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Faculty Employment and R&D Expenditures at Research Universities

by

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Abstract

This study uses panel data to examine the relationship between faculty employment and external R&D expenditures at research and doctoral institutions over a 15-year period of time. Not surprisingly, full-time faculty that are tenured or on tenure-tracks is the main category of faculty that generates external R&D funding. On the other hand, our results suggest that an increasing usage of part-time faculty, holding constant the institution's full-time faculty size boosts an institution's external R&D expenditures, probably through reducing teaching responsibilities for the full-time faculty. Increases in graduate student enrollments are associated with increases in external R&D expenditures. Finally, an institution's external R&D expenditures are significantly influenced by both the amount of its own institutionally financed research expenditures and the level of federal funding for research.

I. Introduction

During the last three decades, there has been a significant growth in the share of faculty members that are employed in part-time or full-time non tenure-track positions (Anderson 2002, Baldwin and Chronister 2001, Conley, Lesley, and Zimbler 2002, Ehrenberg 2004, Ehrenberg and Zhang 2005a). For example, in 1975, full-time tenured and tenure-track faculty members were 56.8% of the faculty nationwide at America's 2-year and 4-year colleges and universities, while full-time non tenure-track faculty and part-time faculty were 13.0% and 30.2%, respectively. By 2003, full-time tenured and tenure-track faculty had fallen to 35.1%, while the latter two categories had risen to 18.7% and 46.3%, respectively (Ehrenberg 2005).

Contingent faculty (full-time non tenure-track and part-time faculty) provide academic institutions with great flexibility in maintaining an academic labor force that is responsive to changes in student enrollment. This is important because of uncertain economics times, tight state budgets, and the end of mandatory retirement for tenure-track faculty members that took place in 1994. The cost savings that result from substituting less costly for more costly faculty members can be substantial. For example, in academic year 2005-2006, the average salary of full-time lecturers (most of whom were not on tenure-tracks) nationwide at America's doctoral universities (which we will focus on in this study) was $48,507, while the average salary of assistant professors at these institutions (most of who are on tenure-tracks) was $62,730 (Thornton 2006, survey report table 1). In other words, for every assistant professor that was replaced by a lecturer, an institution would save, on average, $14,223, or 22.7% percent. The cost savings would actually be much larger when the costs per credit hour are considered because full-time lecturers usually teach more classes than faculty members with tenure or on

tenure-tracks do, and because assistant professor typically mature over their life cycles into higher paid associate and full professors.

While the cost savings from using contingent faculty at first glance may appear desirable in light of the growing financial pressures faced by public and private higher education institutions, researchers only recently have began to examine the potential adverse impact of the increased usage of contingent faculty on the quality of education provided to undergraduate students. For example, Bettinger and Long (2006) used student-level information in 4-year public higher education institutions in Ohio and found that students with "adjunct heavy" course schedules in their first year of study were less likely to persist into the second year. In another study, Ehrenberg and Zhang (2005b) analyzed institutional level data from the College Board and other sources and found that an increase in a 4-year institution's usage of part-time or full-time non tenure-track faculty was associated with a decline in its students' graduation rate.

On the other hand, as undergraduate teaching has been increasingly shifted on the backs of contingent faculty, tenure and tenure-track faculty members may have more time to focus on research, which has been increasingly important for research and doctoral universities in the United States. This rising importance of scientific research is at least in part due to the recent advances in the life sciences, material sciences, and information sciences that have the promise of substantially contributing to improving human welfare and that in turn have led to enormous increases in funding for research from government, corporate, and foundation sources.

A study of the implications of the increased usage of contingent faculty on university research funding is therefore in order to draw a balanced view of the impact of the changing nature of faculty employment practices at American colleges and universities. Such an analysis is

important if we are to seek to have an employment pattern in academia that serves both the teaching and research goals of American higher education.

Our study is the first study to address how the increased usage of part-time and full-time non tenure-track faculty influences the level of external research funding at research and doctoral institutions in the United States. We use panel data for a large sample of institutions over the 15-year period 1990-2004 to analyze these questions. The data come from various sources including the NSF *Survey of R&D Expenditures at Universities and Colleges*, the NSF *Survey of Federal S&E Support to University, Colleges, and Nonprofit Institutions*, the College Entrance Examination Board's *Annual Survey of College Standard Research Compilation* data file (henceforth College Board data), and the IPEDS *Faculty Salary Survey* and *Enrollment Survey*. After the next section briefly describes the data sources and the changes in research activities that occurred during the period, the sections that follow present descriptive data, our analytical framework and empirical findings for research activities at research and doctoral institutions, and a few concluding remarks.

