confirm that special interest groups do play a role in the decision-making process, but she has no hard data to back up these assertions.

Brooks (1994) has a more thorough analysis of the role of special interest groups in medical research funding. She provides some data to demonstrate that interest groups have created shifts in research priorities by the N.I.H.. Her data set is, like Mushkin's, institute-level budgetary data, and consequently of limited usefulness. A contribution of her work is a survey of executives at the N.I.H., who tend to either deny that politics and interest groups have any influence on funding at all, or to blame any irregularities on Congress. One interesting result revealed by the survey was that agency executives were opposed to any coordinated plan of spending and research for the N.I.H. as a whole, such as one based on the burden of disease. Brooks' perception was that such a plan would threaten the power of the bureaucracy at the N.I.H..

An extensive article by Baird (1999) examines the policies of the N.I.H. and the Food and Drug Administration with respect to the inclusion of women and minorities in clinical trials and research studies. Women were routinely excluded from clinical trials after the diethylstilbestrol (DES) and thalidomide problems that surfaced in the 1950's. However, one side effect of the ban on using women of childbearing years in clinical studies was the inability to study therapies and treatments designed just for female diseases. Partly as a result of the women's rights movement of the 1970's,the N.I.H. established its Advisory Committee on Women's Health Issues in 1986. This committee was essentially ignored. The turning point for women's issues came in 1990, when the General Accounting Office prepared to present a report to Congress on the treatment of women in clinical trials and research studies by government funded researchers. Congresswomen Schroeder, Oakar, and Lloyd, along with Senator Snowe, generated widespread publicity for the presentation of the report. Other members of the Congressional Caucus for Women's Issues took up the cause, and in 1990 the Office of Research on Women's Health (ORWH) was established in the N.I.H. to ensure the participation of women in the research process and to address women's health issues. In 1991 the Women's Health Initiative at N.I.H. was begun, which was a massive study of 150,000 women designed to last until 2005. Another result of the ORWH was a sharp increase in the allocation of funds to breast cancer, ovarian and reproductive system cancers, and osteoporosis research by the N.I.H. The 1993 N.I.H. Reauthorization Act prohibited researchers from excluding women or minorities from studies and clinical trials. Baird's examination

demonstrates a that coalition of special interest groups which achieve political power can reap an increase in targeted research funds.

A study of the distribution of N.I.H. research awards among medical schools (Moy, et al., 2000) highlighted the consistency of awards to the same ten schools over the period 1986-1997. Each of these school represents a small special interest group. Increases in research funding to these schools result in increases in size and prestige, and provide a valuable recruiting tool. The ten schools which received the most funding comprise only eight percent of the nation's medical schools, yet they consistently garnered about twenty-five percent of the research money awarded. In contrast, the seventy-five schools getting the least money comprised sixty percent of the medical schools, but only received less than twenty-five percent of the money awarded. The study makes no attempt to explain the distribution data, other than to note that awards to principal researchers with an M.D. increased more than the proportion awarded to researchers with a Ph.D. over the period. The mean value of awards to the top ten schools remained relatively constant at $197,000 (1986 dollars), while the amount awarded to the remainder rose, though it remained substantially below the amount awarded to top school researchers. The authors of the study noted that the N.I.H. may influence the proportion of medical schools that conduct research. Large increases in future N.I.H. budgets should serve to reduce concentration among the top medical schools, while small increases in research budget may tend to increase concentration. However, a review of the data reveals that the N.I.H. budget increased by over one-third in real dollars from 1986-1997, during which time the concentration of research awards among medical schools actually increased, rather than decreased.

This lack of variation in the awards given to the top ten schools over an extended period of time may be evidence of special interest groups at work; conversely, it may be an indication of the quality of the schools.

Along with the role of special interest groups, the impact of political factors must be considered when examining the N.I.H. Both Congress and the Executive Branch influence the funding decisions of the N.I.H. Roessner (1970) examined the role of the House of Representatives in controlling and shaping the National Institutes of Health during the years 1959-1964. His emphasis was on explaining the part that House committees played in directing the funding and activities of the N.I.H.. His findings in some respects were similar to those of Wildavsky (1964): the true control over the N.I.H. in Congress takes place at the committee lever, rather than on the House floor, and Congress relied heavily on the expertise of agency personnel in making decisions affecting the N.I.H..

Weston (1994) examined the determinants of congressional appropriations for the N.I.H.. He used data on total funding for nine institutes over the years 1977-1993, so his data set did not accurately permit identification of research funding to various diseases. His analysis supported the incremental budgeting model formulated by Wildavsky, as current changes in an institute's budget were highly dependent on past changes. Weston also examined interference in the N.I.H. institute appropriations process during the year 1992 by members of the Senate Appropriations Committee. He found that Republicans and Democrats were equally likely to participate in the process, and that senators up for re-election participated more than those who weren't. The N.I.H. is popular with the voting public.

Weston assigned each institute a primary disease focus, and then computed a cause of death ratio for each institute, which was the number of deaths from that disease divided by total deaths for the year. He found a significant negative correlation between the cause of death ratio and funding for that Institute, which he could not explain. He also found that over the years 1977-1993, N.I.H. appropriations did not keep pace with inflation. Additional findings were that Democratic control of Congress increased N.I.H. funding, as did an election year. Members of Congress can improve their chances for re-election by responding to pressures from constituents. Weston's research supports both special interest group theory and the importance of politics in funding decisions.

Former N.I.H. Director Bernadine Healy complained that the "ability of the N.I.H. to fulfill its mission has been eroded by relentless partisan politics." (Healy, 1994) One problem is that the N.I.H. is classified under "Health and Welfare" in the Office of Management and Budget, not under "Science," as are N.A.S.A. and N.S.F.. Because the N.I.H. is a part of the Department of Health and Human Services, its budget can be tapped for uses in the Public Health Service or by the DHHS Secretary. In addition, the N.I.H. budget is appropriated piecemeal by Congress, as each institute has a separately submitted and approved budget. Therefore, the opportunities for meddling by Congress are many. Any scientific judgment that necessitates reallocating more than one percent of an institute's budget requires an Act of Congress. These institutional factors reduce N.I.H. cohesiveness and impede scientific progress. Also, Congress passes from time to time "reauthorization bills" for the N.I.H. which create legally binding directives about spending, but do not

appropriate any money for these activities. The number of specific congressional directives about N.I.H. expenditures increased from 122 in 1984 to 260 in 1991. Healy cites this statistic as evidence of the growing interference of Congress, which makes it difficult for the N.I.H. to do its job. Although biomedical research is popular with both Congress and the public, Healy asserts that the N.I.H. is not itself a politically powerful agency, lacking the "political clout needed to confront inappropriate political pressures." She advocates independent agency status for the N.I.H., similar to that of the N.S.F. and N.A.S.A. Healy, who had a long and close relationship with the N.I.H., is a convincing authority when arguing that political factors play a major role in the decisions made at the N.I.H..

Congress itself recognized the need to examine the decision-making process at the National Institutes of Health in 1996, and mandated a study of the agency by the Institute of Medicine. The results, published as *Scientific Opportunities and Public Needs* in 1998, identified some definite problems with the agency's funding determination process. The committee examined the funding allocation criteria of the N.I.H., and found them vague and lacking in quality information. In particular, the committee criticized the poor data collected on research funding by disease, the absence of reliance on quantifiable measures of burden of disease, and the lack of high-quality data on the burden of disease. They recommended that the N.I.H. should gather better data on funding by the disease, the various burden of disease measures, and the costs of disease. The N.I.H. should then use this data to help allocate funding, and should conduct public evaluations of the impact of their research funding on the

burdens of disease. The Institute of Medicine report found substantial evidence that the N.I.H. did not operate under a true public interest theory of resource allocation.

The committee noted that the N.I.H. followed a decentralized model of decision making, with each institute making its own decisions about which projects to fund. The report complained of the lack of an overall research plan to coordinate research across centers. This, they felt, contributed to the tendency of Congress and the President to intervene in the process and set aside funding for the projects demanded by noisy voters. The Institute of Medicine suggested that an clear, overall strategic plan should be developed and updated regularly, and that this would reduce congressional interference.

Another area in which the N.I.H. was not performing well was interaction with the public. The general public, patient advocacy groups and special populations had no clear means of input into the decision-making process. The N.I.H. was frequently described as unresponsive to these groups. This, in turn, increased petitions to Congress for special intervention into N.I.H. funding decisions. The committee recommended that the N.I.H. establish an Office of Public Liaison in the Office of the Director, and in each institute, to formally seek out and collect public input. The N.I.H. has done this, which should improve its ability to perform as a welfare-maximizing agency.

2.4 Other Federal Agency Funding Studies

Another pioneer in modeling federal agency budgeting was William Niskanen. *Bureaucracy and Representative Government*, published in 1971, develops a model of bureaucratic utility. He defines the relationship between government agencies and the

federal government as that of a bilateral monopoly. Niskanen argues that bureaucrats act to maximize their budget, which leads to a result that federal government output will be larger than optimal, but will be produced at the minimum cost. He formalizes the role of the elected legislature, based on the concept that legislators determine the demand for various government services provided by government agencies, and then monitor the behavior of the agencies.

The role of congressional committees is key, as it is in Wildavsky's framework. Niskanen theorizes that the committee members generally receive the committee assignments they request; consequently, the demand for services by committee members will be higher than that of the median legislator. Because the decisions of the committees are rarely overturned, this results in output that is higher by each government agency than a randomly selected committee would approve. In addition, because legislators have limited time, they will choose to spend very little time monitoring bureaus, which would generate cost savings for all citizens; instead, they devote their time to activities which affect their own constituencies and help them to get re-elected. This results in too little monitoring. Niskanen thus argues that the resulting budgets for federal agencies in general will exceed the social welfare ideal. The theories of both Niskanen and Wildavsky are applicable to the N.I.H., and are useful in explaining its behavior.

An interesting examination of a federal agency similar to the N.I.H. was undertaken by Howard Wachtel in "How the N.S.F. Funds Research in Economics" (2000). Wachtel studied the peer review process at the National Science Foundation during the years 1974-1995. During this period, the N.S.F. awarded over $200 million

in economics research grants to universities, of which $133 million went to fifteen schools. Wachtel argues that the stable "market share" maintained by these schools over twenty years would be used in any other industry as evidence of a cartel. In contrast, the awards received by the remaining schools fluctuated widely from year to year. In any given year, the top fifteen schools received about two-thirds of the awards, and forty or more schools competed for the remaining one-third of available money. Wachtel theorized that the composition of the peer review panels might have some bearing on the award pattern he observed. Although the N.S.F. was uncooperative in his requests for information on peer review panels, he managed to finally obtain the data from the Library of Congress. He found a "remarkable congruence" between the proportion of panel members from the top fifteen schools (sixty-eight percent) and the percentage of grant money awarded to those schools (also sixty-eight percent) over sixteen years. He calls for a broadening of the awards process to include more schools, and more access to the peer-review system. Although his research raises interesting possibilities for examining N.I.H. research awards, the concentration of awards among relatively few schools may simply be a reflection of the quality of the research work done at those schools.

2.5 Conclusions

Although there has been some work done on the positive rate of return from biomedical research (Eshelman, 1971; Mushkin, 1979; Weisbrod, 1967), there has been surprisingly little research done in the area of optimal allocation of a given level of funding among the various diseases. This study will be an advance over previous studies in this area because it will examine funding by actual diseases, rather than

institutes; I will compile a data set not previously used in this context. I will also attempt to quantify the effects of special interest groups and political factors on the allocation process, which has not been done before. Finally, I also hope to examine the distribution of funding by geographic region in relation to various political factors.

CHAPTER 3

TIME SERIES DATA AND REGRESSIONS

3.1 Research Funding Data

The National Institutes of Health collected data on the amount of research funding which they devoted to various diseases only on a limited basis prior to the mid-1990's. Information on research funding by disease was obtained from the N.I.H. web page (http://www.N.I.H.gov) and from correspondence with N.I.H. employees. Examination of allocation patterns by the N.I.H. from 1987-2001 is restricted to those diseases on which they kept statistics.

The data set contains twenty-one diseases: Alzheimer's disease, asthma, breast cancer, cancer (all types), chronic fatigue syndrome, cystic fibrosis, diabetes, Epstein-Barr virus, HIV/Aids, hypertension, kidney disease, lupus, osteoporosis, Parkinson's disease, prostate cancer, sexually transmitted diseases, sickle cell disease, spinal cord injury, stroke, sudden infant death syndrome, and tuberculosis. The information on funding was obtained from the Office of Financial Management at the National Institutes of Health. The choice of diseases depended entirely on what funding statistics the N.I.H. was able to provide. Surprisingly, they did not collect information on the amount of research funding they provided for many diseases during this period, including such major killer diseases as heart disease, pneumonia, and chronic obstructive pulmonary disease. All three of these diseases ranked in the top ten causes of death for each of the fifteen years being studied. Funding information was collected, however, for a number of less deadly diseases such as Epstein-Barr, chronic fatigue syndrome, lupus, and sexually transmitted diseases.

Table 3.1 compares total N.I.H. funding to the amount of funding for the diseases considered in this study. Funding for these diseases comprises from 42 to 49 percent of the total N.I.H. budget during these years. The remainder of the N.I.H. budget was not categorized by disease.

Both the total N.I.H. budget and the amount of funding for these twenty-one diseases increased every year during the period 1987-2001. This is true even when the amounts are adjusted for inflation using the Consumer Price Index (1984 = 100). Figure 3.1 plots the total budget for the N.I.H. in constant dollars. The amounts are converted to logarithmic form to compress the scale into a more manageable picture. The slope of the curve is always upward-sloping, but clearly, the slope is not constant. The rate of increase in the budget amounts was less during the period 1993 to 1998 than during the years 1987-1992. The rate of change increased again in 1999, probably as a result of the congressional mandate to double the N.I.H. budget by the year 2003.

3.2 Death Data

The attribution of deaths to various causes in the United States is carried out by attending physicians' coding of death certificates. These deaths certificates are used by the Centers for Disease Control to compile national death statistics. This compilation process takes about two years. Death data were obtained from the CDC web page (http://www.cdc.gov) using their Wonder database search engine. The death statistics for this study use the International Classification of Diseases, Ninth Revision, for cause of death coding. Table 3.2 lists total deaths for each year 1984 - 1998, the latest year for which death statistics are available. Also shown is the number

Table 3.1
Research Funding Data
(In Thousands of Nominal Dollars)

Year	N.I.H. Total	Data Set Total	Percent
1987	$ 6,180,660	$2,736,126	0.4427
1988	7,186,959	3,085,420	0.4293
1989	7,893,586	3,494,642	0.4427
1990	8,505,256	3,892,914	0.4577
1991	9,217,940	4,277,995	0.4641
1992	10,010,368	4,728,995	0.4724
1993	10,328,117	4,934,196	0.4777
1994	10,910,969	5,347,668	0.4901
1995	11,340,841	5,509,311	0.4858
1996	11,880,847	5,771,061	0.4857
1997	12,770,771	6,112,058	0.4786
1998	13,622,386	6,389,125	0.4690
1999	15,597,189	7,575,300	0.4857
2000	17,793,587	8,591,300	0.4828
2001	20,300,000	9,069,100	0.4468

Source: Office of Communications and Public Liaison, N.I.H. Almanac, 1999.

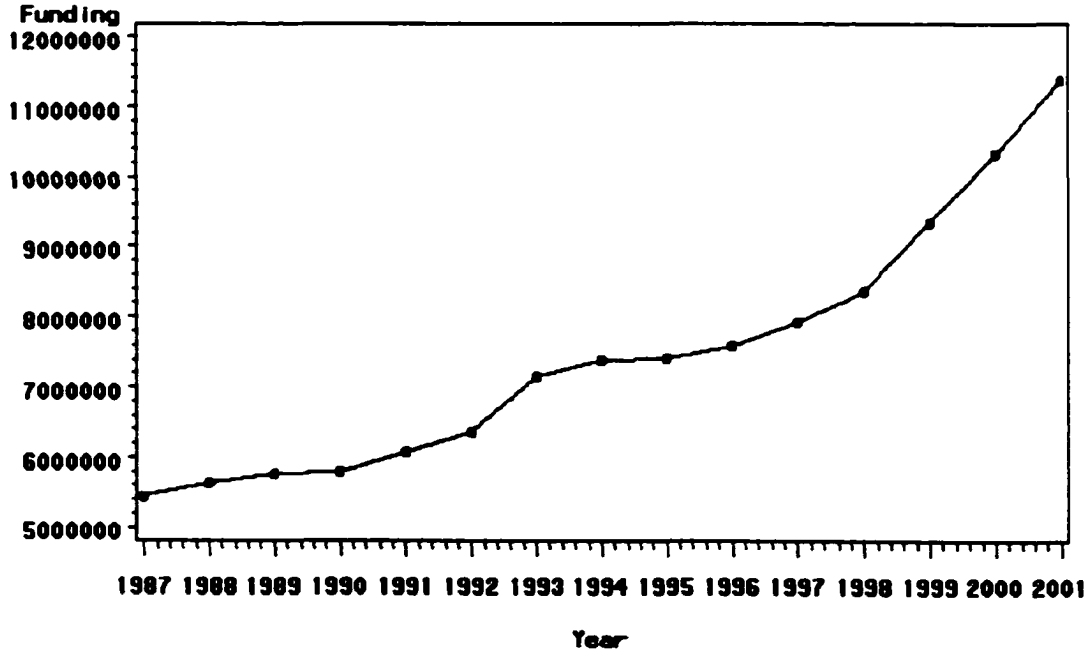

Figure 3.1: Total N.I.H. Funding Over Time (1984 Dollars)
Source: Office of Communications and Public Liaison, N.I. H. Almanac, 1999.

Table 3.2
Death Data

Year	Total Deaths	Data Set Deaths	Percent
1984	2,039,369	701,779	0.3441
1985	2,086,440	716,705	0.3435
1986	2,105,361	728,318	0.3459
1987	2,123,323	743,422	0.3501
1988	2,167,999	759,810	0.3505
1989	2,150,466	779,183	0.3623
1990	2,148,463	791,318	0.3683
1991	2,169,518	807,541	0.3768
1992	2,175,613	820,906	0.3773
1993	2,268,553	850,276	0.3748
1994	2,278,994	868,077	0.3809
1995	2,312,132	884,927	0.3827
1996	2,314,690	881,585	0.3809
1997	2,314,245	871,353	0.3765
1998	2,337,258	874,589	0.3742

Source: National Center for Health Statistics, Vital Statistics, Annual.

of deaths each year attributed to the twenty-one diseases in this data set. The percentage of total deaths examined in this study varies from about thirty-four to thirty-eight percent. The top ten causes of death for each of the years 1984-1998 are listed in Appendix A.

3.3 Patterns of Spending per Death

It is interesting to examine the pattern of funding by disease. Clearly, deaths from a particular disease are one of the most relevant measures of the burden of that disease to our society. If the N.I.H. is using deaths as a measure of the burden of disease, and is using this information to determine what diseases deserve the most research funding, we should see a strong correlation between the number of people who die from a disease and the funding devoted to that disease. Also, if the N.I.H. considers all deaths as equally catastrophic, then deaths from one disease should weigh no more heavily than deaths from any other disease.

Figure 3.2 shows the funding per death by disease category for the year 1994, the mid-point of this study. The amount of research funding the N.I.H. devoted to a disease is divided by the number of people who died from that disease. The resulting dollar amount per death is converted to logarithmic form in order to fit all of the diseases on one page. The graph is a scatter diagram, revealing that funding per death varies widely depending on the cause of death. The highest level is for chronic fatigue syndrome, which kills very few people. The lowest level is for stroke, which is the third largest cause of deaths. A similar irregular pattern is present for each of the fifteen years of the study (1987-2001). If funding per death were equal across all diseases, the graph would be a horizontal line. All deaths are not equal in the eyes of the N.I.H.. What accounts for these disparities?

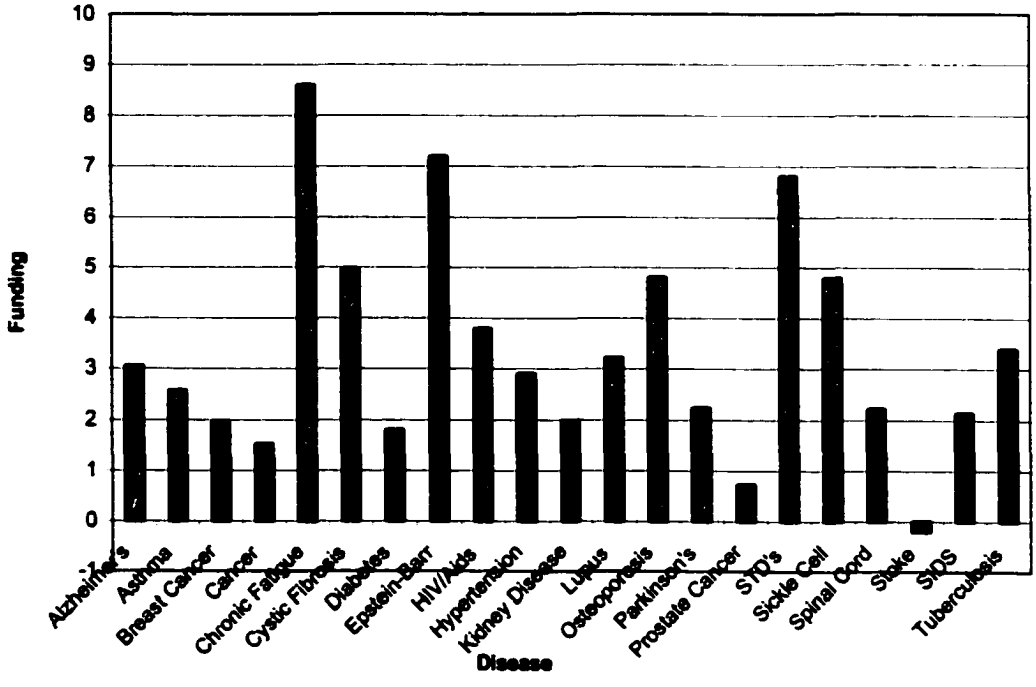

Figure 3.2 Log of Research Funding Per Death 1994. Source: Office of Financial Management, Funding by Selected Categories.

A closer examination of the levels of funding awarded to research on the various diseases reveals some striking differences. Table 3.3 lists the amount of funding per death from each disease for each year 1987 - 2001. Those diseases which caused the deaths of fewer than 1,000 persons per year during each year are marked with an asterisk.

Those diseases which kill very few people, such as Epstein-Barr virus, chronic fatigue syndrome, osteoporosis and sexually transmitted diseases have research funding amounts that frequently exceed $1 million per death. Clearly, the number of deaths does not motivate research in these areas.

Among the ten leading causes of death each year, cancer (second), stroke (third) and diabetes (seventh) are included in this portion of the study. Cancer and diabetes receive far more funding proportionally than does stroke. Even though the amount funded per diabetes death actually decreased slightly during some years, and increased only by thirty-two percent over the entire fifteen year period, the level of funding for diabetes deaths was always at least five times higher than research funding per stroke death. In some years, diabetes funding per death was seventeen times higher than that for stroke.

Funding per diabetes death also exceeded that for cancer during each of the years studied, despite the fact that cancer killed over 500,000 people per year, and diabetes fewer than 65,000 per year. In fact, the amount of per death funding for diabetes was greater than the amount devoted to both cancer and stroke combined for ten of the fifteen years. Stroke research is underfunded relative to both cancer and

Table 3.3
NIH Research Funding per Death
1987-1993 (1984 Dollars)

Disease	1987	1988	1989	1990	1991	1992	1993
Alzheimer's	12,135	10,232	13,491	12,914	18,712	21,271	20,899
Asthma	6,762	6,005	5,992	6,468	8,527	8,585	13,136
Breast Cancer	1,640	1,890	1,972	2,121	2,363	3,597	5,244
All Cancer	3,490	3,583	3,800	3,864	3,995	4,364	4,404
Chronic Fatigue*	111,714	197,600	736,000	479,250	2,822,000	1,557,500	678,250
Cystic Fibrosis*	55,194	72,722	91,324	102,663	131,846	124,049	152,848
Diabetes	6,550	6,526	6,943	6,469	6,478	5,945	5,993
Epstein Barr*	901,533	826,875	1,148,429	963,786	1,073,733	874,050	1,339,769
HIV/Aids	81,635	75,823	59,047	67,171	60,535	47,560	42,660
Hpertension	15,995	14,956	15,404	15,485	16,135	17,305	18,651
Kidney	4,263	5,319	5,467	5,615	5,875	6,996	7,332
Lupus	18,547	19,580	20,845	19,526	19,127	18,235	21,877
Osteoporosis*	64,716	63,565	82,945	108,552	119,357	128,261	126,001
Parkinson's	7,089	7,817	8,001	7,843	7,154	9,337	9,918
Prostate Cancer	518	498	580	662	661	1,313	1,925
STD's*	417,589	601,722	606,980	619,135	744,317	670,455	714,975
Sickle Cell*	98,791	82,940	86,677	91,331	122,193	102,394	100,989
Spinal Cord	7,181	8,067	7,946	8,266	8,837	9,290	9,689
Stroke	367	372	470	522	604	751	778
SIDS	5,369	6,209	7,454	6,877	7,939	7,560	8,372
Tuberculosis	887	925	1,661	1,921	2,564	7,771	19,329

Source: Office of Financial Management, Funding by Selected Categories. Centers for Disease Control, WONDER Mortality Database. *caused the deaths of less than 1,000 people per year.

