

The Impact of State Governance Structures  
on Research Productivity at Public Universities

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**Abstract:** This paper examines the role of state governing boards on research productivity at public universities in the United States. To explore how state governance can affect the incentives towards research activities, the paper relies on the multi-tasking theory of Holmstrom and Milgrom and the administrative federalism theory of Schwager. The former theory suggests that if an organization is involved in multiple tasks that cannot be completely monitored, strict incentives or regulation of the organization will result in lower productivity in the activities that are harder to monitor. The latter theory suggests that if an organization is able to engage in rent-seeking activities or fails to internalize externalities that affect a broader area than it serves, guidance at a state or regional level will promote a more efficient use of resources. Using a panel data set that spans from 1982 to 1998 this paper explores the relationship between research funding and research activities for three types of governance structures: centralized governing board, a coordinating board with some regulatory authority, and a decentralized coordinating board or planning agency. Using an instrumental variables specification, this paper demonstrates, on average, that fewer articles are published and there are fewer citations per article published with an additional dollar of research funding at universities in states with a highly centralized state governing board. The highest level of productivity with respect to publications is seen at universities in states with a coordinating board with regulatory authority over program approval and some oversight of universities' budgets. The results suggest that additional research funding increases citations per article at these universities, on average, by between 1.5 and 2 times the amount for universities in states with a decentralized governance structure. These results suggest that while centralized oversight reduces research productivity, decentralization may not be the solution.

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A common, yet unresolved, public economics issue is whether government provided goods and services should be provided at a centralized or decentralized level. Tied into this issue are at least three questions: how to finance the good, what level of government should provide the good, and at what level, if any, should there be governmental oversight? Empirically it is often difficult to study any one of these questions separately. This paper, using data on public universities, is able to focus solely on the third question, namely how does state government oversight of public universities affect research productivity. In the United States, all public universities receive some level of appropriations from state and federal governments. The manner in which university activities are governed, however, vary across the states. In some states, universities are governed at the state level; in other states, they are governed primarily at the university level. This paper focuses on how state governance structure affects research productivity, examining the relationship between research funding and research activities such as academic publications, the number of graduate students, and faculty salaries.

Over the past two decades, almost half the states have made structural changes in higher education governance systems. Most of these changes introduced greater centralization of public universities. State governments consolidated separate institutional governing boards into a statewide coordinating board or increased the regulatory and financial powers of an existing statewide coordinating board. Today, seventy-five percent of students in American higher education attend colleges and universities that are part of a multi-campus or consolidated governance system under a single board. More recently, the trend has reversed somewhat, with state governments initiating changes that bring more decentralization into the system. In Florida, for example, the legislature is close to dismantling its existing centralized governance

structure that oversees twelve public universities and replace it with individual institutional level boards.

As with other types of government provided goods and services, it is unclear how the structure of government oversight affects the activities of the organization subject to the oversight. If a single organization is able to engage in local rent-seeking behavior or create externalities that extend beyond the area served by the organization, theory would suggest that centralization of the oversight of the organizations located in a bigger area (e.g. in the state) should promote a more efficient use of resources. This simple framework, however, does not take into account, that the organization may be engaged in a variety of activities that may not be easily monitored and that politics may play a different role at a more centralized level.

Public universities are engaged in teaching, research, and various activities that involve public outreach and promoting economic development of the state. These universities inevitably report to several types of principals. At a minimum, universities report to at least one governing board such as a board of trustees and the governor and/or state legislature. In most states, however, there is also a state level board that provides some level of oversight. A centralized state level board has regulatory powers over the operations of the universities for which it is responsible. A decentralized board has only advisory powers that may cover a smaller set of university activities. Thus, states with centralized and decentralized governance structures differ in the degree to which they may intrude upon university operations. As such, because university activities may not be completely monitored by these boards, if centralized governing boards create specific incentives that address some but not all of the activities, the university may engage in less efficient behavior with respect to the activities that can not be easily monitored.

In addition, if the centralized governing board represents another principal to whom the university must report, this can exacerbate potential inefficiencies in university activities.

Research by Knott and Payne (2001) and others have found that research related resources are more abundant at universities in states with a more decentralized governance structure, even after controlling for time-invariant heterogeneity across the universities. This paper segregates the universities into three categories of state governance to explore the effect of an additional dollar of research funding on research activities. The categories are: (1) those with a centralized, consolidated, governing board with extensive regulatory powers; (2) those with a coordinating board with regulatory powers over program approval and some authority over the budget; and (3) those with a decentralized coordinating board or planning agency with only advisory powers. Using measures pertaining to academic publications, across most of the research activities measures, the impact of an additional dollar of research funding is highest at those universities with a coordinating governing board that possesses some regulatory authority. The lowest effect is at those universities with a centralized governing board.<sup>1</sup> Depending on the specification, the average difference in effect of an additional million dollars of research funding between universities in states with a centralized board and universities in states with a coordinating board with some regulatory power ranges between 7 and 18 articles. The average difference between universities in states with a centralized and decentralized governing board ranges between 3 and 13 articles.

Understanding impact of state governance on research productivity is important because research and development is considered an important factor in economic growth as well as an important revenue source for universities. As illustrated by Slaughter (1998), public universities

depend heavily on federal money for research and development and that this type of funding is equally as important to universities as is federal funding for student aid.

A contributing factor to research funding concerns how the policies toward research funding and research activities have changed over the last 25 years. Policies have changed to encourage more interactions between universities and private industry as well as to allow universities to benefit from applications of research conducted by its researchers. For example, the Bayh-Dole Act (1980) permits universities to profit from its inventions by allowing universities to take title to inventions created with federal funding. The National Cooperative Research Act (1984) gives special antitrust status for government-industry-university R&D ventures. Thus, understanding how governance structures affects research productivity represents a first step in understanding how policy changes that affect research promote R&D development.

In addition, given that state legislatures have become increasingly interested in measuring faculty productivity (see, e.g., Presley and Engelbride (1998), Hines (1988), and Fisher (1986)) it is important to understand how the state, itself, can affect productivity.

Understanding faculty productivity and state governance of higher education are not new issues. Many researchers have studied these complex issues surrounding state governance (see, e.g., Millett (1984), Sabloff (1997), Martinez (1999), Cohn, Rhine, and Santos (1989), Goudriaan and DeGroot (1990), Johns (1996, 1999), and Massy (1996)).<sup>2</sup> My contribution is to explore whether governance structures promote different incentive structures that affect research productivity, using a 20-year panel data set that covers most public research universities for

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<sup>1</sup> The effect of an additional dollar of funding on the number of graduate students, however, is highest at those universities with a centralized governing board. The effect of additional funding on average faculty salaries is small and not statistically differentiable across the three types of governing structures.

several types of research activities. The paper proceeds as follows: section I presents a theoretical framework in which to think about the impact of state governance on research productivity. Section II discusses the data used for the analysis, providing a summary tables of the key measures. Section III explores how governance has affected the growth in research resources and the relationship between research funding and different research activities. Finally, section IV provides a brief conclusion.

## **I. Theoretical Framework**

Many justifications have been given to support a state moving towards a more centralized governance structure. A consolidated board structure holds universities accountable to statewide priorities through greater control over institutional missions, policies, and budgets and provides an opportunity for review and assessment of performance (*see*, McGuinness (1997)). Specifically, policy makers and the public have voiced concerns about the continued rise in tuition above the inflation rate and decisions by competing institutions to duplicate expensive graduate professional degree programs. Additionally, many policy makers would like to see universities apply expertise to practical needs of economic development and the solution of social problems. According to McGuinness (1999), policy makers centralize governance systems out of frustration with intense lobbying by individual institutions, administrative barriers to students transferring from one institution to another, and university-initiated proposals to close or reduce the size of small and rural campuses. Underlying these concerns is the belief that a more decentralized governance structure allows a university to operate more like a private

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<sup>2</sup> A related area of research is understanding how to model the university and its activities. *See* Winston (1999) and Ehrenberg (1999) for a summary of the literature and complexities of the issues surrounding such modeling.

university, which is able to engage, to some degree, in rent-seeking behavior based on its reputation and other historical and location factors.<sup>3</sup>

A major question concerning the impact of governance structures is how does the governance of a university affect the activities undertaken by the university. Although professors and other researchers at the university would not be directly affected by the governance structure, there is an indirect effect. Given that most centralized governing boards have regulatory authority over universities, the motivations of the president, provost, deans, and other administrators will mostly likely reflect a desire to garner the most it can from the governing board. This, in turn, will affect efforts expended to maintain quality programs, retain and hire professors. As shown in Knott and Payne (2001), universities operating under a centralized governance system, on average, rely more heavily on appropriations than on tuition revenues, thus, making the university more tied to state government resources. Total resources, however, are greater at universities located in states with a more decentralized form of governance, even after controlling for time invariant differences across the universities. If the actions taken by the university administration reflect the incentives provided by the governing board, we should expect these decisions to affect the incentives given to existing professors as well as to those responsible for hiring new professors.

Given one of the concerns expressed when adopting a more centralized governance structure is to minimize rent-seeking activities and/or to exploit potential positive externalities associated with university behavior, one might expect there to be greater competition among

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<sup>3</sup> The theory of “administrative federalism” is an analogous way to think about these issues. Under this framework, a university in a decentralized structure has the incentive to behave opportunistically and to ignore the externalities associated with its behavior if governed at a local instead of a regional level. Schwager (1999), building upon the work of Tirole (1994), demonstrates that having a centralized agency that provides guidance to a local agency that then undertakes the project for which the guidance has been given can promote a more efficient outcome than under a completely centralized or decentralized structure.

universities in states with a more centralized governance structure. Thus, if a centralized governance structure encourages competition and rewards those institutions that behave more efficiently, the public universities in states with a centralized governing board will have an incentive to operate more efficiently than universities in states with a decentralized governance structure. This hypothesis may be too simple as governing boards may not be able to completely monitor university activities. Given universities perform several tasks, the outputs of these tasks are observable with varying degrees of accuracy. Part of the role of a governing board is to provide incentives to the universities to promote the best utilization of these tasks. The incentives provided by governing board will affect these tasks differently. As such, the impact of a more centralized governing board on universities' activities is not obvious.

The theory concerning incentives in a multi-task setting has been developed by Holmstrom and Milgrom (1991) and others. Holmstrom and Milgrom demonstrate that if activities of a multidimensional firm cannot be perfectly monitored, then incentives that are directed at some of the activities may result in a less efficient output from the activities that are not easily monitored. Dixit (1997) extends this analysis to address the added problem of having multiple principals. The solution to this problem would be to provide general instead of specific incentives to the agent, thereby, minimizing the effect from not being able to completely monitor all activities.