II. The Data

Our main variable of interest is the volume of R&D expenditures at Research and Doctoral universities. Our focus is on how an institution's level of external R&D expenditures is influenced by the composition of its faculty members between full-time tenured and tenure track faculty on the one hand and full-time and part-time non tenure track faculty on the other hand.

The NSF *Survey of R&D Expenditures at Universities and Colleges* provides information on R&D expenditures at higher education institution via its online system WebCASPAR (http://caspar.nsf.gov). We extract two variables for each institution, total academic R&D expenditures and institutionally financed academic R&D expenditures, and compute externally

financed R&D expenditures by subtracting the latter from the former. Because the majority of the research expenditures in higher education take place at research and doctoral universities, we focus on these institutions in our study.[1]

Institutionally financed R&D expenditures have increased substantially over time. During the 1970-71 to 2004-05 period, the weighted average institutional expenditure on research per full-time faculty member at the 228 research and doctoral institutional in the U.S. more than tripled in real terms. During the same period, the share of research expenditures that were financed out of institutional funds rose from 11.2% to 22.7%. Increasingly, academic institutions themselves are bearing a greater share of the ever increasing costs of scientific research (Ehrenberg, Rizzo, & Jakubson forthcoming).While there are a number of reasons why this has occurred, given the increasing competition for external research grants, one might expect that the more an institution spends out of its own funds on research in one year, the greater the external research funding it can generate in future years. As a result, we include institutional financed research expenditures in our analysis to test whether external research expenditures are positively influenced by institutional financed research expenditures in early years.

Our data on faculty employment levels are drawn from two sources, the College Board's *Annual Research* data and IPEDS *Faculty Salary Survey*. Each year, the College Board's data provide information on the number of part-time and full-time faculty at each post-secondary institution in the United States. These data permit us to compute the share of faculty at each institution that is full-time and to test whether this share affects an institution's external research volume. We hypothesize that, all other factors held constant (including the number of full-time faculty members at an institution) that an increased usage of part-time faculty might help reduce

[1] For example, while 602 academic institutions reported R&D expenditure data in the 2004 NSF survey, approximately 85% of the total of R&D expenditures took place at the 228 Research and Doctoral institutions.

the teaching load of full-time faculty members and hence increase the research productivity of the institution.

Full-time faculty members are not a homogeneous group. For example, full-time lecturers and instructors and non tenure track professorial faculty focus more on teaching than do full-time faculty members at these institutions who are tenured or on tenure-tracks. As a result, it is important to examine the impact of the share of full-time faculty members who have tenure or are on tenure tracks on an institution's research productivity as well. While the College Board data do not contain information on the number of full-time faculty by rank and/or by tenure status, the IPEDS *Faculty Salary Survey*, which reports the number of full-time faculty in each rank by tenure status permits us to compute the share of full-time faculty members that are tenured or in tenure-track positions.[2]

The impact of an increased usage of lecturers, instructors and other full-time non tenure track faculty on faculty research productivity is unclear. An increased usage of these faculty members whose main responsibility is for teaching may reduce the teaching load for the full-time tenured and tenure track faculty members and leave these people with more time for research. However, other factors held constant (including the total number of full-time faculty members), a

[2] Data are not available from the IPEDS *Faculty Salary Survey* for 2000-2001 and, for subsequent years, no information is reported on the tenure or tenure track status of faculty in each rank. For these years, we assume that the share of faculty members at a rank in an institution that is tenured or on tenure track is the same as the share was at the institution in 1999-2000, the last year for which this information was reported. So, for example, we obtain an estimate of the share of full-time faculty at the University of Minnesota that were tenured or in tenure track positions in 20004-2005 by multiplying the number of full professors at the university in 2004-2005 by the share of full professors at the university in 1999-2000 that were tenured or in tenure track positions. We repeat this for each rank (associate professor, assistant professor, instructor, lecturer), sum our estimates of the number of tenured and tenure-track faculty members across all ranks and then divide this sum by the full-time faculty size at the university in 2004-2005 to get an estimate of the share of full-time faculty at the university in 2004-2005 that were tenured or in tenure track positions. This may induce some error in the share estimates after 1999-2000 because the calculation does not allow for the proportion of full-time faculty at an institution in a rank that has tenure or is in tenured track positions to change during the last years of our sample (although it does take account of the changing rank distribution of the faculty). To see if this calculation influences our results, the models presented in the table 2 below were also estimated using a shorter sample of years (only data through 1999-2000) and the results proved very similar to those reported in table 2.

decrease in the share of full-time faculty members that are tenured or are on tenure tracks means a decrease in their numbers. This may cause total research activity at the university to decline.