(Table 3.3 continued)

Disease	1994	1995	1996	1997	1998	1999	2000	2001
Alzheimer's	20,982	20,557	18,169	17,354	16,034	18,998	20,752	21,606
Asthma	12,926	13,739	15,793	16,858	17,900	24,775	29,076	30,765
Breast Cancer	6,981	8,392	10,948	11,616	11,932	13,380	14,372	13,140
All Cancer	4,558	4,676	4,851	5,077	5,164	6,260	7,148	7,528
Chronic Fatigue*	5,426,000	7,765,000	787,222	1,987,500	1,300,000	1,675,000	857,143	1,575,000
Cystic Fibrosis*	142,170	147,720	158,346	149,002	143,919	166,512	172,863	189,579
Diabetes	5,998	5,895	5,547	5,579	5,446	7,409	8,384	8,664
Epstein Barr*	1,333,071	924,211	1,162,667	1,057,619	1,104,348	1,693,750	1,629,412	1,333,333
HIV/Aids	43,967	39,740	37,870	35,648	37,182	57,600	121,514	157,282
Hpertension	18,186	16,595	15,514	15,656	13,869	13,550	14,498	14,426
Kidney	7,248	6,991	6,593	7,110	7,223	8,105	8,725	8,862
Lupus	24,652	25,010	25,681	26,203	26,847	32,835	36,592	37,097
Osteoporosis	122,553	131,548	116,542	110,616	120,236	116,638	124,595	121,147
Parkinson's	9,323	9,387	8,472	8,179	10,139	11,169	12,798	12,562
Prostate Cancer	2,062	2,496	2,658	2,756	3,295	5,202	7,273	8,422
STD's*	900,385	1,001,745	1,057,557	1,024,913	1,559,494	1,350,495	1,961,538	2,545,313
Sickle Cell	120,410	102,758	96,369	96,863	91,525	99,408	118,239	115,922
Spinal Cord	9,187	8,924	10,858	11,220	10,253	10,668	11,654	11,384
Stroke	822	835	839	871	1,041	1,215	1,351	1,419
SIDS	8,487	8,945	9,828	11,985	13,335	16,164	18,756	20,907
Tuberculosis	29,297	36,352	39,340	45,552	49,513	60,566	70,069	78,058

Source: Office of Financial Management, Funding by Selected Categories. Centers for Disease Control, WONDER Mortality Database. *caused the deaths of less than 1,000 people per year.

diabetes, and cancer is also underfunded compared to diabetes, based on the number of deaths from each disease.

Another interesting comparison involves funding for breast cancer and that of prostate cancer. Breast cancer is almost entirely a disease confined to women, and prostate cancer occurs only in men. Funding per breast cancer death increased 700 percent, from $1,640 per death in 1987 to $13,140 per death in 2001. Prostate cancer, on the other hand, went from $518 per death in 1987 to $8,422 in 2001, an increase of 1500 percent. Currently, breast cancer kills about 10,000 more people per year than prostate cancer. Is this the reason that breast cancer research receives more funding? If so, why was the increase in prostate cancer funding almost double that of breast cancer? In addition, cancers that are more deadly than either breast or prostate cancer, such as lung cancer and colorectal cancer, receive less funding per death than either breast cancer or prostate cancer. Why are deaths from different cancers treated differently?

The most spectacular increase in research funding per death during the years 1987 - 2001 was for tuberculosis. Funding per death was only $887 in 1987, and it rose to $78,058 per death by 2001, and increase of 8,700 percent. No other disease received increases of such magnitude, despite that fact that deaths from tuberculosis remained relatively constant between 1000 and 2000 people per year for the entire period, and there was no upward trend. Clearly, another factor besides deaths from the disease must be causing this increase. Is it that tuberculosis is contagious?

What conclusions can be drawn from the information in Table 3.3? The N.I.H. is not awarding research funding dollars to a disease solely on the basis of the number

of people who die from that disease. If this were the case, diseases such as chronic fatigue syndrome would not be receiving research funding at all. In addition, the N.I.H. must not perceive all deaths to be equally adverse outcomes, for the deviation in funding per death is substantial, even among those disease that kill large numbers of people each year.

3.4 Patterns of Spending by Disease

In order to help us better understand the allocation process of the N.I.H., it is useful to study both the level and rate of increase in the funding for research on each of the twent-one diseases under consideration during the years 1987-2001. The next group of graphs, Figures 3.3 – 3.24, show the log of constant dollar funding for each disease from 1987-2001. Although all diseases posted a real increase over the course of the period, the slopes vary tremendously. Only Aids, breast cancer, and prostate cancer had persistent increases. As mentioned earlier, tuberculosis had the largest real increase over the period, but even so, there were several years of flat growth. Most diseases had some periods of flat budgets, and many had years of real decreases. Again, all diseases are not treated equally by the N.I.H.

At least part of the explanation for the variation in funding stems from the fact that the N.I.H. relied heavily on investigator proposals during the period being studied. The N.I.H. admittedly did not have funding goals for many diseases during this time. They were under not any constraint to spend a particular amount on research for any disease, unless Congress specifically decreed that they do so. Congressional input will be addressed in a later section.

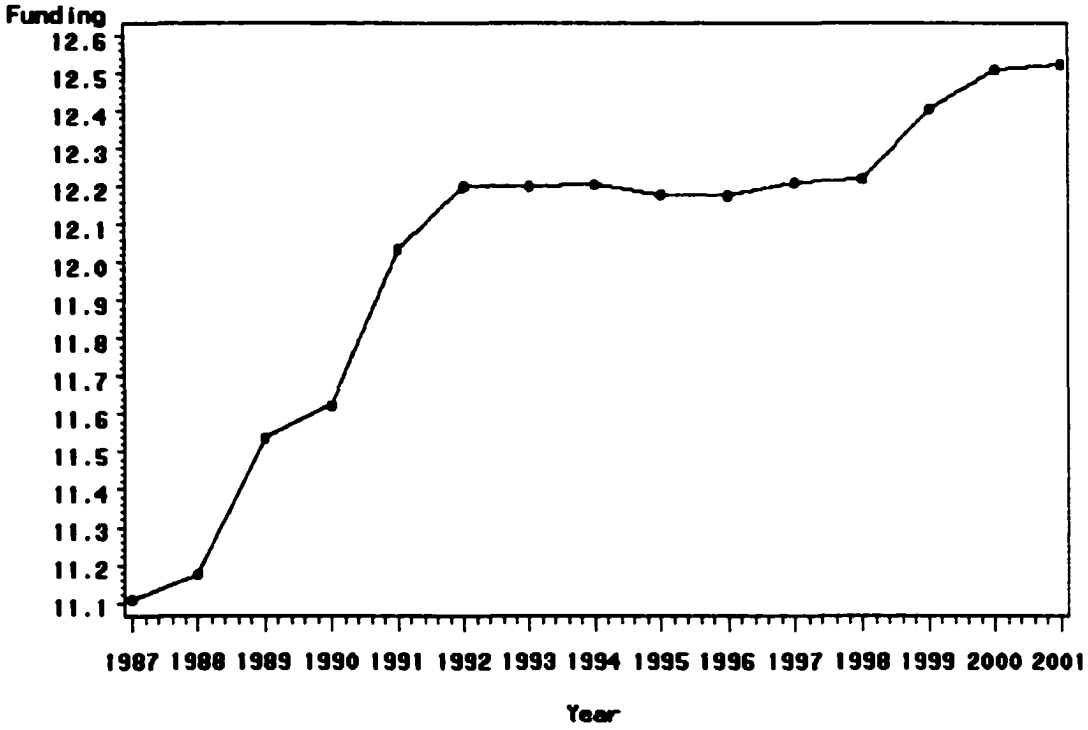

Figure 3.3: Alzheimer's Funding Over Time (Log of 1984 Dollars). Source: N.I.H., Funding by Selected Categories.

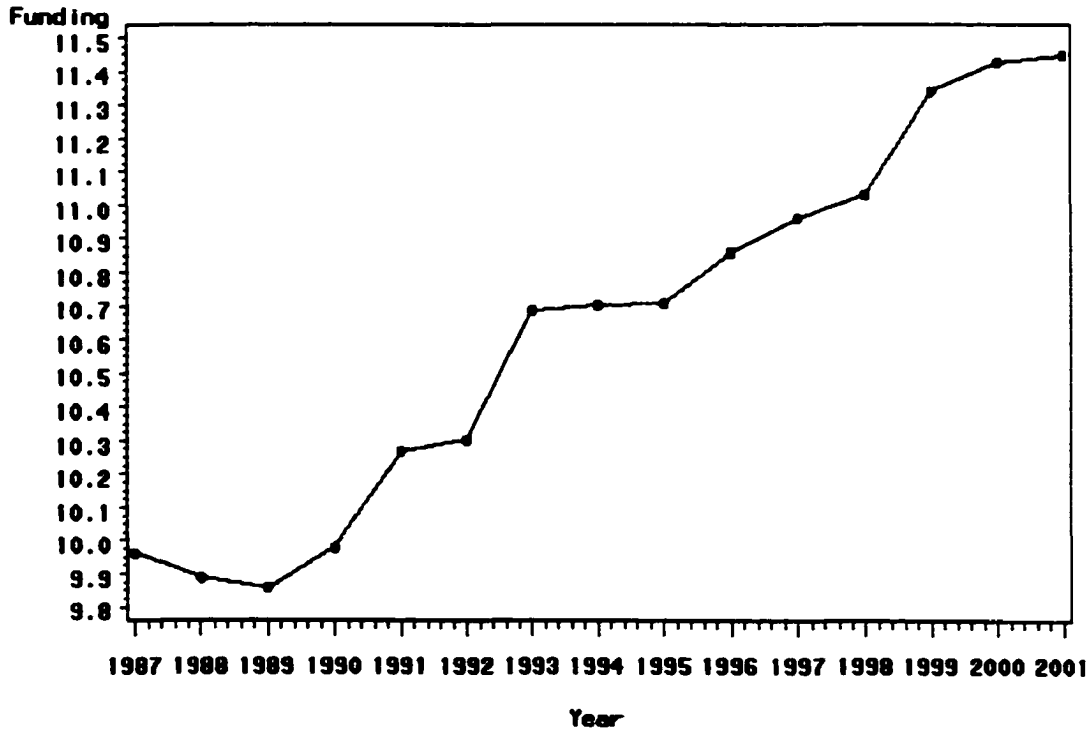

Figure 3.4: Asthma Funding Over Time (Log of 1984 Dollars). Source: N.I.H., Funding by Selected Categories.

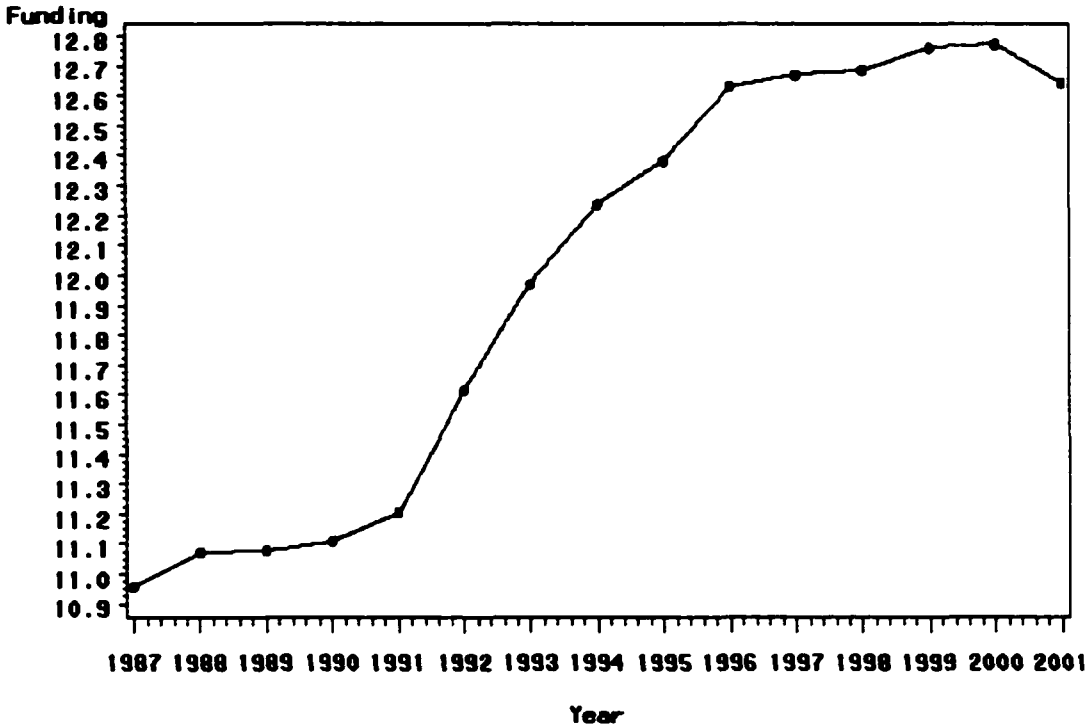

Figure 3.5: Breast Cancer Funding Over Time (Log of 1984 Dollars). Source: N.I.H., Funding by Selected Categories.

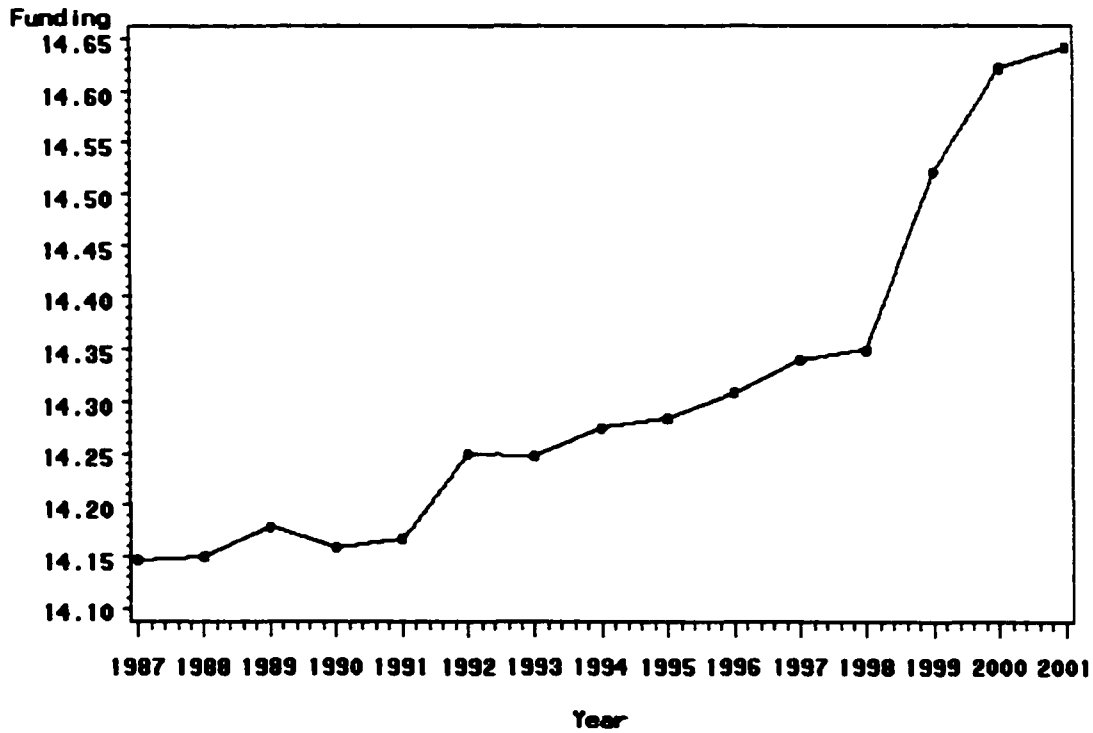

Figure 3.6: Total Cancer Funding Over Time (Log of 1984 Dollars). Source: N.I.H., Funding by Selected Categories.

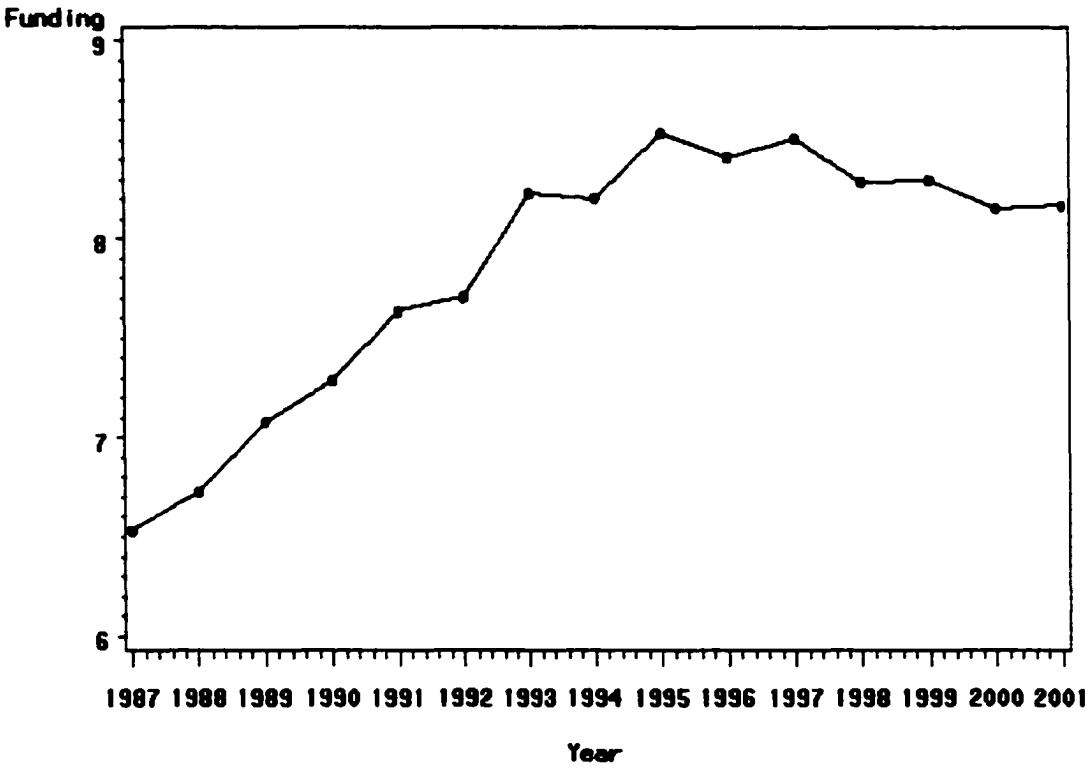

Figure 3.7: Chronic Fatigue Funding Over Time (Log of 1984 Dollars). Source: N.I.H., Funding by Selected Categories.

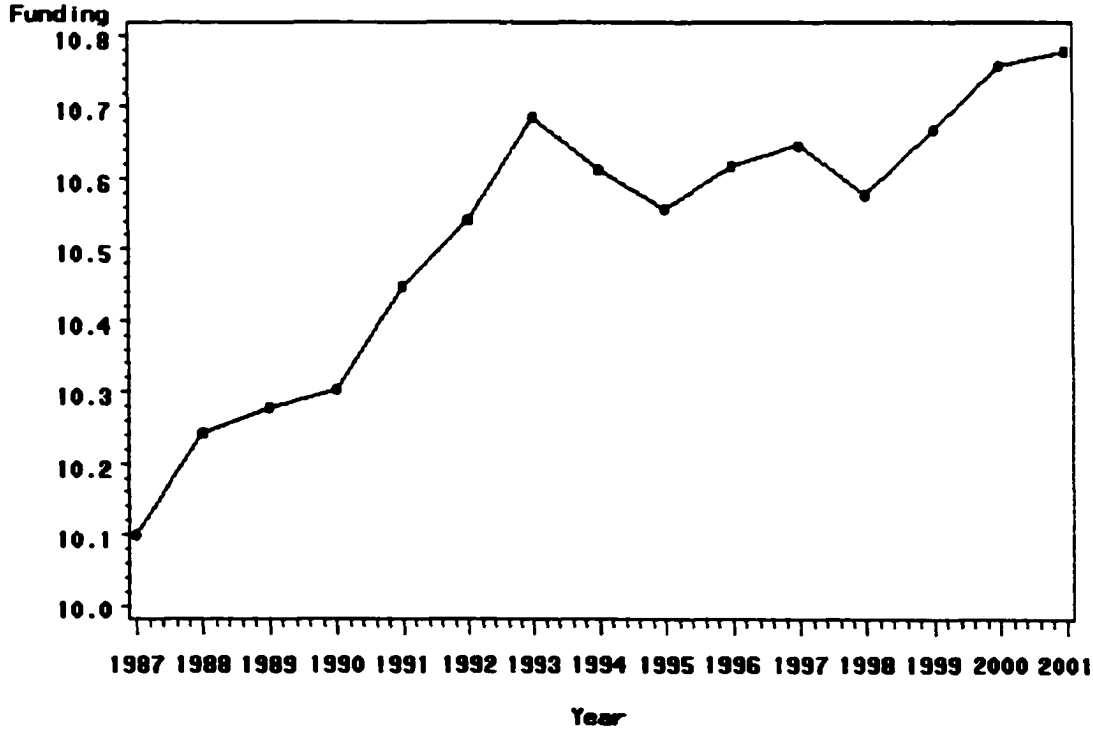

Figure 3.8: Cystic Fibrosis Funding Over Time (Log of 1984 Dollars). Source: N.I.H., Funding by Selected Categories.

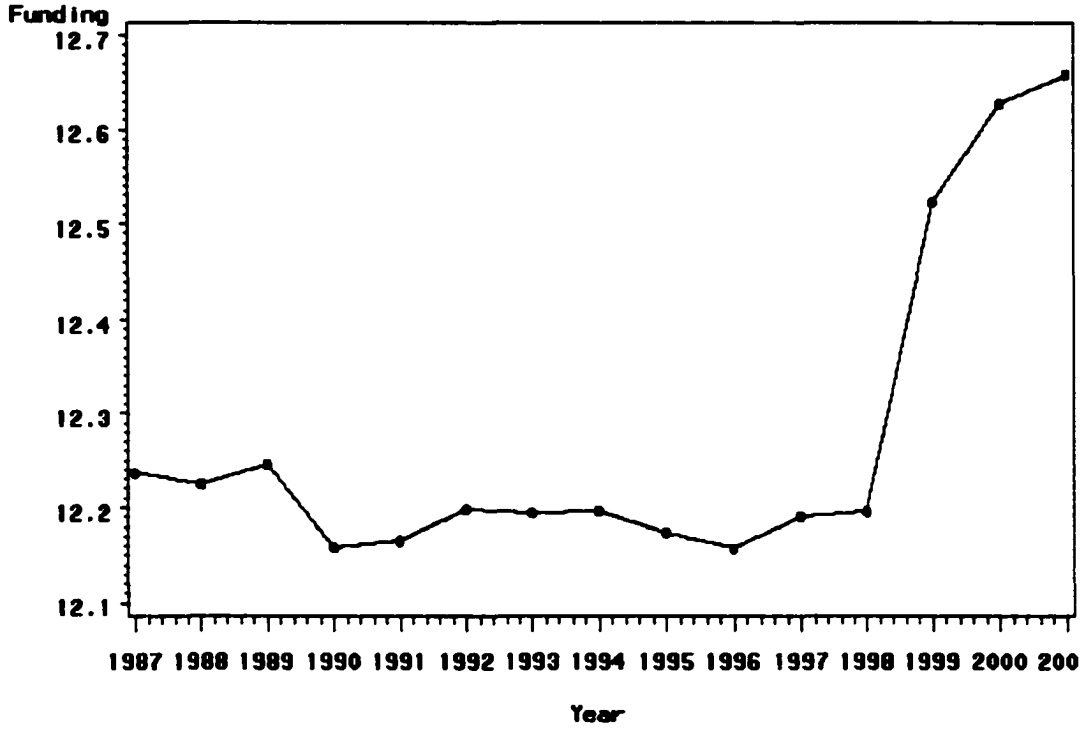

Figure 3.9: Diabetes Funding Over Time (Log of 1984 Dollars). Source: Office of Communications and Public Liaison, Funding by Selected Categories.

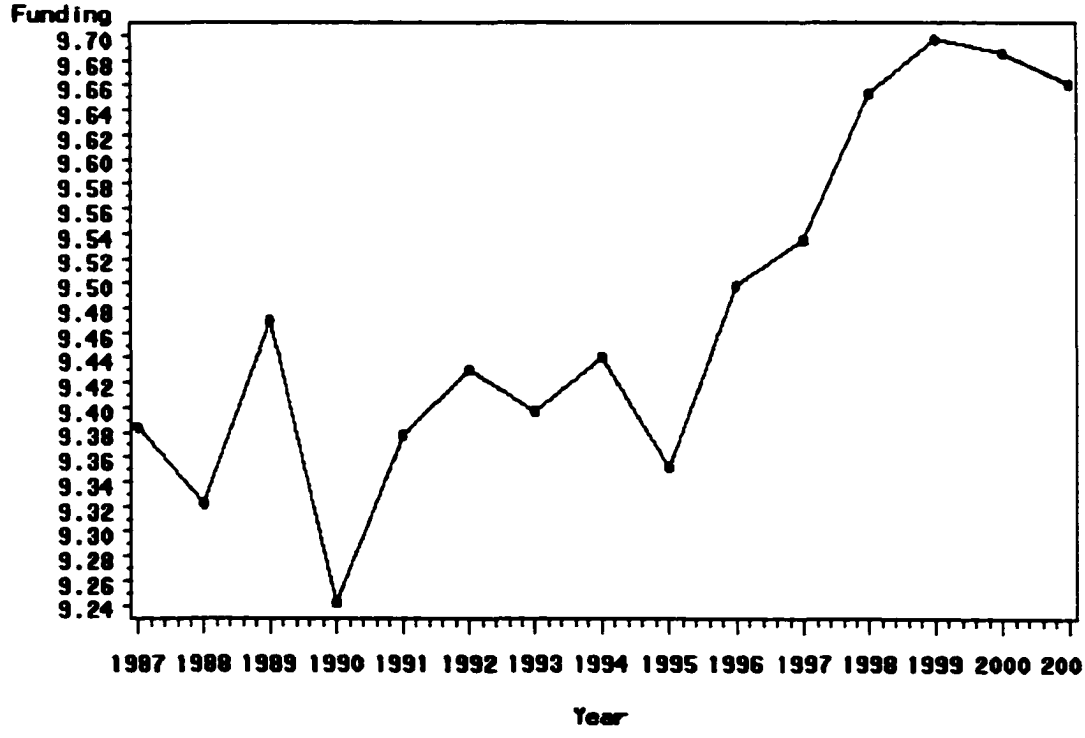

Figure 3.10: Epstein-Barr Funding Over Time (Log of 1984 Dollars). Source: N.I.H., Funding by Selected Categories.