Within a given university, although professors have the freedom to choose their research activities, they are evaluated by their superiors with respect to tenure and promotion issues. These superiors, in many instances are appointed by university administrators that report to university and/or state level governing boards. As such, the types of professors hired, the



departments or programs that grow, as well as the research undertaken by existing professors may be affected based on the incentives provided by these superiors and administrators.

Given that professors are engaged in activities that include teaching, obtaining research funding, publishing research findings, and public outreach, research productivity may be one of the hardest activities to monitor. Teaching activities may be monitored by examining student enrollment, the success of students enrolled in a given program, as well as peer and student evaluations. Similarly, enrollment and success upon completion of a graduate degree is also a demonstration of the success of a graduate program. Two measures of successful research productivity would be publication in high quality journals and receiving research funding. The long run implications of research on a discipline, however, often is unknown when a paper is first published. Thus, some administrators may be inclined to look at dollars brought into a college as well as the quantity of publications instead of ascertaining the quality of the publication.

Incentives given to researchers could also significantly affect the types of research funding sought. For example, two aspects of funding that could affect the type of incentives given to researchers by administrators concern the potential for receiving overhead fees to the university as well as the quantity of research funding to a department or college that could be used to help support such things as research assistants and facilities for conducting research. Many research grants provide overhead fees to be paid to the university, thus administrators could promote incentives to researchers to seek funding from sources that pay overhead fees. There is also heterogeneity in the level of competition involved in obtaining research funding. If administrators are more concerned with the amount of funding brought in than the source of the funding, the incentives could divert the professors' interests from high quality to low quality

research projects if there is a positive correlation between the quality of a research project and the competition for research funding.

The interaction between university administrators and professors will be different across universities if the incentive structure for university administrators varies by governance type. In most states, there is a university level governing board and a state level governing board.<sup>4</sup> The degree of autonomy given to the university level board depends on its relationship with the state level board and the degree of regulatory power held by the state level board. The state level board varies substantially with respect to the powers it has to regulate the public universities. Waller et al. (1999), following the work of McGuinness (1994), classifies U.S. public universities as follows:

1. ***Consolidated governing boards***, which represent the most centralized governance structure, have the authority to govern institutions, establish salaries for chief executives, set faculty personnel policies, develop and implement policies, and allocate resources among the institutions under their jurisdiction.
2. ***Coordinating boards*** do not govern institutions and usually do not have independent corporate status. Coordinating boards have either regulatory or advisory authority over academic programs and budgets. Some coordinating boards have regulatory authority over both academic programs and budgets, while other boards have regulatory authority over only one of these areas and advisory authority over the other area. Some coordinating boards have only advisory authority over both areas.
3. ***State planning agencies***, which represent the least centralized structure, typically do not have regulatory or governance authority over the higher education institutions in their states.

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<sup>4</sup> The following states do not have an university level board: Arizona, Georgia, Hawaii, Idaho, Iowa, Kansas (with the exception of Washburn University), Massachusetts (with the exception of University of Massachusetts), Mississippi, Montana, Nevada, North Carolina, North Dakota, Oregon, Rhode Island, South Dakota, Utah, West Virginia, and Wisconsin. Technically, there is no statewide post secondary coordinating or planning agency in Vermont. There are two institutional governing agencies: the Board of Trustees of the University of Vermont and State Agricultural College and the Board of Trustees of the Vermont State Colleges. In many respects these two boards have similar authorities as statewide boards in other states. For this reason, I treat both of these boards as the statewide level board in my analysis.

These three classifications suggest that state level boards vary with respect to the degree to which it may regulate the public universities and, thus, the incentives under these classifications may vary. Given the consolidated governing board has the greatest power over a university, this type of structure may be associated with having stricter incentives. Similarly, given state planning agencies have the least amount of authority, this type of structure may be associated with have the broadest, least enforceable, incentives. Following the Holmstrom and Milgrom (1991) framework and the multitask nature of universities, research productivity will be lower in states with a consolidated, or centralized, governing board than in states with a planning, or decentralized, agency. This would be true if the strictness of the incentives provided to the universities are positively correlated with the authority possessed by these boards.<sup>5</sup>

Another way to think about this is if we treat the centralized state board as adding another principal to which the university is responsible, treating the decentralized state board as one to which the university does not directly report. In this case, the extension by Dixit (1997) would apply. Dixit demonstrates that if there are multiple principals that do not work collusively, then the multitasking problem associated with not being able to perfectly monitor the activities of the university increases. This extension suggests that if the university in a centralized state reports to more principals than the university in a decentralized state, if the centralized state board creates

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<sup>5</sup>In addition to looking at the regulatory authority possessed by a governing board, one could also examine the manner in which the members are appointed to the board. In most states, however, the majority of the members are appointed by the governor. Moreover, although there are some differences in the composition of the state level and university level governing boards, often, most of the university level board members are also politically appointed. Lowry (2000) explores the distinction between governance structure and method of appointment with respect to tuition. He concludes, "... that governmental structure and process are more important than statutory directives that seek to regulate the substance of tuition decisions." He adds that, "Public universities in systems that enhance the ability of elected officials to enforce their own preferences tend to charge lower tuition than public universities that have more autonomy. The difference in revenue is reflected in spending on functions that most directly benefit faculty and administrators." His findings also show that "different combinations of structure and process can lead to very similar outcomes."

strict incentives with which the university must comply, research productivity will be lower in these states.

One aspect that Holmstrom and Milgrom (1991) and Dixit (1997) do not address is how the multi-tasking problem with multiple principals affects entities that may be able to engage in rent-seeking activities if there is not a centralized governance structure. The lack of state oversight arguably promotes rent seeking behavior by the universities as well as ignores potential spillover effects from the university's activities in a broader area. To the extent that centralized oversight can promote more competitive behavior by universities, this could minimize the effects of the multi-tasking problem.

Another way to think about this problem is to consider the model presented by Schwager (1999). Building upon the work of Tirole (1994), Schwager develops a theory of "administrative federalism." The notion here is that without some centralized oversight, a local agency may be able to engage in opportunistic behavior that benefits its locality or region. If such behavior fails to take into account any spillover effects on other regions from its activities, the local agency would be inefficiently using its resources. Thus, if there is a centralized oversight board that provides guidance but not strict regulation, this oversight is sufficient to promote a more efficient use of resources. Using this framework, a university in a decentralized structure has the incentive to behave opportunistically and to ignore externalities or engage in other rent-seeking behavior if governed at the university instead of the state level. To the extent a coordinating board has authority to provide guidance or weak incentives to universities that a decentralized board does not possess, this would suggest a more efficient outcome, and, thus, a more efficient use of research funding by these universities.

Under both the framework of Schwager (1999) and Holmstrom and Milgrom (1991), a university in a state with centralized governing board will be less productive than a university in a state with a more decentralized governing board, assuming the structure of incentives provided by the centralized governing board are restrictive. Schwager, however, helps to explain why some level of centralized oversight may be desirable if a university in a state with a decentralized governing board is able to behave opportunistically.

## **II. Data and Empirical Framework**

The data set spans the period 1982 to 1998 and covers Ph.D. granting public universities.<sup>6</sup> The data are at the institutional level, allowing me to measure the role of governance systems for the universities. For this period I used the classification schemes and other information from the *State Postsecondary Education Structures Handbook* (1986, 1988, 1990, 1994, 1997). Each handbook reflects the status of the structures for the year in which it was published. Because the handbook is not published on a yearly basis, I attribute the structures from each handbook as follows:

- 1986 structures applied to the period 1982 to 1986.
- 1988 structures applied to the period 1987 to 1988.
- 1990 structures applied to the period 1989 to 1992.
- 1994 structures applied to the period 1993 to 1995.
- 1997 structures applied to the period 1996 to 1998.

I elaborate on how the measures reflecting governance and composition are created below. With respect to the measures of research productivity, I focus on total annual research expenditures of the university, the number of articles published in peer-reviewed academic

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<sup>6</sup> The universities are classified under the Carnegie (1994) classification scheme. Excluded from the analysis are those universities whose highest degree offered is a master's or bachelor's degree, those universities that are considered a specialty school (such as one that focuses entirely on engineering), and those institutions that offer only a 2 year degree. I exclude these schools because the research expenditures of these schools is very low and the data available for them are not as extensive as the data for the universities that are studied. A list of the institutions studied is provided in Appendix 1.

journals, the number of citations per article published in these journals, the average faculty salary, and the number of graduate students at the university. These measures of research activity were chosen to reflect the different effects of research funding on activities within a university. The measures on research funding, salary, and graduate students are from the CASPAR database, maintained by the National Science Foundation. The measures on publications are from the Institute of Scientific Information.<sup>7</sup> My data set covers most of the research and doctoral universities as classified by Carnegie (1994). I exclude those universities whose maximum annual total research expenditures during the period under study is less than \$1 million.

To study the role of state governance on research productivity, I concentrate on the state level board. This board usually has oversight for all 4-year public post-secondary institutions.<sup>8</sup> In most cases there is only one state level board responsible for 4-year public universities. A few states, however, have more than one board at the state level. In this case, one board usually has more powers than the other board, with the other board usually playing an advisory or planning role; I focus the analysis on the board with the greater power.

Knott and Payne (2001), using a smaller sample that covers the period 1987 to 1998, used a reduced form analysis to examine the effect of the structure and composition of state and institutional level boards on research measures at universities. That analysis suggested resources at universities in states with a decentralized board have grown faster than at universities in states with boards with more regulatory powers. This paper extends the analysis of Knott and Payne (2001) to explore the relationship between research funding and different research outcomes for

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<sup>7</sup> These data are publicly available for a subset of the research and doctoral universities. I obtained additional data to cover most of the research and doctoral universities from ISI.

research universities based on the structure of the state level governing board. I group the state level governance structures into three types that are slightly different from the three categories presented above. The categories I use attempt to capture the degree of regulatory authority the state board has over the public universities. The first category covers those states with a consolidated governing board. These structures are the most centralized, as discussed above. The second category covers those states with a coordinating board with regulatory power over both the budget and program approval or with regulatory power over program approval and some statutory responsibility over the budget. This excludes the universities located in New York because the state governing board operates as a coordinating board with regulatory authority over program approval but no statutory authority over the budget.<sup>9</sup> The third type covers those states with are a coordinating board with only advisory powers or solely a planning agency, and the New York universities. I chose to group these two types of structures because of the level of autonomy the state board has over the universities appear to be similar. These structures are the most decentralized.

Over time a university may be included in more than one of the three categories of governance structures. For most states, however, the state level governance structure, in this respect, has not changed between 1982 and today. Table 1 reports the distribution of the states across the three types of governance structures; the states in bold print are those states that have switched from one governing structure type to another during the period under study. There is no clear pattern across the three types of governance to suggest a size or regional bias towards

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<sup>8</sup> In some instances the board also has oversight authority for 2 year institutions, in other instances there is a separate board with oversight authority for 2 year institutions. In some states, the state level board also has some authority over private institutions.