These two share variables—the share of full-time faculty members among all faculty members and the share of the full-time faculty members that are tenured or on tenure-tracks — are the two primary explanatory variables used in our analyses to examine the impact of changing faculty composition on the level of research funding at an institution. As the discussion above suggests, it is important to also control for the number of full-time faculty members at the institution.

Student enrollment is another important factor that affects faculty research productivity because teaching loads determine the amount of time that faculty have to spend on research. Other factors held constant, the more time faculty spend teaching undergraduate classes, the less time they have to spend on research. However, the relationship between graduate enrollment and faculty research is more complex. While graduate education required substantial faculty time, graduates students can also reduce teaching loads and increase research capacity for faculty members when they are employed as teaching and research assistants. In addition, teaching advanced materials to graduate students may enhance faculty members' research productivity.[3] The IPEDS *Enrollment Survey* provides us with information for each institution on undergraduate and graduate student enrollment levels by attendance status (full-time and part-time) and we use these data to compute full-time equivalent (FTE) undergraduate and graduate enrollment levels at the institution.[4]

[3] Adams and Grilliches (1998) and Adams, March and Clemmons (2005) use panel data for over 100 major research universities and find that, other factors held constant, faculty members' publications and citations are related to the number of PhD students at the university. Similarly, Chellaraj, Maskus and Matoo (2005) use national time series data and find that, other factors held constant, an increase in the number of science and engineering PhD students is associated with increases in patent applications, university patents granted, and non-university patents granted.
[4] FTE enrollments are computed by adding one third of the part-time enrollments to the full-time enrollments.

Finally, because the majority of external R&D expenditures received by universities come from federal sources, it is desirable to control for the fluctuations in federal funding over years. Data on the federal funding received from different agencies for each institution are available each year from NSF *Survey of Federal S&E Support to University, Colleges, and Nonprofit Institutions*.

Federal funding for academic research varies over time and the rates of change of individual agency budgets may differ in any given year. The impact of these changes on an individual institution's level of external research expenditures will depends upon the areas of research in which the institution specializes. For example, an institution that is strong in the physical sciences and engineering and has a small medical college will be much more sensitive to what happens to National Science Foundation and Department of Defense research budgets than to what happens to the research budget at the National Institute of Health. Conversely, an institution with a major medical college and a small level of physical sciences and engineering research will be much more dependent on funding changes at the National Institute of Health than it will be to funding changes at the National Science Foundation or Department of Defense.

To account for the relative importance of federal funding from different agencies at individual universities, for each institution we calculate the weighted aggregate level of federal funding available for it to compete for each year, where the weights in each year is the share of its federal funding that the institution received from the different federal agencies in the previous year. In mathematical notation, we compute this variable as $\sum_j F(j,t)S(i,j,t-1)$, where i denotes the institution and j denotes the federal agency. $F(j,t)$ is the federal appropriation for

research to agency j in year t and $S(i, j, t-1)$ is the share of institution i's federal research funding that came from agency j in year t-1.[5]

III. Descriptive Statistics

Descriptive statistics on the percentages of faculty that are full-time, the percentages of full-time professorial faculty that are tenured or on tenure-tracks, total external R&D expenditures, and average R&D expenditures per faculty member at research and doctoral institutions during the sample period appear in Table 1. Similar data for public and private institutions are reported in Appendix Table 1.

Table 1 indicates that both the shares of full-time faculty and full-time faculty that are tenured or on tenure-tracks have both declined during the period, especially in more recent years. For example, the share of full-time faculty among all faculty members at research and doctoral institutions fluctuated between 76 and 77 percent during 1990s, but has fallen by 4 to 5 percentage points since 1999. Similarly, the share of full-time faculty members that is tenured or on tenure-tracks has fallen by approximately 6 percentage points. Similar tabulations reported in Appendix Table 1 suggest that public and private institutions have both experienced similar reductions in the two shares.