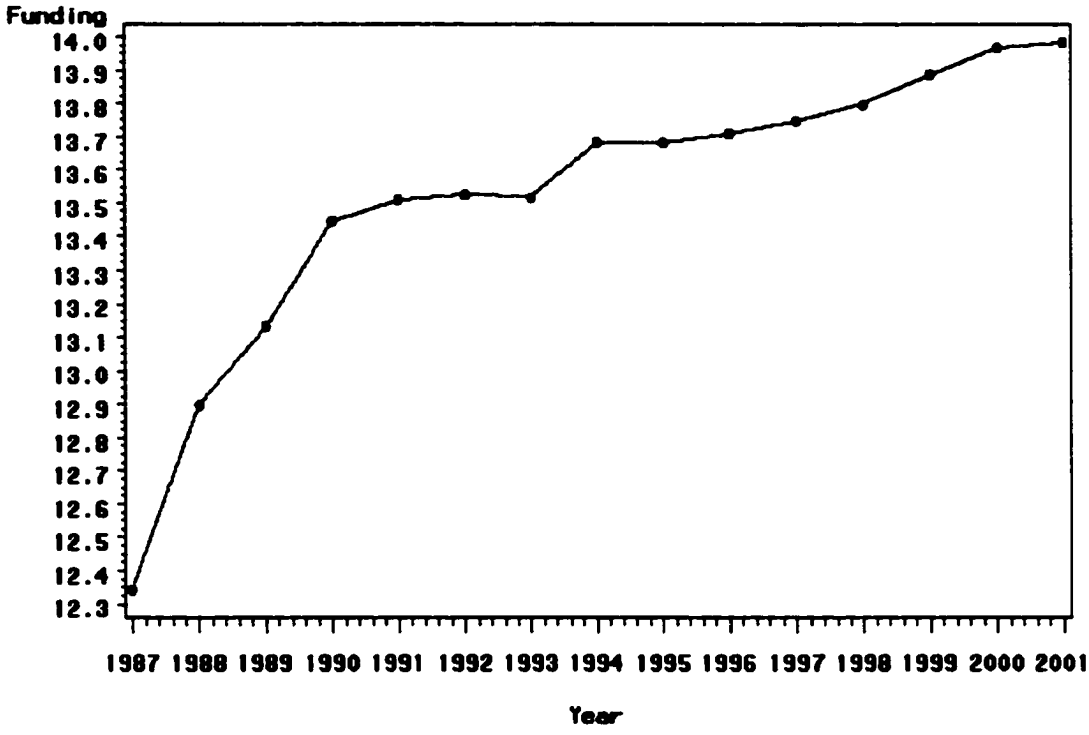

Figure 3.11: HIV/Aids Funding Over Time (Log of 1984 Dollars). Source: N.I.H., Funding by Selected Categories.

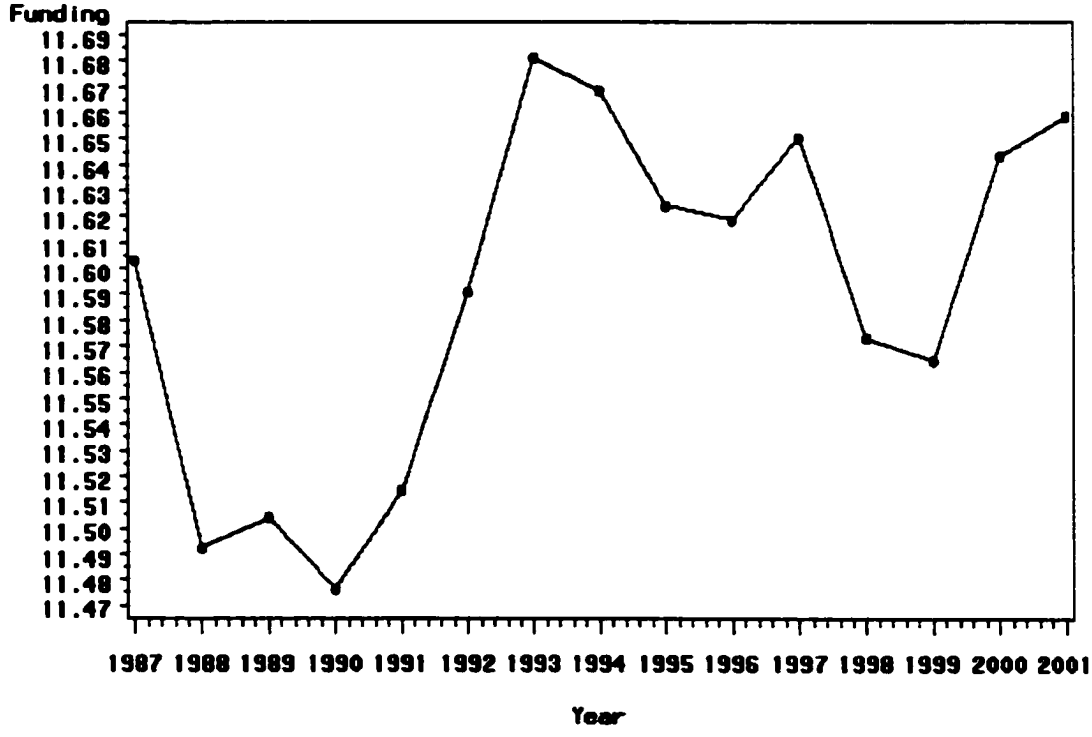

Figure 3.12: Hypertension Funding Over Time (Log of 1984 Dollars). Source: N.I.H., Funding by Selected Categories.

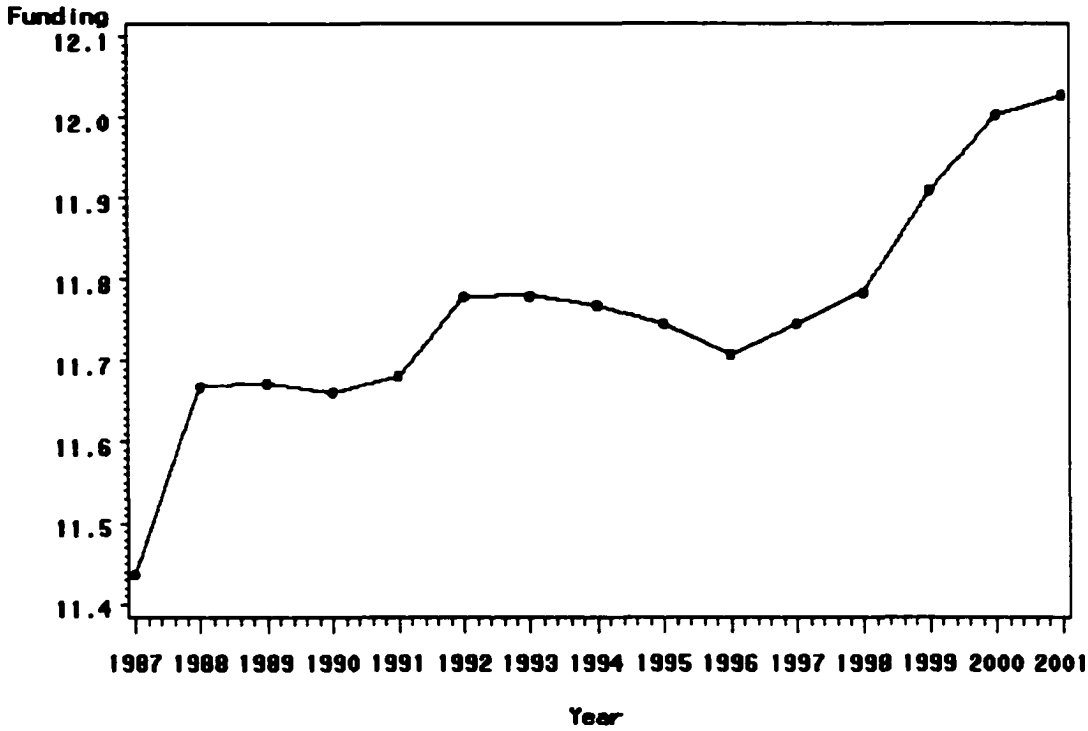

Figure 3.13: Kidney Disease Funding Over Time (Log of 1984 Dollars). Source: N.I.H. Funding by Selected Categories.

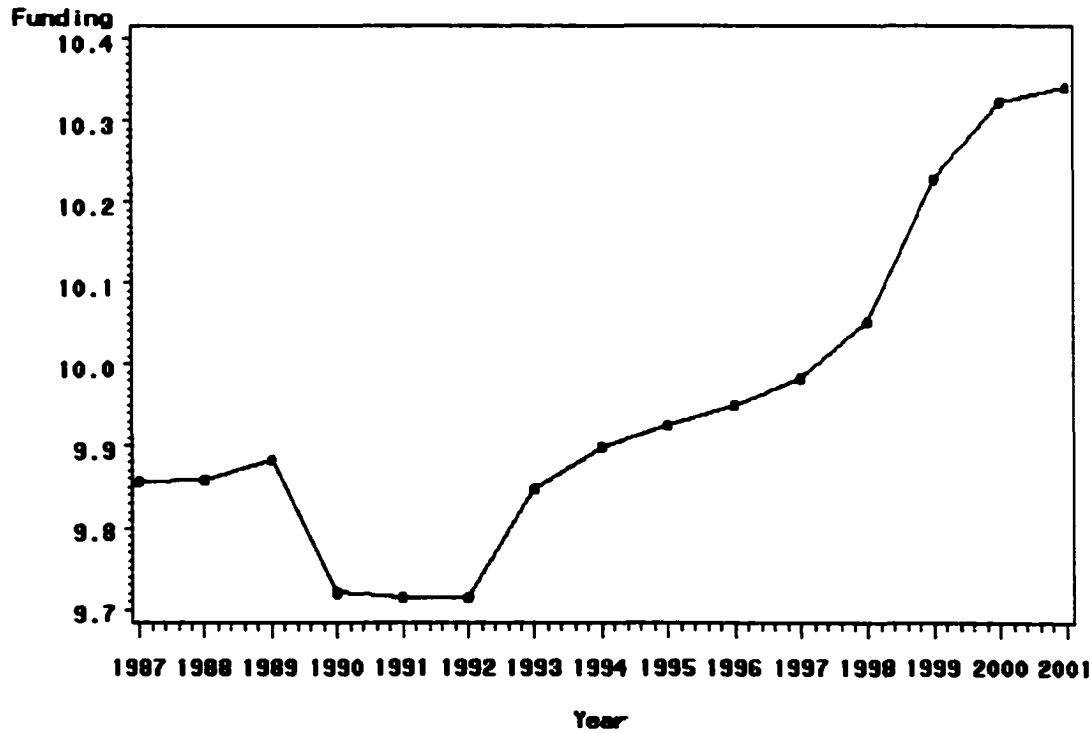

Figure 3.14: Lupus Funding Over Time (Log of 1984 Dollars). Source: N.I.H., Funding by Selected Categories.

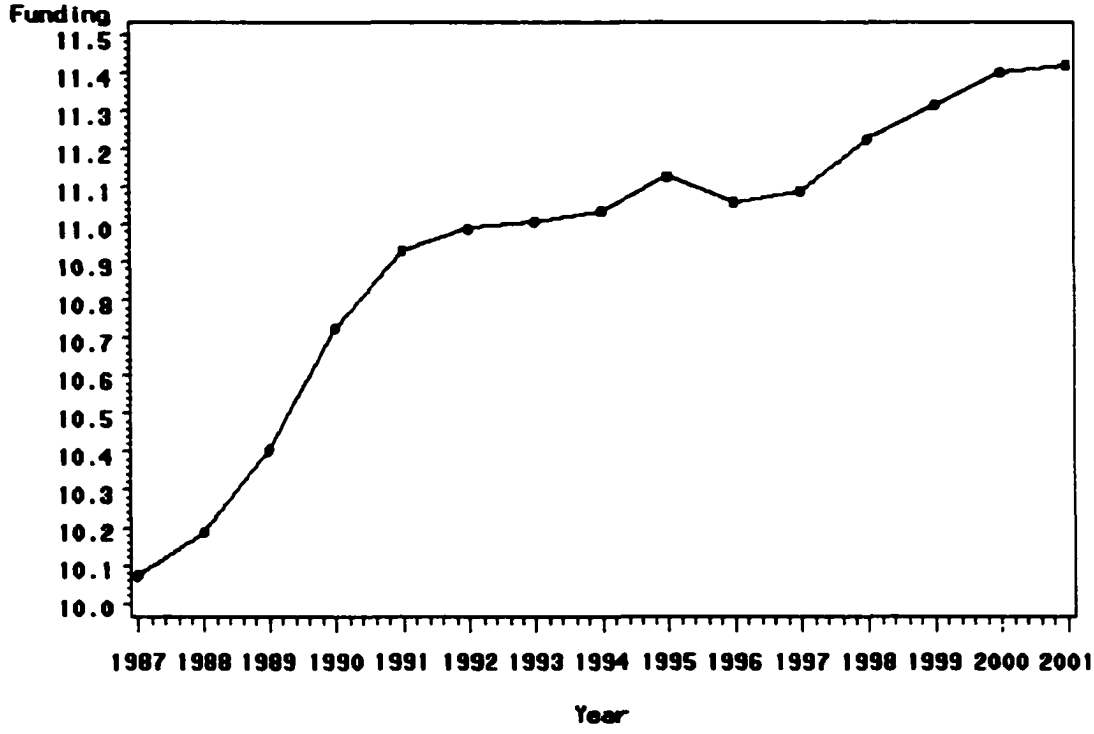

Figure 3.15: Osteoporosis Funding Over Time (Log of 1984 Dollars). Source: N.I.H., Funding by Selected Categories.

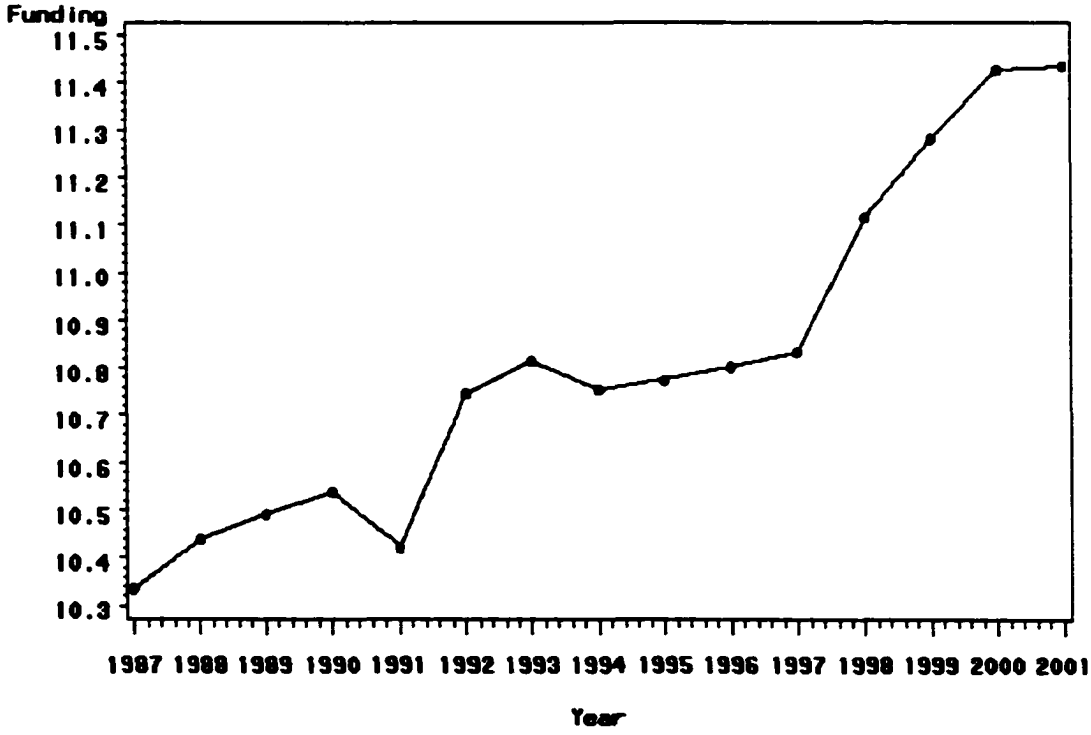

Figure 3.16: Parkinson's Disease Funding Over Time (Log of 1984 Dollars). Source: N.I.H., Funding by Selected Categories.

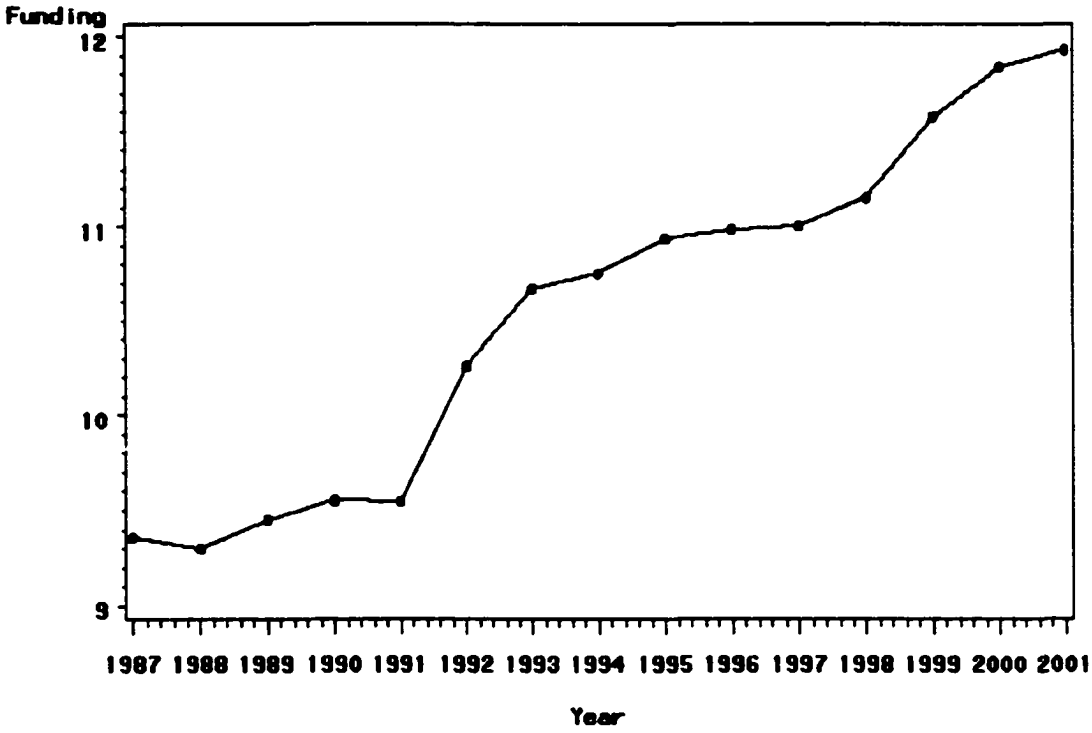

Figure 3.17: Prostate Cancer Funding Over Time (Log of 1984 Dollars). Source: N.I.H., Funding by Selected Categories.

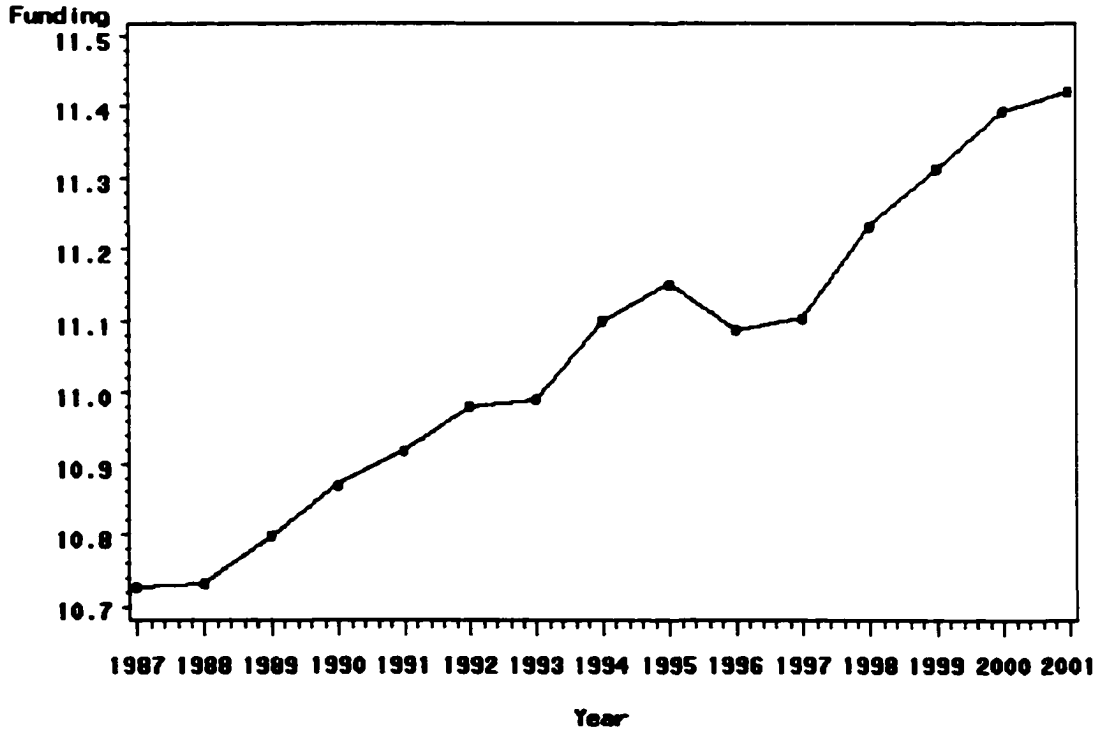

Figure 3.18: Sexually Transmitted Diseases Funding Over Time (Log of 1984 Dollars). Source: N.I.H., Funding by Selected Categories.

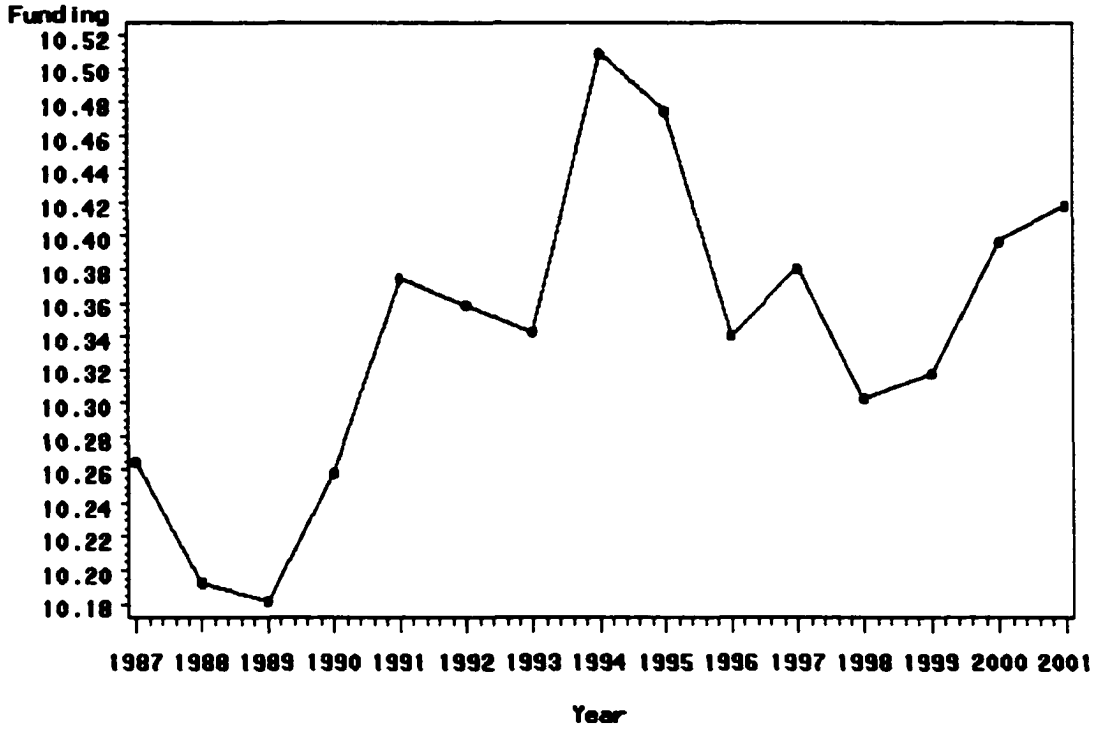

Figure 3.19: Sickle Cell Disease Funding Over Time (Log of 1984 Dollars). Source: N.I.H., Funding by Selected Categories.

