The Role of Politically Motivated Subsidies on University Research Activities

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Since WWII, the federal government has played a significant role in funding basic and applied research at universities. During the initial growth of research funding, the issues surrounding which universities would be the recipients of federal funding were not addressed by the government. As such, by the late 1970s, a majority of research funding was concentrated in a few universities located within a few states. This article examines two politically motivated methods used since 1980 to affect the distribution of funding on research activities, namely, congressional earmarks and set-aside programs. The results suggest that there has been a modest change in the distribution of research funding across research and doctoral universities, especially since 1990. Funding from earmarked appropriations has increased the quantity of academic publications but decreased the quality of these publications as measured by citations per publication. At those universities that qualified for funding under the set-aside programs, however, the quality of publications has increased whereas the quantity of publications has decreased.

Keywords: *research funding; research productivity; politics of funding*

SINCE WWII, the federal government has played a significant role in funding basic and applied research. Recognizing that research and development (R&D) is important for economic growth, the federal government increased

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its role in funding R&D activities, in part by funding university-based research. Today, R&D funding is distributed by several agencies, with the key agencies being the National Institutes of Health (NIH), the National Science Foundation (NSF), the Department of Defense, and the Department of Agriculture. In general, agencies have adopted a peer-reviewed process for distributing research funding to universities. This process attempts to elicit information from researchers engaged in similar research about the quality of the projects for which funding is sought. This process in part seeks to minimize the politics associated with federal agencies and Congress.

Federal research funding represents more than 60% of research funding received by research universities. Although after WWII the federal government was interested in promoting R&D as one means to strengthen economic development, the issues surrounding which universities would be the recipients of federal funding were not addressed. By the late 1970s, a majority of research funding was concentrated in a few universities located within a few states. In 1978, for example, 50% of federal research funding was distributed to 6 states and 80% of the funding was distributed to 18 states.[1]

Although research by Goldin and Katz (1999) suggests that concentration of research funding at a few universities can be traced to historical developments prior to World War II, the high concentration of research funding has been heavily criticized. The peer-reviewed process has been criticized as fostering an "old-boys'" network whereby the universities that have historically received research funding continue to receive high levels of funding, despite the lack of quality research proposals. Another criticism of the high concentration of funding stems from the concern that without a sufficient level of R&D funding, state or regional economic development is constrained. Given these concerns, the inevitable question becomes what can be done to reduce the concentration of funding without sacrificing the quality of research supported by this funding.

The purpose of this article is to explore how the distribution of research funding across universities has changed over the past 30 years as well as to explore the effects of two types of funding programs that were initiated in the early 1980s to combat the problems associated with high levels of concentration of research funding on research activities. The first "program" is known as earmarking and consists of a line item in the federal budget or accompanying documents that specifies a designated amount to be allocated to a

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particular university. In general, a university lobbies members of Congress for the earmarked funding. Earmarked funds have been used for such things as the renovation of a college dormitory, the establishment of a public policy institute named after a particular senator or member of Congress, or the building of a research laboratory.

The second program is one that was first initiated by the NSF and has since been adopted by most of the agencies responsible for distributing federal research funding. This program is one that targets universities in states that have historically received low levels of funding. The program offers competitive grants designed to help build the infrastructure needed for the universities to compete effectively in the general grant programs within the agencies.

Using data that span from 1973 to 1998 (1980 to 1998 with respect to earmarked funding), this article examines the effect of the earmarked funding and set-aside programs on the distribution of funding and on research activity. During this period, on average, \$3.6 million (real dollars, using 1996 as the base year) was allocated for research-oriented earmarked funding per university. Average total federal research funding to universities not located in a state that qualified for the set-aside program was \$39 million. Average total federal research funding to universities located in a state that qualified for the set-aside program was \$16 million.

The results suggest that there has been a modest change in the distribution of research funding across research and doctoral universities, especially since 1990. In general, average funding per university increased at a slightly faster rate at universities identified as Research II or Doctoral II under the Carnegie Foundation for the Advancement of Teaching (1994) classification than the rate for universities classified as Research I. The results further suggest that funding from earmarked appropriations increased the quantity of academic publications but decreased the quality of these publications as measured by citations per publication. Those universities that qualified under the set-aside programs, however, increased the quality of their publications while decreasing the quantity of publications produced.

This article is set forth as follows. The first section provides an overview of the distribution of federal research funding and the data gathered for this article. The second section presents a discussion of changes in the distribution of research funding. The third section presents an econometric analysis of the effect of changes in funding on academic research activities under the two programs. Separate analyses are presented for the effect of earmarked funding and the set-aside programs.

OVERVIEW OF THE DISTRIBUTION OF FEDERAL RESEARCH FUNDING

Although each agency operates somewhat differently, the essence of the programs used to distribute research funding are similar. Before an agency can distribute funding, it must first be allocated the funding through the federal budget. The budget represents the agreement between members of Congress and the president. A history of the research funding process and the role of the federal government may be found in Drew (1985), Geiger (1993), and Kleinman (1995).

With respect to discretionary funding, the appropriations committee is responsible for developing the budget and for providing guidance to the federal agencies. Because membership on the appropriations committee is a highly coveted position, once appointed, members tend to serve on the committee for several years. Thus, the members develop an expertise, and the relationship between the members and the heads of the federal agencies is long-standing. As such, one should expect the members on the appropriations committees and the agencies to be strategic in their budget requests and allocations.

The agency is responsible for allocating that funding as designated in the budget documents. The level of agency discretion over the use of its funds varies across agencies.

To receive a federal research grant, a researcher must submit an application to the agency responsible for distributing the funding. Thus, for the university to receive a grant, the researcher must be given the incentive to apply for the grant by the university, and the researcher must decide that it is worth his or her time and expense to develop a grant proposal.