The 15-year period from 1990 to 2004 was one of rapid increases in external R&D expenditures at research and doctoral institutions. The average total external R&D expenditure at research and doctoral institution increased from about $75 million in 1990 to $130 million in 2004 (both in 2003 constant dollars), representing a nearly 75 percent real increase over this 15-year period. Appendix Table 1 indicates that both public and private institutions enjoyed substantial growth in external R&D expenditure during the period.

[5] The agency research budgets included in the calculation include the Department of Agriculture, the Department of Defense, the Department of Energy, the Department of Health and Human Services, the National Aeronautics and

Because of the large increase in external R&D expenditure and a moderate increase in the number of full-time faculty during this period - the average number of full-time faculty members increased from 676 in 1999 to 820 in 2004, or a 21 percent increase, - external R&D per full-time faculty member also increased substantially. Overall, average external R&D per full-time faculty increased from about $96 thousand in 1990 to $145 thousand in 2004, or a 51 percent increase. Appendix Table 1 indicates that while, on average, faculty members at private institutions have been more productive in generating external R&D funding than their public university counterparts, the relative gap between private and public institutions has narrowed over time. On average faculty at private institutions generate about 75 percent more external funding per faculty member than faculty at public institutions in 1990; however this relative advantage decreased to about 26 percent in 2004.[6]

Average external R&D funding per full-time tenured and tenure track faculty member exhibited similar trends over the period. That is, overall there has been a large growth in average external R&D funding per full-time tenured and tenure track faculty member (72%) and faculty at private institutions have been more productive in generating external R&D funding than their public sector counterparts, but their relative advantage relative has narrowed over time.

IV. Econometric Analyses

In the section, we present a formal regression analysis to examine how external R&D expenditures at an institution are influenced by the types of faculty employed at an institution and other institutional and external variables. Although our descriptive statistics span the 1990 to

Space Administration and the National Science Foundation.

[6] Adams and Clemmons (2006) have documented that while the research share of public universities has grown over the last 20 years, their research productivity (measured in terms of papers and citations per dollar spent on research) has grown less than their private sector counterparts

2004 period, our regression analyses end with 2003.[7] Our analytical approach is to use panel data to estimate models in which external R&D expenditure at institution *i* in year *t* (R_{it}) is specified to be a function of institutionally financed R&D expenditure at institution *i* in year t-1 (I_{it-1}), the number of full-time faculty members at the institution in the year (N_{it}), the share of full-time faculty among all faculty at the institution in the year (S_{fit}), the share of the full-time faculty at the institution that are tenured or on tenure-tracks in the year (S_{pit}), the weighted average of the funding provided by federal agencies in the year (F_{it}), institutional fixed effects (η_i), time fixed effects (δ_t), and a random error term (ε_{it}).

(1) $R_{it} = \alpha_0 + \alpha_1 I_{it} + \alpha_2 N_{it} + \alpha_3 S_{fit} + \alpha_4 S_{pit} + \alpha_5 F_{it} + \eta_i + \delta_t + \varepsilon_{it}$

where the α_k are parameters to be estimated.

The institutional fixed effects control for variables that we cannot observe at the institutional level that are relatively fixed over time and might be expected to influence research funding outcomes (e.g. the proportion of the faculty employed in science and engineering fields). The time fixed effects control for national level variables that vary over time that might influence an institution's success in attracting external research funding (e.g. actions its competitors are taking to beef up their research infrastructures). Because the time fixed effects may "absorb" changes in the faculty share variables over time at the national level (leaving the institutional variables in our model to capture only institutional deviations from the national time trends), we also present estimates of models that eliminate the time fixed effects.

Table 2 presents our empirical estimates. Column (1) reports the estimates when time fixed effects are excluded, while column (2) reports the estimates when time fixed effects are

[7] 2003 is currently the last year that institutional funding for research from different federal agencies is available.

included. In the main our estimates are insensitive to the inclusion of the time fixed effects. These two models are estimated for the pooled sample and then separately for subsamples of public and private institutions.

Turning first to the all institution analyses, the more an institution spends on research out of its own funds in one period, the greater the external funding it generates in the next period, other factors held constant. Both the models with and without time fixed effects suggest that each dollar of internal funds spent on research generates an additional one dollar in external funds in the next period. Similar results hold for both public and private institutions, with perhaps a slightly larger multiple existing for private institutions.