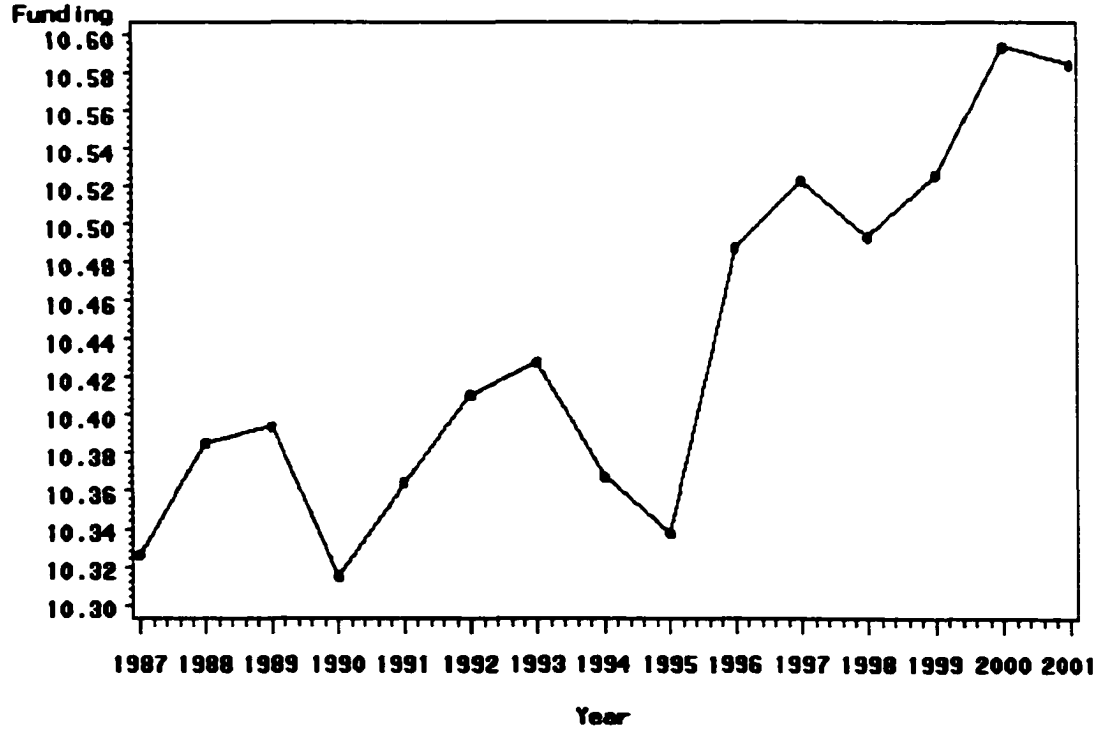

Figure 3.20: Spinal Cord Injury Funding Over Time (Log of 1984 Dollars). Source: N.I.H., Funding by Selected Categories.

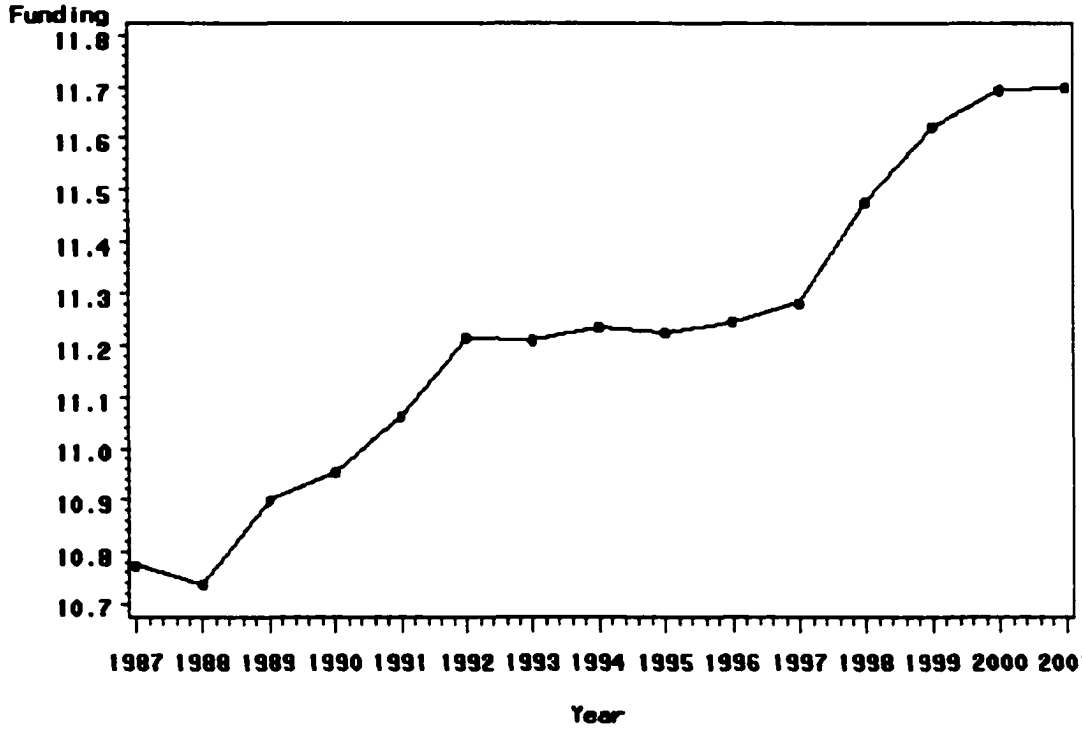

Figure 3.21: Stroke Funding Over Time (Log of 1984 Dollars). Source: N.I.H., Funding by Selected Categories.

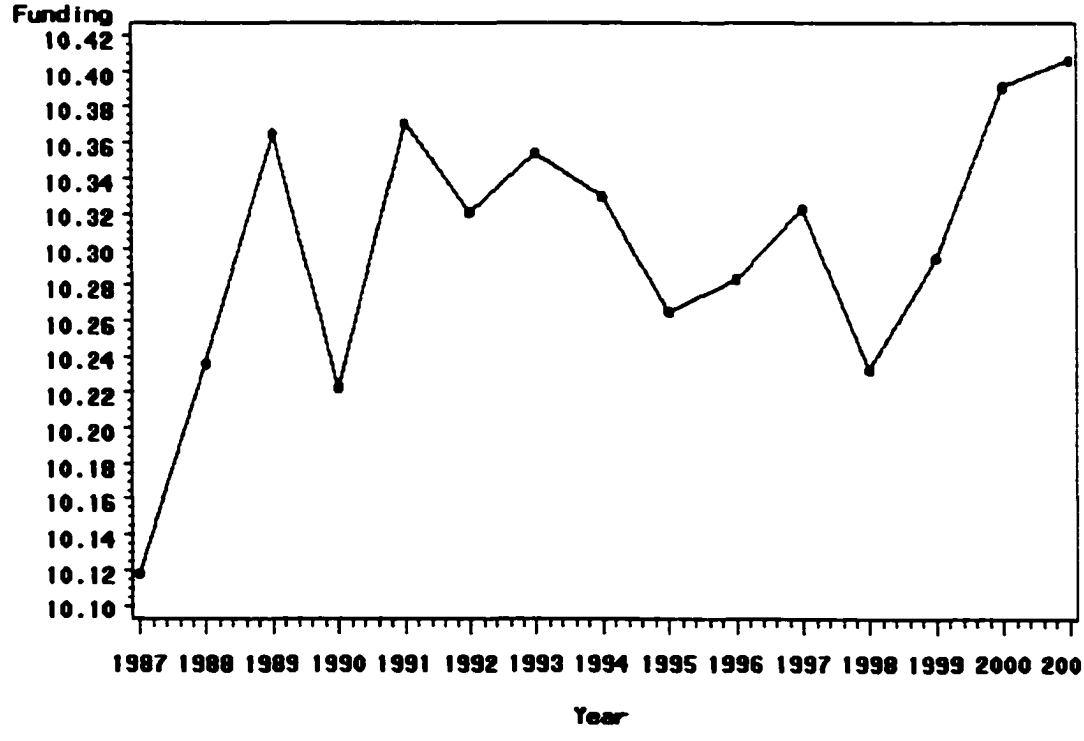

Figure 3.22: Sudden Infant Death Syndrome Funding Over Time (Log of 1984 Dollars). Source: N.I.H., Funding by Selected Categories.

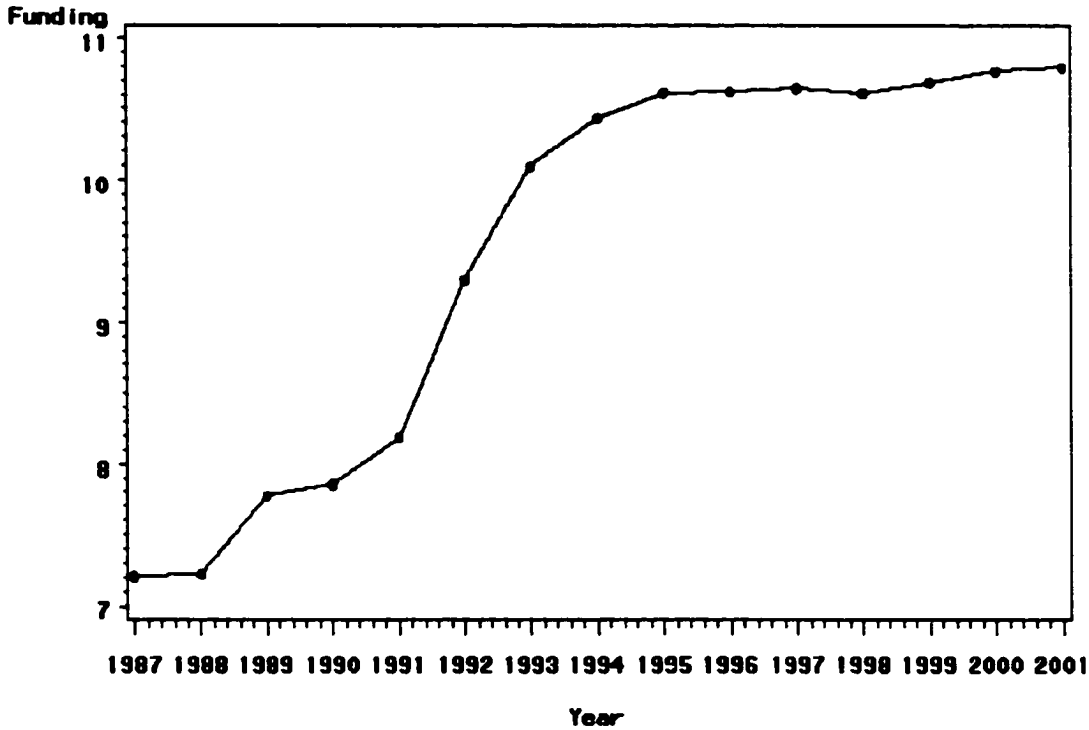

Figure 3.23: Tuberculosis Funding Over Time (Log of 1984 Dollars). Source: N.I.H., Funding by Selected Categories.

In summary, examination of these descriptive statistics gives us substantial information into the relative importance of research on the various diseases as viewed by the National Institutes of Health. What is missing is an understanding of the motivation behind their decisions about the level of spending for research on each disease, as well as the rate at which that spending is increased over the years.

3.5 Regression Results

Does the N.I.H. operate under a pure public interest theory of resource allocation? In an attempt to explain the logic of the decisions made by the N.I.H., a regression analysis was performed to determine whether the amount of research funding allocated to various diseases at the National Institutes of Health depends on the number of deaths from that disease. The dependent variable is real N.I.H. funding of research on that disease for each year from 1987 through 2001. Nominal dollar

amounts have been converted to constant (1984) dollars using the annual Consumer Price Index published by the U.S. Department of Commerce.[1] The independent variable is deaths from a disease in each year from 1979 through 1998, the latest year for which final death statistics are available. Death data were obtained from the Centers for Disease Control WONDER Mortality Database (http://wonder.cdc.gov). Death statistics require two years for compilation and finalization, and budgets are prepared almost a year in advance. Consequently, the latest death data available when planning the 2001 fiscal year budget, for example, is the death data from 1998. It is quite possible, however, that a longer lag time than three years is needed for death data to be incorporated into research funding allocations. It may take a number of years for changing death patterns to be evaluated and research directed toward specific disease areas. It is therefore hypothesized that funding in any given year should respond to deaths from that disease in earlier years. In order to test the public interest hypothesis as fully as possible, various lags of the death data from three years to eight years prior to the funding data will be used in the analysis.

Because the incremental budgeting model quite accurately describes the budgeting process for the N.I.H., as well as other federal agencies, it is hypothesized that budget increases for many diseases in many years are simply based on a percentage of the previous year's budget. Because there is a consistent upward trend to the amounts spent, a log-linear model was used.

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[1]Bureau of Labor Statistics, Consumer Price Index [database on-line] (Washington, D.C.: U.S. Department of Labor, 2001), Internet. Available from ftp://ftp.bls.gov/pub/special.requests/cpi, (accessed 15 February 2001).

3.5.1 Fifteen Year Pooled Data Regressions

Because the data contain both a cross-section of diseases and a time-series of fifteen years, a model incorporating panel data was deemed appropriate. There are twenty-one diseases tracked over the fifteen year period from 1987 through 2001, for a total of 315 observations. The diseases are listed in Table 3.3. There are no missing observations. The one-way fixed effects panel data model in Equation 1.1 is called **Model One**. This model allows the initial level of funding for each disease to be different, which is appropriate. However, the model assumes that the slopes are constant across time and across diseases. The equation estimated in Model One can be written as:

$$\text{LNCFUNDS}_{it} = \beta_1 + \sum_{j=1}^{N-1} \delta_j D_{jt} + \beta_2 \text{DRATIO}_{it-3} + \beta_3 \text{YR} + \beta_4 \text{DYR}_t + \beta_5 \text{DYRDTH}_{it} + \beta_6 \text{CDEM}_{t-1} + \beta_7 \text{PDEM}_{t-1} + e_{it} \quad (3.1)$$

where

LNCFUNDS_{it} = log of N.I.H. research funding for disease *i* in year t

DRATIO_{it-3} = log of deaths from disease *i* in year *t* divided by total deaths in year t-3

$$D_{jt} = \begin{cases} 1 \text{ if disease i = j} \\ 0 \text{ otherwise} \end{cases}$$

YR = time trend

$$\text{DYR}_t = \begin{cases} 1 \text{ if t} \geq 1999 \\ 0 \text{ otherwise} \end{cases}$$

$\text{DYRDTH}_{it} = \text{DYR}_t * \text{DRATIO}_{it}$

$$\text{CDEM}_{t-1} = \begin{cases} 1 \text{ if Democrats control the Congress in year t-1} \\ 0 \text{ otherwise} \end{cases}$$

$$\text{PDEM}_{t-1} = \begin{cases} 1 \text{ if Democrats control the Presidency in year t-1} \\ 0 \text{ otherwise} \end{cases}$$

The dependent variable is the log of N.I.H. research funding for disease *i* in year *t* (LNCFUNDS). The independent variable measuring the burden of disease is the death ratio (DRATIO), which is deaths from disease *i* in year *t-3 (t-4,...,t-8)* divided by the total deaths from all diseases in year *t-3 (t-4, ...,t-8)*. The number of deaths from each disease is scaled by the total deaths for that year to eliminate the effect of increasing deaths over time due to population increases. If the N.I.H. allocates spending on the basis of the burden of disease, this variable should be positive.

A time trend variable, YR, was included to capture the incremental budgeting effect. A dummy variable, DYR, was included for the years 1999-2001, because in 1998 Congress received the report on the N.I.H. they had commissioned from the Institute of Medicine, and the Congress vowed to double the N.I.H. budget over the next five years. Funding for many diseases took a major jump in 1999; however, some individual members of Congress as well as the Institute of Medicine report encouraged the N.I.H. to be more sensitive to the burden of disease when allocating funds. We included an interaction variable, DYRDTH, to capture any change in the relationship between funding and deaths after 1998.

Two political variables are included: CDEM and PDEM. These are time-based dummy variables which measure Democratic Party control of the Congress and Presidency in the year the funding was determined (year t-1). The controlling party for the House and Senate both was the Democrats from 1986-1994 and the Republicans from 1995-2000. The President was a Republican from 1986 to 1992 and a Democrat from 1993 to 2000. If Democrats are bigger spenders than Republicans, then the effects of these Democratic party variables on funding will be positive.

The results of estimating Equation 3.1 (Model One) are shown in Table 3.4 under the heading "With Dummy Variables." The model, which has an R^2 of 0.9225, explains a significant amount of the variation in LNCFUNDS. The model compares the first nineteen diseases to the omitted disease, which is tuberculosis. Cancer (all types combined) was omitted from this regression, so that breast cancer and prostate

Table 3.4
Model One Regression Results
15-Year Pooled Data
Dependent Variable = Log of Funding

	With Dummy Variables		Without Dummy Variables	
Variable	Estimate	t-statistic	Estimate	t-statistic
Alzheimer's	2.4993	16.24*	2.5105	16.28*
Asthma	1.1084	8.08*	1.1110	8.06*
Breast Cancer	2.4693	9.41*	2.4977	9.52*
Chronic Fatigue	-1.6679	-12.24*	-1.6689	-12.18*
Cystic Fibrosis	1.0001	7.35*	1.0002	7.31*
Diabetes	2.7550	9.42*	2.7917	9.57*
Epstein-Barr	-0.0437	-0.32	-0.0447	-0.33
HIV/Aids	4.0043	22.64*	4.0182	22.68*
Hypertension	2.0703	14.39*	2.0772	14.39*
Kidney Disease	2.2381	11.27*	2.2576	11.37*
Lupus	0.4329	3.18*	0.4328	3.17*
Osteoporosis	1.4129	10.38*	1.4126	10.33*
Parkinson's	1.2938	9.19*	1.2997	9.20*
Prostate Cancer	1.0357	4.90*	1.0568	5.00*
STD's	1.5348	11.26*	1.5339	11.20*
Sickle Cell	0.8206	6.03*	0.8199	5.99*
Spinal Cord	0.9156	6.66*	0.9185	6.65*
Stroke	1.7077	2.14**	1.8090	2.27**
SIDS	0.7814	5.70*	0.7832	5.69*
Intercept	8.6366	54.98*	8.8985	84.96*
Yr	0.1006	6.88*	0.0778	15.50*
Dratio	-0.2619	-0.06	-0.5962	-0.14
Dyr	0.1130	-1.30	-	-
Dyrdth	1.2010	0.88	-	-
Cdem	0.1741	2.06**	-	-
Pdem	-0.0053	-0.06	-	-
Model R^2	0.9224		0.9205	

*significant at the 0.01 level. **significant at the 0.05 level.

cancer could be included. A regression which included overall cancer and dropped breast cancer and prostate cancer specifically produced very similar results. Of the nineteen diseases then included, eighteen had intercepts that differed from the tuberculosis intercept. Again, this is evidence that the N.I.H. does not consider some diseases to be as deserving of research as other diseases, because the exogenous level of funding differs across diseases. Some diseases are more equal than others.

The death ratio was insignificant, which indicates that the N.I.H. is not altering funding priorities over time as the death ratio changes. A joint F-test for DRATIO and DYRDTH had a p-value of 0.6726, so we could not reject the null hypothesis that they were both equal to zero. One explanation for this seemingly unexpected lack of significance of DRATIO might be that the data did not exhibit enough variation; however, an examination of DRATIO for each disease over time revealed that this was not a problem. Another possibility is that the effect of deaths is captured in the disease dummy variable. We explore this possibility below.

The time trend variable was positive and significant, providing support for the incremental budgeting theory. It appears that the initial distribution of funds across diseases is largely maintained over time, with overall budget increases causing most increases in individual disease funding. The coefficient of DYR, the dummy variable for the years 1999-2001, was not significant. The sudden increase in the N.I.H. budget had less impact on funding than the time trend. The interaction term, DYRDTH, was not significant, so the relationship between deaths and funding did not change after 1999. The join F-test for DYR and DYRDTH had a p-value of 0.3916, so once again we could not reject the null hypothesis that they were both equal to zero.

The political time-based dummy variable CDEM was positive and significant, capturing the decline in funding which took place in 1995 after the Republicans took over Congress from the Democrats. However, the change from a Republican President to a Democratic one in 1993 did not significantly affect funding. Congress may simply be more important than the President in making funding decisions for the N.I.H.

Model One was re-estimated dropping the dummy variables DYR, DYRDTH, CDEM, and PDEM. These results are also shown in Table 3.4, under the heading "Without Dummy Variables." The results are almost identical to those of the initial regression. The R^2 is 0.9205, and the same eighteen diseases have intercepts which differ from that of tuberculosis, with approximately the same coefficients. Again, the time trend variable, YR, is significant and positive, while the death ratio variable, DRATIO, is not significant.

The values in Table 3.4 show us which diseases have an intercept that is significantly different than that of the excluded disease, tuberculosis. While this is useful information, we cannot judge from this the magnitude of the differences. We can, however, determine the percentage change in funding for each disease over the funding for tuberculosis for each of the diseases included in the model. These results are shown in Table 3.5. The transformation is from Halvorsen and Palmquist (1980), and is shown below:

Let $\ln y = \beta_1 + \beta_2 x + \delta D + e$, where $D = \begin{cases} 1 \\ 0 \end{cases}$

Then $\ln y_1 = (\beta_1 + \delta) + \beta_2 x_1$ when $D = 1$, and $\ln y_0 = \beta_1 + \beta_2 x_0$ when $D = 0$.

The percent change in $y = e^{\delta} - 1$ when $D = 1$ versus $D = 0$.

We have computed the estimates for Model One without the dummy variables. We can see from Table 3.5 that there is a significant percentage increase in the funding for seventeen of the nineteen diseases. The largest of these is for HIV/Aids; there is a fifty-five percent change in exogenous funding for HIV/Aids. Diabetes received about sixteen percent more funding, while breast cancer experienced an increase in exogenous funding of slightly more than eleven percent. These percentage shifts in funding represent the higher priority given to those diseases by the N.I.H. Only one disease has a significant decrease in the funding: chronic fatigue syndrome. For two diseases, Epstein-Barr disease and stroke, we cannot reject the null hypothesis of no change in the exogenous level of funding relative to tuberculosis.

Table 3.5
Model One Estimation Results
Fifteen Year Pooled Data
Estimation of Percentage Change in Funding

Variable	Estimate (Percent)	t-statistic
Alzheimer's	11.31	5.96*
Asthma	2.04	4.87*
Breast Cancer	11.15	3.50*
Chronic Fatigue	-0.81	-31.44*
Cystic Fibrosis	1.72	4.62*
Diabetes	15.31	3.22*
Epstein-Barr	-0.04	-0.33
HIV/Aids	54.60	5.54*
Hypertension	6.98	6.06*
Kidney Disease	8.56	4.51*
Lupus	0.54	2.57**
Osteoporosis	3.11	5.53*
Parkinson's	2.67	5.15*
Prostate Cancer	1.88	3.09*
STD's	3.64	5.73*
Sickle Cell	1.27	4.09*
Spinal Cord	1.51	4.35*
Stroke	5.10	1.05
SIDS	1.19	3.94*

*significant at the 0.01 level. **significant at the 0.05 level

While the fixed-effects Model One provides support for the incremental theory of governmental budgeting, and confirms that funding varies significantly across diseases even after controlling for deaths, it does not provide an explanation for the initial allocation across disease at the beginning of the period. In an attempt to explain these initial distributions, we compared the 1987 research funding for each disease to the 1979 death ratio of that disease. Death data for 1979 is the earliest available from the CDC WONDER Mortality Database. The following equation was estimated:

$$LNFUNDS_{it} = \beta_1 + \beta_2 LNDEATHS_{it} + e_{it} \qquad (3.2)$$

where

$LNFUNDS_{it}$ = Log of research funding for disease *i* in 1987

$LNDEATHS_{it}$ = Log of deaths from disease *i* in 1979

The results of the estimation, **Model Two**, are shown in Table 3.6. The model has an R^2 of 0.4285. There is a significant, positive relationship between research funding and deaths for each disease. The coefficients represent the elasticity of funding with respect to deaths; an increase in deaths from a disease of one percent causes an increase in funding of 0.38 percent. We tested the model specification following Ramsey (1969,1974) and could not reject the hypothesis that no significant variables were omitted from the model.

Table 3.6
Model Two
Fifteen Year Pooled Data
Dependent Variable = Log of Funding

R^2 0.4285		
Variable	Estimate	t-statistic
Intercept	7.5762	9.08*
Lndeaths	0.3807	3.77*

*significant at the 0.01 level

The level of deaths from each disease apparently mattered when the N.I.H. made initial funding decisions, which means that the N.I.H. is concerned with the public interest. Once the relative level of funding has been established, the N.I.H. seems to follow an incremental budgeting pattern. Another examination of the fifteen year data set was conducted to verify these conclusions. A regression was run using the 1979 death ratios and a time trend to explain the funding for all years from 1987-2001 and using ordinary least squares. These results were verified using a random coefficients model. The results of this estimation, **Model Three**, are shown in Table 3.7. The equation estimated was as follows:

$$LNFUNDS_{it} = \beta_1 + \beta_2 DRATIO_i + \beta_3 YR + \beta_4 DRATYR_i + e_{it} \quad (3.3)$$

where

$LNFUNDS_{it}$ = Log of funding for disease *i* in year *t*

$DRATIO_i$ = Deaths from disease *i* in 1979 divided by total deaths in 1979

YR = Time trend

$DRATYR_i$ = $DRATIO_i$*YR

Table 3.7
Model Three
Fifteen Year Pooled Data
Dependent Variable = Log of Funding

R^2 0.4668		
Variable	Estimate	t-statistic
Intercept	10.6787	48.54*
Dratio	0.0553	13.93*
Yr	5.6126	2.30**
Dratyr	0.0081	0.18

*significant at the 0.01 level.