Congressional Earmarking

Apart from the usual budgeting process whereby an agency receives funding to support its programs, members of Congress may divert funds to particular individuals, firms, or institutions. An earmark represents a funded amount identified in the appropriations bills or accompanying reports that is allocated to one or more universities. Earmarked funds are transferred to the agency, and the agency is expected to allocate these funds as per the language designated in the bill or the reports.[2]

Earmarks are used in a variety of ways for R&D activities. Many earmarks are designated for institutes, laboratories, and other capital-intensive projects. Earmarks are also awarded for smaller, discrete research projects. It is not unusual for these smaller projects to be related to a larger capital-intensive earmarked grant or to receive earmarked funding for multiple years.

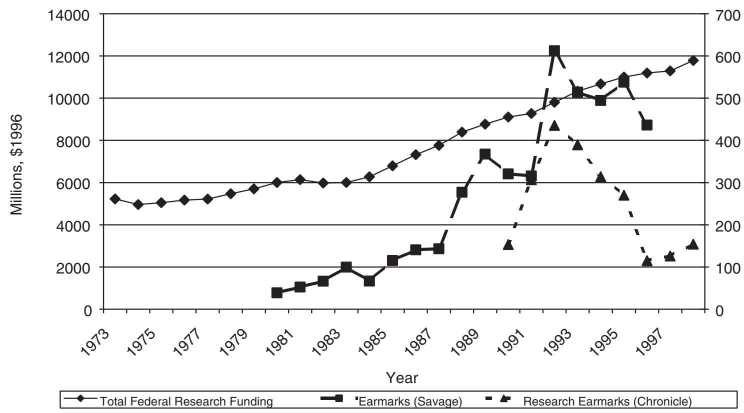

Figure 1. Federal Funding Over Time, Research and Doctoral Universities
Note. Earmarks are measured along the right axis.

Proponents claim earmarking allows universities that are not "traditional" recipients of federal research funding to build the infrastructure necessary to compete for peer-reviewed funding. Others believe this type of funding distribution represents pork-barrel allocations that are not used as productively as peer-reviewed funding.[3]

To seek an earmark, a university must ask for special treatment by a member of Congress. In general, a university will identify a set of projects for which it would like funding. These projects can include such things as establishing a new academic program or school, building a research laboratory, renovating a dormitory, or funding a particular research project. Although individuals and researchers within the university may be interested in receiving an earmark, the top administrators at the university usually decide for which projects they will seek funding. Once a university has constructed its list of ideal earmarked projects, it will then employ resources to lobby members of Congress for the earmarked funding. Thus, given the process associated with seeking an earmark, this raises the question of whether there is a difference in quality between the projects that receive earmarked funding and the projects that receive funding under the more traditional peer-reviewed competition.

Figure 1 depicts the total level of real federal research funding allocated to the sample of research and doctoral universities as well as the total level of real earmarked funding designated to this same group of universities. As explained in more detail below, the measure of earmarked funding is from two sources. From 1973 to about 1985, federal research funding remained fairly flat. Since 1985, funding has gradually increased. From approximately 1982 to 1987, earmarked funding dramatically increased. Between 1987 and 1996, earmarked funding declined. Subsequent to 1996, earmarked funding has been increasing.

Set-Aside Programs

The program initiated by the NSF in 1980 was driven in part by politics. In 1977, members serving on the House Committee on Science, Research, and Technology expressed a concern that a high proportion of research funding was going to only a few states (see Lambright, 2000). As a result of this concern, the NSF developed a program that was designed to stimulate more competitive research at universities in states with historically low levels of funding.

Although the program has gone through several changes, the essence of the program remains the same. Once a state is given EPSCoR (Experimental Program to Stimulate Competitive Research) status, the state is responsible for identifying an *EPSCoR entrepreneur*. This entrepreneur can come from state government, private industry, or a university. The entrepreneur is responsible for working with universities, state government, and/or private industry to develop a plan for improving the research infrastructure of the state. In addition, the entrepreneur must raise money from the state government and/or private industry to match any funding that is awarded by the NSF under the EPSCoR program. What follows is a brief description of the program as run by the NSF. Although other agencies have adopted similar programs, there are differences in the treatment of states and universities that qualify for the set-aside programs.[4]

There are several limitations in the EPSCoR program. First, a state may submit only one proposal at a time. As such, the program is designed to encourage cooperation among universities within the state. Not all universities within the state, however, are required to participate in the plan developed by the entrepreneur. The second limitation is that a proposal is not automatically awarded funding. The proposal must undergo a peer-reviewed competitive process whereby proposals submitted by all states eligible for EPSCoR funding are evaluated based on their merits. In practice, the chance of success is dramatically greater for the proposals submitted under the non-EPSCoR programs.

Initially, five states were eligible for EPSCoR funding: Arkansas, Maine, Montana, South Carolina, and West Virginia. In 1985, seven more states were added: Alabama, Kentucky, Nevada, North Dakota, Oklahoma, Wyoming, and Vermont. In 1987, four more states were added: Idaho, Louisiana, Mississippi, and South Dakota. In 1992, two more states were added: Kansas and

Nebraska. Although not studied in this article, Alaska, Hawaii, and New Mexico were recently added to the list of EPSCoR states.

Thus, the goal of the set-aside programs is to encourage universities to develop the infrastructure needed to be able to compete effectively in the general granting programs offered by the federal agencies.

Hypotheses for Analysis

There are many ways to study the effect of politically motivated funding on research activities. This article examines the effect of these funding sources/programs on overall research funding and research activity as measured by academic publications, a more traditional outlet for research activity. Thus, the questions raised in this article concern how the university as a whole has been affected by these different outlets of research funding.

Given the literature on research universities and the effects of politically motivated activities, this article examines three hypotheses. First, given the historical development of research universities, it is very difficult for these universities to improve their levels of research funding and research activities. Given this, can funding that is politically motivated affect dramatically the distribution of research funding across universities? Second, does politically motivated funding result in a lower quality of research activity because politicians lack the information that is needed to fully evaluate the quality of research proposals as well as because the motivations of politicians may be different from the socially optimal outcome? Third, are set-aside programs more successful than earmarked funding with respect to the promotion of quality research funding? One might expect this to be true given the programs' attempt to create an environment whereby proposed research projects are more fully evaluated and incentives are given to states to promote areas of research in which they show some strength.