<sup>9</sup> Although program approval is an important aspect over which to govern, if the coordinating board does not have any statutory authority over the budgets of the universities it governs, it seems important to distinguish this state from the others states that fall within the second classification.

one of the governance structures. The fewest number of states and the most amount of change during the period under study are with the category of decentralized boards; this reflects the move during this period towards a more centralized system of governance.

Table 2 reports the mean values of the research measures across the three types of state governance structure. All dollars were deflated using the NSF higher education price index and are reported in 1996 dollars. Across all measures, the values are highest for those universities that fall under the decentralized classification. Average annual total research expenditures are \$117 million or \$156 thousand per faculty at universities in decentralized states; average expenditures are only \$67 million or \$75 thousand at universities in centralized states. The average number of articles published is 1549, or 2 articles per faculty at universities in decentralized states; the average is 750 or less than 1 article per faculty at universities in centralized states. Similarly the number of citations per article is 18 at universities in decentralized states and only 12 at universities in centralized states. The number of graduate students and average faculty salary are also higher in states with decentralized governance structures. Thus, based on the averages of these measures, it is easy to see that universities in states with decentralized governance structures appear to be more productive and better off than at universities in states with centralized structures.

The last column of Table 2 reports the mean values of the research measures for private universities. Many of the means, especially the citations per article published and number of graduate students per faculty, for the private universities are similar to those reported for public universities with a decentralized governance structure.

Figure 1 depicts the average per faculty total research funding based on the state governance structure over time. Throughout the entire period, the average funding is highest for



universities with a decentralized structure. The average funding at the universities with a structure that is centralized and at universities with a structure that allows for some regulation are very similar. Over time, the average growth in funding is higher at public universities with a decentralized governance structure than at the other universities. Figure 2 depicts the average number of articles published per faculty based on the state governance structure over time. As with figure 1, The average and growth in articles published also are highest at universities with a decentralized governance structure.

Figure 3 depicts the average number of citations per article based on the state governance structure over time. Because this measure reflects the number of citations for articles published in a given year through to 1999, the number of citations per article published is higher in the earlier years. Throughout the entire period, the average for the public universities with a decentralized structure and private universities are statistically the same. This is also true of public universities with a centralized structure and those universities with a structure that allows for some regulation. Interestingly, the difference between these two groups of universities is the same in the first part of the period. This difference, however, declines in the last six years.

Figures 4 and 5 depict the average number of graduate students and faculty salary per faculty, respectively. As with the other figures, the average is highest for those universities with a decentralized governance structure. Unlike the previous figures, however, there is some evidence of a difference (albeit small) between universities with a centralized governance structure and those universities with a governance structure that allows for some regulation.

Table 2 and the figures fail to take into account the heterogeneity that exists across universities. For example, some states may choose to more centralized governance structure given the state demographics, the reputation of the university, or some other historical

phenomenon that would explain the position held by the state's research universities. The next section pursues this question of how state governance affects research resources and productivity after taking into account the heterogeneity that exists across universities.

### III. Results

#### A. Relationship between research funding and research activities, OLS specification

Using the three types of governance structures that represent the centralized, decentralized, and some regulatory power types of governing boards, I use the following empirical model to explore the relationship between research funding and research activities:

$$Y_{ist} = \alpha_{it} + \beta_g R_{ist-1} + S_{st} \gamma + \lambda_t + \varepsilon_{ist}$$

Y represents the research activity (articles published, citations per article published, number of graduate students, and average faculty salary) for university i, located in state s, at time t. R represents total research funding, S represents a vector of state level economic, demographic, and political variables that are designed to proxy the conditions under which the universities operate that could affect the type of research undertaken at the universities, the types of researchers, students, and other factors that would affect research productivity.<sup>10</sup> The level of research funding is interacted with a dummy variable to reflect the three different governance structures, thus allowing the relationship between research funding and research activity to vary by governance type. I lag the value of research funding by one year to reflect that research grants may awarded in one year, spent in a future year and results in research outcomes following the spending of the research funding.<sup>11</sup> In addition, the specification includes a time trend and a

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<sup>10</sup> I use the following state level measures: The percent of the population that is under 18; the unemployment rate, the per capital gross state product in the following industries: chemical, agriculture, health, state and local government, and private industry; a dummy variable equal to one if the state governor's political affiliation is with the Democratic Party; the percent of state upper and lower legislature members that are affiliated with the Democratic party.

<sup>11</sup> If I use a two year lag instead of a one year lag, the results are very similar.

university fixed effect interacted with the time trend. The time trend is designed to capture macro level shocks that affect all universities similarly.

The university fixed effect is designed to capture differences across universities due to heterogeneity. I interact the fixed effect with a time trend to allow universities to grow at different rates. Given previous research suggests that universities with a medical school, for example, have experienced more growth in research funding and other measures than other universities, the university fixed effect interacted with a time trend will capture this type of difference.

As illustrated in the theoretical framework, I expect the coefficients on  $\beta$  to be different from each other. To the extent that a more centralized governance structure results in stricter regulation and, thus, stricter incentives to which a university must comply, I expect the coefficient to be less than the coefficients on the other types of governing structures. Similarly, to the extent a more decentralized structure reduces the number of principals to which the university reports or reflects a lower incentive scheme, the marginal effect of an additional dollar of research funding to be greater than for the other structures. If, however, the state board needs more than advisory powers to be able to influence the activities of the university, following the theory of administrative federalism, the marginal effect of an additional dollar of research funding may be greater at universities that report to a state governing board with some regulatory power than at universities with a decentralized governing board.

Table 3 reports the results from the OLS regressions. Column 1 reports the results when the number of articles published is the dependent variable. All three coefficients on the measures of research funding are statistically significant with a p-value of less than five percent. If the university is in a state with a centralized governance structure or a coordinating board with some

regulatory authority, on average, an additional \$1 million in total research funding increases the number of articles published by 11.6. In contrast, the number of articles published is 12.5 for universities in states with a more decentralized structure, suggesting a difference of 1 article from those universities with more centralized governing structures. The coefficient for the decentralized measures is statistically different from the coefficients for the centralized board and the coordinating board with some regulatory authority at a p-value value less than .06.

Column 2 reports the results using the number of citations per article as the dependent variable. This measure reflects potential quality in the publications insofar as the articles are cited in other publications. The coefficients under this specification also suggest a difference between universities in states with a centralized governance structure and those universities in states with a decentralized structure. On average, if the university is in a state with a centralized structure, an additional \$1 million in total research funding increases the number of citations per article by .06. In contrast, the number of citations per article is increased by .08 at universities in states with a more decentralized structure. Thus, with respect to publications, the results suggest more articles of a higher quality are published at universities in a state with a more decentralized governance structure.

Column 3 reports the results when the number of graduate students is the dependent variable. Unlike the publications measures, the results do not suggest a statistically different effect from an increase in research funding between universities in states with a centralized structure and universities in states with a decentralized structure. The greatest impact from an increase in funding, however, occurs at universities in states with a governing board that has some regulatory powers. The results suggest, on average, that an addition \$1 million in funding increases the number of graduate students by 21.

Column 4 reports the results when the average faculty salary is the dependent variable. The results suggest that, on average, an increase in \$1 million of total research funding increases average faculty salaries between \$46 and \$49, depending on the type of state governance structure. The coefficients across the three governance types are not statistically significantly different from each other. The results from this measure are interesting insofar as they suggest a minimal effect from bringing in additional research funding on average faculty salaries. It also suggests that if, indeed the research endeavors vary across universities based on the incentives provided by the type governing boards, these differences are not reflected in faculty salaries.

Across the four measures of research outcomes, the results are mixed. Given, however, these measures capture different aspects of research productivity, this should not be surprising. With respect to the publication measures, the results are analogous to averages reported in Table 2 and Figures 1 through 5. The results suggest that, even after controlling for time-varying heterogeneity across the universities, universities in states with a decentralized governance structure are more productive than the other public universities. The results also suggest an insignificant difference in research productivity between universities in states with a centralized governance structure and universities in states with coordinating boards with some regulatory power.

#### B. Relationship between research funding and research activities, IV specification

The OLS specification may not accurately depict the differences between the research funding and the research activities measures for three potential reasons. First, as explained in Payne and Siow (2000), if there is more than one input used to produce an output and the shadow prices of these inputs are correlated, an OLS reduced form specification of the output regressed on one of the inputs will be biased. Second, if the research funding is endogenous then the OLS

specification will be biased. In this instance endogeneity is a concern for at least some of the measures. Third, if there are variables that are correlated with research funding and the research outcome measure that are omitted from the empirical specification, then the coefficient on the research funding measure will be biased. For example, if there is a shock at the state or local level that would result in research being refocused in a particular area and this shock is not captured using the state level measures then the coefficient on the research funding measure would be biased. To address all of these potential problems, I use an instrumental variables (IV) specification.

In designing a set of instruments, my goal was to find a set of measures that would help predict the level of research funding by reflecting potential changes in the shadow price of funding and productivity shocks. I focused on the level of research funding at private universities that are similarly situated as the public universities under study in terms of regulatory environment and research activities. Thus, in effect I am using the data from the private universities to create a measure that compares “peer” institutions. If public universities in states with a more regulated governing structure do not operate similarly to private universities, using the data from the private universities as instruments presents a problem. As shown below, the measures used as instruments are strongest for those universities in states with a decentralized board. This finding follows the belief that universities with decentralized governing board operate similarly to private universities. The instruments for the universities in the other two types of governance states are strong, with f-statistics of 7.5 or greater, suggesting they help in the prediction of government funding. One reason the instruments may work is if, regardless of the type of government regulation, all public universities are likely to have similar

research goals as private universities, and, thus, to this extent the activities of a private university will proxy the activities of public universities.

For each public university, I developed two sets of instruments. For each set, I created three measures of research funding based on the location and level of research productivity of the private universities. I use the average of the per faculty total research funding at the private universities to reflect that most private and public universities differ in terms of size. Both sets of instruments use two criteria to capture similarities in location: first I identified those universities located in the three regions outside of the region for the public university under study. Second, within each region, I identified those private universities in states with similar public university governing boards as the governing board for the university under study; for this exclusion, I used two categories: whether the university is in a state with a governing board that has regulatory powers or advisory powers. Thus, for the creation of the instruments, I collapsed the first two categories of governing boards discussed above into one. I excluded the region in which the public university is located to avoid potential correlation from shocks within the region and research activities by all universities that are not captured by the set of exogenous variables used in the specification.<sup>12</sup> I focused on the private universities within the same regulatory environment but in other regions to capture the dynamics that may exist between private and public universities operating in similar regulatory environments.