As expected, both models indicate a positive and significant effect of the number of full-time faculty on total external R&D expenditures after controlling for other variables in the model. On average, each additional full-time faculty is associated with additional external R&D expenditure of around $16,000 to $17,000. On average, the estimated effect is slightly larger at private than at public institutions, although the difference is not statistically significant.[8]

Turning to the two faculty composition variables, both models suggest that the higher the proportion of full-time faculty at an institution, the smaller the volume of total external R&D expenditures at the institution, other variables held constant including the institution's full-time faculty employment level. Put it in a slight different way, an increased usage of part-time faculty, which leads to a lower proportion of full-time faculty, is associated with a higher level of total external R&D expenditure. For our overall sample, both models suggest that a one percentage point increase in the share of part-time faculty members is associated with an increase in the total external R&D expenditure of about $107 thousand. The magnitude of this relationship appears to

be larger at public institutions than at private institutions. Why the return, in terms of increased external R&D expenditures, of increasing the share of part time faculty is larger at public than at private institutions is an open question.

Quite strikingly, when the total number of full-time faculty and the proportion of full-time faculty are held constant, an increase in the proportion of the full-time faculty members that is tenured or on tenure-tracks is associated with an increase in the volume of external R&D expenditures. For example, column 1 indicates that an increase in the share of full-time faculty members that are tenured or on tenure- track lines by one percentage point is associated with an increase in total external R&D expenditure of $218 thousand; the estimated impact in the model with time fixed effects is even larger ($311 thousand). Similar findings hold for both public and private institutions. These results suggest that while substituting full-time non tenure track for tenured and tenure track faculty may yield cost savings to the university, this will have a negative impact on the level of external research funding that the institution's faculty members generate.

The student enrollment variables included in our empirical model yield somewhat different results. Other variables held constant, increasing undergraduate enrollments are not associated with a change in the level of external research funding generated by the faculty. However, this finding masks different relationships that exist in public and private higher education. While in private institutions, increases in undergraduate enrollments are associated with decreases in faculty productivity in generating external research grants, the relationship in private universities is positive. An increase in graduate enrollments, however, increases faculty

[8] When we added a quadratic term in faculty employment to the model to test if there are economies or diseconomies of scale in generating external research expenditures both the quadratic and linear terms became insignificant (perhaps due to collinearity).

members' productivity in generating external research funding, other variables held constant, at both public and private institutions.

Finally, other variables held constant, increases in federal research funding influences an institution's external R&D expenditures as expected. For example, an increase in the weighted funding of $1 million from federal agencies is associated with approximately a $5 thousand increase in an institution's external R&D expenditures, on average. This estimated relationship is significant for both private and public institution, although it is slightly larger for the former.[9]

V. Concluding Remarks

Our study is the first to use panel data on the employment of faculty of different types to examine the relationship between faculty employment and the external R&D expenditures generated at research and doctoral institutions. Not surprisingly, full-time faculty members that are tenured or on tenure-tracks are the main category of faculty that generates external R&D funding. As the share of the full-time faculty that is tenured or on tenure-tracks at an institution increases, the institution's total external R&D volume also increases, other factors held constant. Ehrenberg and Zhang (2005a) documented the increase in the share of new full-time faculty appointments not on tenure tracks in recent decades. While institutions may benefit from the cost savings by hiring non tenure-track faculty to fill positions left vacant by tenured or tenure-track faculty, the institutions' ability to generate external research funding might be harmed and, as we have previously demonstrated, there are potential adverse impact on undergraduate education as well (Ehrenberg and Zhang 2005b).

On the other hand, our analyses suggest that an increasing usage of part-time faculty, holding constant the level of full-time faculty employment, can actually boost an institution's

[9] Appendix Table 2 tests the robustness of our findings by utilizing log linear rather than linear models (keeping the faculty share variables in share form). The results in this table are very similar to those reported in the text.

external R&D expenditures, probably via the route of a reduction in the teaching responsibilities for full-time faculty members that it permits. Given the adverse impact that part-time faculty have, on average, on undergraduate students (Ehrenberg and Zhang, 2005b), universities must weigh the benefits that they provide in terms of possible enhanced research from the full time faculty, versus their costs in terms of undergraduate education.

Finally, our analyses strongly confirm that graduate students are an essential input into the research function at doctoral universities. Increases in graduate enrollments are associated with higher levels of external research funding, other variables held constant. Balancing the demand for graduate students for research and teaching purposes with the employment opportunities (or lack of such) that are out there for them when they graduate is an important role that graduate deans and departments should play.