Data Used in Analysis

To study the effects of earmarks and the set-aside programs on research funding and research activities, this article has concentrated on developing a set of measures for those universities that are classified as a research or doctoral university under the Carnegie (1994) system. The measures reflect the level of research funding and research activity at these universities. With respect to research funding, I use the federal research funding expenditures data reported in the NSF's Computer Aided Science Policy Analysis and Research (CASPAR) data set. This measure reflects the expenditures by universities from federal funding sources on an annual basis from 1972 to 1998. Data for these institutions are consistently reported for 218 institutions.

Although not all research and doctoral universities are included in the data set, there are data for more than 90% of these universities.

In addition to having data on the total federal research expenditures, I have also obtained data that reflect the level of earmarked funding received by a university. Earmarks have been measured several ways. Savage (1991, 1999) examined the appropriations legislation and accompanying reports to identify the recipient institutions and the amounts allocated to these institutions. The *Chronicle of Higher Education* (2001) identified earmarks by asking the federal agencies responsible for distributing the earmarked funding. The agencies provided information on the amounts distributed, the recipient university, and the reason for the earmark. Although these two methods appear similar, they differ substantially. The Savage data suffer from the lack of knowledge as to whether the agency indeed distributed the funding as well as the actual amount distributed by the agency. Although agencies are expected to distribute earmarked funding, in some instances the agency may require an institution to submit a proposal for the research covered by the earmark and may reject the proposal under certain conditions. Similarly, the agency may "tax" part of the earmarked amount to cover the administrative costs associated with distributing the earmark.[5]

In analyses conducted by the *Chronicle of Higher Education* (2001) and the American Association for the Advancement of Science (AAAS) (2001), the bulk of earmarks are distributed by the Departments of Agriculture and Commerce and by the National Aeronautics and Space Administration (NASA). There are no earmarks allocated through the NSF and very few, if any, earmarks are allocated through the NIH. Although the bulk of earmarked funding is directed at activities concerned with R&D activities at the universities, earmarks also cover such things as distance learning projects, university transportation systems, renovations of dormitories, and projects identified as community outreach projects (e.g., job-training programs). Identifying these types of earmarks is more difficult using the Savage (1991, 1999) data set than using the data set from the *Chronicle of Higher Education* (hereafter referred to as *Chronicle*).

The data on earmarks and federal research funding are not measured exactly the same way. The federal research funding measure reflects annual expenditures and would include university overhead and other benefits. In addition this measure includes funding received by the universities for earmarked funding related to research activities. In contrast, earmarks could be expended over several years and do not necessarily exclude any agency administrative costs or other amounts that might be excluded from the earmark prior to the university receiving the funds. Thus, although we can compare the level of earmarks and total federal funding using simple statistics, it would be inappropriate to try to use these two measures together in a more complex analysis.

To measure the effect of the earmarked funding and set-aside programs on research activities, I focus on academic publications, a more traditional measure of research activities. The advantage to using publication measures is that we can identify both the number of publications produced as well as the number of citations to these publications. Thus, we have both a quantity and quality measure of research activity. To the extent that most federal research funding is directed at basic research, it is important to study the effect of the set-aside programs and earmarking on publications. One concern, however, may be that universities are also involved in applied types of research projects that produce things other than academic publications. Although ideally one would want to examine the effect of the set-aside programs and earmarked funding on several types of activities, measuring outputs related to applied research activities is more difficult. As such, this article will focus solely on academic publications and will leave for future research a study on the effect of the program on other types of activities.

The data on publications were obtained from the Institute for Scientific Information (ISI). ISI provides data on the number of articles per year and the number of citations to articles published in a given year for most research and doctoral institutions as classified under the Carnegie (1994) system from 1981 to 1998. The citations are a cumulative sum of the citations starting from the year of publication and ending in 2000. Thus, articles published in early years will, on average, have more citations than articles published in later years.[6]

DIRECTION OF FUNDING

Table 1 depicts the distribution of universities classified as a research or doctoral institution as well as the percentage of universities that received earmarked funding. Within the classifications, Research I universities are those with the highest rank and Doctoral II universities are those with the lowest rank. I measure earmarked funding as the total allocated in a given year. Thus, within a given year a particular institution may receive more than earmarked. For the analysis conducted in this article, however, I examine only whether an institution received at least one earmark within any given year.

With the exception of the Doctoral I universities, at least 75% of the universities within each classification received at least 1 year of earmarked funding. In addition, more than 50% of the Research I and II universities received more than 5 years of earmarked funding.

Table 1
Distribution of Universities and Earmarked Funding

	All Universities			Universities in EPSCoR States		
Carnegie Classification	*(1) Number*	*(2) % With at Least One Earmark*	*(3) % With at Least Five Earmarks*	*(4) Number*	*(5) % With at Least One Earmark*	*(6) % With at Least Five Earmarks*
Research I	86	84.9	57.0	7	100.0	85.7
Research II	37	75.7	54.1	13	100.0	92.3
Doctoral I	43	44.2	11.6	3	100.0	66.7
Doctoral II	52	75.0	23.1	13	100.0	46.2
Total	218	72.9	39.4	36	100.0	72.2

Note. At least one earmark means at least 1 year of earmarked funding, which could include earmarks for more than one project. Similarly, at least five earmarks means at least 5 years of earmarked funding. EPSCoR = Experimental Program to Stimulate Competitive Research.

The majority of universities that have received many years of earmarked funding are public universities. Of those universities that received 5 or more years of earmarked funding, 80% of the Research I, 90% of the Research II, 60% of the Doctoral I, and 83% of the Doctoral II universities are public universities. Thus, it appears that the bulk of earmarks are awarded to public universities classified as research universities.

In Columns 4 through 6 of Table 1, I report the distribution of universities in states that were eligible to participate in the EPSCoR and other set-aside programs by 1998. Interestingly, 20 of the 36 universities are classified as a research university. All of the universities in these states received at least 1 year of earmarked funding. Most of these universities also have received 5 or more years of earmarked funding.