To capture similar research environments, my goal was to use criteria that reflected the quality and/or type of research activities, historically. The obvious measure to use is the National Research Council's ratings of the research universities. Unfortunately, this rating does not exist for all of the universities under study. Thus, I use the two sets of instruments to reflect

different aspects of research activities. For the first set, I use the number of citations per article three years prior to the year of the government funding.<sup>13</sup> I use the citations per articles for the universities to divide the universities into three categories: those in the bottom, middle, and top third in the number of citations per article. Thus, this criterion attempts to pair the public universities with those private universities based on a similar average number of citations per article. To the extent that the citations per article measure is a proxy of the quality of academic research, the peer institutions should reflect differences associated in this proxy.

For the second set of instruments, I focus on the proportion of federal research funding from the National Science Foundation (“NSF”) and National Institutes of Health (“NIH”) to the total research funding at the university, lagged one year. Research funding is derived from many sources. NSF and NIH funding are two of the more prestigious and biggest government agencies from which to receive funding. This criterion attempts to capture similar research environments between the private and public universities. Thus, this instrument represents a potential difference in research activity that is reflected in a reliance on peer competitive research funding from a federal source. To do this, I classified the universities into three groups based on whether the share is in the bottom, middle, or top third of the average share of funding for the previous three years, by ownership type, across the universities.

A list of the private universities and the minimum and maximum ranking of the proxy for research environment during the period under study is provided in Appendix Table 2. I excluded information from Johns Hopkins University because the research funding at this university is

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<sup>12</sup> For example, if the state or region is interested in creating a “research corridor” that focuses on certain types of research to attract a particular industry, we might expect both public and private universities would benefit from such an interest.

<sup>13</sup> For the years prior to 1986, I used the citations per article from 1982.



dramatically higher than that of any other university, thus representing an outlier in the data.<sup>14</sup> I was able to match universities in the regions outside of the region in which the public university under study is located for all of the universities for at least two of the three regions for most of the universities. The exception is for most of the universities in New York and California; for these universities the instruments were created only for one region (region 4 for New York and region 1 for California). This problem is due to the lack of similar private universities in states with a decentralized governing board in states located in regions 2 and 3.

Table 4 reports the coefficients on the instruments in the first stage regression and the f-statistic on the group of instruments. The coefficients for the first set of instruments are reported in the top half of the table and the coefficients for the second set are reported in the bottom half. Column 1 reports the coefficients for the regression for the research funding measure interacted with the dummy variable that is equal to one if the state has a centralized governing board. Column 2 reports the coefficients for the regression for the research funding measure interacted with the dummy variable that is equal to one if the state's governing board has some regulatory authority. Column 3 reports the coefficients for the regression for the research funding measure interacted with the dummy variable that is equal to one if the state has a decentralized governing board. Across all three funding measures for both sets of instruments, the coefficients on the instruments are individually and jointly significant. The f-statistics for the set of coefficients for all three measures are highly significant, suggesting they are good predictors of research funding measures.

Table 5 reports the coefficients from the IV regressions for the four research activity measures. For each regression, I report the coefficients on the total research funding measure,

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<sup>14</sup> Inclusion of the data from Johns Hopkins dramatically changes the coefficient on the instrument for the region in which it is located and the group of four instruments, in most of the specifications, fail to pass the over-identification

interacted with the dummy variables for the type of state governance structure, the f-statistic which tests whether the three coefficients are different from each other, and the p-value from the Hausman (1978) and over-identification tests. The Hausman test is used to determine whether the coefficient from the IV regression is significantly different from the coefficient from the OLS regression. A low p-value suggests the IV estimate is significantly different from the OLS regression and is more efficient, assuming the over-identification test is satisfied. The over-identification test is used to determine whether the instruments would have any explanatory power if used in the second stage regression instead of the first stage regression. A high p-value suggests the instruments belong in the first stage and not the second stage regression. Across all of the specifications, the Hausman test is satisfied. The over-identification test is satisfied for all of the specifications except for the specification that uses the number of graduate students as the dependent variable and the first set of instruments.

The regressions that use the set of instruments that use the citations per article as the measure to distinguish the universities by research activities are reported in the top panel of the table. The regressions that for the set of instruments that use the ratio of NSF and NIH funding to total research funding to distinguish the universities by research activities are reported in the second panel. Regardless of the instrument set used, across all four measures of research activity, the IV coefficients on the research funding measures are the same as or lower than the OLS coefficients for the research funding measure for universities in states with a centralized governing board. The IV coefficients are greater than the OLS coefficients on the other research funding measures.

The striking results are seen in the coefficients on the research funding measure for the universities in states with a governing board with some regulatory power. The point estimates

are highest for this measure and are statistically different from the estimates for both the centralized and decentralized governing boards. The coefficients suggest, on average, that the additional number of articles published from an additional million dollars in funding at universities in states with some regulatory increases by 19 for the first instrument set and 31 for the second instrument set. This represents an additional 7 or 31 articles from the universities in states with a centralized board, depending on the instrument set used. The number of additional citations per article at the universities in states with some regulatory power is greater by .4 for the first instrument set and .7 for the second instrument set. The number of graduate students is greater by 15 for the first instrument set but not statistically different for the second instrument set. These results that research productivity is greatest in states with a coordinating board with some regulatory power.

The results also suggest that there are more articles published per dollar of research funding at universities in states with a decentralized governance structure compared to universities in states with a centralized structure. With respect to the first set of instruments, the coefficient for the decentralized governing board suggests that, on average, there are 4 more articles published from an additional \$1 million in research funding than at universities at with a centralized board. With respect to the second set of instruments, this difference amounts to 18 more articles. Given the average level of research funding per public university is \$72 million, these results suggests a very large difference between centralized and decentralized governing boards. There is also a difference between centralized and decentralized governing boards with respect to citations per article.

With respect to graduate students, the story is different. Focusing on the results reported in the second panel of Table 5, the number of graduate students per million dollars of research

funding is greater at universities with a centralized board than at universities with a decentralized board. Graduate students as a measure represents a potential output with respect to research funding and a potential input with respect to research productivity. As such, interpreting the impact of state governance on the relationship between the number of graduate students and research funding is difficult. The results suggest that the incentive structure from a centralized governance structure promotes increased graduate student enrollments but whether this promotes or detracts from research productivity is unclear. With respect to average faculty salary, as with the OLS estimates, the results suggest there is not a significant difference in the relationship between salary and research funding based on the governance structure under which a university operates.

These results suggest that centralizing oversight of universities by using a consolidated governing board with extensive regulatory powers results in lower productivity. To the extent that a consolidated governing board involves stricter control over the activities of the university, these results support the Holmstrom and Milgrom (1991) theory. The results also suggest, however, that having a state level board with only advisory powers may not be enough to promote research productivity. Thus, the results support the theory presented by Schwager (1999) that the state should play a role that involves limited authority over public universities.

#### B. Comparison with Private Universities

A common perception in the literature is that universities operate similarly to private universities. To examine this issue, in the bottom panels of Tables 3 and 5, I report the regression results when I examine private universities separately from public universities. If we examine only the OLS results, with respect to articles published, citations per article, and faculty salaries, the results suggest that an increase in research funding at private universities increases

these outcomes more than at public universities, regardless of the governance structure under which the public universities operate. The IV results, however, tell a different story. As instruments, I used the analogous instruments used for the public universities for the private universities. The  $f$ -statistic on the instruments is significant for both sets. The over-identification test, however, is satisfied only with the second set of instruments. The IV results suggest that the relationship between research funding and research outcomes at private universities is not that different from public universities. With the exception of the specification that uses the number of graduate students as the dependent variable, the results for the private universities are closest to those reported for the universities in a state with a decentralized board. The results, however, are not dramatically different from those reported for the universities in states with a centralized governing board. Thus, the results weakly support the common belief that universities in decentralized states behave similarly to private universities.

#### **IV. Conclusion**

This paper explores how the structure of state oversight boards for public universities affects the relationship between research funding and various research activities at these universities using a panel data set that spans from 1982 to 1998. The research activities studied are academic publications, citations to academic publications, number of graduate students, and average faculty salaries. Universities were classified as follows: those universities in states with a consolidated governing board (centralized); those universities in states with a coordinating board with some regulatory authority; and those universities in states with a coordinating board with only advisory powers or a planning agency (decentralized). The results suggest, on average, that resources are greater at universities in states with a decentralized governance structure. The effect of increasing research funding on research activities, however, is

substantially greater at universities in states with a coordinating board with some regulatory power. Universities in states with a decentralized governance structure also have a greater relationship between research funding and academic publications than at universities in states with a centralized governance structure. With respect to graduate students, there are more graduate students per dollar of research funding at universities in states with either a centralized or coordinating board governance structure. Finally, there is no strong evidence that the relationship between research funding and faculty salaries differ substantially based on state governance structures.

The results support the underlying theories that suggest that if an organization is engaged in multiple tasks and there is incomplete monitoring of those tasks, the incentives given to the organization should be less restrictive, suggesting a more decentralized structure. The results, however, also support the notion that if an organization can engage in rent-seeking activities or fails to internalize potential externalities associated with its activities, then some oversight at a broader level is important to promote a more efficient use of resources by the organization.

This paper focuses solely on the effect of state governance systems. An extension not developed in this paper concerns the interaction between state and local governance structures. Given that many universities report to both a university level and state level governance board, it is important to understand further the effect of having both structures on research productivity and other university activities. A second extension not pursued in this paper is one that examines in more detail, the political economy of the membership on the governing boards and the activities by the universities as well as the actions taken by the state legislature and governor relative to the governance type.