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Table 1

Faculty Composition and R&D Expenditures at Research and Doctoral Universities
(in constant 2003 dollars)

Year	Percentage of Faculty That is Full Time [a]	Percentage of Full-Time Faculty That is Tenured or Tenure Track	Total External R&D Expenditure (thousands)	External R&D per Full-time Faculty (thousands)	External R&D per Full Time Tenured and Tenure Track Faculty (thousands)
1990	75.39	86.52	74710	95.86	116.63
1991	76.05	86.73	76870	100.42	126.15
1992	76.54	87.11	79855	102.79	130.25
1993	77.49	87.25	81104	101.91	123.97
1994	77.14	86.86	83137	104.37	128.83
1995	77.63	87.16	85036	109.81	134.08
1996	76.88	86.78	84235	108.37	133.12
1997	76.63	86.05	76258	98.30	122.19
1998	77.22	84.87	90885	112.77	140.12
1999	77.03	84.35	94351	113.73	142.24
2000 [a]	74.26		98152		
2001	72.40	82.27 [b]	103443	117.60	153.12 [b]
2002	73.23	81.47	113320	124.21	163.61
2003	72.51	81.21	122692	132.09	172.17
2004	72.82	80.19	130421	144.71	200.79

Note:
(a). Data on full-time faculty are not available from IPEDS Faculty Salary Survey in 2000.
(b). Data on tenure status are not available from 2001 on. As described in the text, we compute this for each institution in 2001 and thereafter by using the shares of full-time faculty members in each rank at the institution that were tenured or on tenure-tracks in 1999 and then aggregating across all ranks and all institutions.

Table 2
Total External R&D Expenditures (in $1000s) Equations
(t statistics are in parentheses)

All Institutions	(1)		(2)	
Lag institutional R&D expenditures (in $1000)	0.962	(22.66)	0.936	(22.27)
Number of full-time faculty	16.919	(3.98)	16.157	(3.86)
Share of faculty that is full-time	-107.504	(-2.37)	-106.427	(-2.38)
Share of full-time faculty tenured or on tenure track	218.075	(2.85)	311.206	(4.01)
FTE of undergraduate enrollment	0.365	(0.91)	0.211	(0.52)
FTE of graduate enrollment	5.696	(5.51)	5.224	(5.07)
Weighted federal funding ($1M)	5.325	(21.96)	4.028	(11.36)
Institution fixed effect	Yes		Yes	
Year fixed effect	No		Yes	
# observations	2506		2506	
R-squared	0.9782		0.9791	
Public Institutions				
Lag institutional R&D expenditures (in $1000)	0.968	(23.43)	0.942	(22.90)
Number of full-time faculty	14.954	(2.70)	15.320	(2.80)
Share of faculty that is full-time	-153.246	(-2.72)	-153.222	(-2.75)
Share of full-time faculty tenured or on tenure track	171.855	(1.34)	348.623	(2.61)
FTE of undergraduate enrollment	1.328	(3.27)	1.297	(3.18)
FTE of graduate enrollment	3.265	(2.84)	2.741	(2.39)
Weighted federal funding ($1M)	4.614	(15.20)	3.381	(8.21)
Institution fixed effect	Yes		Yes	
Year fixed effect	No		Yes	
# observations	1650		1650	
R-squared	0.9762		0.9774	
Private Institutions				
Lag institutional R&D expenditures (in $1000)	1.140	(7.86)	1.139	(7.93)
Number of full-time faculty	17.047	(2.35)	17.150	(2.39)
Share of faculty that is full-time	-77.577	(-1.01)	-81.264	(-1.06)
Share of full-time faculty that is tenured or on tenure track	210.434	(1.95)	273.202	(2.52)
FTE of undergraduate enrollment	-3.154	(-1.96)	-3.866	(-2.39)
FTE of graduate enrollment	9.275	(4.40)	8.276	(3.89)
Weighted federal funding ($1M)	6.010	(13.81)	4.456	(6.70)
Institution fixed effect	Yes		Yes	
Year fixed effect	No		Yes	
# observations	856		856	
R-squared	0.9804		0.9812	

Appendix Table 1

Faculty composition and R&D expenditures at Research/Doctoral Institutions, in $1000
(2003 Constant Dollars)