The model has an R^2 of 0.4668. The coefficients of both the death ratio (DRATIO) and the time trend (YR) are significant and positive. The interaction term,

DRATYR, was not significant. These results support our earlier contention that the N.I.H. allocates funding in accordance with the burden of diseases, and budgets using an incremental budgeting model. The regression was also run including the political dummy variables DYR, CDEM, and PDEM; however, these were never significant and did not add to the explanatory power of the model.

3.5.2 Ten Year Pooled Data Regressions

Data were collected on a broader cross-section of twenty-seven diseases for the ten year period 1992-2001, for a total of 270 observations. The additional diseases include some of the major killers in the United States: heart disease, pneumonia/influenza, chronic obstructive pulmonary disease (COPD), liver disease, and lung cancer. Schizophrenia is also included. Table 3.8 gives the dataset funding as a percent of the N.I.H. total budget for the years 1992-2001, and Table 3.9 compares dataset deaths to total deaths for the years 1989-1998. The percentage of funding covered by this study is always at least sixty percent of total N.I.H. funding, while the fraction of total deaths contained in the death dataset is about two-thirds.

Table 3.8
Research Funding Data
(In Thousands of Nominal Dollars)

Year	N.I.H. Total	Data Set Total	Percent
1992	$10,010,368	$ 6,138,923	0.6133
1993	10,328,117	6,498,086	0.6292
1994	10,910,969	7,072,782	0.6482
1995	11,340,841	7,444,928	0.6565
1996	11,880,847	7,941,119	0.6684
1997	12,770,771	8,397,660	0.6576
1998	13,622,386	8,776,865	0.6443
1999	15,597,189	10,453,800	0.6702
2000	17,793,587	11,785,300	0.6623
2001	20,300,000	12,299,500	0.6059

Source: Office of Communications and Public Liaison, N.I.H. Almanac, 1999.

Table 3.9
Death Data

Year	Total Deaths	Data Set Deaths	Percent
1989	2,150,466	1,412,539	0.6569
1990	2,148,463	1,412,761	0.6577
1991	2,169,518	1,425,941	0.6573
1992	2,175,613	1,431,841	0.6581
1993	2,268,553	1,497,628	0.6602
1994	2,278,994	1,499,735	0.6581
1995	2,312,132	1,521,695	0.6581
1996	2,314,690	1,516,580	0.6552
1997	2,314,245	1,505,035	0.6503
1998	2,337,258	1,513,487	0.6475

Source: National Center for Health Statistics, Vital Statistics, Annual.

Cardiovascular disease is the number one cause of death in the United States and has been for the second half of the twentieth century. COPD ranks consistently fourth or fifth, while pneumonia/influenza is generally sixth (see Appendix A). Liver disease was the tenth leading cause of death from 1994-1998, and was the ninth leading cause of death for 1984-1990. Even though these diseases accounted for a substantial number of deaths, the N.I.H. does not have statistics on the funding for research on these diseases before 1992. Failure to collect this data was one of the shortcomings cited in the Congressionally-mandated review of the N.I.H. ordered in 1996. This study is the first to examine the relationship between these devastating diseases and the amount of N.I.H. research funding directed toward them.

A pooled time-series cross-section regression was used to estimate Equation 3.4. As with the fifteen year data set, the regressions were run in a one-way fixed effects format (the intercept varies only by disease). The regressions were run using both total cancer (all sites) funding and deaths, and the separate numbers for breast

cancer, prostate cancer, and lung cancer. There was no significant difference in the results. Also, the model was estimated with and without the dummy variables.

The equation estimated was as follows:

$$\text{LNCFUNDS}_{it} = \beta_1 + \sum_{j=1}^{N-1} \delta_j D_{jt} + \beta_2 \text{DRATIO}_{it-3} + \beta_3 \text{YR} + \beta_4 \text{DYR}_t + \beta_5 \text{DYRDTH}_{it} + \beta_6 \text{CDEM}_{t-1} + \beta_7 \text{PDEM}_{t-1} + e_{it} \quad (3.4)$$

The variables have interpretations identical to those in Equation 3.1. The model was estimated both with and without the dummy variables. The results of this regression, **Model Four**, are shown in Table 3.10.

For ease of comparison with the results of the fifteen-year study, the omitted disease is again tuberculosis. Of the twenty-five diseases included, the intercept varied significantly from that of tuberculosis for nineteen of the diseases in the model estimated with dummy variables. The exogenous level of funding for sixteen of these diseases is greater than that for tuberculosis, after controlling for the number of deaths from each disease. Conversely, cardiovascular disease, COPD and pneumonia/influenza (three of the deadliest diseases) had intercepts that did not vary statistically from that of tuberculosis. We cannot conclude that these diseases received higher exogenous levels of funding than tuberculosis. Chronic fatigue, Epstein-Barr, and lupus had intercepts that were significantly lower than that of tuberculosis.

As in the fifteen year data results, the time trend was highly significant, again lending support to the incremental budgeting theory. The measure of deaths from each disease, DRATIO, was not significantly different from zero. This lack of significance was not due to any lack of variation in the death ratio data during this time. The joint F-test of the hypothesis that both DRATIO and DYRDTH were equal

Table 3.10
Model Four Regression Results
Ten Year Pooled Data
Dependent Variable = Log of Funding

	With Dummy Variables		Without Dummy Variables	
Variable	Estimate	t-statistic	Estimate	t-statistic
Alzheimer's	1.8360	20.65*	1.8418	21.34*
Asthma	0.4942	6.29*	0.4955	6.34*
Breast Cancer	2.0042	14.80*	2.0191	16.22*
Cardiovascular	3.3323	1.73	3.5906	2.12**
Chronic Fatigue	-2.2042	-28.26*	-2.2047	-28.35*
Cystic Fibrosis	0.1888	2.42**	0.1884	2.42**
Diabetes	1.8837	11.64*	1.9028	2.97*
Epstein-Barr	-0.9128	-11.70*	-0.9133	-11.94*
HIV/Aids	3.3099	30.94*	3.3196	32.85*
Hypertension	1.1772	14.33*	1.1808	14.58*
Kidney Disease	1.3837	13.01*	1.3935	13.89*
Lupus	-0.4289	-5.51*	-0.4290	-5.52*
Osteoporosis	0.7117	9.14*	0.7115	9.16*
Parkinson's	0.5486	6.79*	0.5515	6.90*
Prostate Cancer	0.6717	5.85*	0.6830	6.36*
STD's	-0.7222	9.26*	0.7217	9.28*
Sickle Cell	-0.0715	-0.92	-0.0719	-0.92
Spinal Cord	0.0222	0.28	0.0236	0.30
Stroke	1.0084	2.61*	1.0593	3.10*
SIDS	-0.1335	-1.71	-0.1326	-1.70
COPD	0.0046	0.02	0.0367	0.16
Liver Disease	1.1560	10.82*	1.1659	11.57*
Lung Cancer	0.9540	2.42**	1.0059	2.89*
Pneumonia/Influenza	0.1368	0.60	0.1654	0.82
Schizophrenia	0.9379	12.03*	0.9375	12.06*
Intercept	10.1988	125.66*	10.1512	172.67*
Dratio	-0.7688	-0.20	-1.2680	-0.37
Yr	0.0467	3.06*	0.0555	14.79*
Dyr	0.0626	1.14	-	-
Dyrdth	0.0804	0.28	-	-
Cdem	0.0153	0.31	-	-
Pdem	0.0277	0.60	-	-

*significant at the 0.01 level. **significant at the 0.05 level.

to zero had a p-value of 0.4548. This is the same result as that which occurred in the fifteen year study, and supports the theory that incremental budgeting dominates once

the initial levels of funding are allocated. Changes in the death share after the initial year do not appear to alter funding allocations. Cardiovascular disease alone kills over 800,000 people a year in the United States. Including these additional diseases gives a clearer picture of the relationship between N.I.H. research funding and deaths from a disease during the last decade.

As expected, the time trend variable is positive and highly significant, supporting the incremental budgeting theory. DYR, corresponding to the Congressional decision to double N.I.H. funding in five years (1999-2003), was not significant in this regression (or in the earlier one). Instead, the time trend accounts for essentially all of the increase in funding. Again, the interaction variable, DYRDTH, was not significant, indicating that the slope of the relationship between DRATIO and LNCFUNDS did not change in 1999. These results were confirmed by a join F-test of the significance of DYR and DYRDTH, which had a p-value of 0.8972.

Neither of the political variables, CDEM or PDEM, was significant The change from a Democratically-controlled Congress to a Republican Congress (CDEM) did not materially affect funding; this is a different result than the one obtained in the fifteen year panel data regression. The difference between the results in the ten and fifteen year regressions may be due to the differences in the diseases in the two datasets. The ten year dataset contains all of the top ten disease causes of death; this is more than twice as many deaths as that contained in the fifteen year data. The amount of funding for these major killer diseases may not fluctuate as much with political changes as funding for those diseases that kill fewer people. It is logical for Congress to fund research on those diseases which impact the lives of many voters.

Another explanation for the difference in the results may be the reduced variation in funding over the ten year period as compared to the fifteen year period.

As in the fifteen year analysis, we are interested in the magnitude of the intercept changes across diseases. Table 3.9 shows the percentage change in funding by disease. Of the twenty-five diseases included in the regression, seventeen had percentage changes in funding that were significant relative to the funding for tuberculosis. The largest was HIV/Aids, whose exogenous level of funding was 26.65

Table 3.11
Model Four Estimation Results
Ten Year Pooled Data
Estimation of Percentage Change in Funding

Variable	Estimate	t-statistic
Alzheimer's	5.31	9.75*
Asthma	0.64	5.00*
Breast Cancer	6.53	6.97*
Cardiovascular	35.25	0.57
Chronic Fatigue	-0.89	-103.73*
Cystic Fibrosis	0.21	2.21**
Diabetes	5.70	5.80*
Epstein-Barr	-0.60	-19.19*
HIV/Aids	26.65	9.54*
Hypertension	2.26	8.56*
Kidney Disease	3.03	7.49*
Lupus	-0.35	-6.89*
Osteoporosis	1.04	6.55*
Parkinson's	0.74	5.30*
Prostate Cancer	0.98	4.61*
STD's	1.06	6.61*
Sickle Cell	-0.07	-0.96
Spinal Cord	0.02	0.30
Stroke	1.88	1.91
SIDS	-0.12	-1.82
COPD	0.04	0.16
Liver Disease	2.21	6.83*
Lung Cancer	1.73	1.82
Pneumonia/Influenza	0.18	0.75
Schizophenia	1.55	7.83*

*significant at the 0.01 level. **significant at the 0.05 level

percent higher than that of the omitted disease, tuberculosis. Other diseases with large funding increases were breast cancer (6.53 percent), Alzheimer's disease (5.31 percent), and diabetes (5.70 percent). Three diseases had significant percentage decreases in funding: chronic fatigue (-0.89 percent), Epstein-Barr (-0.60 percent), lupus (-0.35 percent). For four of the deadliest diseases, cardiovascular disease, stroke, COPD, and pneumonia/influenza, we cannot reject the hypothesis that their funding did not differ significantly from that of tuberculosis.

3.5.3 Separate Regressions

In addition to the panel data regressions, separate time-series regressions were run for each of the twenty-one diseases. The graphs of funding by disease presented earlier clearly showed that the slopes of the funding curves were not the same for all diseases. The fixed-effect models' assumption that this condition is true is not realistic. There is a trade-off between the loss of information which can only be obtained from the use of pooled data, and the gain from a more accurate assumption about the rate of change in funding for various diseases over time. As in the earlier models, the dependent variable in each equation is the log of constant dollar funding by the N.I.H. on that disease (LNCFUNDS), and the independent variable is the log of deaths from that disease lagged three years (LNDEATH). The equation estimated was:

$$\text{LNCFUNDS}_t = \beta_1 + \beta_2 \text{LNDEATH}_{t-3} + e_t \qquad (3.6)$$

The results of these twenty-one individual time-series regressions are summarized in Table 3.12. The intercept term was significant for fifteen of the twenty-one diseases, showing that the exogenous levels of funding set in 1987 were a

Table 3.12
Fifteen Year Separate Regression Results
Dependent Variable = Log of Funding

Disease	Intercept	Lndeath
Alzheimer's	1.5854	1.0922*
Asthma	-19.0297*	3.4975*
Breast Cancer	-161.9915*	16.3233*
All Cancer	-13.9017**	2.1479*
Chronic Fatigue	7.9273*	-0.0614
Cystic Fibrosis	10.2866**	0.0388
Diabetes	6.9691*	0.4920**
Epstein Barr	8.3359*	0.4042
HIV/Aids	8.7674*	0.4834*
Hypertension	10.0462*	0.1676**
Kidney	-2.5684	1.3992*
Lupus	-4.1256	1.9704*
Osteoporosis	3.8423*	1.0697*
Parkinson's	1.2529*	1.0648*
Prostate Cancer	-62.3313*	7.0450*
STD's	14.5634*	-0.7635*
Sickle Cell	8.4470*	0.3104**
Spinal Cord	2.1843	0.9634*
Stroke	-28.6664	3.3570
SIDS	11.0399*	-0.0879
Tuberculosis	43.9438**	-4.6744**

*significant at the 0.01 level. **significant at the 0.05 level

prime determinant of later funding. The models are in log-log form, so the coefficients on LNDEATH represent the elasticity of disease research funding with respect to deaths from that disease. For the following diseases, a change in deaths was not a significant predictor of a change in research funding: chronic fatigue, cystic fibrosis, Epstein-Barr syndrome, hypertension, stroke, and sudden infant death syndrome. Of these diseases, stroke was consistently the third cause of death from 1984-1998. Chronic fatigue syndrome and Epstein-Barr syndrome almost never kill anyone, so it is not surprising that funding for these diseases is not related to deaths. Even hypertension (by itself), cystic fibrosis, and sudden infant death syndrome cause a relatively low number of deaths. Two diseases had elasticities that were negative

and significant: sexually transmitted diseases and tuberculosis. These diseases had increases even though the number of deaths from them was either declining or flat, indicating that the N.I.H. is considering other factors when allocating funding for these diseases, such as the fact that both of these diseases are communicable.

Those diseases for which the elasticity of funding with respect to deaths was positive and significant were Alzheimer's, asthma, breast cancer, cancer (all types), HIV/Aids, hypertension, kidney disease, lupus, osteoporosis, Parkinson's disease, prostate cancer, sickle cell disease, and spinal cord injury. Of these diseases, only cancer and diabetes were in the top ten causes of death for all fifteen years; Aids was in the top ten causes for seven of those fifteen years. All of the estimates were positive, and ranged from a low of 1.0648 for Parkinson's disease to a high of 16.3233 for breast cancer. Only asthma, breast cancer, and prostate cancer had elasticity estimates greater than three. An increase in deaths for any of these three diseases generated increases in research funding that were disproportionately large. An increase in breast cancer deaths of one percent, for example, caused a 16.59 percent increase in research funding for breast cancer.

It should be kept in mind that because there are only fifteen observations for each disease, the statistical reliability of these estimates is not strong. Because of the low degrees of freedom, the time dummy variables were not included in these models.

3.6 Conclusions

The public interest theory of biomedical research hypothesizes that policy-makers should allocate research funds in such a way as to provide the maximum benefit to all of the citizens of the nation. A logical interpretation would be to

evaluate whether the N.I.H. is distributing research dollars in accordance with the distribution of the burden of disease. This chapter evaluated specifically the relationship between disease research funding allocations from 1987-2001 and one measure of the burden of disease, total deaths from each disease. Another important theory we tested is whether or not the N.I.H. follows an incremental budgeting model. We also included variables to assess the impact of political changes on the funding process.

For the both fifteen year and ten year panel datasets, our results showed that changes in the burden of disease measure (DRATIO) once the initial allocations had been made did not significantly affect the distribution of research funding across diseases. The burden of disease did impact the initial allocation of funds; however, after that, the process of incremental budgeting explains increases in funding. The time trend variable, YR, was always positive and highly significant.

The political variables PDEM and DYR, capturing the effect of the election of a Democratic President and the 1998 Congressional decision to double the N.I.H. overall budget, had no impact on funding in the fifteen year dataset regression estimation. These results were substantiated by our examination of the larger ten-year panel data set. However, we did not get consistent results when measuring the effect of the change from a Democratically-controlled Congress to a Republican Congress (CDEM). CDEM was significant and positive in the fifteen year dataset regression; the level of funding decreased after 1995. This result was not confirmed by the estimation of the ten year dataset regression; CDEM was positive, but not significant. We cannot conclude, then, that political factors do not affect N.I.H. funding.

For both the fifteen and ten year panel data sets, alternative specifications of the model were used to test for robustness. Using either a four year or five year lag between deaths and funding decisions did not alter the results. Including a lag of funding as an explanatory variable provided strong support for the incremental budgeting theory, but did not provide any illumination about the allocation among the various diseases, which was what we were seeking. Finally, the use of first differencing and shift-share formats for the models was tried and rejected, as the fit with the data was not good.

The separate evaluations of twenty different diseases over the period 1987-2001 found a significant positive correlation between deaths and funding over time for most diseases; however, the sample size did not permit the inclusion of time trend or political variables.

In subsequent sections, this dissertation will attempt to explain these differences across diseases using both political and special interest group variables. Additional data on more diseases will be included.

CHAPTER 4

CROSS SECTIONAL DATA AND REGRESSIONS

4.1 Introduction

This chapter analyzes the allocation of N.I.H. research funding across diseases for the most recent year data is available. This cross-sectional data enables us to consider a larger number of diseases, alternative measures of the burden of diseases, and the effects of politics and special interest group influence that were not possible wit the pooled data. The number of diseases included was expanded to forty-two. N.I.H. research funding levels for this analysis were for the year 1999, and death data was consequently that for 1996, the latest year available when funding decisions were made in 1998. The diseases, the number of deaths, the years of life lost (YLL), and the amount of funding for research are shown in Table 4.1. Funding data were obtained from the N.I.H. web page (http://www.N.I.H..gov) and from correspondence with N.I.H. employees. Death data was obtained from the Centers for Disease Control web page (http://www.cdc.gov) using the CDC Wonder Mortality Database search tool. Deaths are classified using the International Classification of Diseases, Ninth Revision.

Table 4.1
Cross Section Data

Disease	Deaths*	YLL**	Discharges*	Funds***
Alzheimer's	21,397	171,206.1	16,000	$ 406,500
Asthma	5,665	124,430.4	474,000	140,400
Breast Cancer	43,447	760,035.6	123,000	474,700
Cancer	539,508	8,222,523.5	1,805,000	3,377,300
Cardiovascular	733,262	8,691,801.4	4,229.000	1,327,100

Source: N.I.H., Funding by Selected Categories. Centers for Disease Control, WONDER Mortality Database. *1996 figures. **years of life lost 1996. ***in thousands of nominal dollars.

(Table 4.1 continued)

Variable	Deaths*	YLL**	Discharges*	Funds***
Chronic Fatigue	4	26.7	N/A	6,700
Cystic Fibrosis	430	22,409.6	14,000	71,600
Diabetes	61,766	876,685.1	503,000	457,600
Epstein Barr	16	864.7	9,000	27,100
HIV/Aids	31,123	1,187,247.4	101,000	1,792,700
Hypertension	12,945	147,655.3	284,000	175,400
Kidney Disease	30,586	376,768.4	485,000	247,900
Lupus	1,404	38,467.3	23,000	46,100
Osteoporosis	1,172	9,853.3	175,000	136,700
Parkinson's	11,845	103,995.1	20,000	132,300
Prostate Cancer	34,122	355,490.5	90,000	177,500
STD's	101	2,330.2	N/A	136,400
Sickle Cell	507	21,835.1	56,000	50,400
Spinal Cord	5,821	229,229.1	72,000	62,100
Stroke	153,041	1,584,088.5	955,000	186,000
SIDS	3,050	232,105.0	N/A	49,300
Tuberculosis	1,202	21,567.5	7,000	72,800
COPD	98,647	1,124,605.6	137,000	80,000
Liver Disease	28,881	637,909.1	112,000	185,637
Lung Cancer	152,007	2,290,162.4	180,000	163,000
Pneumonia/Influenza	83,717	895,418.1	1,223,000	73,000
Schizophrenia	420	5,454.6	257,000	200,600
ALS	4,159	68,342.3	N/A	17,200
Arthritis	2,908	32,345.4	449,000	238,800
Autism	2	76.5	N/A	40,000
Ovarian Cancer	13,342	209,865.5	31,000	65,400
Fibromyalgia	42	645.4	9,000	6,400
Hepatitis C	2,577	57,843.9	7,000	39,700
Malaria	4	136.8	N/A	25,300
Multiple Sclerosis	2,291	51,923.4	20,000	96,300
Muscular Dystrophy	996	35,191.3	6,000	16,700
Nutritional Problems	3,594	32,526.0	15,000	587,500
Obesity	2,097	53,114.2	16,000	161,400
Cervical Cancer	4,513	107,530.7	N/A	75,200
Colorectal Cancer	56,515	765,016.8	155,000	175,900
Epilepsy	1,413	46,883.1	N/A	81,700
Septicemia	23,707	452,289.2	355,000	16,500

Source: N.I.H., Funding by Selected Categories. Centers for Disease Control, WONDER Mortality Database. *1996 figures. **years of life lost 1996. ***in thousands of nominal dollars.

Examination of this broader collection of diseases reveals the same variation across diseases in the levels of funding per death from a disease. Figure 4.1 shows the

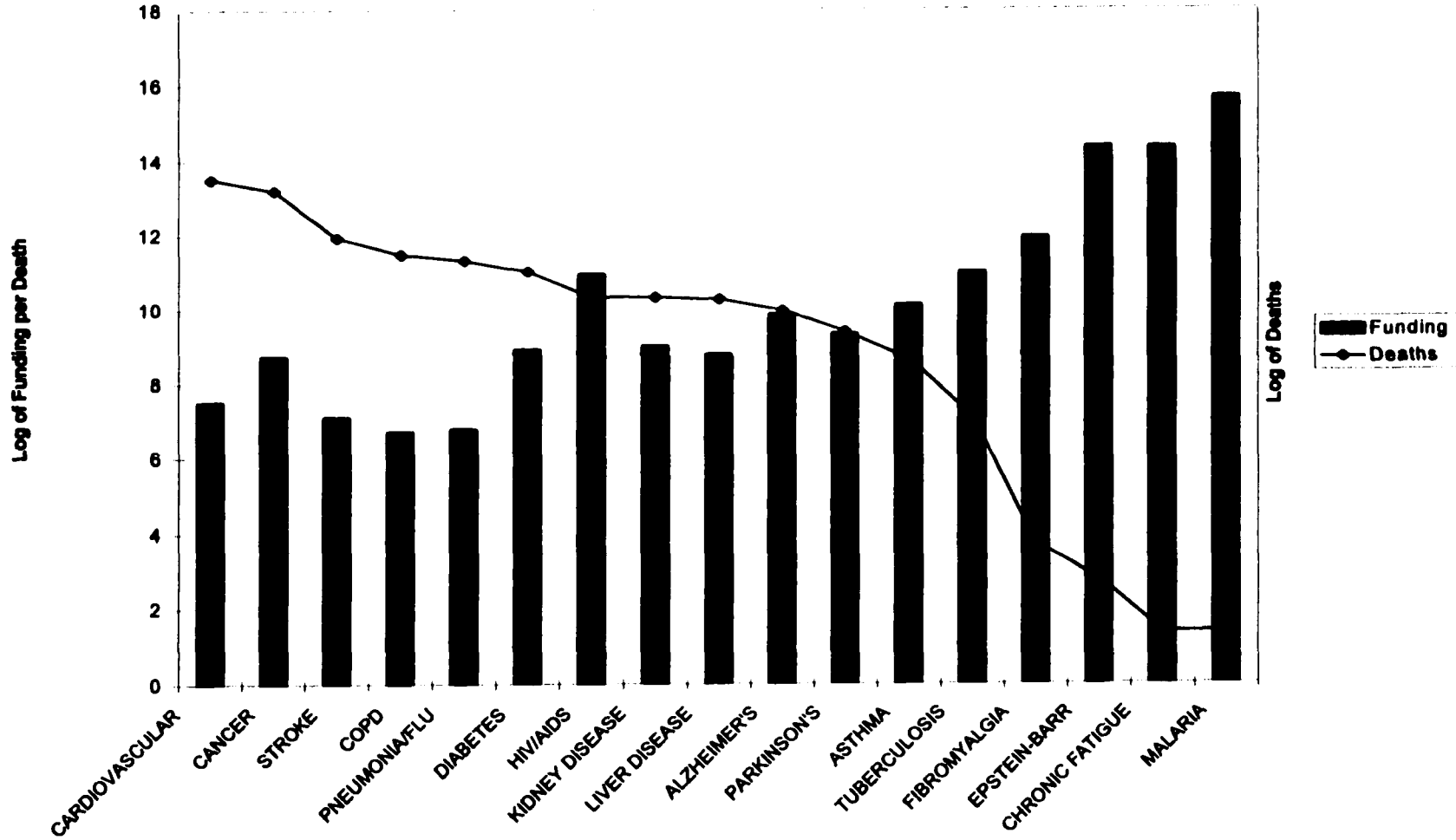

Figure 4.1: Log of Total Deaths (1996) and Funding Per Death by Disease (1999). Source: Office of Communications and Public Liaison, Funding by Selected Categories. Centers for Disease Control, WONDER Mortality Database.

log of 1999 funding per death for seventeen of the forty-two diseases and the log of the number of deaths from that disease in 1996. The top ten causes of death are included, as are the five diseases that caused the fewest deaths in the dataset. If funding is proportional to deaths, then the ratio should be the same for all diseases. As the graph shows, the ratio fluctuates quite a lot. Also, there is something of an inverse relationship depicted: the funding per death increases as the number of deaths declines.