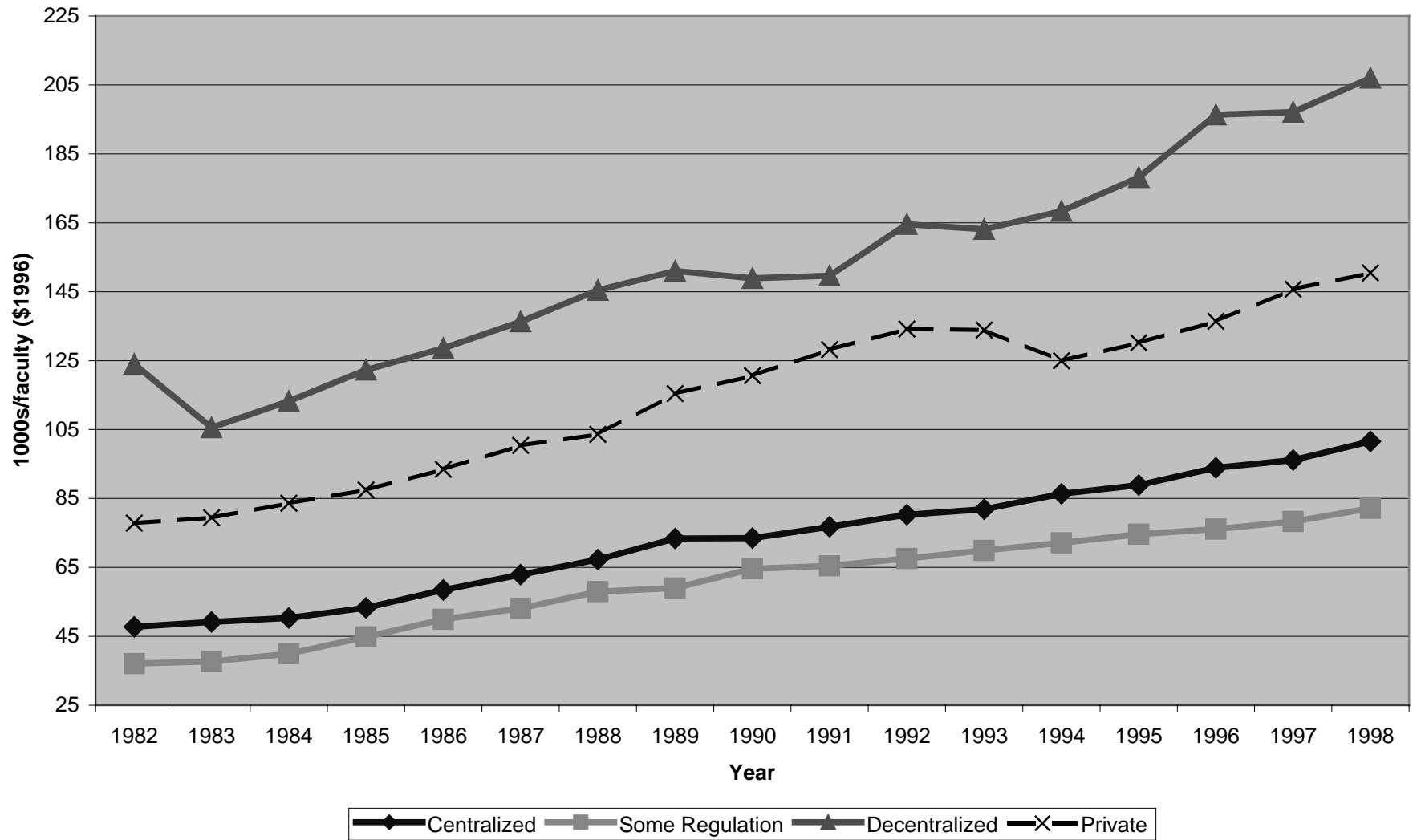
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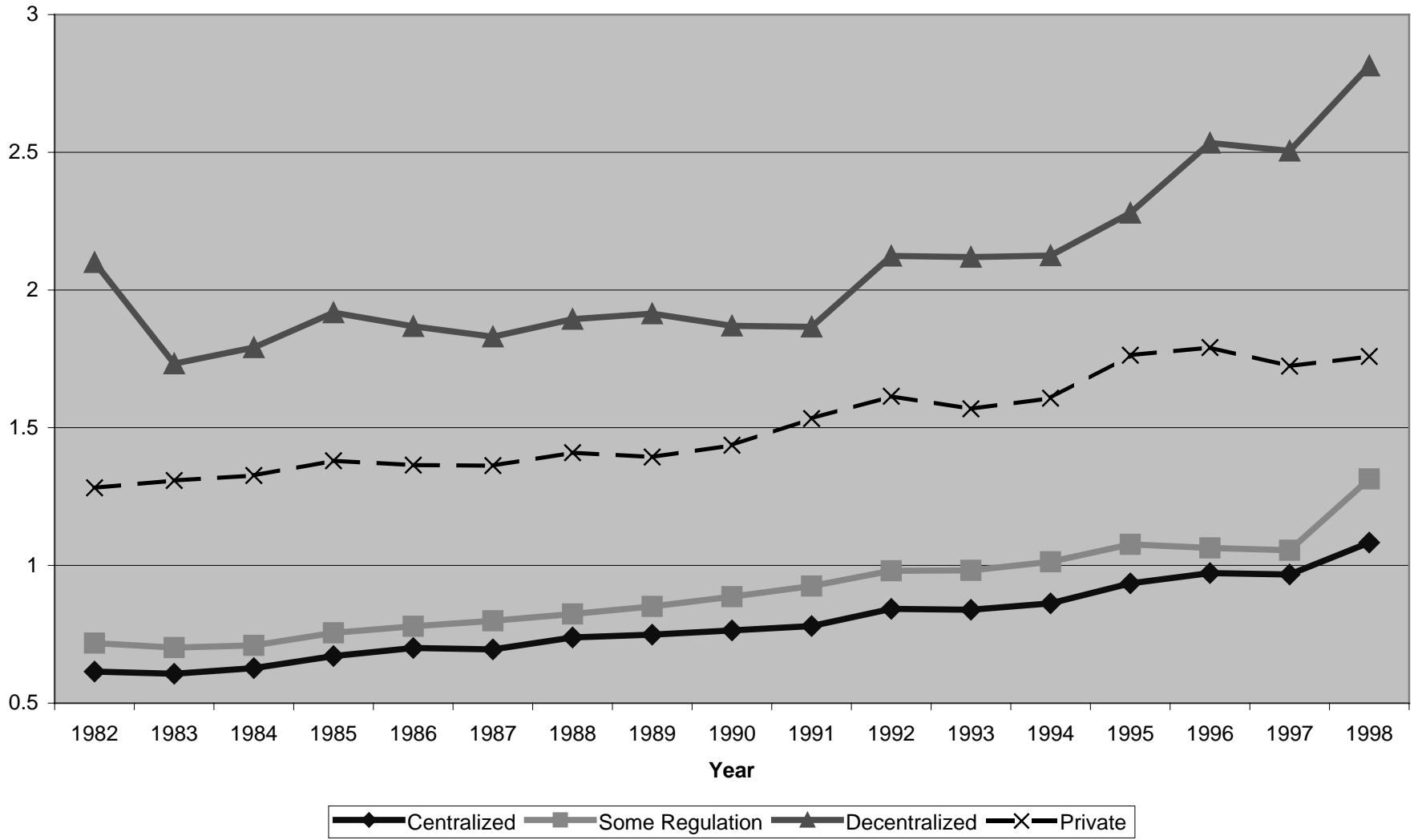
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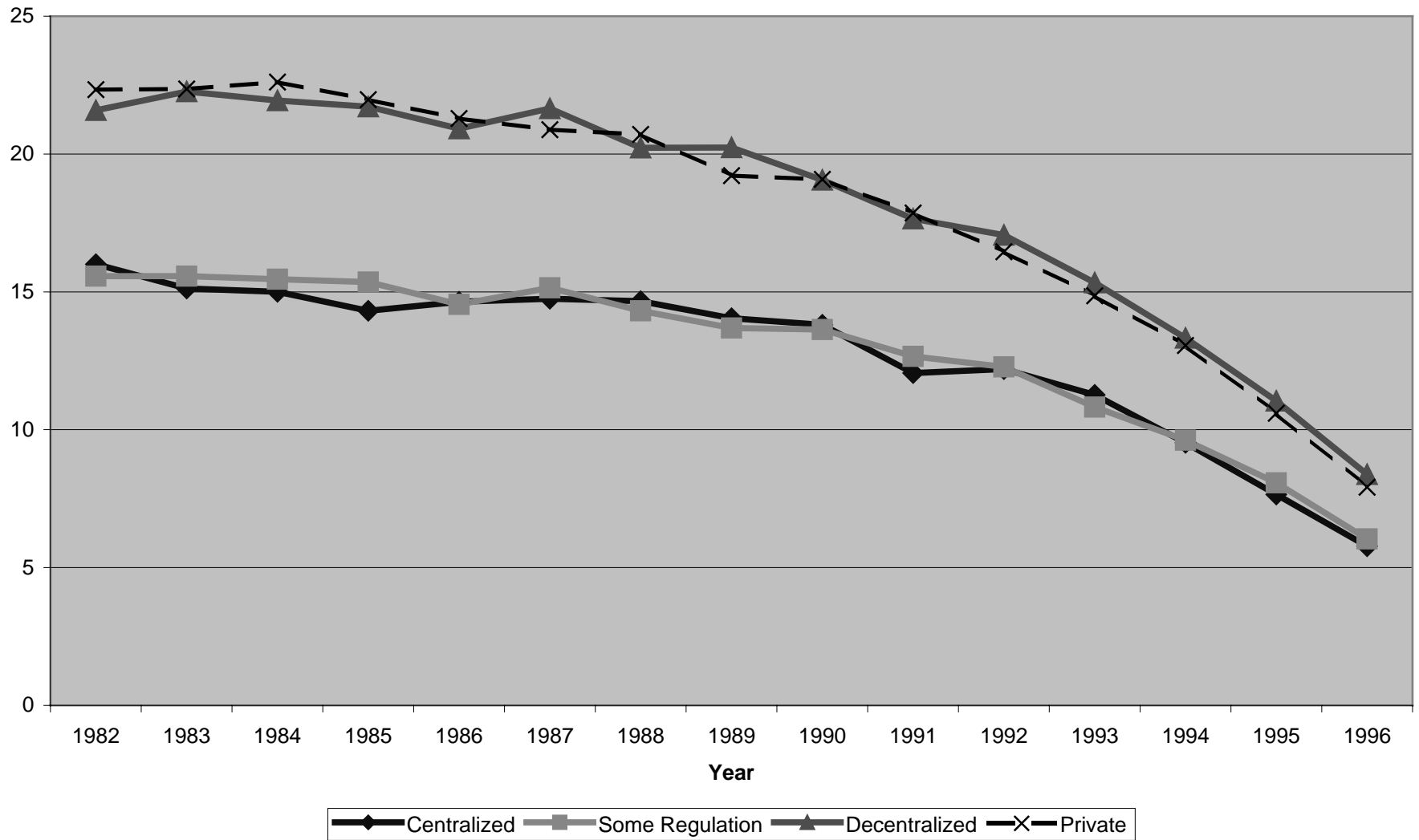
**Figure 1:**  
**Annual Total Research Funding Per Faculty**