In Table 2, I depict the average federal research funding, earmarked funding, articles published, and citations per publication across the four groups of universities. In Panel A, I report the summary statistics for all of the universities. Not surprisingly, the bulk of federal research funding is distributed to universities in the Research I category. On average, universities in this category received a total of $83 million, or $99,000 per faculty, over the sample period.[7] The average level of earmarked funding as identified in the Savage (1991, 1999) data set was $5.3 million, whereas the average level of research oriented earmarked funding as identified in the *Chronicle* (2001) data set was $4.4 million. Thus, for Research I universities, earmarked funding represents a very low level of funding to these institutions, approximately 5%.[8]

With respect to the Research II universities, the average level of federal research funding is $16 million, or $26,700 per faculty. Earmarked funding represents approximately 15% of federal funding to these universities. Earmarked funding seems to have the biggest effect for the Doctoral I universities. On average, these institutions receive the lowest level of federal funding, $3.4 million, or $8,000 per faculty. Earmarked funding represents approximately 86% of this funding. Doctoral II universities receive an average of $6.2 million in research funding, with earmarked funding representing approximately 51% of this funding.

In Figure 2, I depict the average level of funding for five periods for the four groups of universities. The average level of funding is depicted on the left axis for the Research I universities and on the right axis for the other types of universities. Between 1975 and 1990, the average growth in real funding was similar for all of the groups except for the Doctoral I universities. The growth was relatively flat for this group of universities. Subsequent to 1990, however, the average growth in funding for the Research II universities was slightly higher than for the other groups of universities. The growth in

Table 2
Summary Statistics

Carnegie Classification	*Federal Research Funding (in millions of dollars)*		*Per Faculty Funding (in thousands of dollars)*		*Earmarked Funding (in millions of dollars)*		*Research Oriented Funding (in millions of dollars)*		*Articles Published*		*Articles per Faculty*		*Citations per Article*	
Panel A:														
All universities														
Research I	82.91	(59.68)	98.94	(103.50)	5.33	(8.47)	4.41	(7.58)	1,838.73	(1,089.06)	2.08	(1.95)	18.93	(9.96)
Research II	15.95	(8.83)	26.69	(17.50)	3.99	(6.29)	2.47	(3.52)	504.18	(197.26)	0.79	(0.37)	12.60	(6.73)
Doctoral I	3.38	(3.75)	8.05	(9.98)	1.52	(2.11)	2.92	(3.97)	244.79	(344.14)	0.51	(1.05)	9.95	(6.56)
Doctoral II	6.15	(8.18)	19.49	(40.16)	4.02	(8.13)	3.11	(3.42)	201.47	(257.83)	0.56	(0.73)	10.04	(7.03)
Total	39.32	(53.69)	51.79	(80.73)	4.59	(7.76)	3.63	(6.05)	915.46	(1,046.22)	1.20	(1.55)	14.01	(9.18)
Panel B: Universities														
in EPCSoR states														
Research I	36.75	(23.81)	43.60	(36.65)	4.53	(5.68)	6.50	(8.97)	1,046.48	(414.85)	1.05	(0.29)	12.51	(5.00)
Research II	17.24	(8.63)	25.02	(13.05)	5.30	(7.62)	2.31	(3.32)	530.33	(201.80)	0.73	(0.26)	10.45	(5.25)
Doctoral I	3.68	(3.58)	6.25	(4.81)	0.93	(1.27)	3.27	(4.67)	160.08	(119.83)	0.29	(0.13)	8.56	(4.15)
Doctoral II	6.76	(6.46)	17.51	(19.02)	6.24	(10.54)	2.97	(3.02)	169.34	(123.48)	0.42	(0.32)	9.19	(5.23)
Total	16.42	(16.89)	24.58	(23.98)	5.10	(7.96)	3.34	(5.11)	455.81	(389.49)	0.64	(0.37)	10.19	(5.26)

Note. Standard deviations are in parentheses. All dollars are real with 1996 as the base year. Federal research funding represents the average expenditures per university per classification during the sample period (1980 to 1998). Earmarked funding represents all earmarks as reported by Savage (1999). Research earmarked funding represents earmarks identified to be associated with a research project, laboratory, or institute in the *Chronicle of Higher Education*'s (2001) database. Articles published and citations per article are from the Institute of Scientific Information. EPSCoR = Experimental Program to Stimulate Competitive Research.

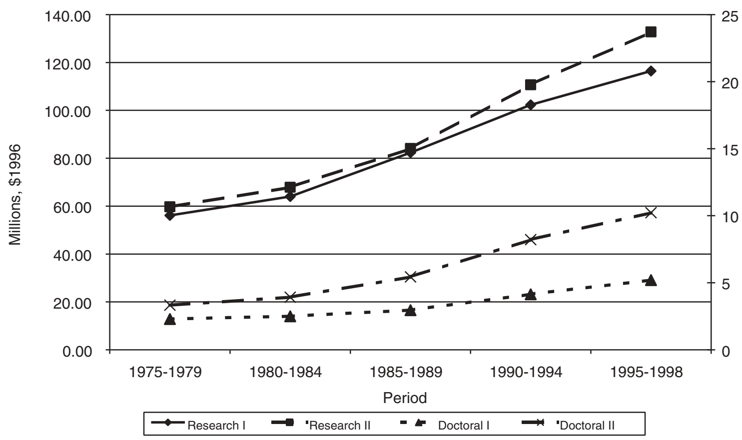

Figure 2. Average Federal Research Funding per Institution by Carnegie Classification
Note. Research II, Doctoral I, and Doctoral II funding depicted along right axis.

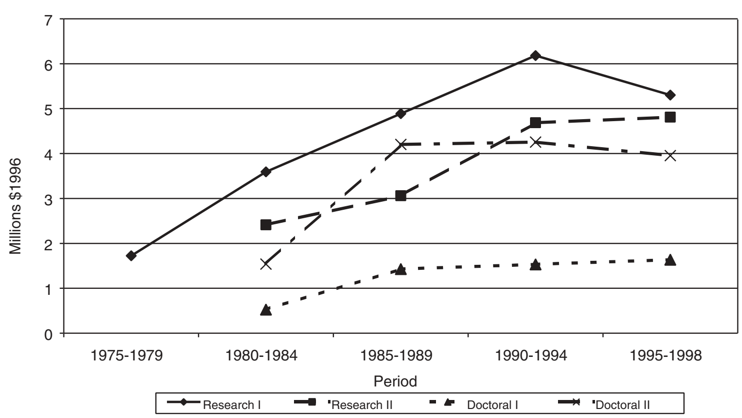

Figure 3. Average Federal Research Funding per Institutions, EPSCoR States
Note. EPSCoR = Experimental Program to Stimulate Competitive Research.

funding for the Research I and Doctoral II universities appears to be similar. Average funding for the Doctoral I universities also grew.