Public Institutions

Year	Percentage of Faculty That is Full-Time	Percentage of Full-Time Faculty That is Tenured or on Tenure Track	Total External R&D Expenditure	External R&D per Full-time Faculty	External R&D per Full-Time Tenured and Tenure Track Faculty
1990	80.26	87.07	71568	76.82	95.03
1991	80.86	87.45	74242	79.83	98.69
1992	81.88	87.88	77293	81.93	101.53
1993	82.55	88.05	78798	84.49	104.31
1994	82.45	87.52	80355	86.48	110.32
1995	81.87	87.78	82492	92.52	114.14
1996	80.73	87.39	82584	91.93	113.94
1997	81.00	86.76	73679	81.04	101.59
1998	81.52	85.81	88161	91.63	113.99
1999	80.63	84.99	91689	93.19	117.05
2000	78.99		97266		
2001	77.57	82.85	102076	100.97	130.55
2002	77.78	82.19	112012	106.43	137.94
2003	77.37	81.63	120773	114.19	149.14
2004	77.45	81.01	127286	131.93	185.95

Private Institutions

Year	Percentage of Faculty That is Full-Time	Percentage of Full-Time Faculty that is Tenured or Tenure Track	Total External R&D Expenditure	External R&D per Full-time Faculty	External R&D per Full Time Tenure and Tenure Track Faculty
1990	66.63	85.44	80240	134.51	160.47
1991	67.40	85.51	81553	137.13	175.08
1992	66.82	85.79	84453	140.22	181.78
1993	68.16	85.87	85279	133.45	159.56
1994	67.34	85.72	88239	137.16	162.76
1995	69.83	86.07	89700	141.49	170.63
1996	69.77	85.72	87262	138.52	168.28
1997	68.48	84.81	80986	129.94	159.95
1998	69.23	83.25	95814	151.02	187.44
1999	70.35	83.25	99168	150.67	187.53
2000	65.64		99718		
2001	63.28	81.26	105887	147.32	193.70
2002	65.00	80.19	115657	156.37	209.75
2003	63.45	80.47	126166	164.50	213.55
2004	64.12	78.75	136242	168.44	228.15

Appendix Table 2
Log Total External RD Expenditure at an Institution

All Institutions	(1)		(2)	
Log lagged institutional R&D Expenditures	0.052	(6.11)	0.038	(4.71)
Log number of full-time faculty	0.145	(3.05)	0.111	(2.49)
Share of faculty that is full-time	-0.253	(-4.79)	-0.234	(-4.73)
Share of full-time faculty that is tenured or on tenure track	0.034	(0.39)	0.291	(3.46)
Log FTE of undergraduate enrollment	0.181	(2.84)	0.062	(1.01)
Log FTE of graduate enrollment	0.468	(8.41)	0.318	(5.94)
Log weighted federal funding	0.267	(19.71)	0.029	(1.44)
Institution fixed effect	Yes		Yes	
Year fixed effect	No		Yes	
# observations	2289		2289	
R-squared	0.9847		0.9867	
Public Institutions				
Log lag institutional R&D expenditures	0.068	(5.54)	0.033	(2.89)
Log number of full-time faculty	0.145	(1.81)	0.144	(1.97)
Share of faculty that is full-time	-0.372	(-5.30)	-0.295	(-4.56)
Share of full-time faculty that is tenured or on tenure track	-0.270	(-1.67)	0.299	(1.94)
Log FTE of undergraduate enrollment	0.333	(4.21)	0.166	(2.23)
Log FTE of graduate enrollment	0.251	(3.73)	0.054	(0.85)
Log weighted federal funding	0.286	(17.46)	0.026	(1.14)
Institution fixed effect	Yes		Yes	
Year fixed effect	No		Yes	
# observations	1563		1563	
R-squared	0.9823		0.9854	
Private Institutions				
Log lag institutional R&D expenditures	0.033	(2.77)	0.034	(2.94)
Log number of full-time faculty	0.133	(2.12)	0.105	(1.72)
Share of faculty that is full-time	-0.100	(-1.27)	-0.137	(-1.76)
Share of full-time faculty that is tenured or on tenure track	0.127	(1.18)	0.233	(2.18)
Log FTE of undergraduate enrollment	-0.172	(-1.56)	-0.221	(-2.04)
Log FTE of graduate enrollment	0.844	(8.88)	0.771	(8.14)
Log weighted federal funding	0.179	(7.10)	0.013	(0.33)
Institution fixed effect	Yes		Yes	
Year fixed effect	No		Yes	
# observations	726		726	
R-squared	0.9886		0.9895	