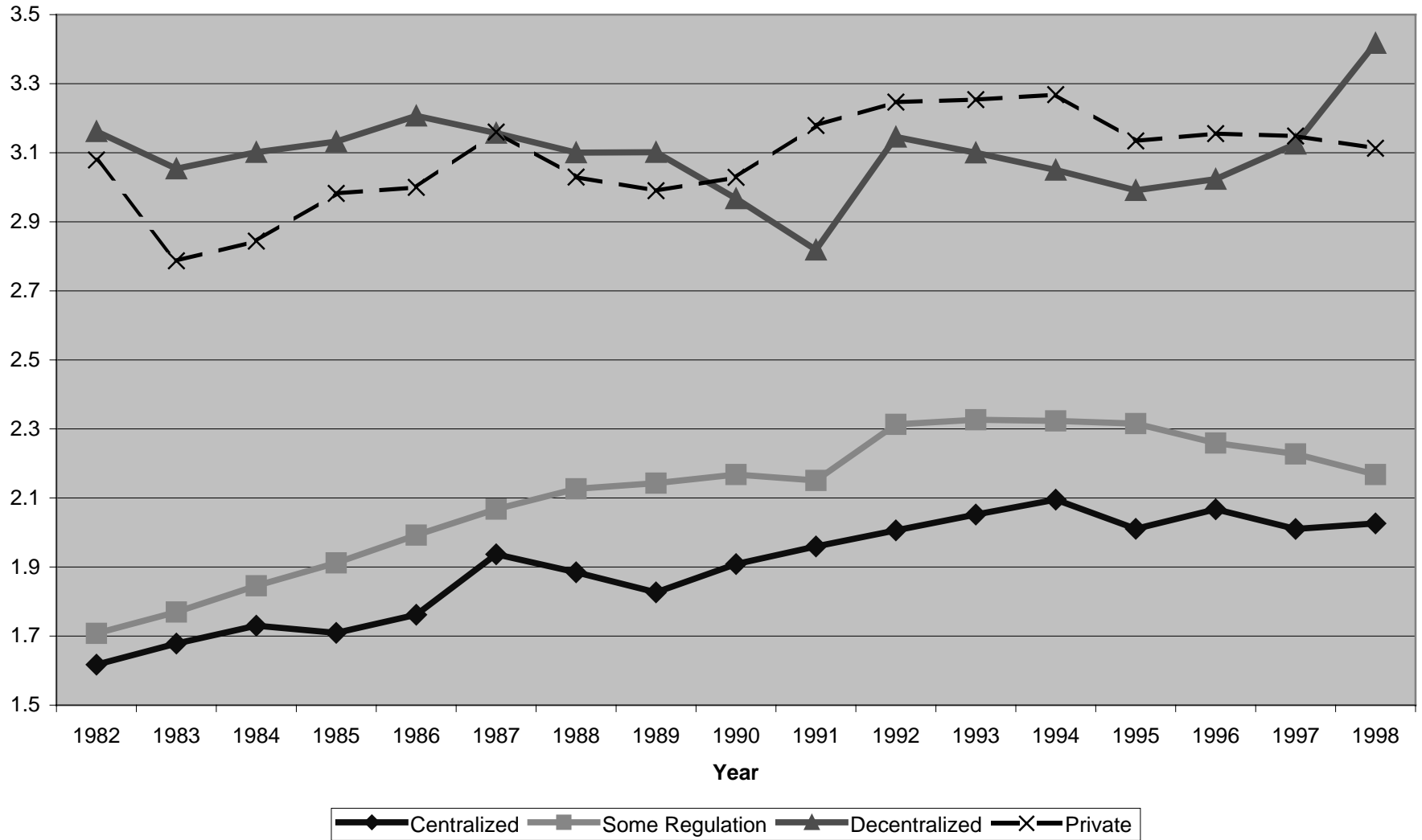
**Figure 2:  
Average Annual # of Articles Published**



**Figure 3:  
Average Citations Per Article**



**Figure 4:  
Average Number of Graduate Students Per Faculty**



**Figure 5:  
Average Salary Per Faculty**

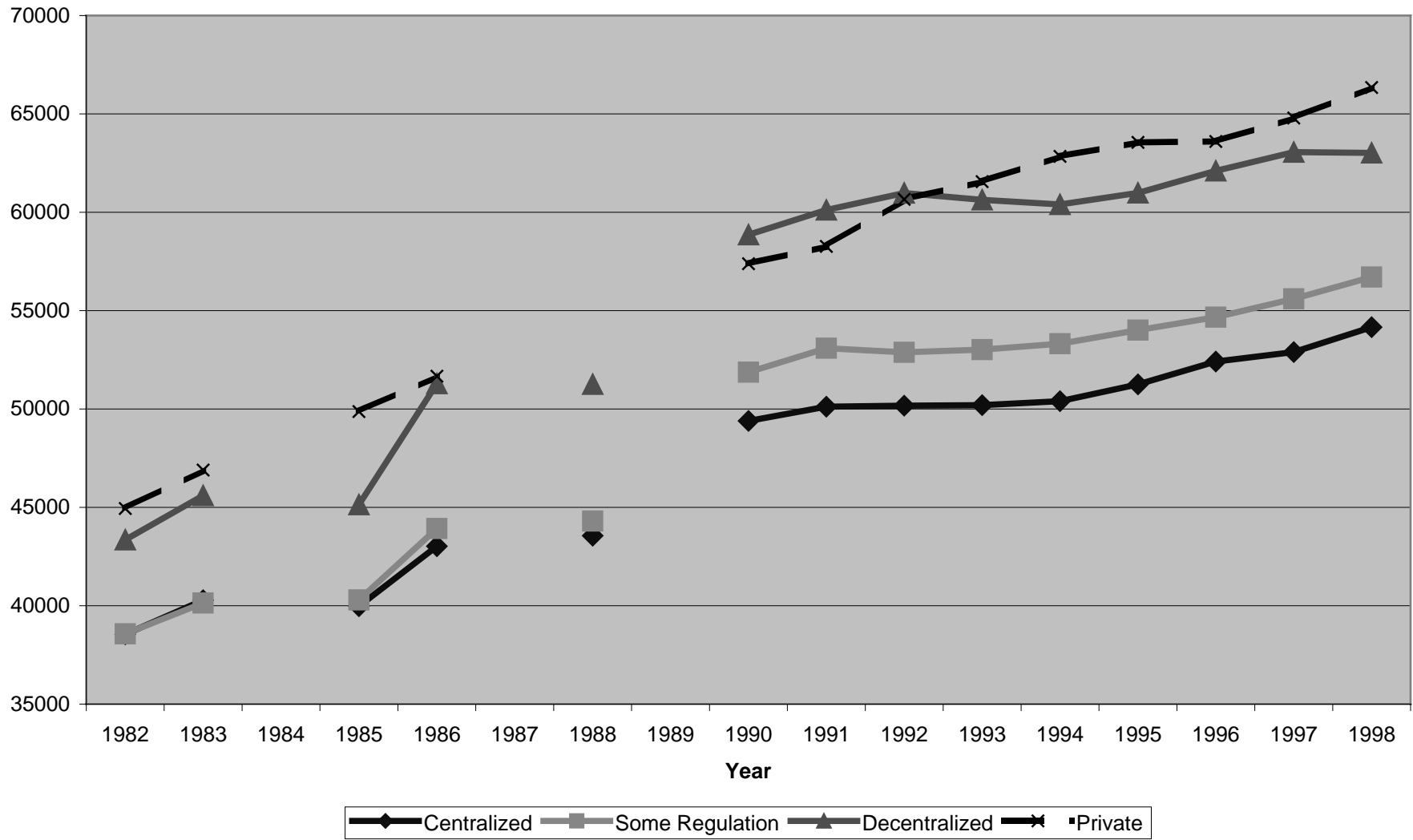


Table 1: Distribution of State Governing Boards

State	Region	Period if Not All Years	# of Research	Universities Doctoral
<b>Centralized Governing Board</b>				
Maine	1		0	1
<b>Massachusetts</b>	1	1986-1990	1	1
New Hampshire	1		0	1
<i>Rhode Island</i>	1		1	0
<b>Vermont</b>	1	1994-1997	1	0
<i>Iowa</i>	2		2	0
<i>Kansas</i>	2		2	1
<b>Minnesota</b>	2	1997	1	0
<i>North Dakota</i>	2		0	2
<i>South Dakota</i>	2		0	1
<i>Wisconsin</i>	2		2	0
Florida	3		3	3
<i>Georgia</i>	3		2	1
<i>Mississippi</i>	3		2	1
<i>North Carolina</i>	3		2	1
<b>West Virginia</b>	3	1986-88, 1994-97	1	0
<i>Arizona</i>	4		2	1
<i>Idaho</i>	4		1	1
<i>Montana</i>	4		0	2
<i>Nevada</i>	4		0	1
<i>Oregon</i>	4		2	1
<i>Utah</i>	4		2	0
Wyoming	4		1	0
<b>Governing Board w/ Some Regulatory Authority</b>				
Connecticut	1		1	0
<b>Massachusetts</b>	1	1994-1997	1	1
New Jersey	1		1	1
<b>Pennsylvania</b>	1	1986-1990	3	0
Illinois	2		3	2
Indiana	2		2	2
Missouri	2		1	3
<b>Nebraska</b>	2	1994-1997	1	0
Ohio	2		4	6
Alabama	3		2	2
<b>Arkansas</b>	3	1990-1997	1	0
Kentucky	3		2	0
Louisiana	3		1	2
Maryland	3		1	1
Oklahoma	3		2	0
South Carolina	3		2	0
Tennessee	3		0	2
Texas	3		4	5
Virginia	3		3	3
Colorado	4		2	1
<b>New Mexico</b>	4	1986	2	0
Washington	4		2	0
<b>Decentralized Governing Board</b>				
New York	1		3	3
<b>Pennsylvania</b>	1	1994-1997	3	0
<b>Vermont</b>	1	1986-1990	1	0
Michigan	2		2	2
<b>Minnesota</b>	2	1986-1994	1	0
<b>Nebraska</b>	2	1986-1990	1	0
<b>Arkansas</b>	3	1986-1988	1	0
Delaware	3		1	0
<b>West Virginia</b>	3	1990	1	0
California	4		9	1
<b>New Mexico</b>	4	1988-1997	2	0

Note: States in bold identify those states that whose state governing board type has changed over the sample period. States in italics identify those states with state level but no university level governing board. A centralized governing board is one that has a state level consolidated governing board as defined in the text. A governing board with some regulation is one that is a coordinating board with regulatory powers over program approval and some regulatory authority over the budget. A decentralized governing board is one that is a coordinating board with only advisory powers, a planning agency, and New York, which is a coordinating board with regulatory power over program approval but no statutory authority over the budget.