In Panel B of Table 2, I report the summary statistics for the group of universities in states that are eligible to participate in the set-aside programs. Except for the Research I institutions, the average level of federal funding is similar to the average level of funding for all universities (reported in Panel A). Earmarked funding appears to represent a greater percentage of federal funding at these institutions than at the institutions that are not located in a state eligible to participate in the set-aside programs.

Figure 3 depicts the average level of funding for five periods for the four groups of universities in states that are eligible to participate in the set-aside programs. There is a steady increase in real federal funding for the Research I universities prior to the last period. In the last period, the average level of funding declined slightly. Average funding has also increased for Research II universities, especially during the period from 1985 to 1994. Average funding for Doctoral I universities increased slightly during the mid-1980s but has remained fairly flat since then. Average funding for Doctoral II universities increased sharply during the mid-1980s but has remained fairly flat, with a slight decrease, since then.

EFFECT ON RESEARCH ACTIVITIES

Congressional Earmarking

In assessing how to model the effect of earmarks on publications, it is important to consider the intended effect on research. Given most earmarks are used for infrastructure related purposes, we should expect a long-term effect insofar as the funding improves research at the university by enabling the university to hire better researchers, have better facilities, and so on. I summed the earmarked funding from the first year of each data set from the beginning of the period. This measure thus represents a stock of accumulated funding. The average stock of funding for the Savage (1991, 1999) data set is $21 million. The average stock of funding is $13 million for the *Chronicle* (2001) research-oriented data set.

To measure the effect of publications on the stock of earmarked funding, I use the following empirical specification:

$$P_{ist} = \alpha_i + \lambda_t + \beta \sum_{0}^{t-1} E_{is} + S_{s'}\gamma + \varepsilon_{ist} \tag{1}$$

where P is the measure of research productivity for university i in year t and E is the measure of earmarked funding for university i, summed from the beginning of the data set to year $t-1$. I lag the earmarked funding measure by 1 year to reflect the fact that the publication year for many articles is not the same as the year in which they are written.[9] Also included in the specification are year and university-fixed effects and state-level measures. The year effects are intended to capture macro effects that affect all universities similarly. The university-fixed effects capture non-time-varying aspects of the university that could affect the publications and funding of the university. For example, a university with a strong reputation in research is likely to publish more than a university with a weak reputation in research.[10] The state-level measures capture time-varying changes in the socioeconomic and political environment under which the university operates.[11]

E is potentially correlated with the error term of the regression, as the error term would include other inputs involved in the production of research. If the shadow prices of these other types of inputs are correlated with the shadow price of earmarked funding, the coefficient on *E* will be biased, as illustrated in Payne and Siow (2002). For example, if a university has strong lobbying ties to the members of Congress who are responsible for granting earmarked funding, that university's researchers may not seek peer-reviewed funding from other sources. Merely including measures of these other inputs in the regression equation will not remove this bias if the shadow prices of these inputs are correlated. As such, the preferred estimation is one that uses instrumental variables.

Another problem concerns the fact that not all universities receive earmarked funding. In part, this is due to the fact that not all universities seek an earmark, thus raising a potential selection issue. Fortunately, the data set on publication measures covers the majority of universities classified as a research or doctoral institution, so the sample is *not* restricted to only those that receive earmarks. This fact and the use of a fixed-effects instrumental variables estimation minimizes the potential selection bias.

To construct a set of instruments, I sought to use measures that would help predict earmarked funding that would not be directly correlated with the publications measures. An obvious set of instruments would be to use measures that reflect whether a member serving on the congressional appropriations committee is affiliated with the university receiving the earmarked funding. Unfortunately, these measures are not very powerful in the first stage regression. Instead, I created a set of four measures to reflect the research activities at universities located outside of the region in which the university under study is located and with the same type of Carnegie (1994) research or doctoral classification. These measures help to proxy the level of competition for federal research funding and the level of productivity the university under study faces from other universities.[12]

I divided the level of total federal research funding by the number of articles published by academic discipline, lagged by 2 years. I use the disciplines of social sciences, engineering, life sciences, and agricultural sciences. These measures help to proxy the distribution of research funding to other universities and the productiveness of this funding by other universities, thus

Table 3
Effect of Stock of Earmarked Funding on Publications

Dependent Variable	*(1) Number of Publications*	*(2) Citations per Publication*
2SLS specification		
Earmarked funding (in millions of dollars)	22.32*	–0.74*
(summed from first year of data set)	(3.30)	(0.11)
F statistic on instruments	11.75	11.75
p value from first stage instruments	(.000)	(.000)
p value from overidentification test	(.620)	(.094)
p value from Hausman test	(.000)	(.000)
Fixed effects	school and year	school and year
Number of observations	1,683	1,683

Note. Also included in the regression are the following state-level political, economic, and demographic measures: state population, percentage of the state population younger than the age of 18, unemployment rate, dummy variable equal to 1 if the governor is affiliated with the Democratic Party, and measures of the level of political competition in the state upper and lower legislatures. Sample period covers 1990 to 1998 and reports the results using data obtained from the *Chronicle of Higher Education* (2001). The results are similar to those reported if the Savage (1999) data set is used in the analysis. See the text for an explanation of the overidentification and Hausman tests. Standard errors reported in parentheses unless otherwise stated. 2SLS = two stage least squares.
*Significant at $p < .05$.

providing a measure of the interest by the university under study in seeking earmarked funding.