Because the analysis only covers 1999, it was possible to gather other explanatory variables in addition to the number of deaths as a measure of the burden of disease. It was also possible to create variables to measure the effect of special interest group influence and public interest. The National Institutes of Health has an obligation to act in the pubic interest. Ways in which they might do this include such things as reducing the burden of disease on our society and preventing the spread of contagious diseases. There are several possible methods of determining the burden of disease to society, such as the number of deaths from a disease, the incidence of disease, the cost of treatment, the severity of the disease, or lost work time and income foregone to a disease. Burden of disease measures are used to quantify the impact of various diseases on our society.

Total deaths as a measure of the burden of disease have the property that all deaths are equal in their undesirability. The death of one person from any disease is no more important to society than the death of any other person from any other disease. This measure ignores such factors as the age, sex, race, income, or contribution to society of a person when determining the effect of his death on society

as a whole. Using total deaths, then, would mean that the death of a white child was not more important than the death of a black child; the death of an infant was no worse than the death of an eighty-year-old man; the death of the President of the United States was no more devastating than the death of an unemployed woman; and the death of Albert Schweitzer was no different than the death of Adolf Hitler. The complete impartiality of this measure is both an advantage and a disadvantage. If a society values equality and abhors discrimination, it is a suitable ethical measure of the impact of deaths. It is expected that the N.I.H. would spend more money on research for diseases that kill the most people, so this variable should have a positive impact on research funding allocated to a disease.

However, in a purely economic sense, total deaths from a disease may not be the best measure of the burden of that disease to society. Economically speaking, all deaths are not equal. The death of a forty-year-old man is more costly than the death of an eighty-year-old man, because the death of the younger man deprives society of his labor and productivity for a larger number of years. This reduces national income below what it would have been had the man not died. Deaths at earlier ages, then, impose larger costs to society than deaths at later ages. A measure of the burden of disease which takes the age at death into account is the years of life lost to a disease. The total years of life lost (YLL) to a disease is thus weighted by both age of deaths and number of deaths. The years of life lost to each disease in 1996 is also presented in Table 4.1.

Note that this measure is not based on productivity of each individual as is the Disability Adjusted Life Year. The weighting scheme in that construction puts a zero

value on infants (who earn no income), rises over time to age 27, and falls thereafter, approaching zero again at very high ages.[1] The ethical implications of such a construction are staggering. If infants receive zero weight, why not unemployed people, disabled people, prisoners? Years of life lost does not create these ethical dilemma, and is less offensive to our sense of fairness. Distinctions based on age do not create discrimination on the basis of sex, race, religion, or socio-economic status. Within a given age group, all people are treated equally. However, there is no denying that this measure discriminates against older people and heavily favors children. This may be perceived as acceptable discrimination, given that society recognizes the finite nature of life and the inevitability of death at some age. Distributing research dollars among diseases on the basis of years of life lost may be acceptable to society as a whole, but it probably doesn't please older people, who are highly participatory voters. If the N.I.H. attaches more value to the deaths of younger people than to deaths of older people, we would expect the effect of years of life lost on funding to be positive.

Another useful indicator of the burden of disease is provided by the National Hospital Discharge Survey. When patients are discharged from a hospital, the reason for their visit, called a diagnosis code, is recorded by hospital staff. In this survey, the first-listed diagnosis code on the patient's discharge from a hospital is used to construct the number of hospital discharges (Discharges) each year attributable to each disease. This information, also shown in Table 4.1, was available for thirty-four of the forty-two diseases in the study. Inpatient hospitalization is a proxy for both the severity of a disease and the cost of treatment, because hospitalization is reserved for

[1]C.J.L Murray, "Quantifying the Burden of disease: The Technical Basis for Disability-Adjusted Life Years," Bulletin of the World Health Organization, 1994, 72(3):435-436.

very sick people and it is very expensive. Data from the 1996 survey is used in the analysis, because that is the data that would have been available at the time of the initial 1999 budget formulation. We predict that this measure should have a positive impact, if the N.I.H. spends more money on those diseases that make people sickest or require the costliest treatment.

The N.I.H. has a duty to act in the best interest of the public. Another way in which the N.I.H. could perform a public health function is to act to prevent the spread of communicable diseases. Consequently, we might expect to observe that the N.I.H. allocates more research dollars to those diseases which can be transmitted from one person to another. A dummy variable was constructed to indicate whether or not a particular disease was contagious. It is expected that this variable will have a positive coefficient in a regression estimation if prevention of contagion is a consideration of the N.I.H. in making budgetary decisions.

The effect of special interest groups on the research dollar allocation process is measured by constructing several lobbying variables. Special interest group theory argues that organized groups with something to gain from federal regulation will spend money to exert influence with congressmen. Congressmen can reward these special interest group contributors with favorable legislation, and the cost of this legislation is passed on to the millions of taxpayers. This is the principal of concentrated benefits and diversified costs. Data on the existence of a registered lobbyist for a particular disease and the amount of lobbying dollars spent were collected from the Center for Responsive Politics.[2] A tiered variable was designed.

[2] Center for Responsive Politics, "Influence Inc.: Lobbyists' Spending in Washington," Internet. Available from http://www.opensecrets.org/lobby/ (accessed 2 March 2001).

The first dummy variable, LOB, took the value of 1 if there was a registered lobbyist for a disease advocacy group and spending was less than $100,000 during the 1997-1998 election cycle. The dummy variables LOB1 measured the impact of lobbying dollars spent in 1997 and 1998 greater than $100,000 but less than $200,000. The dummy variable LOB2 measured the effect of spending more than $200,000 during 1997-1998. It is predicted that these lobbying expenditures will have a positive effect on research spending for that disease.

4.2 Regression Analysis Using Death Data

The initial regression model for this cross sectional analysis, Model One, was

$$LNFUNDS_{it} = \beta_1 + \beta_2 LNDEATHS_{it-3} + \beta_3 LOB_{t-1} + \beta_4 LOB1_{t-1} + \beta_5 LOB2_{t-1} + \beta_6 COMM + e_i \quad (4.1a)$$

where

$LNFUNDS_{it}$ = Funding in 1999 for disease i

$LNDEATHS_{it-3}$ = Deaths in 1996 from disease i

$LOB_{t-1} = \begin{cases} 1 \text{ if disease advocacy group has a registered lobbyist and spent} < \$100{,}000 \\ 0 \text{ otherwise} \end{cases}$

$LOB1_{t-1} = \begin{cases} 1 \text{ if lobbying dollars} \geq \$100{,}000 \text{ but} < \$200{,}000 \\ 0 \text{ otherwise} \end{cases}$

$LOB2_{t-1} = \begin{cases} 1 \text{ if lobbying dollars} \geq \$200{,}000 \\ 0 \text{ otherwise} \end{cases}$

$COMM = \begin{cases} 1 \text{ if the disease is communicable} \\ 0 \text{ otherwise} \end{cases}$

The results from this regression are shown in Table 4.2. The log-log specification was chosen over the linear model based on the Box-Cox likelihood

estimator test of the relative sizes of the sum of squared errors.[3] The model has an R^2 of 0.5721, and the F-statistic for overall significance of the model is 9.62.

Table 4.2
Cross Section Model One
Using Deaths as Explanatory Variable
Dependent Variable = Log of Funding

	F-Value 9.62 R^2 0.5721	
Variable	Estimate	t-statistic
Intercept	9.1447	20.14*
Lndeaths	0.2264	4.28*
Lob	0.4029	0.95
Lob1	0.6728	1.28
Lob2	1.2466	3.37*
Comm	0.4453	0.97

*significant at the 0.01 level

The coefficient of LNDEATHS is positive and significant, which is what we expected. An increase of one percent in deaths from a disease causes an increase in funding of 0.2264 percent. The LOB and LOB1 variables were insignificant, indicating that very low levels of lobbying expenditures did not have an impact. However, LOB2 was positive and significant, indicating that special interest group influence was effective in increasing funding. Because the amounts of lobbying dollars included in this variable range from $200,000 to $1 million, it is difficult to place an exact numerical impact on the effect of lobbying. However, it is certainly fair to say that those diseases which spend large amounts of money lobbying Congress apparently get increased research funds. This result substantiates the special interest group theory approach to regulation, which is not unexpected.

[3] William E. Griffiths, R. Carter Hill, and George G. Judge, *Learning and Practicing Econometrics*, (New York: John Wiley and Sons, 1993), 345-346.

The public interest group variable COMM, on the other hand, does not have the expected result. The COMM variable, which signifies a contagious disease, does not appear to be an important element in the distribution of research dollars. Its coefficient is not significant. Another interesting point is that the intercept term is large and highly significant. While the intercept term captures the effect of any omitted variables, it also represents the exogenous level of funding allocation to a disease by the N.I.H. The incremental theory of budgetary management discussed in the previous section tells us that the initial decisions about funding levels made by the N.I.H. are likely to be maintained over the years.

4.2.1 Regression Analysis Using Grouped Death Data

Model One postulates a linear relationship between funding and deaths, and one overall intercept term (exogenous funding level) that is the same for all diseases. The study of the panel data in Chapter 3, however, provided substantial evidence that the intercept term is not the same for all diseases and that the relationship between funding and deaths may not be linear. Consequently, we also estimated a step-wise function, which divided the data into groups based on the number of deaths, allowing the relationship between funding and deaths to be different for varying levels of deaths. The equation estimated was:

$$\begin{aligned} LNFUNDS_{it} = {} & \beta_1 + \beta_2 DEATH2_{t-3} + \beta_3 DEATH3_{t-3} + \beta_4 DEATH4_{t-3} \\ & + \beta_5 DEATH5_{t-3} + \beta_6 LOB_{t-1} + \beta_7 LOB1_{t-1} + \beta_8 LOB2_{t-1} + \beta_9 COMM + e_i \end{aligned} \qquad (4.1b)$$

where

$LNFUNDS_{it}$ = Log of funding for disease *i* in 1999

$DEATH2_{t-3}$ = Diseases causing between 2,000 and 9,999 deaths in 1996

$DEATH3_{t-3}$ = Diseases causing between 10,000 and 34,999 deaths in 1996

$DEATH4_{t-3}$ = Diseases causing between 35,000 and 99,999 deaths in 1996

$DEATH5_{t-3}$ = Diseases causing at least 100,000 deaths in 1996

And LOB, LOB1, LOB2, and COMM have interpretations identical to those in Equation 1.1. The omitted (reference) group is diseases which killed less than 2,000 people in 1996.

The results of the estimation are shown in Table 4.3. This estimation gives a clearer and more intuitively-pleasing picture of the relationship between funding and deaths. The coefficient of DEATH2 is not significant, indicating that the number of deaths is not the motivator of funding for diseases which kill relatively few people.

Table 4.3
Death Groups Regression Results
Dependent Variable = Log of Funding

R^2 0.5640 F-statistic 5.34		
Variable	Estimate	t-statistic
Intercept	10.2033	32.82*
Death2	0.5047	1.20
Death3	1.1238	2.61*
Death4	1.2381	2.34*
Death5	2.0689	3.43*
Lob	0.6408	1.37
Lob1	0.5401	0.97
Lob2	1.3924	3.63*
Comm	0.6779	1.39

*significant at the 0.01 level.

The coefficients of DEATH3, DEATH4, and DEATH5 are all positive and significant; what is equally informative is that the coefficients become larger as the number of deaths increases. This makes sense. The coefficient of DEATH5 is almost twice as large as the coefficient of DEATH3. These results tell us, then, that the relationship between funding for a disease and deaths from that disease becomes stronger as the number of deaths increases.

The special interest group variables have the same signs and significances as they did in the previous regression. That is, neither LOB nor LOB1 was significant; but LOB2 had a coefficient that was positive and significant, supporting the theory that large amounts of lobbying dollars do alter funding outcomes. As before, the communicable disease variable, COMM, is not significant. This is puzzling.

4.2.2 Regression Analysis Using Legislative Variables

The analysis of the forces driving the allocation of research funding was expanded to include more specific Congressional influence variables based on information taken from the Congressional Record. Legislators of the 105th Congress (1997-1998) enacted the appropriations bills for the N.I.H. and its component institutes for fiscal year 1999. An examination of the index of bills introduced and those that became law gives us some indication of the direction which Congress wishes the N.I.H. to take in research.

Consequently, the Congressional Record for the 105th Congress was searched for all bills pertaining to the N.I.H. in general, any institutes or offices of the N.I.H., and all forty-two of the specific diseases in the data set. Two dummy variables were created. One, labeled INTRO, indicated that a bill supporting additional research on a specific disease had been introduced in that Congress; the other, PASSED, indicated that a bill pertaining to that specific disease had become public law. Our goal was to test the hypothesis that members of Congress directly affect the research allocation decisions of the N.I.H. by either introducing or passing legislation. The equation in Model One was modified to include these additional variables:

$$LNFUNDS_{it} = \beta_1 + \beta_2 LNDEATHS_{it-3} + \beta_3 LOB3_{t-1} + \beta_4 BILL_i + e_i \quad (4.1c)$$

where in Estimate One:

$$BILL_i = \begin{cases} 1 \text{ if a bill supporting research in disease i was introduced} \\ 0 \text{ otherwise} \end{cases}$$

and in Estimate Two:

$$BILL_i = \begin{cases} 1 \text{ if a bill specifically designating research on disease i passed} \\ 0 \text{ otherwise} \end{cases}$$

The remaining variables have the same interpretation as they did in Equation 4.1.

The results of the modified regression, shown in Table 4.4, do not support the hypothesis that the N.I.H. altered 1999 research allocations in response to Congressional interest in pushing research on a particular disease. While there were a number of bills introduced recommending increases in funding for particular diseases, very few passed into law. These few did not have enough impact to substantially affect the distribution of funds by the N.I.H. Neither INTRO nor PASSED was significant in any regression.

Table 4.4
Regression Including Legislative Variables
Dependent Variable = Log of Funding

Variable	Estimate 1	t-statistic	Estimate 2	t-statistic
Intercept	9.1451	19.88*	9.1471	19.83*
Lndeath	0.2257	4.20	0.2260	4.20*
Lob	0.3608	0.76	0.3974	0.91
Lob1	0.6557	1.22	0.6721	1.26
Lob2	1.2021	2.83*	1.2378	3.17*
Comm	0.4466	0.96	0.4479	0.96
BILL (Intro)	0.0829	0.22	-	-
BILL (Passed)	-	-	0.0436	-0.08
R^2	0.5727		0.5721	

*significant at the 0.01 level

As in the earlier regression, LOB2 continued to be both significant and positive. An examination of the relationship between lobbying and the introduction or passage of bills was informative, as there was a significant, positive correlation

between both INTRO and LOB2 and between PASSED and LOB2. Separate regressions using INTRO and PASSED in place of LOB2 still did not produce estimates which were significant. It is logical that lobbying affects the introduction and passage of bills in Congress. The relationship between the introduction of bills and the direction of N.I.H. spending is less clear.

4.3 Regression Analysis Using Years of Life Lost Data

The regression model was altered by using years of life lost (YLL) as the measure of burden of disease instead of total deaths from a disease. Years of life lost is calculated as follows:

$$YLL = \sum_{x=0}^{x=l} d_x e_x \qquad (4.2a)$$

where x = age

l = the last age group

e_x = life expectancy at age x in the United States in 1996

d_x = deaths at age x in the United States in 1996

The age groups are those used by the Centers for Disease Control in its WONDER Mortality Database. Twelve groups were used; the youngest group is "under 1 year" and the oldest group is "over 85 years". The life expectancy used was that provided by the U.S. National Center for Health Statistics. In this calculation for YLL, both decreases in the age of death and increases in the number of deaths will cause years of life lost to become larger. Thus resulting equation, **Model Two,** was estimated as

$$LNFUNDS_{it} = \beta_1 + \beta_2 LNYLL_{it-3} + \beta_3 LOB_{t-1} + \beta_4 LOB1_{t-1} + \beta_5 LOB2_{t-1} + \beta_6 COMM + e_i \qquad (4.2b)$$

where LNYLL = log of years of life lost to disease *i* in 1996, and LOB, LOB1, LOB2 and COMM have the same definitions as in Equation 4.1.

The results for Model Two are shown in Table 4.5, and are almost identical to those of Model One. The R^2 is 0.5586, with the overall F-value being 9.11. The variables have the same sign, the same significance, and almost the same coefficients as in the model using total deaths as the measure of burden of disease. Years of life lost as a measure of the burden of disease does not appear to be any more or any less important to the N.I.H. than total deaths from a disease. Thus we cannot infer that the N.I.H. places more emphasis on researching the diseases that kill younger people as opposed to the elderly.

Table 4.5
Cross Section Model Two
Using Years of Life Lost as Explanatory Variable
Dependent Variable = Log of Funding

	F-Value 9.11 R^2 0.5586	
Variable	Estimate	t-statistic
Intercept	8.4337	13.42*
Lnyll	0.2299	4.08*
Lob	0.4243	0.98
Lob1	0.6307	1.19
Lob2	1.2840	3.43*
Comm	0.4319	0.92

*significant at the 0.01 level

4.4 Regression Analysis Using Hospital Discharge Data

The third regression model, **Model Three**, used the number of hospital discharges for each of the disease codes during the year 1996 as the measure of burden of disease. The equation estimated was:

$$LNFUNDS_{it} = \beta_1 + \beta_2 LNDISCH_{it-3} + \beta_3 LOB2_{t-1} + e_i \qquad (4.3)$$

where LNDISCH was the log of hospital discharges having a first-listed diagnosis code corresponding to disease *i*. Hospitals code each patient by the primary cause requiring hospitalization. This information is then collected for use in the National Hospital Discharge Survey. The LOB2 variable has the same definition as before, that is, lobbying expenditures greater than $200,000. LOB, LOB1, and COMM were dropped from this model, because they were never significant and they reduced the degrees of freedom below thirty unnecessarily. The results are shown in Table 4.6.

Table 4.6
Cross Section Model Three
Using Hospital Discharges as Explanatory Variable
Dependent Variable = Log of Funding

	F-Value 10.51 R^2 0.4040	
Variable	Estimate	t-statistic
Intercept	10.3205	20.47*
Lndisch	0.2496	2.12**
Lob2	1.0758	2.49**

*significant at the 0.01 level. **significant at the 0.05 level.

The National Hospital Discharge Survey provided data on the number of discharges for thirty-four of the forty-two diseases in the cross section. Data on discharges for chronic fatigue syndrome, sexually transmitted diseases, malaria, autism, ALS, sudden infant death syndrome, cervical cancer, and epilepsy were not collected by the National Center for Health Statistics. However, the results of this regression were still quite similar to those of Models One and Two. The overall model R^2 was lower, 0.4040, but the variables retained their signs and significance. Hospital discharges had a similar elasticity to both total deaths or years of life lost with respect to disease research funding; when hospital discharges increased one

percent, funding increased 0.25 percent. Lobbying was only slightly less profitable than in earlier models.

4.5 Regression Analysis Using Combined Data

Combined regressions were performed using various combinations of deaths, hospital discharges, and years of life lost. However, these variables are so highly correlated that only one measure of the burden of disease was ever significant in any equation. Pearson correlation coefficients are shown in Table 4.7. The results of these combined regressions are shown in Table 4.8.

Table 4.7
Combined Model Correlation Coefficients
(Prob > |r| under H_0: Rho = 0)

Variable	lndeaths	lnyll	lndisch
Lndeaths	1.0000	0.9778 <.0001	0.6990 <.0001
Lnyll	0.9778 <.0001	1.0000	0.6678 <.0001
Lndisch	0.6990 <.0001	0.6678 <.0001	1.0000

Table 4.8
Combined Model Regression Results
Dependent Variable = Log of Funding

Variable	Estimate	t-statistic
Intercept	9.5314	6.22*
Lndeaths	0.3694	1.07
Lnyll	-0.1206	-0.33
Lndisch	0.0042	0.03
Lob2	1.0222	2.53*
Comm	0.1265	0.24

*significant at the 0.01 level.

Hospital discharges became insignificant, whether combined with deaths, years of life lost, or both. Also, deaths and years of life lost are so closely correlated (Pearson correlation coefficient = 0.977) that both became insignificant when used

together. As in previous regressions, COMM was never significant, and LOB2 always significant. No added information was gained from combining the models.

4.6 Cost of Illness Analysis

Another important measure of the burden of disease on American families is the cost of treating the disease. Estimates of the direct costs of treating various diseases are shown in Table 4.9. These estimates are taken from a report entitled Disease-Specific Estimates of Direct and Indirect Costs of Illness and N.I.H. Support" prepared by the N.I.H. in response to a request by the Senate Committee on Appropriations (Senate Report 103-318) seeking an explanation of the societal costs of various diseases. The report was compiled from data obtained by the separate Institutes and allows wide flexibility in the computation of both direct and indirect costs, resulting in cost estimates that are "uneven and essentially non-comparable."[4] The N.I.H. does not view economic costs as a significant factor to evaluate when making research funding allocation decisions.[5] However, an examination of the relationship between research funding on a disease and the cost of treatment for that disease is informative, as even crude cost estimates provide another valuable measure of the burden of disease on society.

Another data set was compiled using the information in the Cost of Illness report. It was not possible to use the same forty-two diseases as were used previously, because cost data was not available for all of them. The cost estimate data set contains twenty-six of the original forty-two diseases, plus six additional diseases for which

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[4] Office of the Director, "Disease-Specific Estimates of Direct and Indirect Costs of Illness and N.I.H. Support," Bethesda, Md.: N.I.H., 1997, p. 2.
[5] Disease-Specific Estimates, p4.

Table 4.9
Cost of Illness Data

Disease	Funds*	Direct Costs*	Deaths
Allergic Rhinitis	$ 1,020	$ 1,211,000	1
Alzheimer's	244,000	9,345,800	21,397
Arthritis	143,340	10,833,900	2,908
Asthma	8,427	7,648,200	5,667
Cancer	2,027,190	21,040,600	539,508
Breast Cancer	284,930	5,049,700	43,447
Cervical Cancer	45,140	459,100	4,540
Colorectal Cancer	105,580	4,973,200	56,496
Lung Cancer	97,900	3,902,100	152,007
Ovarian Cancer	39,260	688,600	13,342
Prostate Cancer	106,540	3,596,000	34,122
Stroke	111,640	17,362,000	153,041
Liver Disease	119,090	1,115,200	28,881
COPD	59,840	13,251,500	98,647
Diabetes	274,670	27,276,600	61,766
Gallbladder	7,620	4,089,200	2,816
Peptic Ulcer	6,240	3,345,700	1,958
Epilepsy	49,040	2,138,300	1,338
Cardiovascular	753,900	61,104,400	733,262
HIV/Aids	76,050	8,043,200	31,123
Spinal Cord Injury	95,320	7,127,600	5,821
Kidney Disease	186,070	24,349,400	30,586
Multiple Sclerosis	57,920	1,835,500	2,291
Obesity	97,000	33,858,300	2,097
Osteoporosis	82,050	9,055,100	1,172
Otitis Media	4,860	2,006,900	37
Parkinson's	79,410	1,425,500	11,845
Pneumonia/Flu	44,660	11,164,500	83,717
Psoriasis	3,120	2,024,300	17
Septicemia	9,900	3,006,100	21,679
Sickle Cell	30,310	393,700	507
Tuberculosis	43,760	514,000	1,202

Source: Office of the Director, Estimate of Direct and Indirect Costs of Illness and N.I.H. Support. *in thousands of 1984 dollars.

both cost and funding data were available. The diseases included in this data set are also shown in Table 4.9. The table also shows the deaths from each disease. The analysis was limited to direct economic costs of treatment, as the methods of calculating indirect costs were too inconsistent to permit their use.

A regression analysis was performed using the following equation:

$$LNFUNDS_{it} = \beta_1 + \beta_2 LNCOST_{it-3} + e_i \qquad (4.4)$$

where

$LNFUNDS_{it}$ = Log of 1999 research funding for disease i

$LNCOST_{it-3}$ = Log of 1996 direct costs of treating disease i

The results of the regression analysis are shown in Table 4.10. The model has an R^2 of 0.2982 and an overall F-statistic of 12.75. The coefficient of LNCOST is positive and significant, with an estimate of 0.6839. This estimate represents the elasticity of funding with respect to direct cost of treatment, so that a one-percent increase in costs causes a 0.6839 percent increase in funding for that disease. This result is consistent with the results obtained using the larger cross-sectional data set of forty-two diseases with the other measure of burden of disease. Given the N.I.H.'s claim that it does not consider the cost of treating an illness as a criterion for allocating research funding, this result is surprising. But the cost of treatment may be serving as a proxy for omitted variables. For example, there is a strong positive relationship between funding and cost of treatment.

Table 4.10
Cost of Illness Regression Results
Dependent Variable = Log of Funding

F Value 12.75 R^2 0.2748		
Variable	Estimate	t-statistic
Intercept	-3.7709	-9.93*
Lncost	0.6839	3.57*

*significant at the 0.01 level

4.7 Conclusions

These regressions reveal that the National Institutes of Health is behaving rationally when allocating research funds. Allocations are highly correlated with both total deaths from a disease and years of life lost to a disease. Both of these findings are consistent with previous research. However, we find that allocation is also responsive to hospitalization required by a disease; this was not found to be the case in the only recent other recent study of N.I.H. distribution of research funds (Gross et al.). Using the direct cost of treatment for a disease as a measure of the burden of disease exhibited rather low explanatory power in explaining funding, when compared to the other measures of burden of disease. The N.I.H. does not assign much weight to the cost of treating a disease, even though it is a valid element of the burden of disease and, therefore, part of the public interest theory paradigm.