Table 2: Average Research Funding and Research Activities

	Centralized		Some Regulation		Decentralized		Private Universities	
	# of Obs	Mean	# of Obs	Mean	# of Obs	Mean	# of Obs	Mean
Total Research (millions)	738	<b>66.5</b>	1,141	<b>65.0</b>	463	<b>117.3</b>	1,178	<b>66.9</b>
Total Research/Faculty (thousands)	693	<b>74.9</b>	1,073	<b>61.8</b>	437	<b>155.7</b>	971	<b>117.2</b>
Federal Research (millions)	737	<b>37.0</b>	1,141	<b>36.0</b>	463	<b>72.9</b>	1,168	<b>53.1</b>
Federal Research/Faculty (thousands)	692	<b>41.6</b>	1,073	<b>33.6</b>	437	<b>95.9</b>	961	<b>91.2</b>
Articles Published	722	<b>750.2</b>	1,103	<b>847.0</b>	441	<b>1549.0</b>	1,108	<b>935.4</b>
Articles/Faculty	679	<b>0.8</b>	1,036	<b>0.9</b>	416	<b>2.1</b>	917	<b>1.5</b>
Citations Per Article	722	<b>12.7</b>	1,103	<b>12.9</b>	394	<b>18.1</b>	971	<b>18.0</b>
Graduate Students	738	<b>1537.5</b>	1,134	<b>1795.9</b>	463	<b>2122.1</b>	1,178	<b>1312.6</b>
Grad Students/Faculty	693	<b>1.9</b>	1,066	<b>2.1</b>	437	<b>3.1</b>	971	<b>3.1</b>
Faculty Salary	607	<b>47,676</b>	940	<b>49,435</b>	381	<b>56,354</b>	841	<b>58,141</b>

Note: All dollars are \$1996, using the NSF CASPAR higher education price index.

Table 3: Relationship Between Total Research Funding and Research Activities, OLS Regression

Dependent Variable	Articles Published	Citations Per Article	Graduate Students	Faculty Salary
<b>All Public Universities</b>				
Centralized State (a)	<b>11.648</b> (0.418)	<b>0.055</b> (0.007)	<b>17.621</b> (0.665)	<b>48.850</b> (4.936)
Some Regulatory Authority (b)	<b>11.560</b> (0.374)	<b>0.064</b> (0.006)	<b>21.193</b> (0.691)	<b>45.526</b> (3.422)
Decentralized State (c)	<b>12.454</b> (0.420)	<b>0.078</b> (0.007)	<b>16.805</b> (0.998)	<b>47.058</b> (3.561)
F-Test a=b (p-value)	0.030 (0.853)	1.460 (0.227)	20.130 (0.000)	0.420 (0.519)
F-Test a=c (p-value)	3.670 (0.055)	6.160 (0.013)	1.160 (0.281)	0.180 (0.673)
F-Test b=c (p-value)	4.460 (0.035)	4.820 (0.028)	19.990 (0.000)	0.170 (0.681)
R-square	0.963	0.694	0.910	0.918
# of Observations	2264	2023	2034	1926
# of Universities	139	139	139	139
<b>All Private Universities</b>	<b>12.005</b> (0.617)	<b>0.130</b> (0.009)	<b>12.255</b> (0.684)	<b>55.481</b> (4.254)
R-square	0.968	0.761	0.804	0.890
# of Observations	1107	970	1177	840
# of Universities	70	70	70	70

Note: Standard errors reported in parentheses unless otherwise noted. Coefficients in bold identify are statistically significant at a p-value<.05. Other measures included in the regression: time trend, university fixed effect interacted with a time trend, the following state level measures: The percent of the population that is under 18; the unemployment rate, the per capital gross state product in the following industries: chemical, agriculture, health, state and local government, and private industry; a dummy variable equal to one if the state governor's political affiliation is with the Democratic Party; the percent of state upper and lower legislature members that are affiliated with the Democratic party.



Table 4: First Stage Regression

	Centralized	Some Regulation	Decentralized	Private**
<b>Instrument Set A</b>				
Research funding at Private Universities, Region 1	-12.66 (8.13)	<b>-41.02</b> (10.14)	<b>233.36</b> (19.19)	<b>146.24</b> (37.31)
Research funding at Private Universities, Region 2	<b>-35.27</b> (17.56)	<b>97.47</b> (21.32)	<b>-119.55</b> (17.10)	<b>131.73</b> (34.46)
Research funding at Private Universities, Region 3	<b>177.10</b> (38.18)	<b>155.90</b> (27.23)	<b>-234.92</b> (33.68)	<b>144.14</b> (48.12)
Research funding at Private Universities, Region 4	<b>-66.90</b> (20.69)	<b>-48.93</b> (20.98)	<b>192.37</b> (33.02)	<b>318.35</b> (36.96)
F-test on Instruments (p-value)	7.54 (0.00)	16.86 (0.00)	49.54 (0.00)	41.76 (0.00)
R-square	0.88	0.88	0.91	0.89
# of Observations	2340	2340	2340	1177
<b>Instrument Set B</b>				
Research funding at Private Universities, Region 1	-18.01 (10.61)	<b>-81.90</b> (14.30)	<b>185.67</b> (19.40)	<b>81.54</b> (35.47)
Research funding at Private Universities, Region 2	<b>-83.87</b> (19.98)	<b>110.66</b> (22.76)	<b>-119.12</b> (18.02)	<b>77.57</b> (38.93)
Research funding at Private Universities, Region 3	<b>174.79</b> (39.83)	<b>167.70</b> (26.12)	<b>-282.19</b> (42.21)	<b>148.14</b> (41.04)
Research funding at Private Universities, Region 4	-7.40 (9.78)	<b>-62.36</b> (15.90)	<b>89.89</b> (23.03)	19.81 (16.83)
F-test on Instruments (p-value)	6.51 (0.00)	17.01 (0.00)	34.77 (0.00)	7.52 (0.00)
R-square	0.88	0.88	0.88	0.86
# of Observations	2340	2340	2340	1177

Note: standard errors reported in parentheses unless otherwise noted. Coefficients in bold are significant with a p-value<.05. Each column and each panel (A and B) represents a separate regression. See notes to Table 3 for list of other measures included in the regression. Instrument Set A: Average per faculty research funding at private universities in each region in which the public university under study is not located that share a similar regulatory environment (centralized & some regulatory power or decentralized) and similar rate of citations per articles in previous years (bottom third, middle third, top third). Instrument Set B: Average per faculty research funding at private universities in each region in which the public university under study is not located that share a similar regulatory environment (centralized & some regulatory power or decentralized) and similar ratio of NIH + NSF funding to total funding in previous years (bottom third, middle third, top third).

\*\* : for private universities, the instruments are constructed in the same manner using average per faculty research funding at similar public universities.



Table 5: Relationship Between Research Funding and Research Activities, IV

Dependent Variable	Articles Published	Citations Per Article	Graduate Students	Faculty Salary
<b>Instrument Set A</b>	(1)	(2)	(3)	(4)
Centralized State (a)	<b>11.93</b> (2.57)	-0.18 (0.23)	<b>12.89</b> (3.91)	<b>102.23</b> (22.57)
Some Regulatory Authority (b)	<b>19.22</b> (1.78)	<b>0.42</b> (0.11)	<b>28.02</b> (2.68)	28.47 (17.38)
Decentralized State (c)	<b>16.19</b> (0.68)	<b>0.21</b> (0.04)	<b>19.48</b> (1.24)	<b>68.07</b> (8.79)
F-Test a=b (p-value)	3.23 (0.07)	3.52 (0.06)	6.61 (0.01)	4.94 (0.03)
F-Test a=c (p-value)	2.47 (0.12)	2.34 (0.13)	3.21 (0.07)	2.96 (0.09)
F-Test b=c (p-value)	3.54 (0.06)	6.46 (0.01)	10.36 (0.00)	6.25 (0.01)
Over-Id Test (p-value)	(0.64)	(0.55)	(0.00)	(0.16)
Hausman Test (p-value)	(0.00)	(0.00)	(0.00)	(0.00)
<b>Instrument Set B</b>				
Centralized State (a)	<b>16.03</b> (6.23)	-0.03 (0.20)	<b>24.16</b> (2.87)	<b>56.93</b> (22.58)
Some Regulatory Authority (b)	<b>46.68</b> (12.29)	<b>0.73</b> (0.27)	<b>28.64</b> (5.97)	72.59 (42.49)
Decentralized State (c)	<b>34.11</b> (8.09)	<b>0.50</b> (0.19)	<b>22.49</b> (4.27)	<b>69.84</b> (28.17)
F-Test a=b (p-value)	6.58 (0.01)	6.31 (0.01)	0.65 (0.42)	0.15 (0.70)
F-Test a=c (p-value)	5.23 (0.02)	4.57 (0.03)	0.22 (0.64)	0.27 (0.60)
F-Test b=c (p-value)	5.17 (0.02)	4.54 (0.03)	5.98 (0.01)	0.02 (0.88)
Over-Id Test (p-value)	(0.87)	(0.92)	(0.11)	(0.00)
Hausman Test (p-value)	(0.00)	(0.00)	(0.07)	(0.72)
Private Universities (using Instrument set B)	<b>22.43</b> (2.06)	<b>0.37</b> (0.06)	<b>5.59</b> (2.66)	57.33 (32.76)
Hausman Test (p-value)	(0.92)	(1.00)	(0.01)	(0.25)
Over-Id Test (p-value)	(0.00)	(0.00)	(0.00)	(0.95)

Note: Standard errors in parentheses unless otherwise noted. Coefficients in bold are significant at a p-value <.05. See notes to Table 3 for additional measures included in the regressions. See notes to Table 4 for instruments used in first stage regression.