The coefficient from the instrumental variables specification estimates the change in the research outcome (e.g., publications) when a university receives more earmarked funding. Because of the potential correlation among the shadow prices of the inputs used toward research activities, the IV estimate captures the total change in the research outcome. Thus, the IV estimate captures the potential substitution and complement effects associated with earmarked funding and other types of funding. Payne and Siow (2002) provided a more extensive discussion of this issue.

Table 3 reports the effects of a change in the stock of earmarked funding on the number of articles published and citations per article under the IV estimations. Column 1 reports the results using the number of publications as the dependent variable. Column 2 reports the results using the number of citations per publication as the dependent variable. I report the results using the *Chronicle* (2001) data set. The results, however, are very similar if I use the Savage (1991, 1999) data set. Payne (2002a) explored the robustness of the specification.[13]

The effect of earmarked funding on the number of publications is positive and statistically significant at a p value less than .05. The results suggest that an additional $1 million in research funding provides an additional 22 publications. Given that average earmarked funding is $3.5 million, this suggests that on average a university will produce 77 more articles per year, an increase of 7%. In contrast, increasing the stock of earmarked funding decreases the number of citations per article. Citations per article declined by 0.74, approximately 31%.

By treating earmarked funding as a stock that can be used to help strengthen a university's research endeavors, the results are consistent. The results in Table 3 suggest earmarked funding increases the number of articles published but decreases the quality of those articles, as measured by the number of citations per article. Thus, these results suggest that politically motivated funding that lacks the structure of a peer-reviewed or thorough evaluation of the proposed research activities may result in a research infrastructure that does not support quality research as measured by a more traditional research activity outlet. Alternatively, these results suggest that the motivations of the members of Congress who support earmarked funding are not socially optimal.

Set-Aside Programs

With respect to the set-aside programs, I have identified the states that are eligible to participate in these programs. I have not identified the funding received from these programs. Although others such as Feller (2000), Lambright (2000), and Teich (1996) have studied the mechanics and uses of the set-aside funding, my approach is different. Given one of the goals of the program was to help universities build the infrastructure needed to compete more effectively in the general funding program, I focus on total federal funding received by the university. Thus, the analysis is concerned with understanding the extent to which research activity improves at universities in states that have been targeted for these special programs relative to other universities.

To study the effect of the set-aside programs on research activities, I want to compare two things. First, I want to compare how, within a given university, being in a state that is eligible for set-aside funding affects the research activities of the university. Second, I want to compare across two sets of universities how qualifying for the set-aside programs affects the research activities given the research activities undertaken by a comparable set of universities that do not qualify for the programs. Essentially, I am interested in estimating

$$P_{iest} = \alpha_i + \gamma_t + \lambda_{e-3} + \pi_{e92} + \beta F_{iest-3} + \theta S_{st} + \varepsilon_{iest}, \qquad (2)$$

where α_i is a university specific intercept; γ_t represents macro level changes that are common across all universities; β represents the effect of an additional million dollars in federal research funding on the research activity; θ represents time-varying political, economic, and demographic changes at the state level that could affect the research activity within the state; and ε_{iest} identifies temporary changes in measures that are unobserved.[14]

I am interested in measuring λ and π, the estimated effect of being eligible to participate in the set-aside programs. The first coefficient reflects the effect after becoming eligible to participate in the set-aside programs. The second coefficient reflects the effect after 1992. Given that there was a big expansion in the programs in the early 1990s with respect to funding and in the number of agencies sponsoring a program, this second coefficient reflects the effect associated with the expansion.

The specification is commonly referred to as the "difference in differences" technique. In essence, one is estimating the within-variation from becoming eligible to participate in the program and comparing this variation against a set of universities that are not eligible to participate in the program.

If the group of universities eligible for set-aside program funding are selected due to time-invariant characteristics (which would mean that α_i and ε_{iest} are not correlated), even though the universities are not randomly selected, the estimate of λ and π will not be biased. If the selection of the universities is correlated with temporary shocks that I do not observe, then comparing the set of universities that are eligible for the set-aside program with any other set of universities is problematic (see, e.g., Klette & Moen, 1998). Is this a problem about which there should be concern? On one hand, following the research of Goldin and Katz (1999), one could argue that the situation of the universities that qualify for the set-aside program pertain to factors that were established well before the set-aside program was created. Under this scenario, the fixed effects control for any problem associated with the fact that universities eligible to participate in the program were not randomly selected. On the other hand, if one looks at the order in which the states were brought into the set-aside program, the state with the lowest level of federal research funding in the late 1970s was not included in the initial group of states.

For example, using the ranking of the states based on 1978 measures of federal research funding, the first five states to be included in the EPSCoR program were ranked 3, 7, 9, 10, and 13, where the rank of 1 means the state received the lowest level of funding. Universities located in the state that was ranked number 1 in 1978, South Dakota, did not become eligible for EPSCoR funding until 1987. Thus, if time-varying issues (such as the political clout of the congressional members from the state) affect whether a state is eligible for EPSCoR funding, then fixed effects alone will not control for the selection problem.

Following Heckman, Ichimura, Smith, and Todd (1998), I have attempted to match the universities that are eligible for this type of funding with universities that are not eligible for funding but possess similar qualities with respect to their research activities. Because qualification in the set-aside programs is a function of whether the state has historically received low levels of funding, there are many universities that have historically received low levels of federal funding but are not located in states that have qualified for the set-aside programs.[15]

The sample data set covers 100 research and doctoral universities. A total of 66 universities are in the control group; 42 universities are public and 24 universities are private. A total of 34 universities are in the treatment group; 32 universities are public and 2 universities are private. Table 4 reports the results from the regression analysis based on Equation 2.

The specification lags the values of the research funding and the initial set-aside program qualification by 3 years. The reason for the lag is to allow some time to pass for the universities to participate in the program, given that funding is not automatic. The length of the lag is not as important as one might think because the estimation incorporates university-fixed effects. Table 4 reports the results when a 3-year lag in research funding is used. If a shorter or longer lag in funding is used, the coefficients are very similar to those reported; the standard errors vary, however. As such, Table 4 reports the results with a 3-year lag because the standard errors on this specification are lower than if a 2- or 1-year lag is used.