Neither the impact of special interest groups nor public interest variables has really been studied in this context before. We find that the N.I.H. does respond to political pressure from special interest groups; lobbying plays a role in budget allocations. Given that the N.I.H. is a government agency responsible to politicians, this is not a surprise. What is surprising is that the communicability of a disease does not appear to increase research funding on that disease. We should note that while the Congressional bills introduced and bills passed did not influence current funding, this negative finding should be cushioned by the fact that political influence may occur in Congressional Committees rather than on the floor of Congress. We consider this subject in the next chapter.

CHAPTER 5

GEOGRAPHIC DISTRIBUTION OF RESEARCH FUNDS

5.1 Introduction

This chapter analyzes the allocation of N.I.H. research funding across the fifty states for the most recent year data is available. This allows us to measure the influences of Congressional politics on funding allocation while holding the influence of important state characteristics constant. It is also informative to determine what state characteristics have a significant impact on N.I.H. funding decisions. The equation to be estimated in this case is:

$$LNFUNDS_{it} = F(\text{State Characteristics}_{t-1}, \text{Congressional Politics}_{t-1}) \quad (5.1)$$

where State Characteristics are:

$LNFUNDS_i$ = N.I.H. research funding for state *i* in 1999

$LNPOP_i$ = Log of population of state *i* in 1998

LMD_i = Log of number of Medical Doctors in state *i* in 1998

$MEDS_i$ = Medical Schools in state *i*

$$TIER = \begin{cases} 1 \text{ if State has a Tier 1 or Tier 2 research university} \\ 0 \text{ otherwise} \end{cases}$$

$COTH_i$ = Number of teaching hospitals in state *i*

and Congressional Politics are (for 105^{th} Congress):

$$CHM_i = \begin{cases} 1 \text{ if Committee chairman is from state } i \\ 0 \text{ otherwise} \end{cases}$$

$$RANK_i = \begin{cases} 1 \text{ if Ranking committee member is from state } i \\ 0 \text{ otherwise} \end{cases}$$

$$SUB_i = \begin{cases} 1 \text{ if subcommittee chairman is from state } i \\ 0 \text{ otherwise} \end{cases}$$

$$SFIN_i = \begin{cases} 1 \text{ if Senator from state } i \text{ is on Senate Finance Committee} \\ 0 \text{ otherwise} \end{cases}$$

$$SHELP_i = \begin{cases} 1 \text{ if Senator from state } i \text{ is on Senate Health, Education, Labor and Pensions Committee} \\ 0 \text{ otherwise} \end{cases}$$

HWM_i = Number of Representatives from state *i* on House Ways and Means Committee

$HAPP_i$ = Number of Representatives from state *i* on House Appropriations Committee

$HCOM_i$ = Number of Representatives from state *i* on House Commerce Committee

5.2 State Characteristics Variables

The dependent variable in all regressions is the log of 1999 N.I.H. research funding awarded to state *i*. There are a number of state characteristics that must be considered when evaluating research funding distribution. States with larger populations are likely to receive more funding from the N.I.H. than smaller states because of more research grant proposals or larger Congressional delegations. Therefore state population is included as an explanatory variable. However, differences in population cannot completely explain the variation in funding across states, as shown in Figure 5.1. The figure plots the log of per capita funding for the states receiving the most and the least funding in 1999. As Figure 5.1 shows, there is still a large variation in funding awarded to each state even after adjusting for population.

States which have a higher number of doctors are likely to submit more research proposals to the N.I.H., and the proportion of awards made to MDs has risen over the last fifteen years. We expect that greater numbers of MDs will cause an increase in funding to that state, but we recognize that the number of MDs is

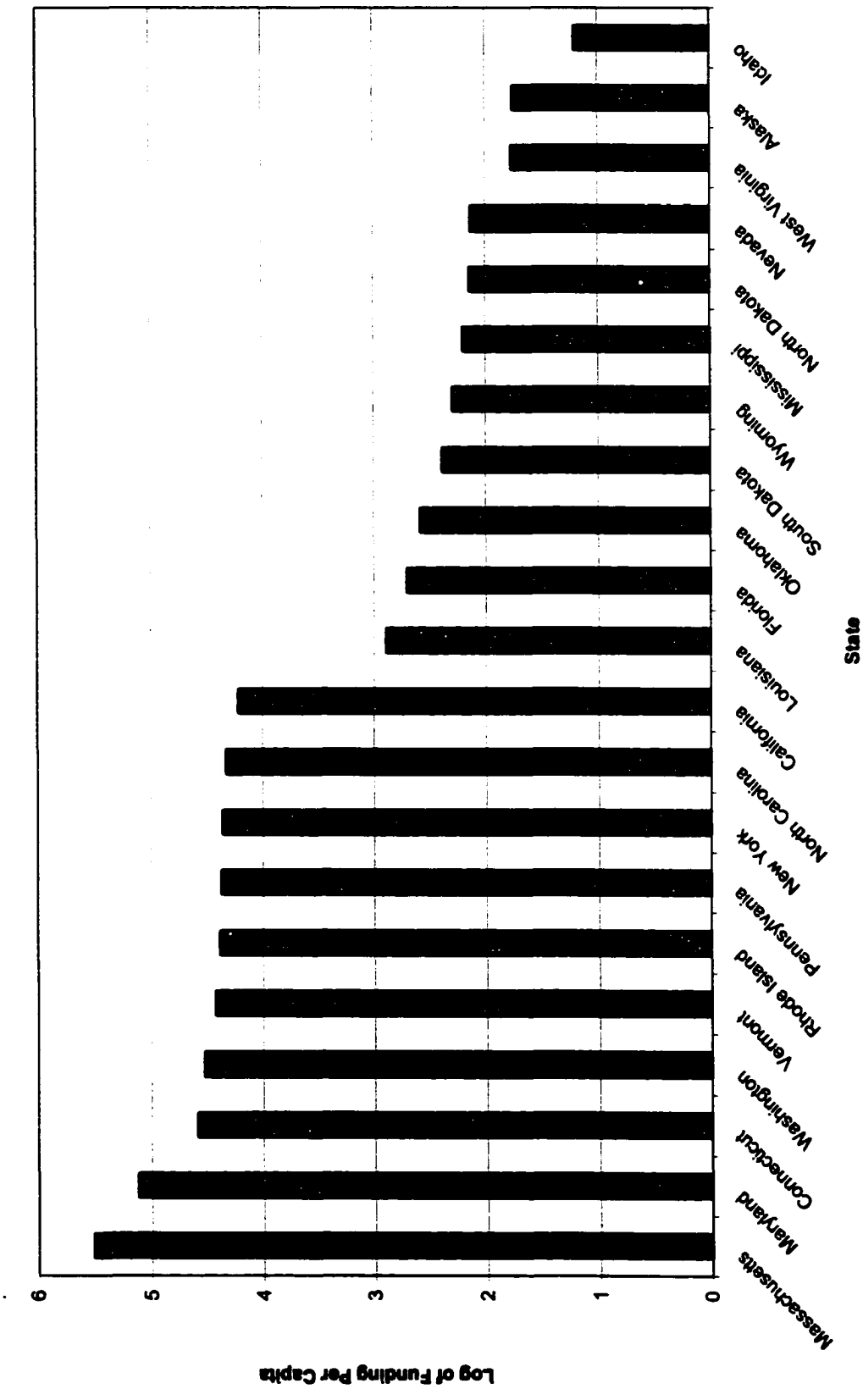

Figure 5.1: Log of Funding Per Capita (1999) by State. Source: Office of Extramural Research, N.I.H. Awards by State.

positively correlated with state population, so the measured effect of MDs may be reduced due to multicollinearity. Similarly, much research is carried out at accredited teaching hospitals, so the variable COTH, which is the number of hospitals in the state accredited by the American Association of Medical Colleges Council on Teaching Hospitals, should have a positive sign in a regression estimation.

The quality of research institutions in the state is another factor which should logically influence the amount of research money a state gets. Data on the ranking of research universities was obtained from the Princeton Review (1998). TIER is a dummy variable indicating the presence of Tier 1 and Tier 2 research universities in each state. MEDS measures the number of accredited medical schools in the state, according to the American Association of Medical Colleges. Frequently, a medical school is part of a Tier 1 or Tier 2 institution, so these variables are correlated with MEDS. We expect that all three of these variables should have a positive impact on funding.

5.3 Congressional Politics Variables

A number of variables were constructed to attempt to measure Congressional influence in the distribution of N.I.H. research awards among the states. There are two Senate Committees and three House of Representatives Committees which have some control over health issues in general or the N.I.H. in particular. Membership, chairmen, and ranking member statistics are for the 105th Congress elected in 1996. Do the states with positions on these powerful committees receive additional funding?

The Senate Finance Committee is primarily known as the tax-writing body of the Senate, but it also oversees general health care policies and issues. The committee

chairman was Roth (R-Delaware) and the ranking member was Moynihan (D-New York). The Subcommittee on Health Care chairman was Craig (R-Idaho) and the ranking member was Kennedy (D-Massachusetts). There are sixteen members on the Finance Committee.

The Senate Health, Education, Labor and Pensions Committee is specifically responsible for public health and biomedical research and development, among many other responsibilities. The chairman was Jeffords (R-Vermont) and the ranking member was Kennedy (D-Massachusetts). There are three subcommittees which influence the National Institutes of Health: Aging, Children and Families, and Public Health. The chairman of the Aging Subcommittee was DeWine (R-Ohio), and the ranking member was Mikulski (D-Maryland). For Children and Families, the chairman was Gregg (R-New Hampshire), and the ranking member was Dodd (D-Connecticut). Finally, the chairman of the Public Health Subcommittee was Frist (R-Tennessee), and the ranking member was Kennedy (D-Massachusetts).

In the House of Representatives, the three committees which affect the N.I.H. are Appropriations, Commerce, and less directly, Ways and Means. The Appropriations Committee sets the budget for the N.I.H. It was chaired by Young (R-Florida), while the ranking member was Obey (D-Wisconsin). The Labor, Health and Human Services, Education, and Related Agencies Subcommittee was chaired by Porter (R-Illinois) and ranking member Obey.

The House Commerce Committee has primary responsibility for overseeing and directing federal health care issues, including biomedical research. The chairman was Bliley (R-Virginia) and the ranking member was Dingell (D-Michigan). The

Health and Environment Subcommittee was chaired by Bilirakis (R-Florida) and the ranking member was Brown (D-Ohio).

Finally, the House Ways and Means Committee controls matters relating to health care payments made by the government and public health delivery systems. Its chairman was Archer (R-Texas) and the ranking member was Rangel (D-New York). The Health Subcommittee was chaired by Thomas (R-California), with the ranking member being Stark (D-California).

We have constructed several variables to determine if positions on these committees and subcommittees affects the distribution of awards. The variable CHM is a dummy variable indicating that a delegate from state *i* is chairman of a committee. SUB indicates that a delegate from state *i* is chairman of a subcommittee. RANK indicates that a delegate from state *i* is the ranking members of a committee or relevant subcommittee. Finally, the variables SFIN, SHELP, HAPP, HCOM, and HWM measure membership on one of the five committees with some influence over the N.I.H. or health care. If members of Congress use their positions to help institutions in their states receive grants, then we would expect all or some of these variables to have positive signs.

5.4 Regression Results

The results of the geographic distribution regression are shown in Table 5.1. The model has an R^2 of 0.8957, telling us that the model explains the great majority of the variation in funding across states. The model is in logarithmic form, so the coefficients represent elasticities. As expected, LNPOP has a significant positive impact on the funding a state receives. The elasticity of funding with respect to

population is 1.1729; an increase of one percent in population causes an increase in funding of slightly more than 1.17 percent. Surprisingly, the coefficient on LMD is also significant and positive. An increase of one percent in the number of doctors causes a 1.2921 percent increase in research funding. States with a higher number of doctors do receive additional funding, and an increase in the number of doctors is slightly more important than an increase in population.

Table 5.1
Results of Geographic Regression
Dependent Variable = Log of Funding

	F-Value 39.26 R^2 0.8957	
Variable	Estimate	t-statistic
Intercept	-5.5379	-2.43*
Lnpop	1.1729	6.74*
Lmd	1.2921	3.02*
Tier	0.6477	2.96*
Chm	0.0480	0.14
Sub	-0.3261	-1.25
Rank	0.1480	0.58
Shelp	0.6769	3.56*
Sfin	-0.2628	-1.37
Happ	-0.0587	-0.47
Hcom	-0.0218	-0.19
Hwm	0.0945	0.76

*significant at the 0.01 level

Evidently, the quantity of research institutions does not drive funding allocations. Neither the number of medical schools (MEDS) nor the number of teaching hospitals (COTH) was ever significant.

The presence of a Tier 1 or Tier 2 research university has a significant positive effect on funding, as expected; apparently, the quality of research institutions does

matter. States with high-quality institutions are getting more research dollars than states without such institutions.

Among the Congressional variables, neither the holding of a chairmanship (CHM, SUB) nor being the ranking member (RANK) was significant. For the committee membership variables, only membership on the Senate Health, Education, Labor and Pensions Committee had a significant positive influence on state funding. Membership on the House Ways and Means (HWM) Committee was sometimes weakly significant.

While these results indicate that contemporary leadership and membership on Congressional committees does not play a major role in the allocation of N.I.H. research funding across the states, it must be remembered that the N.I.H. is subject to incremental budgeting and that the current allocation of N.I.H. funds across the states may have been influenced by the leadership and membership composition of Congressional Committees from earlier years.

5.5 Conclusions

There is some objective justification for the discrepancies in funding across states. States with larger populations, more doctors and nationally respected research universities receive more funds than other states. However, Congressional influence seems to play a role in funding distribution, as states which have membership on the Senate HELP committee have higher funding. As we concluded in Chapter 4, the N.I.H. is behaving rationally when allocating funds.

CHAPTER 6

REGRESSION ANALYSIS USING MICRO-DATA

6.1 Introduction

In addition to the data on N.I.H. research funding per disease which was analyzed earlier, another data set was compiled using micro-level data. The N.I.H. maintains a database on government-funded research projects entitled Computer Retrieval of Information on Scientific Programs (CRISP). Each individual research project funded by the N.I.H. is entered into this database by title, author, and subject. It is possible to do a subject search for each disease of interest to retrieve the grants awarded to do research on that disease.

A year-by-year search of the CRISP database was performed in order to duplicate the data on research funding collected earlier. Entering the subject "Alzheimer's disease" and the year "1990", for example, will result in 458 hits. Each hit represents a research project on Alzheimer's disease. This process was repeated for each of the twenty-one diseases in the original data set for the years 1987 - 2001. The diseases are listed in Table 6.1.

The number of grants awarded in a given subject area is a crude measure of the emphasis placed on that disease by the N.I.H. It is possible for a grant to have multiple subject listings; for example, a research project may cover two or more related diseases. There is no way to prevent this double counting when using the CRISP data set; however, there is no reason to believe that projects in any one disease area are more or less likely to contain multiple subjects than projects in any other area.

Table 6.1
Diseases in Data Sets

15 Year Data	10 Year Data	1999 Cross Section
Alzheimer's	Alzheimer's	Alzheimer's
Asthma	Asthma	Asthma
Breast Cancer	Breast Cancer	Breast Cancer
Chronic Fatigue	All Cancer	Cancer
Cystic Fibrosis	Chronic Fatigue	Cardiovascular
Diabetes	Cystic Fibrosis	Chronic Fatigue
Epstein-Barr	Diabetes	Cystic Fibrosis
HIV/Aids	Epstein Barr	Diabetes
Hypertension	HIV/Aids	Epstein Barr
Kidney Disease	Hypertension	HIV/Aids
Lupus	Kidney	Hypertension
Osteoporosis	Lupus	Kidney Disease
Parkinson's	Osteoporosis	Lupus
Prostate Cancer	Parkinson's	Osteoporosis
STD's	Prostate Cancer	Parkinson's
Sickle Cell	STD's	Prostate Cancer
Spinal Cord	Sickle Cell	STD's
Stroke	Spinal Cord	Sickle Cell
SIDS	Stroke	Spinal Cord
Tuberculosis	SIDS	Stroke
	Tuberculosis	SIDS
	COPD	Tuberculosis
	Liver Disease	COPD
	Lung Cancer	Liver Disease
	Pneumonia/Influenza	Lung Cancer
	Schizophrenia	Pneumonia/Influenza
		Schizophrenia
		ALS
		Arthritis
		Autism
		Ovarian Cancer
		Fibromyalgia
		Hepatitis C
		Malaria
		Multiple Sclerosis
		Muscular Dystrophy
		Nutritional Problems
		Obesity
		Cervical Cancer
		Colorectal Cancer
		Epilepsy
		Septicemia

The number of awards included in this analysis is quite large, varying from about 8,800 in 1987 to slightly over 31,000 in 2000.

6.2 Fifteen Year Pooled Data Regression

A regression was performed using the number of grants awarded in a disease area as the dependent variable for the years 1987-2001. The model was specified to be a one-way fixed effects model, which allows the intercept to vary across diseases but not over time. The omitted disease is tuberculosis, as it was in the earlier panel data regressions. The equation estimated for Model One was:

$$LNGRANTS_{it} = \beta_1 + \sum_{j=1}^{N-1} \delta_j D_{jt} + \beta_2 YR + \beta_3 DRATIO_{it-3} + \beta_4 DYR + \beta_5 DYRDTH_{it} + \beta_6 CDEM + \beta_7 PDEM + e_{it} \qquad (6.1)$$

where

$LNGRANTS_{it}$ = the log of the number of grants to disease *i* in year t

$DRATIO_{it-3}$ = the number of deaths from disease *i* in year *t* divided by the total number of deaths for all diseases in year *t*

YR = time trend

$$D_{jt} = \begin{cases} 1 \text{ if disease i=j} \\ 0 \text{ otherwise} \end{cases}$$

$$DYR = \begin{cases} 1 \text{ if the year is 1999, 2000, 2001} \\ 0 \text{ otherwise} \end{cases}$$

$DYRDTH_{it}$ = $DYR * DRATIO_{it-3}$

$$CDEM_{t-1} = \begin{cases} 1 \text{ if Democrats control the Congress in year t-1} \\ 0 \text{ otherwise} \end{cases}$$

$$PDEM = \begin{cases} 1 \text{ if the President is a Democrat} \\ 0 \text{ otherwise} \end{cases}$$

The dependent variable is LNGRANTS, which is the log of the number of grants awarded in a particular disease area each year. The public interest variable is DRATIO, which is the number of deaths from disease *i* divided by the total number of deaths each year from all included diseases. Using this measure of the burden of disease prevents increases in the number of deaths each year from affecting the results.

A glance at Figure 6.1, Total Dataset Grants Over Time, shows that the number of grants increased over the period. We include a time trend, YR, to capture the incremental budgeting effect. In addition, there are several distinct breaks in the curve. We attempted to explain these changes using dummy variables. In 1998

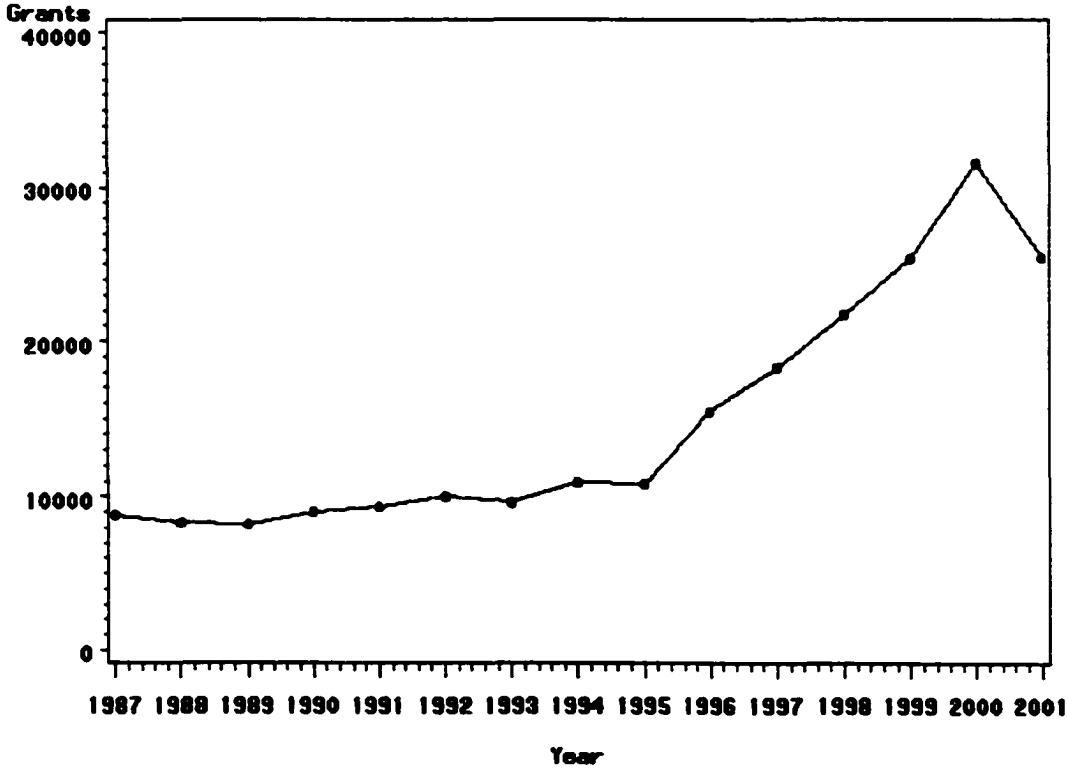

Figure 6.1: Total Dataset Grants Over Time. Source: Office of Extramural Research, Computer Retrieval of Information on Scientific Projects.

Congress voted to establish a goal of doubling the N.I.H. budget between 1999 and 2003. The dummy variable DYR takes the value of one for the years 1999, 2000, and 2001, and is zero in earlier years. The DYR variable measures the impact of this decision by Congress on the various diseases. The DYRDTH variable captures any interaction between DRATIO and DYR.

Two political dummy variables are included: CDEM and PDEM. These variables measure Democratic party control over the Congress and the Presidency, respectively, during the year when budget decisions are made (t-1). If the Democrats have control, the variables have a value of one; otherwise they take the value of zero. Both the House of Representatives and the Senate were controlled by Democrats from 1986-1994; after the elections in 1994, both bodies were controlled by Republicans (1995-2000). The President was a Republican from 1986-1992 and a Democrat from 1993-2000.

The results of this regression are presented in Table 6.2, along with the results of the original regression over this same time period. The regression using CRISP data performs reasonably well; it has an R^2 of 0.7912. The cross-sectional (disease-specific) intercept effects are almost identical; thirteen of the same eighteen diseases have intercepts which differ significantly from that of tuberculosis, and the signs are the same as those is the funding regression in Chapter 3. There are two differences in the CRISP regression and the funding regression: first, the sign for SIDS is positive in the funding regression, but negative in the CRISP regression. The explanation for this may lie in the crudeness of the number of grants as a measure of allocation, or in the method of retrieving the number of grants (searching by disease subject listing). The

Table 6.2
Comparison of Fifteen Year Data Regression Results
Dependent Variable = Log of Grants (CRISP Model)
Dependent Variable = Log of Funding (Funding Model)

Variable	CRISP Model		Funding Model	
	Estimate	t-statistic	Estimate	t-statistic
Alzheimer's	1.6832	7.21*	2.4993	16.24*
Asthma	0.8122	3.84*	1.1084	8.08*
Breast Cancer	1.8317	4.78*	2.4693	9.41*
Chronic Fatigue	-1.1483	-5.46*	-1.6679	-12.24*
Cystic Fibrosis	0.4546	2.16**	1.0001	7.35*
Diabetes	2.1290	5.02*	2.7550	9.42*
Epstein-Barr	0.0370	0.18	-0.0437	-0.32
HIV/Aids	2.2844	8.66*	4.0043	22.64*
Hypertension	1.9407	8.86*	2.0703	14.39*
Kidney Disease	2.1190	7.20*	2.2381	11.27*
Lupus	0.3320	1.58	0.4329	3.18*
Osteoporosis	0.5376	2.56**	1.4129	10.38*
Parkinson's	0.7095	3.28*	1.2938	9.19*
Prostate Cancer	0.9392	3.01*	1.0357	4.90*
STD's	0.2735	1.30	1.5348	11.26*
Sickle Cell	0.3462	1.65	0.8206	6.03*
Spinal Cord	1.1927	5.63*	0.9156	6.66*
Stroke	1.4826	1.30	1.7077	2.14**
SIDS	-1.2022	-5.69*	0.7814	5.70*
Intercept	3.8530	15.89*	8.6366	54.98*
Yr	0.1071	4.74*	0.1006	6.88*
Dratio	-0.8960	-0.31	-0.2619	-0.06
Dyr	0.6683	4.97*	0.1130	-1.30
Dyrdth	0.3175	0.32	1.2010	0.88
Cdem	0.3432	2.63*	0.1741	2.06**
Pdem	-0.2025	-1.40	-0.0053	-0.06

*significant at the 0.01 level. **significant at the 0.05 level.

other difference is that in the funding regression, the intercepts for lupus, sickle cell disease, sexually transmitted diseases, and stroke do vary significantly from that of tuberculosis, while in the CRISP regression, this is not the case.