Appendix Table 1: List of Public Universities Studied

State	University	Carnegie
AL	Auburn University	Research
AL	University of Alabama at Birmingham	Research
AL	University of Alabama	Doctoral
AL	University of Alabama in Huntsville	Doctoral
AR	University of Arkansas	Research
AZ	Arizona State University	Research
AZ	University of Arizona	Research
AZ	Northern Arizona University	Doctoral
CA	University of California-Berkeley	Research
CA	University of California-Davis	Research
CA	University of California-Irvine	Research
CA	University of California-Los Angeles	Research
CA	University of California-Riverside	Research
CA	University of California-San Diego	Research
CA	University of California-San Francisco	Research
CA	University of California-Santa Barbara	Research
CA	University of California-Santa Cruz	Research
CA	San Diego State University	Doctoral
CO	Colorado State University	Research
CO	University of Colorado	Research
CO	Colorado School of Mines	Doctoral
CT	University of Connecticut	Research
DE	University of Delaware	Research
FL	Florida State University	Research
FL	University of Florida	Research
FL	University of South Florida	Research
FL	Florida Atlantic University	Doctoral
FL	Florida International University	Doctoral
FL	University of Central Florida	Doctoral
GA	Georgia Institute of Technology+A69	Research
GA	University of Georgia	Research
GA	Georgia State University	Doctoral
IA	Iowa State University	Research
IA	University of Iowa	Research
ID	University of Idaho	Research
ID	Idaho State University	Doctoral
IL	Southern Illinois University-Carbondale	Research
IL	University of Illinois at Chicago	Research
IL	University of Illinois at Urbana-Champaign	Research
IL	Illinois State University	Doctoral
IL	Northern Illinois University	Doctoral
IN	Indiana University	Research
IN	Purdue University	Research
IN	Ball State University	Doctoral
IN	Indiana State University	Doctoral
KS	Kansas State University	Research
KS	University of Kansas	Research
KS	Wichita State University	Doctoral
KY	University of Kentucky	Research
KY	University of Louisville	Research
LA	Louisiana State Univ	Research
LA	Louisiana Tech University	Doctoral
LA	University of Southwestern Louisiana	Doctoral
MA	University of Massachusetts at Amherst	Research
MA	University of Massachusetts Lowell	Doctoral
MD	University of Maryland at College Park	Research
MD	University of Maryland Baltimore County	Doctoral
ME	University of Maine	Doctoral
MI	Michigan State University	Research
MI	Wayne State University	Research
MI	Michigan Technological University	Doctoral
MI	Western Michigan University	Doctoral
MN	University of Minnesota	Research
MO	University of Missouri, Columbia	Research
MO	University of Missouri, Kansas City	Doctoral
MO	University of Missouri, Rolla	Doctoral
MO	University of Missouri, St Louis	Doctoral
MS	Mississippi State University	Research
MS	University of Mississippi	Research
MS	University of Southern Mississippi	Doctoral
MT	Montana State University - Bozeman	Doctoral

MT	University of Montana	Doctoral
NC	North Carolina State University at Raleigh	Research
NC	University of North Carolina at Chapel Hill	Research
NC	University of North Carolina at Greensboro	Doctoral
ND	North Dakota State University	Doctoral
ND	University of North Dakota	Doctoral
NE	University of Nebraska at Lincoln	Research
NH	University of New Hampshire	Doctoral
NJ	Rutgers the State Univ of NJ	Research
NJ	New Jersey Institute Technology	Doctoral
NM	New Mexico State University	Research
NM	University of New Mexico	Research
NV	University of Nevada-Reno	Doctoral
NY	SUNY at Albany	Research
NY	SUNY at Buffalo	Research
NY	SUNY at Stony Brook	Research
NY	CUNY Graduate School and University Center	Doctoral
NY	SUNY at Binghamton	Doctoral
NY	SUNY College of Environmental Sci & Forestry	Doctoral
OH	Kent State University	Research
OH	Ohio State University	Research
OH	Ohio University	Research
OH	University of Cincinnati	Research
OH	Bowling Green State University	Doctoral
OH	Cleveland State University	Doctoral
OH	Miami University	Doctoral
OH	University of Akron	Doctoral
OH	University of Toledo	Doctoral
OH	Wright State University	Doctoral
OK	Oklahoma State University	Research
OK	University of Oklahoma	Research
OR	Oregon State University	Research
OR	University of Oregon	Research
OR	Portland State University	Doctoral
PA	Pennsylvania State University	Research
PA	Temple University	Research
PA	University of Pittsburgh	Research
RI	University of Rhode Island	Research
SC	Clemson University	Research
SC	University of South Carolina	Research
SD	University of South Dakota	Doctoral
TN	Tennessee State University	Doctoral
TN	University of Memphis	Doctoral
TX	Texas A&M University	Research
TX	Texas Tech University	Research
TX	University of Houston	Research
TX	University of Texas at Austin	Research
TX	Texas Southern University	Doctoral
TX	Texas Woman's University	Doctoral
TX	University of North TX	Doctoral
TX	University of Texas at Arlington	Doctoral
TX	University of Texas at Dallas	Doctoral
UT	University of Utah	Research
UT	Utah State University	Research
VA	University of Virginia	Research
VA	Virginia Commonwealth University	Research
VA	Virginia Polytechnic Institute and State University	Research
VA	College of William and Mary	Doctoral
VA	George Mason University	Doctoral
VA	Old Dominion University	Doctoral
VT	University of Vermont	Research
WA	University of Washington - Seattle	Research
WA	Washington State University	Research
WI	University of Wisconsin-Madison	Research
WI	University of Wisconsin-Milwaukee	Research
WV	West Virginia University	Research
WY	University of Wyoming	Research

Appendix Table 2: List of Private Universities Used to Create Peer Institutions

State	University	Citations/Article		Ratio NSF+NIH/Total Research		
		Minimum Value	Maximum Value	Minimum Value	Maximum Value	
<i>Region 1</i>						
Connecticut	Yale University	Top Third	Top Third	Top Third	Top Third	
	Massachusetts	Boston College	Middle Third	Top Third	Bottom Third	Middle Third
Massachusetts	Boston University	Top Third	Top Third	Top Third	Top Third	
	Brandeis University	Top Third	Top Third	Middle Third	Top Third	
	Clark University	Bottom Third	Middle Third	Bottom Third	Top Third	
	Harvard University	Top Third	Top Third	Top Third	Top Third	
	Massachusetts Institute of Technology	Top Third	Top Third	Bottom Third	Middle Third	
	Northeastern University	Middle Third	Top Third	Middle Third	Top Third	
	Tufts University	Top Third	Top Third	Middle Third	Top Third	
	Worcester Polytechnic Institute	Bottom Third	Middle Third	Bottom Third	Bottom Third	
	New Hampshire	Dartmouth College	Top Third	Top Third	Middle Third	Top Third
	New Jersey	Princeton University	Top Third	Top Third	Middle Third	Middle Third
Seton Hall University		Bottom Third	Top Third	Bottom Third	Bottom Third	
New York	Stevens Institute of Technology	Bottom Third	Middle Third	Bottom Third	Bottom Third	
	Clarkson University	Bottom Third	Middle Third	Bottom Third	Middle Third	
New York	Columbia University	Top Third	Top Third	Top Third	Top Third	
	Cornell University	Top Third	Top Third	Middle Third	Middle Third	
	Fordham University	Bottom Third	Middle Third	Top Third	Top Third	
	Hofstra University	Bottom Third	Bottom Third	Bottom Third	Top Third	
	New School for Social Research	Bottom Third	Middle Third	Bottom Third	Top Third	
	New York University	Top Third	Top Third	Middle Third	Top Third	
	Polytechnic University	Bottom Third	Middle Third	Bottom Third	Bottom Third	
	Rensselaer Polytechnic Institute	Bottom Third	Middle Third	Bottom Third	Middle Third	
	Rockefeller University	Top Third	Top Third	Middle Third	Middle Third	
	St John's University	Bottom Third	Middle Third	Bottom Third	Top Third	
	Syracuse University	Middle Third	Top Third	Bottom Third	Middle Third	
	Teachers College, Columbia University	Bottom Third	Bottom Third	Middle Third	Top Third	
	University of Rochester	Top Third	Top Third	Middle Third	Top Third	
	Yeshiva University	Top Third	Top Third	Top Third	Top Third	
	Pennsylvania	Allegheny University of the Health Sciences	Bottom Third	Bottom Third	Middle Third	Top Third
		Carnegie Mellon University	Top Third	Top Third	Bottom Third	Bottom Third
		Drexel University	Bottom Third	Middle Third	Bottom Third	Middle Third
		Duquesne University	Bottom Third	Middle Third	Bottom Third	Top Third
		Lehigh University	Bottom Third	Middle Third	Bottom Third	Bottom Third
	Rhode Island	University of Pennsylvania	Top Third	Top Third	Top Third	Top Third
Brown University		Top Third	Top Third	Middle Third	Top Third	
<i>Region 2</i>						
Illinois	De Paul University	Bottom Third	Middle Third	Bottom Third	Top Third	
	Illinois Institute of Technology	Bottom Third	Top Third	Bottom Third	Middle Third	
	Loyola University of Chicago	Middle Third	Top Third	Bottom Third	Top Third	
	Northwestern Univ	Top Third	Top Third	Middle Third	Top Third	
	University of Chicago	Top Third	Top Third	Top Third	Top Third	
Indiana	University of Notre Dame	Middle Third	Top Third	Middle Third	Middle Third	
Michigan	University of Detroit Mercy	Bottom Third	Bottom Third	Bottom Third	Top Third	
Missouri	St Louis University+C11	Middle Third	Top Third	Top Third	Top Third	
	Washington University	Top Third	Top Third	Top Third	Top Third	
Ohio	Case Western Reserve University	Top Third	Top Third	Top Third	Top Third	
Wisconsin	Marquette University	Bottom Third	Middle Third	Bottom Third	Top Third	
<i>Region 3</i>						
Florida	Florida Institute of Technology	Bottom Third	Middle Third	Bottom Third	Bottom Third	
	Nova Southeastern University	Bottom Third	Top Third	Middle Third	Top Third	
	University of Miami	Top Third	Top Third	Middle Third	Top Third	
Georgia	Clark Atlanta University	Bottom Third	Middle Third	Bottom Third	Middle Third	
	Emory University	Top Third	Top Third	Middle Third	Top Third	
Louisiana	Tulane University	Middle Third	Top Third	Bottom Third	Top Third	
North Carolina	Duke University	Top Third	Top Third	Top Third	Top Third	
	Wake Forest University	Top Third	Top Third	Top Third	Top Third	
Oklahoma	University of Tulsa	Bottom Third	Middle Third	Bottom Third	Bottom Third	
Tennessee	Vanderbilt University	Top Third	Top Third	Top Third	Top Third	
Texas	Baylor University	Bottom Third	Middle Third	Bottom Third	Top Third	
	Rice University	Top Third	Top Third	Middle Third	Top Third	
	Southern Methodist University	Middle Third	Top Third	Bottom Third	Middle Third	
Texas Christian University	Bottom Third	Middle Third	Bottom Third	Top Third		
<i>Region 4</i>						
California	California Institute of Technology	Top Third	Top Third	Middle Third	Top Third	
	Claremont Graduate School	Bottom Third	Top Third	Bottom Third	Top Third	
	Loma Linda University	Middle Third	Top Third	Bottom Third	Top Third	
	Stanford University	Top Third	Top Third	Middle Third	Top Third	
	University of Southern California	Top Third	Top Third	Middle Third	Middle Third	
	University of the Pacific	Bottom Third	Top Third	Bottom Third	Top Third	
Colorado	University of Denver	Bottom Third	Top Third	Bottom Third	Middle Third	
Utah	Brigham Young University	Bottom Third	Top Third	Bottom Third	Middle Third	