Table 4 reports the results using a fixed-effects two stage least squares (2SLS) specification. As explained above, Equation 2 is a semireduced equation insofar as it identifies only one of several possible inputs used by researchers. If the shadow prices or the costs associated with obtaining different types of research funding (inputs) are correlated, then merely including some of all of the possible inputs in the regression will bias the coefficients on the input measures, if not all inputs for which there are correlated shadow prices can be measured. As such, it is important to adopt a 2SLS specification, instrumenting the federal research funding. The coefficient on the funding measure in the 2SLS specification reflects the total change in the publication measure when there is a change in the funding measure.

The instruments are four measures that reflect the average research funding per article published in four disciplines for universities located outside of the region in which the university under study is located. The four disciplines are engineering, physical sciences, social science, and life sciences. These

Table 4
Effect of Set-Aside Programs on Publications

Dependent Variable	*(1) Articles*	*(2) Engineering Articles*	*(3) Life Sciences Articles*	*(4) Citations/ Article*	*(5) Engineering Citations/ Article*	*(6) Life Sciences Citations/ Article*
2SLS specification						
Dummy for EPSCoR participation	–37.80*	–2.20	–24.73*	–0.23	1.69*	0.03
(lagged 3 years)	(13.40)	(2.62)	(9.12)	(0.50)	(0.59)	(0.58)
Dummy for EPSCoR participation	–9.05	2.34	–19.94*	1.08*	1.45*	1.85*
post-1992	(14.07)	(2.81)	(8.97)	(0.33)	(0.64)	(0.57)
Federal research funding	21.00*	8.93*	15.35*	–0.15*	–0.24	–0.24*
(lagged 3 years)	(1.42)	(1.39)	(1.49)	(0.04)	(0.34)	(0.10)
F statistic from first stage instruments	36.07	13.57		30.23	11.84	
p value from first stage instruments	(.00)	(.00)		(.00)	(.00)	
p value from overidentification test	(.61)			(.64)		
p value from Hausman test	(.00)			(.03)		
School and year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	1,497	1,302	1,302	1,290	1,266	1,266

Note. Also included in the regression are the following state-level political, economic, and demographic measures: state population, percentage of the state population younger than the age of 18, unemployment rate, dummy variable equal to 1 if the governor is affiliated with the Democratic Party, and measures of the level of political competition in the state upper and lower legislatures. Also included in the regressions are the average state gross domestic products for states located in the same region as the state under study for the following industries: agriculture, health, chemicals, and electrical equipment. Sample period covers 1981 to 1998. See the text for an explanation of the over identification and Hausman tests. Standard errors reported in parentheses unless otherwise stated. EPSCoR = Experimental Program to Stimulate Competitive Research. 2SLS = two stage least squares.
*Significant at $p < .05$.

measures proxy the federal dollars spent per paper produced by other universities. Thus, as this average changes over time, the ease with which the university under study may receive federal research funding will be affected. The *F* statistics of the instruments from the first stage regressions are quite high, more than 30, suggesting they are good predictors of federal research funding for the universities under study.

With respect to the number of publications, Column 1, there is a negative effect overall for being located in a state that has qualified for the EPSCoR programs. On average, qualifying for the set-aside programs results in a decline of 31 articles, representing a 5% decline. The effect subsequent to 1992 is imprecisely measured.

The results suggest that after the expansion of the program, the quality of the publications improved. When the number of citations per article is used as the dependent variable, Column 2, the overall effect of the set-aside programs is negligible. Subsequent to 1992, however, there is an increase in the citations per article by 1.1, representing, on average, an increase of more than 10%.

The results in Table 4 suggest that the set-aside programs have had a positive effect on research activities at universities. On average, the quantity decreased but the quality increased as a result of being in a state that is allowed to participate in the set-aside programs. To the extent that more effort is required to produce a high-quality publication than a low-quality publication, the results suggest the EPSCoR program has helped to improve the quality of research activity in states with historically low levels of research funding. Thus, these results suggest that set-aside programs provide a viable vehicle for helping universities that have historically received low levels of funding to improve their research quality. To the extent that with a higher quality of research the university will be able to attract better researchers and attract more research funding, these universities potentially will benefit from the set-aside programs in many ways.

Are these results consistent across disciplines? Given the various federal agencies that are responsible for funding different types of research, one might expect the results to vary based on academic discipline. In Columns 3 through 6 in Table 4, I report the results when examining the effect of the EPSCoR program on the disciplines of engineering and life sciences. I use a three stage least squares technique, allowing the error terms across the two disciplines to be correlated. The *F* statistics reported for the instruments in the first stage regression reflects the joint test of the instruments in the two equations in the first stage regression.

Across the two disciplines, the relationship between federal research funding and publications differs quite substantially. On average, the additional number of publications from an additional $1 million in federal funding is 8.9

in engineering and 15.4 in the life sciences. This reflects, in part, the dramatic differences seen in Table 2 between the average level of federal funding and number of publications across these two disciplines.

The set-aside programs have had an effect on publication activity by the universities in the treatment group in both disciplines. This should not be that surprising given that engineering is one of the major disciplines funded by the NSF (although other agencies also fund engineering projects). And with respect to the life sciences, this is the discipline that has experienced the most dramatic rise in research funding to universities over the sample period. Thus, to the extent that federal agencies (especially NIH) have devoted their resources toward funding projects in the life sciences, one should also expect the set-aside programs to have an effect on the life sciences.

For both disciplines, on average, the set-aside programs have resulted in an increase in the number of citations per publication. The effect on the number of publications, however, differs across the two disciplines. With respect to engineering, the coefficients on both EPSCoR measures are imprecisely measured. Thus, the effect of the set-aside programs on the number of publications is unclear. With respect to the life sciences, the results suggest that the bulk of the overall results with respect to academic publications may be driven by the effect of the set-aside programs on this discipline. On average, the effect of the state becoming eligible to participate in the program is negative, suggesting on average a decline in 25 publications (8%). The effect after 1992 is greater, suggesting an average decline of 45 publications (14%).