Another similarity between the regression using CRISP data and that using research funding is that in both regressions, the time trend is significant and positive, supporting the incremental budgeting theory. With disease dummy variables included

in the model, the number of deaths from a disease has no explanatory power; DRATIO is not significant in either model. This lack of significance for DRATIO was confirmed using joint F-tests for DRATIO and DYRDTH. PDEM is never significant in the fifteen year models.

The political dummy variable CDEM, which measures the effect of Democratic control of Congress during the period, is positive and significant in both models. This give us important additional evidence that politics does matter in determining funding; both models show a decrease in funding after the Republicans took control of Congress.

The dummy variable DYR is positive and significant in the CRISP model, but not in the funding model. The decision by Congress to substantially increase N.I.H. funding beginning in 1999 had a positive impact on the number of grants. The discrepancy between the CRISP result and the funding model result on this variable may be due to the crudeness of number of grants as a funding estimate, or the number of grants may have varied more than the amount of funding at that time. DYRDTH is not significant in either model. Overall, the CRISP data confirms the results of our earlier estimation using funding dollars as the dependent variable.

6.3 Ten Year Pooled Data Regression

The CRISP data was expanded to include twenty-seven diseases for the years 1992-2001, to provide a basis for comparison with the ten year data set regressions results presented earlier. The diseases are listed in Table 6.1. The equation estimated below for Model Two was the same as that estimated previously in Equation 6.1; all of the variables have the same meanings.

The results for this ten year panel data are shown in Table 6.3, along with the results from the ten year regression using dollar funding. The CRISP model has an R^2

Table 6.3
Comparison of Ten Year Data Regression Results
Dependent Variable = Log of Grants (CRISP Model)
Dependent Variable = Log of Funding (Funding Model)

	CIRSP Model		Funding Model	
Variable	Estimate	t-statistic	Estimate	t-statistic
Alzheimer's	1.2490	4.32*	1.8360	20.65*
Asthma	0.4181	1.64	0.4942	6.29*
Breast Cancer	1.2150	2.76*	2.0042	14.80*
Cardiovascular	-0.6581	-0.11	3.3323	1.73
Chronic Fatigue	-1.5573	-6.14*	-2.2042	-28.26*
Cystic Fibrosis	0.0721	0.28	0.1888	2.42**
Diabetes	1.3406	2.55**	1.8837	11.64*
Epstein-Barr	-0.4482	-1.77	-0.9128	-11.70*
HIV/Aids	1.7492	5.03*	3.3099	30.94*
Hypertension	1.3099	4.91*	1.1772	14.33*
Kidney Disease	1.3027	3.77*	1.3837	13.01*
Lupus	-0.2470	-0.98	-0.4289	-5.51*
Osteoporosis	0.1959	0.77	0.7117	9.14*
Parkinson's	0.2743	1.04	0.5486	6.79*
Prostate Cancer	0.4698	1.26	0.6717	5.85*
STD's	-0.1508	-0.60	-0.7222	9.26*
Sickle Cell	-0.1778	-0.70	-0.0715	-0.92
Spinal Cord	0.5766	2.26**	0.0222	0.28
Stroke	0.3569	0.28	1.0084	2.61*
SIDS	-1.7631	-6.93*	-0.1335	-1.71
COPD	-1.2820	-1.57	0.0046	0.02
Liver Disease	1.0003	2.88*	1.1560	10.82*
Lung Cancer	0.3101	0.24	0.9540	2.42**
Pneumonia/Influenza	0.1051	0.14	0.1368	0.60
Schizophenia	0.6364	2.51**	0.9379	12.03*
Intercept	3.4403	11.67*	10.1988	125.66*
Yr	4.4088	8.63*	0.0467	3.06*
Dratio	0.4284	0.35	-0.7688	-0.20
Dyr	-0.2859	-1.61	0.0626	1.14
Dyrdth	-0.0567	-0.06	0.0804	0.28
Cdem	1.1541	7.20*	0.0153	0.31
Pdem	-0.7663	-5.14*	0.0277	0.60

*significant at the 0.01 level. **significant at the 0.05 level

of 0.7993. The cross-sectional effects are somewhat different in the two models. In the CRISP regression, only eleven diseases have intercepts which differ significantly from that of tuberculosis, compared to nineteen in the funding data regression. The signs on the significant coefficients are the same in both models.

The time trend is positive and significant in the both the regression using CRISP grants and the regression using funding dollars as the dependent variable, providing support for the incremental budgeting theory. Neither DYR nor DRYDTH is significant in either model. However, the time-based political dummy variables CDEM and PDEM are both significant in the CRISP model; only CDEM was significant in the funding model. Given our earlier results in the fifteen year panel data (both CRISP and funding models), these ten year CRISP data regression estimation results lend more support to the idea that political factors do influence funding. We certainly cannot conclude that there are no political effects at work.

Also, the public interest variable DRATIO is not significant in either model when disease dummy variables are included in the model. While there are more differences between the CRISP model and the funding model for the ten year data than there are for the fifteen year data, the important result that initial levels of funding for diseases are maintained over time (incremental budgeting) is supported by both models; as is the result that politics matters in the funding process.

6.4 Cross-Sectional Data Regression

Finally, CRISP grant award data was used to replicate the results of the 1999 cross-sectional analysis presented earlier in Table 4.2. The diseases in the cross section are listed in Table 6.1. The number of grants awarded in forty-two disease

categories served as the dependent variable. The equation estimated for Model Three was:

$$LNGRANTS_i = \beta_1 + \beta_2 LNDEATHS_{it-3} + \beta_3 LOB_{t-1} + \beta_4 LOB1_{t-1} + \beta_5 LOB2_{t-1} + \beta_6 COMM \quad (6.3)$$

where

$LNGRANTS_i$ = log of the number of grants awarded to disease *i* in 1999

$LNDEATHS_{i-3}$ = log of the number of deaths from disease *i* in 1996

$LOB = \begin{cases} 1 \text{ if the disease had a registered lobbyist group which spent less than \$100,000} \\ 0 \text{ otherwise} \end{cases}$

$LOB1 = \begin{cases} 1 \text{ if disease advocates spent between \$100,000 and \$200,000 lobbying} \\ 0 \text{ otherwise} \end{cases}$

$LOB2 = \begin{cases} 1 \text{ if disease advocates spent over \$200,000} \\ 0 \text{ otherwise} \end{cases}$

$COMM = \begin{cases} 1 \text{ if a disease is communicable} \\ 0 \text{ otherwise} \end{cases}$

The dependent variable is the log of the number of grants awarded to disease *i* in 1999. The public interest variables are the log of the number of deaths from disease *i* in 1996 (LNDEATHS), and COMM, indicating whether or not a disease is contagious. The special interest group variables here are LOB, LOB1, and LOB2. LOB has a value of one if a disease has a registered lobbyist and spent less than $100,000 lobbying during the 1997-1998 election cycle, and a value of zero otherwise. LOB1 represents lobbying expenditures between $100,000 and $200,000, and LOB2 represents lobbying expense above $200,000 during the 1997-1998 election cycle. It is not possible to use CDEM and PDEM in a cross-sectional analysis, because the controlling party does not change.

The results of the cross-sectional regression are presented in Table 6.4, along with the results of the earlier regression using funding as the dependent variable. There are some differences. The CRISP model has a much smaller R^2, 0.4001 versus 0.5721 for the funding model. However, in both models, the public interest variables have the same signs and significance. LNDEATHS is positive and significant, as expected, indicating that both funding levels among diseases and the number of grants awarded in 1999 are related to the burden of disease on the public. LOB2 is significant and positive in both models; the other special interest group variables are always insignificant. Very low levels of lobbying do not appear to result in additional funding for any disease, while high lobbying levels do provide a reward.

Table 6.4
Comparison of Cross Sectional Data Regression Results
Dependent Variable = Log of Grants (CRISP Model)
Dependent Variable = Log of Funding (Funding Model)

Variable	CRISP Model		Funding Model	
	Estimate	t-statistic	Estimate	t-statistic
Intercept	4.7794	11.33*	9.1447	20.14*
Lndeaths	0.1400	2.83*	0.2264	4.28*
Lob	0.0704	0.18	0.4029	0.95
Lob1	0.6511	1.35	0.6728	1.28
Lob2	0.8750	2.55**	1.2466	3.37*
Comm	0.3382	0.80	0.4453	0.97

*significant at the 0.01 level. **significant at the 0.05 level

The CRISP data was also used to replicate the cross-sectional regressions using years of life lost (YLL) and the number of hospital discharges (DISCHARGES) as explanatory variables. The results of the estimation using YLL is shown in Table 6.5. The CRISP regression reproduces the results using funding as the dependent variable quite well. Both the burden of disease measure, years of life lost (LNYLL), and LOB2, representing large lobbying dollar amounts, were significant and positive in

Table 6.5
Comparison of Cross Section Results Using YLL
Dependent Variable = Log of Grants (CRISP Model)
Dependent Variable = Log of Funding (Funding Model)

Variable	CRISP Model		Funding Model	
	Estimate	t-statistic	Estimate	t-statistic
Intercept	4.4334	7.53*	8.4337	13.42*
Lnyll	0.1329	2.51**	0.2299	4.08*
Lob	0.0895	0.22	0.4243	0.98
Lob1	0.6145	1.25	0.6307	1.19
Lob2	0.9172	2.64**	1.2840	3.43*
Comm	0.3367	0.78	0.4319	0.92

*significant at the 0.01 level. **significant at the 0.05 level

both regressions. The remaining variables, LOB, LOB1, and COMM, were not significant in either regression.

The estimation of the hospital discharge equation was also repeated using the number of grants as the dependent variable. These results are shown in Table 6.6. Once again, the reduced number of cross-sectional observations (thirty-four), made it necessary to eliminate some explanatory variables. Consequently, only discharges (LNDISCH), the large lobbying variable (LOB2), and the contagious disease variable (COMM) were included in this estimation. The results using the CRISP grant data are similar to the results achieved using the funding data. Lobbying has a positive, significant impact on funding in both models. COMM is not significant in either model. Surprisingly, the coefficient on discharges (LNDISCH) is not significant in the model using CRISP data, whereas it is significant in the funding model. This represents the only major difference in the cross-sectional results between the CRISP models and the models using funding as the dependent variable.

Table 6.6
Comparison of Cross Section Results Using Discharges
Dependent Variable = Log of Grants (CRISP Model)
Dependent Variable = Log of Funding (Funding Model)

Variable	CRISP Model		Funding Model	
	Estimate	t-statistic	Estimate	t-statistic
Intercept	5.6812	12.38*	10.2517	19.57*
Lndisch	0.1249	1.19	0.2560	2.14**
Lob2	0.7079	1.87**	1.0814	2.48**
Comm	0.3098	0.63	0.3239	0.57

*significant at the 0.01 level. **significant at the 0.05 level

6.5 Conclusions

The use of the micro-level data provided by the CRISP grants registry was helpful in confirming the results obtained using the macro-level funding data. In all three regressions, using fifteen year panel data, ten year panel data, and 1999 cross-sectional data, the CRISP regression results generally validated our earlier results. The level of N.I.H. funding varies significantly across the various diseases. When the influence of the diseases are accounted for, the disease death ratio (DRATIO) has no influence on N.I.H. grant decisions. When disease dummy variables are not included in the model, the disease death ratio has a significant, positive influence on N.I.H. grants, which is consistent with the public interest hypothesis.

The CRISP data analysis provided solid supplemental support for the incremental budgeting theory and special interest group theory; the time trend and the large lobbying variable were always significant and positive. In addition, the CRISP results bolstered our confidence in the result attained with the fifteen year panel data funding model that political factors influence funding. Considering our pooled data CRISP models and our pooled data funding models together, we found evidence that politics mattered in three of the four regressions.

CHAPTER 7

SUMMARY AND CONCLUSIONS

The National Institutes of Health is the largest biomedical research facility in the world, and the largest non-military research agency of the United States federal government. The N.I.H. received over $20 billion in tax-dollar funding for the fiscal year 2001; the decisions made by the N.I.H. about funding priorities affect the lives of all Americans. Consequently, an analysis of the resource allocation process at the N.I.H. is of substantial interest.

Our model hypothesizes that the N.I.H. policy-makers follow a combination of public interest, incremental budgeting, and special interest group economic theory. They must respond to both the health care demands of the public, as well as the political demands of Congress, the President, disease advocacy associations, patients, and other special interest groups. Our primary goals are to determine whether the N.I.H. is responding to the burden of disease on the U.S. population when making resource allocation decisions, to evaluate the role of political and special interest groups in the allocation process, to determine whether or not the N.I.H. follows the incremental budgeting model, and to examine the distribution of research funds across states as well as across diseases. We used both pooled time-series cross-sectional data and pure cross-sectional data to perform our analyses.

When analyzing panel data on research funding for a pool of twenty-one diseases during the period 1987-2001, we found evidence that the N.I.H. considers the death ratio from a disease as a significant factor in making the initial funding allocations. Our results indicated that these initial allocations are maintained over

time, and that the N.I.H. does not alter the distribution of funding in response to changing death patterns. We identified persistent variations in the levels of funding across diseases, even after controlling for deaths. We included a time trend variable to explicitly test for the incremental budgeting effect, and found it to be present. Our results both substantiate and amplify the work of Niskanen (1971) and Weston (1994), who found some evidence of incrementalism. Our study, however, is the first to use disease-level data in this context, eliminating the institute-disease identification problem present in the work of Mushkin (1979) and Weston (1994). We also found that the shift from a Democratic Congress to a Republican Congress in 1995 reduced funding.

This analysis was repeated using ten years of data (1992-2001) for twenty-seven diseases. This data set included heart disease, chronic obstructive pulmonary disease, pneumonia and influenza, and liver disease, which are major causes of death in the United States. Our study was the first to include all of these diseases, and the first to include all of the top ten causes of death over the last fifteen years in the U.S. Including these diseases in such a study greatly improves the relevance of the results. No previous study considered such data in this quantity or detail. Our results substantiate the incremental budgeting theory; after initial allocations are made, the funding allocations do not appear to change significantly in response to deaths. We did find, however, that the shift from a Democratic to Republican Congress did not have a significant effect in this regression. Our results concerning political influence, then, were mixed; however, we cannot exclude the possibility that politics plays a role in funding allocations.

We performed an extensive cross-sectional analysis of the N.I.H. research funding allocation among forty-two diseases for the fiscal year 1999. We included four measures of the burden of disease (deaths, years of life lost, hospital discharges, and communicability) as explanatory variables representing the public interest. Three of these measures had significant positive impacts on research funding allocations, providing support for the argument that the N.I.H. is now allocating funds, at least in part, in accordance with public interest theory. Our findings were slightly different than those of Gross et al. (1999), who found that both deaths and years of life lost mattered, but that hospital discharges were not significant. However, our cross-section included fifty percent more diseases than theirs, and the disease categories were more specific, which may account for the difference. The communicability of a disease was not considered by Gross et al.; surprisingly, we never found it to be a significant factor in determining research funding allocation.

Our study is the first to consider the effect of the direct cost of treatment (another measure of the burden of disease) on research funding allocations. An analysis of a cross-section of thirty-four diseases also found a significant, positive relationship between the cost of treating a disease and research funding, even though the N.I.H. does not explicitly consider this measure of the burden of disease when making allocation decisions.

In addition, we expanded the 1999 cross-sectional analyses to include variables to measure the impact of lobbying efforts on the allocation process. We found that diseases which had extensive Congressional lobbying expenses received additional funding, providing support for the special interest group theory of government

behavior. Although Stigler (1974), Peltzman (1976), and Becker (1983) developed special interest group theory and applied it in other forums, ours is the first to include a quantitative evaluation of the effect of lobbying on research funding at the N.I.H. We also evaluated the effect of the introduction of bills in Congress requesting additional research funding for specific diseases, but found no evidence to support the hypothesis that the introduction of a bill affected current N.I.H. funding.

We examined the distribution of research funding for fiscal year 2000 across the fifty individual states to determine whether the distribution depended entirely on quantifiable factors, or whether political factors played a role. None of the earlier work on the N.I.H. considered the distribution across states. We identified six state characteristic variables which could justify an increased level of funding, as well as eight Congressional political variables which might affect the funding a state receives. Our results provided support for both the public interest and special interest group theories of allocation. The population, number of medical doctors and the quality of research institutions in the state were significant and positive factors in a state's funding level; however, having a Senator on the Senate Health, Labor, Education, and Pensions Committee apparently contributed to an increase in the state's funding. Whether this effect was entirely due to current membership on the Committee, or was an accumulated effect incorporating membership in prior years, or whether this variable acted a proxy for some other omitted variable, could not be determined.

Finally, we replicated our evaluations of all three of the disease-related data sets (fifteen-year panel, ten-year panel, and 1999 cross section) using micro-level data obtained from the CRISP registry of individual N.I.H. grant awards. The number of

grants included in the study varied from 8,800 to over 31,000. Our results using grants as the dependent variable measuring N.I.H. spending on a disease essentially substantiated our earlier results, especially our conclusions regarding the presence of incremental budgeting and the influence of lobbying. One result was that using the CRISP data for both the fifteen and ten year datasets, we found evidence that the change from a Democratic Congress to a Republican Congress reduced funding. Thus, in three of our four pooled data regressions, we found evidence that politics does affect research funding. This confirmation of our macro-level results boosts our confidence in the validity of our findings. While Lichtenberg (1996) was the first to use CRISP data in a cross-sectional evaluation of research funding, we have expanded the application by incorporating panel data from the CRISP database.

A number of additional issues remain to be examined concerning the N.I.H. The N.I.H. is improving its record-keeping and data-processing methods in response to Congressional and public concerns. This, in turn, will improve our ability to evaluate the allocation process in the future. The N.I.H. has been advised by Congress to be more explicit in their consideration of the burdens of disease when making allocation decisions, and more communicative about the allocation process.

Our study does not include data on the incidence or prevalence of various diseases, because the data available is spotty and inconsistent; for many diseases, no government records are available for either incidence or prevalence. This is critical information that needs to be compiled and made readily available for future researchers in order to comprehensively evaluate public policy on research allocation among diseases.

The relationship between Congress and the N.I.H. warrants further study. We hope to evaluate the role of Congress in determining changes in the direction of N.I.H. research. In addition, the issue of selectivity bias needs to be addressed. We need access to information about both the funded and unfunded N.I.H. research grant applications to more fairly and completely analyze the research priorities of the N.I.H.

As the population of the United States ages during the 21st century, the National Institutes of Health will play a progressively larger role in improving the health of the American people. A thorough understanding of the N.I.H. decision-making process and the research agency's priorities will be an essential part of managing our own health, and therefore, our lives.

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APPENDICES

Appendix A

Table A.1
Leading Causes Of Death

	1	2	3	4	5	6	7	8	9	10
1984	Heart Disease	Cancer	Stroke	Accidents	COPD	Pneumonia/ Influenza	Diabetes	Suicide	Liver Disease	Kidney Disease
1985	Heart Disease	Cancer	Stroke	Accidents	COPD	Pneumonia/ Influenza	Diabetes	Suicide	Liver Disease	Kidney Disease
1986	Heart Disease	Cancer	Stroke	Accidents	COPD	Pneumonia/ Influenza	Diabetes	Suicide	Liver Disease	Kidney Disease
1987	Heart Disease	Cancer	Stroke	Accidents	COPD	Pneumonia/ Influenza	Diabetes	Suicide	Liver Disease	Kidney Disease
1988	Heart Disease	Cancer	Stroke	Accidents	COPD	Pneumonia/ Influenza	Diabetes	Suicide	Liver Disease	Kidney Disease
1989	Heart Disease	Cancer	Stroke	Accidents	COPD	Pneumonia/ Influenza	Diabetes	Suicide	Liver Disease	Homicide
1990	Heart Disease	Cancer	Stroke	Accidents	COPD	Pneumonia/ Influenza	Diabetes	Suicide	Liver Disease	HIV/Aids
1991	Heart Disease	Cancer	Stroke	COPD	Accidents	Pneumonia/ Influenza	Diabetes	Suicide	HIV/Aids	Homicide
1992	Heart Disease	Cancer	Stroke	COPD	Accidents	Pneumonia/ Influenza	Diabetes	HIV/Aids	Suicide	Homicide
1993	Heart Disease	Cancer	Stroke	COPD	Accidents	Pneumonia/ Influenza	Diabetes	HIV/Aids	Suicide	Homicide
1994	Heart Disease	Cancer	Stroke	COPD	Accidents	Pneumonia/ Influenza	Diabetes	HIV/Aids	Suicide	Liver Disease
1995	Heart Disease	Cancer	Stroke	COPD	Accidents	Pneumonia/ Influenza	Diabetes	HIV/Aids	Suicide	Liver Disease

Source: National Center for Health Statistics, Vital Statistics, annual.

(table continued)

1996	Heart Disease	Cancer	Stroke	COPD	Accidents	Pneumonia/ Influenza	Diabetes	HIV/Aids	Suicide	Liver Disease
1997	Heart Disease	Cancer	Stroke	COPD	Accidents	Pneumonia/ Influenza	Diabetes	Suicide	Kidney Disease	Liver Disease
1998	Heart Disease	Cancer	Stroke	COPD	Accidents	Pneumonia/ Influenza	Diabetes	Suicide	Kidney Disease	Liver Disease

Source: National Center for Health Statistics, Vital Statistics, annual.

Appendix B

Computation Of Dummy Variable Estimates

1. Let $\ln y = \beta_1 + \beta_2 x + \delta D + e$

   where

   $$D = \begin{cases} 1 \\ 0 \end{cases}$$

2. Then $\ln y_1 = (\beta_1 + \delta) + \beta_2 x_1$. When $D = 1$, and $\ln y_0 = \beta_1 + \beta_2 x_0$ when $D = 0$.

3. Then $\ln y_1 - \ln y_0 = \delta$.

4. Then $\ln(\frac{y_1}{y_0}) = \ln y_1 - \ln y_0 = \delta$.

5. Then $\frac{y_1}{y_0} = e^{\delta}$.

6. Therefore, $\frac{y_1 - y_0}{y_0} = e^{\delta} - 1$.

7. The percent change in $y = e^{\delta} - 1$ when $D = 1$ versus $D = 0$.

Appendix C

Table C.1
N.I.H. Budget Fiscal Year 1999

Institute	Amount*
National Cancer Institute	$2,900,435
National Heart, Lung and Blood Institute	1,781,389
National Institute of Dental and Craniofacial Research	238,163
National Institute of Diabetes and Digestive and Kidney Diseases	996,189
National Institute of Neurological Disorders and Stroke	898,521
National Institute of Allergy and Infectious Diseases	1,575,065
National Institute of General Medical Sciences	1,196,798
National Institute of Child Health and Human Development	752,909
National Eye Institute	396,634
National Institute of Environmental Health Sciences	388,228
National Institute on Aging	599,741
National Institute of Arthritis and Musculoskeletal and Skin Diseases	307,080
National Institute on Deafness and Other Communication Disorders	231,295
National Institute of Mental Health	854,640
National Institute on Drug Abuse	607,579
National Institute on Alcohol Abuse and Alcoholism	259,030
National Institute of Nursing Research	69,985
National Human Genome Research Institute	268,901
National Center for Research Resources	554,270
National Center for Complimentary and Alternative Medicine	49,967
Fogarty International Center	35,391
National Library of Medicine	181,131
Office of the Director	43,436
Building and Facilities	6,100
TOTAL	**$15,597,189**

Source: N.I.H., http://www4.od.nih.gov/ofm/budget/. * in thousands of dollars.

Appendix D

Table D.1
N.I.H. Research Funding By Selected Categories

Research/Disease Areas	Amount*
AIDS	$1,215,000
ALS	17,200
Alzheimer's Disease	406,500
Arthritis	238,800
Asthma	140,400
Autism	40,000
Cancer	3,377,300
Breast Cancer	474,400
Lung Cancer	163,000
Ovarian Cancer	65,400
Prostate Cancer	177,500
Cardiovascular Research	1,327,100
Chronic Fatigue Syndrome	6,700
Cystic Fibrosis	71,600
Diabetes	457,600
Epstein-Barr Syndrome	27,100
Fibromyalgia	6,400
Hepatitis C	39,700
Hypertension	175,400
Kidney Disease	247,900
Lupus	46,100
Malaria	25,300
Multiple Sclerosis	96,300
Muscular Dystrophy	16,700
Nutrition	587,500
Obesity	161,400
Osteoporosis	136,700
Parkinson's Disease	132,300
Schizophrenia	200,600
Sexually Transmitted Diseases	136,400
Sickle Cell Disease	50,400
Spinal Cord Injury	62,100
Stroke	186,000
Sudden Infant Death Syndrome	49,300
Tuberculosis	72,800

Source: N.I.H., http://www4.od.nih.gov/ofm/diseases/. * in thousands of dollars.

VITA

Janet Daniel graduated Magna Cum Laude with a B.A. in English from Louisiana State University, and then received a Master of Business Administration degree. She worked for several years as a financial analyst in private industry, and then taught as an instructor in the Department of Freshman English at L.S.U. She entered the graduate program in Economics at L.S.U. in the fall of 1993. As an instructor in the Economics Department, she has taught Introduction to Macroeconomics, Introduction to Microeconomics, and Money and Banking, and received an Excellence in Teaching Award. Janet received her Doctor of Philosophy degree in Economics in December, 2001.

DOCTORAL EXAMINATION AND DISSERTATION REPORT

Candidate: Janet B. Daniel

Major Field: Economics

Title of Dissertation: An Economic Analysis of the Allocation of Research Funding at the National Institutes of Health

Approved:

William J. Moore
Major Professor and Chairman

Dean of the Graduate School

EXAMINING COMMITTEE:

R. Carter Hill

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Date of Examination:

October 24, 2001