For both engineering and the life sciences, citations per article increase as a result of being in a state that is eligible to participate in the set-aside programs. There is a positive and significant effect for both of the EPSCoR coefficients with respect to engineering. The effect of the university being in a state that is eligible for the funding increases citations per article on average by 1.7 (26%). The total effect after 1992 is an average increase of 3.2 citations per article (50%). Given the relationship between engineering funding and the NSF, these results suggest a dramatic effect of the NSF program on publication quality.

With respect to the life sciences, only the coefficient that represents the additional effect of the set-aside programs subsequent to 1992 is statistically significant. The results suggest that the citations per article in the life sciences subsequent to 1992 increase by 1.9 (14%).

CONCLUSION

Direct funding of research activities by Congress through the appropriations process has increased at research and doctoral universities over the past decade. Similarly, programs at the agency level designed to improve the research infrastructure at universities that have historically received low levels of research funding have also increased. Although previous research has concentrated on the role played by politics on the distribution of funding as well as on how the universities have reacted to the set-aside programs, little research has been conducted on understanding how these two different types of funding have affected research activity. This article studies this question.

Using a panel data set that contains measures on federal research funding, funding received from earmarks, and academic publications, this article looks at how earmarked funding and set-aside programs have affected both the quantity and quality of publications. With respect to earmarked funding, the results suggest that although the quantity of publications increases, the quality decreases. In contrast, the results suggest that set-aside programs help to improve research quality at universities in states eligible for the set-aside programs.

Thus, the results suggest that despite the fact that earmarking and set-aside programs were initially politically driven, there are differences in the effect of these two sources of funding on research activity. Why are the effects different depending on whether one is studying earmarked funding or set-aside programs? One explanation for this is that with earmarked funding, a politician is being lobbied for funds for a specific project. The lobbying process and the decision making involved in the appropriations process may not allow for the politicians to receive all of the information needed to evaluate fully the quality of the research funding. Additionally, the underlying motivation of the politician in awarding the earmarked funding may be different from the motivations of the bureaucrats responsible for evaluating and awarding funding under the set-aside and other research funding programs. In contrast, the set-aside programs are designed to foster cooperation between the universities within the state eligible to compete for the funding under the set-aside programs. Thus, these universities must develop a high-quality proposal that will be competitive with other universities seeking funding from the same source. This added competition and the more rigorous review of the research proposals may help to explain why the set-aside programs appear to be more successful in improving research quality than the earmarked funding.

This article explores the question of how different methods of distributing federal research funding affect publication activities at universities. There are many more questions that remain unanswered. One question concerns how these different activities have affected research activities other than academic publications. Another question concerns how the set-aside programs have affected economic growth in the states that have had historically low levels of research funding. A third question is how the funding of the set-aside program has enabled universities to become more competitive in seeking other types of federal research funding.

NOTES

1. The top six states were California, New York, Massachusetts, Pennsylvania, Texas, and Illinois.

2. In rare instances, earmarks are used to resurrect research programs that were agency-sponsored research projects in prior years but that the agency had since discontinued. In these instances, the agency may award the funding under a peer-reviewed process. Often this occurs in the area of agriculture, where some grants are distributed using a formula.

3. See Teich (1996) for a discussion of these issues.

4. For more detailed information on the various set-aside programs, see www.epscorfoundation.org.

5. For exploring the politics of earmarks, the Savage (1991, 1999) data set is superior because it identifies the appropriations subcommittee responsible for proposing the earmark.

6. Although it would be desirable to measure citations for articles published for a fixed set of years, to develop such a measure is prohibitively expensive.

7. Note that all dollars are reported in constant dollars with 1996 as the base year.

8. If one just looks at public universities, earmarked funding represents approximately 8% of funding at Research I universities. The portion of federal funding attributable to earmarking for public universities in the other categories of institutions are as follows: Research II, 26%; Doctoral I, 41%; Doctoral II, 72%.

9. The results do not vary dramatically for longer lags on earmarked funding.

10. The results do not vary dramatically if, instead of a fixed-effects estimation, I use a first-differenced estimation.

11. The state-level measures included in the analysis are the state population, the percentage of the state population younger than the age of 18, the unemployment rate, a dummy variable equal to 1 if the governor is affiliated with the Democratic Party, and measures of the political competition in the state upper and lower legislatures.

12. I excluded the universities that are located within the same region as the university under study to remove any potential correlations between the universities that are engaged in similar types of research activities due to the economic and political environments in which they are located (e.g., the research triangle in North Carolina, the technology belt in California).

13. In addition to reporting the coefficient on earmarked funding from the second stage regression, I report the p value of the F test of the instruments from the first stage regression, the p value from the overidentification test, and the p value from the Hausman (1978) test. The first test is used to measure the power of the instruments in predicting the level of earmarked funding. The second test is used to measure whether the instruments belong in the second stage regression; a low p value suggests they belong in the first and not the second stage regression. The third test is used to measure whether the coefficient in the second stage regression is statistically different from the coefficient in the first stage regression. Across all columns, the three tests discussed are satisfied.

14. The state-level measures included in the analysis are given in Note 11. In addition, because the set-aside programs create an incentive for universities within a state to collaborate with state government and industry, I also include the average gross domestic product for those states in the same region as the state in which the university is located for the following industries: agriculture, health, chemicals, and electrical equipment.

15. To construct a control group of universities, I used the level of federal research funding in 1978 to identify universities. This is a year that is prior to any evidence of concern being expressed by Congress over the skewed distribution of research funding to a few states and is prior to the initiation of EPSCoR (Experimental Program to Stimulate Competitive Research) and similar programs. I ranked the universities in three parts: First, I ranked the total federal research funding of those universities whose portion of federal research funding attributable to the life sciences was more than 60%; second, I ranked the total research funding of those universities whose portion of federal research funding attributable to engineering was more than 25%; third, I ranked the total federal research funding of the remaining universities. Thus, in constructing the control group, I controlled for differences in the research needs of different academic disciplines. Given the two disciplines with the largest amount of research funding are the life sciences and engineering, the method used to create a control group matches universities based on whether they have emphasized their research on life sciences, engineering, or something else. Payne (2002a) compared the control and treatment groups as well as explored control groups created under different criteria.

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